Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

PROCEEDINGS

Seventh Regional Stakeholders cum Coordination Meeting (RSC7)
18-19 May 2013
and
Thirteenth Session of the Intergovernmental Meeting (IG13)
20 May 2013

Dhaka, Bangladesh

RRC.AP

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** Note: This book does not include the following meeting documents. These were published separately by the Secretariat.*

- *Data Analysis Report (IG13/2/1)*
- *Synthesis Report on Malé Declaration (IG13/5/1)*
- *Revised Standard Operating Procedures (SOP) (IG13/6/3)*

I. Seventh Regional Stakeholders cum Coordination Meeting

18-19 May 2013

Seventh Regional Stakeholders cum Coordination Meeting

REPORT OF THE MEETING

I. INTRODUCTION

1. The Seventh Regional Stakeholders cum Coordination Meeting (RSC7) of the Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia (Malé Declaration) was held in Dhaka, Bangladesh on 18-19 May 2013.

2. The meeting was attended by the Malé Declaration (MD) National Focal Points (NFPs) and National Implementing Agencies (NIAs) of the participating countries which included: Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan, and Sri Lanka. Some international organizations, namely, Stockholm Environment Institute (SEI), United Nations Environment Program (UNEP) Headquarters, South Asia Cooperative Environment Programme (SACEP), and the Regional Resource Centre for Asia and the Pacific (RRC.AP) were represented. A number of international and local resource persons, and some local stakeholders were also present at the meeting. The list of participants is enclosed as Annex I.

II. INAUGURAL SESSION

3. Mr. Aparup Chowdhury, Additional Secretary, Ministry of Environment and Forests Bangladesh, delivered a Welcome Address. He acknowledged all guests and warmly welcomed and participants at the meeting. He highlighted the achievements of Bangladesh at each phase of implementation of the Male Declaration. He also mentioned the current initiatives undertaken by the MOEF to combat air pollution in the country, including the introduction of cleaner technology and fuels, among others. He mentioned that the meeting created opportunities for developing greater awareness on health and other risks caused by air pollution, implementation of effective policies, and close monitoring of the status of air pollution. He added that the meeting would enhance the network among various institutes and organizations towards the reduction of air pollution.

4. Ms. Adelaida B. Roman, Head, Network Support Component, RRCAP, gave the introduction and overview of the meeting. She gave a briefing on the achievements of Malé Declaration from Phase I until Phase IV. She mentioned that MD had been instrumental in the establishment of air quality monitoring stations of member countries and enhanced the capacity to monitor the transboundary effects of air pollution which has impact on crops, health, corrosion and other impacts on environment. She recognized the importance of convening these meetings (RSC7 and IG13) so countries could share the progress of the monitoring and other activities and trace the issues and challenges, to better plan for the next phase. She pointed out the cessation of the Swedish International Development Cooperation Agency (Sida) funds in December 2012, with currently committed funds; hence contributions

from the member countries are crucial in continuing the work for the proposed Phase V. She also provided a brief overview on the agenda of the two meetings.

5. Dr. Jonathan Shaw, Deputy Director, RRC.AP, delivered the Opening Remarks on behalf of the Malé Declaration Secretariat. He mentioned that owing to the increase in industrial activity, and exponential growth in number of vehicles and population, environmental degradation remains a challenge in the Malé Declaration member countries. He affirmed, however, that since its inception in 1998, MD had made considerable progress in building the required capacity and linkages in South Asia to assess air pollution impacts and prevention and control options. He highlighted the achievements of MD in areas such as emission inventory preparation, air pollution monitoring and modeling, health, crop, ecosystem and corrosion impact assessments, integrated assessment modeling, development of policy responses and awareness raising activities. He also noted and acknowledged the financial contributions made by India and Maldives for the implementation of activities in the MD, and thanked the other countries which had signified intentions and already in the process of providing contributions.

6. Mr. S.M.D.P. Anura Jayatalake, Director General SACEP delivered the Opening Remarks. He provided a short background of the South Asia Cooperative Environment Programme (SACEP) which was established by the governments in South Asia in 1982 for the protection, management and enhancement of the environment in the region. He informed that the Male Declaration was agreed and established during the 7th Governing Council meeting of SACEP held in Male, Maldives in 1998. He affirmed that MD was the first regional agreement to address the transboundary air pollution issues, and that participation from different stakeholders is vital to the process. He mentioned that the RSC forum was established to obtain participation of stakeholders, to achieve and fulfill the objectives of the Declaration. The meeting is hoped to boast the confidence of stakeholders for the future of MD. He also informed that during the upcoming GC of SACEP in Pakistan later this year, they intend to arrive on direction for the future of MD and its implementation.

7. Dr. Qazi Kholiquzzaman Ahmad, Chairman PKSF, gave an Address. He recognized that MD is a regional initiative of the countries which shared common problems and had agreed to address those problems. He noted that Bangladesh is seriously concern about air pollution and climate change. Increase in emission has been inevitable with the increasing population, and expansion of development, all activities of which is related to the use of energy. He emphasized a need to promote the use of clean energy in the region. Further, he pointed out that efficiency in energy use is something to focus on. He also mentioned about the increasing concern on vehicular pollution. He suggested some measures including awareness and involvement of different stakeholders, i.e schools, etc., to make contributions in the process of reducing pollution. He emphasized that MD is an excellent example of South-South cooperation within the framework of the global process in promoting sustainable development.

8. Dr. Hasan Mahmud, MP, Honorable Minister, Ministry of Environment and Forests Bangladesh, delivered his Address. He expressed great pleasure in hosting the RSC7 and IG13 meetings, affirming that the gesture reflected the country's strong commitment to the MD. He confirmed that Bangladesh has the highest population density in the world. Due to the affluence of the people, vehicular pollution has also worsened. He mentioned that although air pollution sources might be local but the impact could be regional. He presented some major sources of urban outdoor air pollution in Bangladesh, including, motor transport, small-scale manufactures and other industries, burning of biomass and coal for cooking and heating, etc. He also mentioned the current initiatives undertaken by the government to combat air pollution with limited resource, including among others, introduction of lead-free gasoline, CNG-driven vehicles, clean cooking stove initiative, vehicular monitoring, the use of coal-fire power plants, regulating brick kiln industry and introduction of MRT, etc. He was delighted to inform that the government of Bangladesh has recently received a certificate from Ozone section of UNEP in recognition for the successful implementation of Montreal Protocol which reflected that Bangladesh has been serious for the protection of environment, improvement of air quality and for the protection of people who had been affected by climate change. In closing, he put forward a suggestion on the promotion of hybrid vehicles, and request that member countries could look into finding effective ways to promote the technology.

9. Mr. Md. Shafiqur Rahman Patwari, Secretary, Ministry of Environment and Forests Bangladesh, delivered his Address. He expressed great pleasure for the opportunity to host these important meetings of MD and warmly welcomed all participants. He gave a brief account on the air pollution issues in the region and how the MD initiative has been instrumental to combat the problem. He also briefly mentioned about the local situation in Bangladesh and the measures undertaken by the government to address them.

III. RSC7 HIGHLIGHTS

10. Mr. Mr. Aparup Chowdhury, MOEF, Bangladesh, Mr. Md. Shahjahan, Additional Director General, DOE, Bangladesh, and Mr. Mr. J.S. Kamyotra, Member Secretary, Central Pollution Control Board, India co-chaired the RSC7.

Malé Declaration and its Implementation

11. Ms. Adelaida B. Roman, RRC.AP presented the progress on the implementation of the Malé Declaration in 2010-2012. Major activities undertaken during Phase IV were highlighted according to the six objectives. It was reported that important meetings (IG12, RSC6 and TFFD3) were successfully convened; regional and national trainings on emission inventory, and a refresher training on monitoring transboundary air pollution were conducted; and health and crop impact studies had been concluded. Draft reports of the studies has been prepared and some publications and newsletters were published.

Overview of the National Level Implementation of the Malé Declaration

12. The NIAs of the Malé Declaration presented the progress during the Phase IV implementation in their respective countries. The presentations were focused on the institutional arrangements, monitoring activities, impact assessment and awareness activities, and the plan for the future.

13. Mr. Q. S. I. Hashmi and Mr. Syed Ahmmad Kamir presented the status of implementation of the Malé Declaration in Bangladesh. He provided updates on the monitoring activities, including the analysis of the concentration of air pollutants (dry deposition), rain water analysis (wet deposition); and data collection of meteorological parameters, and presented the result. He also reported that emission inventory & modelling had been initiated but they encountered difficulties in the availability and accuracy of data from all sectors. He informed that health and crop impact assessment studies were successfully conducted and awareness materials in printed and electronic forms were developed and published. The future plan includes continuous monitoring of all parameters, PM2.5 may be measured and a second monitoring station may be setup, depending on the availability of funds.

14. Mr. Sonam Dagay, National Environment Commission, Bhutan presented the status of implementation of the Malé Declaration in the country during the Phase IV implementation phase. He briefly summarized the activities undertaken and updated on the establishment of a station at Bhur, Gelephu as a monitoring site for MD. He mentioned that support from MD had been instrumental to start the air quality monitoring in the country. He also reported that regular passive sampling is continuing and that the network of air quality monitoring stations had been setup. He reported completion of crop impact assessment by the Sherubtse College. Upcoming activity will be the update of the emission inventory.

15. Mr. J.S. Kamyotra, Member Secretary, Central Pollution Control Board, India presented the progress in India. He provided details of the activities being carried out at Phase IV, including, among others, (i) continued monitoring on ambient air quality and wet deposition; (ii) initiated discussion to setup monitoring stations in bordering areas in addition to the 6 transboundary monitoting stations in operation; (iii) corrosion and health impact studies completed; (iv) completed and regularly updated the national emission inventory; (iv) organized regional and local meetings and training programmes for the successful implementation of MD activities; and (iv) maintained a dynamic website for raising awareness. He also mentioned about the emission trading pilot study being initiated. The present programme is focused on formulating future development plans for sustainability. For the upcoming phase, it is planned to develop and/or upgrade air quality standards, to consider new parameters, i.e other health-related parameters like PM2.5, benzene, bezo(a) pyrene; and signature metal analyses like nickel, arsenic & lead. He also mentioned a current agreement with the Royal Government of Bhutan for capacity building, demonstration & training, adding that similar initiative could also be signed with other countries, if needed. On the request for submission of monitoring of data to the Secretariat, he committed to submit the data soonest.

16. Mr. Masood Zandi presented the status of implementation of the Malé Declaration in Iran. He mentioned some major sources of air pollution in Iran, including large and small industrial processes, power refinery and petrochemical industries, and the emerging dust storm phenomena. He updated on some policies being setup for the improvement of air quality, including, industrial improvement of fuel quality; improvement of vehicles standards; setting of required laws and regulations; and formulating plans to minimize effect of the dust storm phenomena. Specific measures mentioned, include among others, improvement and development of public transportation; increasing green spaces; expanding parameters for air quality monitoring; and improvement of traffic management in mega cities; and installing on-line monitoring system for industries. He also highlighted in his presentation the dust storm phenomenon which had been an emerging air pollution issue in the country. Activities initiated and planned to abate this problem included, the establishment of regional secretariat on dust and sandstorm management; and formulating action plans to combat drought and desertification in collaboratin with the neigbouring countries, i.e Iraq, Turkey and Syria, and with likely assistance from international organizations.

17. Mr. Ibrahim Mohamed, Environmental Protection Agency (EPA), briefly presented the status of the implementation of the Malé Declaration in Maldives. He mentioned that the primary source of air pollution in the country is vehicular emissions. He reported that monitoring air quality data started in December 2011 but mentioned difficulty of obtaining complete set of data, due to the lack of laboratory facilities and trained personnel. Only PM10 has been monitored.

18. Mr. Teekra Ram Pokharel, Department of Environment, Nepal, presented the status of implementation of the Malé Declaration in the country. He updated on the achievements during 2010-2012, including, completion of the rapid urban assessment, as well as the health and crop impact assessment studies, with the successful publication and wide dissemination of the reports. He also updated on the existing legal framework on air quality, new standards have been formulated, and environmental policy drafted. In the coming year, they plan to establish six more air quality monitoring stations and expand measurement to other parameters related to air quality. He also accounted the factors contributing to air pollution in the country which included rapid urbanization, brick kilns operation, increased numbers of vehicles, traffic congestion and increasing demand of fossil fuel, and industrialization.

19. Mr. Dilshad Ahmad Babar, Ministry of Climate Change, Pakistan, presented the status of implementation of the Malé Declaration in the country. He highlighted the activities undertaken at each of the four phases of implementation of MD, from baseline information & awareness-raising during phase I; capacity-building in phase II; tackling air pollution problems at phase III and enhancing regional cooperation in phase IV. At the last two phases, specific achievements included, among others, establishment of continuous air quality monitoring systems at federal and provincial capitals; conduct and completion of impact assessment

programmes, including, crop, health, and corrosion impacts. At the last phase, the government had initiated new partnerships and collaborations with other air-pollution networks to promote better air quality management.

20. Mr. R.M. Kulasena, Central Environmental Authority, presented the overview of the national level implementation of the Malé Declaration in Sri Lanka. He informed of the continuous air quality monitoring activities and presented the data reports. He presented the status of the second crop impact assessment study initiated in collaboration with the Rajarata University. He also updated on the emission inventory programme in Sri Lanka. He reported the conduct of emission inventory training programmes for local stakeholders as well as the international training in 2012. He mentioned that there remained some data gaps due to some contributing factors such as vegetation and forest fires, evaporation of solvents and other products; industrial fugitive emissions and process emissions.

Data Analysis Report

21. Dr. H. K. Pawana presented the draft analysis report. Since information of some countries had been missing, she was not able to provide a thorough synthesis and analysis of data. Hence, in her presentation, she just presented and sought suggestions on the layout of the report. She requested countries to provide at the earliest the required information to the Secretariat, with a copy to her, so the data report could be completed.

Crop Impact Assessment Studies

22. Dr. Kevin Hicks, SEI-York University, presented the final report on crop impact assessment studies conducted in six countries, namely, Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka. He emphasized that the crop impact study has been a success story in the implementation of MD. He gave a brief introduction of the study, its objectives, the methodology, the overview of the sites and crops used, and presented the results. He summarized the achievements of the study which included, (i) new large-scale experimental evidence of effects of O3 on the yield of important South Asian crops; (ii) widespread evidence of plant-damaging concentrations levels of O3 during main growing seasons; (iii) development of standardised risk assessment methodologies that have been evaluated for application across SA; (iv) increased awareness of yield-damaging effect of O3 among policy-makers, scientific community and general public; (v) successful capacity-building and enhanced cooperation within the region on active mutual exchange of knowledge and skills especially among scientists; and (vi) the establishment of a Regional Centre of Crop Impact Assessment in Pakistan to oversee coordination, quality control and reporting of the MD crop impact activities. He also mentioned some data gaps and suggested future steps.

Health Impact Assessment Studies

23. Dr. Frank Murray, Murdoch University, Australia presented the final report of the health impact assessment studies conducted in Dhaka, Islamabad and Kathmandu. He briefly presented the rationale of the project, measuring the effects of air pollution on health of children in large cities of SA. He gave a background on the two components of the studies, namely, (1) the baseline survey and (2) the health impact assessment, mentioning the methodologies applied at each phase. He also presented the results of the studies in the three cities and the analysis report. The studies concluded that if emissions of PM2.5 in Dhaka, Islamabad, Kathmandu and similar cities could be reduced, the harmful impacts on the respiratory health of children could be substantially decreased with social and economic benefits. He also suggested as a further step the conduct of a regional study to quantify the health, social and economic costs of ambient health damaging PM2.5 particles in MD countries. This initiative is aimed to enable more thorough national assessments of impacts, policy options, costs and health benefits of key options to reduce the burden of disease caused by air pollution.

Updates on air pollution from national stakeholders initiative

24. Dr. Bilkis A Begum, Atomic Energy Centre, Bangladesh, presented a study on the "Identification of haze creating sources from fine particulate matter in Dhaka Aerosol using Carbon Fractions Data". She highlighted on the impact of air pollution on visibility. She mentioned that reduced visibility is noticeable in Dhaka during winter due to smog. She also confirmed that the most serious pollutant in Dhaka and other cities of Bangladesh is particulate matter (PM). She briefly presented the objectives and methodology of the study, as follows: (1) assessment of ambient air quality particularly PM in Dhaka city; (2) assessment on the impact of various policy interventions, i.e. unleaded gasoline, CNG adaptation, etc.; (3) identification of potential source locations and long range transport; and (4) identification of haze creating sources. She summarized the findings and concluded that to address the air pollution issues locally, some measures, i.e careful monitoring of emissions from motor vehicles; reduction of soil dust including dust from the road; and replacement of existing brick kiln with energy-efficient and environment-friendly brick production technology, have to be undertaken. The study also suggested that it is necessary to address the air pollution issues regionally as the transboundary effects may increase the local air pollution.

25. Dr. Abdus Salam, University of Dhaka, presented on the "Aerosol Optical Depth (AOD) Measurements from a Newly Established NASA-AERONET Station in Dhaka, Bangladesh". He provided a brief overview of the work of NASA AERONET (AErosol RObotic NETwork) program which is a federation of ground-based remote sensing aerosol networks, two stations of which are located in Bangladesh. He highlighted on the use of Sunphotometer to measure the sun and sky radiances, and of which is also used to monitor AOD measurements, along with the other parameters. He mentioned that aerosol optical depth or optical thickness is the

degree of which aerosols prevent the transmission of light by absorption or scattering of light. He presented the graphical data and analysed reports. He briefly summarized the conclusions of the study, as follows: (1) Dhaka AOD is slightly higher than other South Asian locations and much higher than the North American sites; (2) Bimodal size distributions were observed in most cases but coarse particles are dominating during monsoon months; (3) Clear and hazy days can be distinguished from AOD measurements; and (4) AOD measurements showed that Dhaka aerosol has a significant contribution from transboundary pollution.

26. Mr. Golam Soroar, Scientific Officer, delivered a presentation on a Clean Air and Sustainable Environment (CASE) project "A national initiative to reduce air pollution in Bangladesh". He gave an overview of the CASE project which addresses the issues on air pollution abatement and improved mobility in Dhaka. The project, which is implemented by the Ministry of Environment and Forests, builds on the experiences and lessons from two World Bank projects, namely the Air Quality Management Project (AQMP) and the Dhaka Urban Transport Project (DUTP). It is aimed at: (i) strengthening capacity to plan, monitor, regulate and implement sustainable environmental initiatives in transport and brick sector; (ii) greening the brick making industry; (iii) increasing pedestrian mobility; (iv) reducing congestion by improving traffic flows; and (v) enhancing the institutional capacity of multi-sector players to abate air pollution. Mr. Golam mentioned that there were three sub-components under the environment component, namely, (i) capacity building for air quality management; (ii) brick kilns emission management; and (iii) communication campaign and clean air initiatives facility, and presented the specific measures and activities undertaken at each phase.

27. Dr. Md Anisur Rahman, CASE Project DTCA, presented the Dhaka Bus Network and Regulatory Reform. He mentioned that an affordable and efficient public transport is vital for the development of Dhaka, given the current socio-economic framework. He informed that in Dhaka, the DTCA is undertaking major efforts at bus system, including, (i) infrastructure development, i.e. high capacity BRT system along main corridors and priority bus routes as feeders; (ii) development of management model with public-private partnership; and (iii) building a sustainable business model. He presented the proposed transit network plan, detailing the phase by phase implementation towards the year 2050. He also mentioned that major challenges for the bus reform are the lack of political support and funding, and negotiation with the operators on the routes packages for contract operation.

28. Prof. Ashraf Ali, Civil Engineering Department, Bangladesh University of Engineering & Technology (BUET), Dhaka, presented the report of the National Air Pollution Reduction Strategy for Bangladesh. He mentioned that BUET had been assisting DoE in the development of the air pollution reduction strategy as part of the implementation of MD. He briefly gave an overview on how the work proceeded, detailing the activities undertaken at each phase, leading to the identification of key control strategies and potential policies. He also presented the structure of the report. The study also identified some relevant policy issues, including, regulatory and fiscal reform; awareness and motivation across sectors; further

research and development to address knowledge and information gaps; cooperation and coordination among various stakeholders; capacity-building and knowledge retention; and institutional setup and governance.

Updates from initiatives focusing on air pollution at the regional/sub-regional level

29. Ms. Suwimol Watanawiroon, Programme Officer, RRC.AP, made a presentation on the progress of EANET. She provided an overview on the work of EANET and highlighted the major achievements on acid deposition monitoring and compilation/evaluation of data; strengthening technical capacity, promotion of QA/QC activities; related research and studies; and public awareness activities. Current and future activities of EANET were also pointed out and the on-going discussion on the possible future expansion of the scope of EANET was mentioned.

30. Mr. Mylvakanam Iyngararasan, UNEP Headquarters and Dr. Ram Lal Verma, Programme Officer, RRC.AP presented the progress in the implementation of the ABC programme including the national emission scenarios for Selective South Asian countries and guidelines for national ABC programmes. The draft guidelines will be circulated to the national implementing agencies of the Malé Declaration for their comments.

Updates on air pollution related activities in the member countries of MD

31. Mr. Ijlal Hussain, Pakistan Environment Protection Agency, presented on the "Air Pollution and Control Activities: Pakistan's Scenario". Ha gave an account of the major pollution issues in Pakistan, including among others, high concentration of PM10 and PM2.5, haze and smog formation in urban centres, increasing concentration of oxides and nitrogen, excessive use of coal in industries; and burning of municipal solid waste. He briefly outlined the major steps undertaken to control air pollution through the Pakistan Clean Air Program (PCAP), as follows: (i) use of clean fuels; (ii) improved technology; (iii) vehicle emission testing centres; (iv) enforcement of standards; and (v) establishment of air quality monitoring system. Major activities and achievements at each step were also mentioned. Some communication and logistical constraints; poor equipment maintenance, unavailability of funds, and weak coordination were mentioned as among the challenges encountered in the course of implementation.

32. Dr. Mohammad Sadegh Sekhavatjou, Islamic Azad Universsity, Iran presented a study on the "Air pollutants concentration changes and exposure risk levels in the most important petrochemical complex zone in Iran". He mentioned that petrochemical industries are the major emission sources of volatile organic components (VOCs) in the atmosphere and which are toxic and have potential impact on human health. The main goals of the study were to determine the concentration of gases - benzene, hexane, toluene, etc.; particulate matters; heavy metals; Hg and other substances in the petrochemical complex zone (PET zone) in Iran.

The results of which were used to assess the air quality and VOC exposure risk to in the area. He outlined in details the methodology and presented the results which indicated a high exposure risk in the PET zone, hence, it is essential for industrial zones to have comprehensive plan for air pollution control, which considers identification of emission sources, measurement of VOCs and other pollutants, application of air pollution dispersion and emission modelling, and preparing emission reduction methodologies.

IV. SUMMARY AND CONCLUSION OF THE SESSION

33. Mr. Chowdhury, Chairperson summarized the 2-day RSC7 event with the following points:

- The Malé Declaration monitoring network has been strengthened in Phase IV. The countries submission of the data is needed to complete the Data Analysis Report in 2013. Countries, that have not submitted the montoring data to the Secretariat so far ,shall submit the same, right after the meeting. Lack of information on monitoring sites, limitation or insufficient data and old meteorological data were pointed out. Temperature data is missing in passive samplers. It was suggested, that in case of power failure continuing at the present site, the site should be moved to other location or have some alternative sites for monitoring.

- It was reminded that sustainable financial contribution is crucial for the implementation of the proposed Phase V due to the ownership of the member countries to Male' Declaration and considering that the Swedish International Development Cooperation Agency (Sida) financial support has beens completed.

- Challenges encountered by few countries of Male Declaration include: inadequate manpower to conduct the monitoring activities, malfunctioning of equipment and erratic power supply. It was suggested that these issues need to be resolved at the national level.

- On basis of database, it was pointed out that standard and action plans might be developed. The capacity and level of implementation shall be enhanced in the Male' Declaration countries. The gaps and weaknesses shall be covered up.

- It was informed that the Crop Impact Assessment Studies and Health Impact Assessment Studies will be endorsed at the Thirteenth Session of Intergovernmental Meeting to be held one day after the Regional Stakeholders Meeting, 20 May 2013.

- Local air pollution related studies, case studies and experiences of regional air pollution networks and programmes together with the activities under the Male' Declaration can contribute in abatement and control of air pollution in the Asia region.

34. Dr. Jonathan Shaw, RRCAP delivered the Closing Remarks. He conveyed his appreciation to all people who contributed to the success of the event. He thanked the participating countries,

the resource persons, RRC.AP colleagues, the chairpersons of the sessions, and most specially the local host, DOE & MOEF, for a job well done. He looked forward to the next phase of implementation of the Male Declaration so that sharing of experiences and expertise on air pollution issues in South Asia will continue, and the network would be further strengthened.

35. The Session was officially closed by the Chairperson.

Annex I

List of Participants

Bangladesh Mr. Aparup Chowdhury Additional Secretary Ministry of Environment and Forests Bangladesh Secretariat, Dhaka email: Aparup Chowdhury <aparup.chy@gmail.com>	 Mr. Quazi Sarwar Imtiaz Hashmi Director (Planning) & PD, Malé Phase IV Project Department of Environment Paribesh Bhaban Room No. 101, E-16, Agargaon, Sher-E-Bangla Nagar, Dhaka-1207, Bangladesh Fax: 880-2-9118682/ 9113328 (Telefax) Email: hashmi@doe-bd.org
Bhutan Mr. Ugyen Tshering Chief, Adminstrative and finance National Environment Commission Royal Government of Bhutan PO Box 466, Thimphu, Bhutan, Tel: +975-2-323384, 324323 Fax: +975-2-323385 Email: ugyentshering33@yahoo.com	 Mr. Sonam Dagay Environment Officer National Environment Commission Royal Government of Bhutan PO Box 466, Thimphu, Bhutan, Email: sonamdagay@nec.gov.bt
India Mr. N. A. Siddiqui Under Secretary (CP Division), Ministry of Environment and Forests Lodhi Road, CGO Complex New Delhi-110003, India Email: nasiddiqui@nic.in	 Mr. J.S. Kamyotra Member Secretary Central Pollution Control Board Parivesh Bhavan, East Arjun Nagar Delhi 110 032, India Email: jskamyotra.cpcb@nic.in
Iran Mr. Masood Zandi Deputy of Air Pollution Research Bureau Department of Environment Environmental Research Center Hemmat Highway Pardisan Park Tehran, Islamic Republic of Iran Tel: +98-21-8267996 Fax: +98-21-8269920 Email: Zandi740@yahoo.com	 Mr. Mohammad Sadegh Sekhavatjou Azad University, Department of Science and Research Group of Engineering Environment Pasdaran Boulevard, Ahvaz City Islamic Republic of Iran Email: sekhavatjou@gmail.com

Maldives Mr Ibrahim Mohamed Deputy Director General Environment Protection Agency P.O Box: 20329, Male', Republic of Maldives. Tel: (960) 333 5949, Fax: (960) 333 5953 Email: Ibrahim.mohamed@epa.gov.mv	 Mr. Hassan Azhar Environment Analyst Environment Department Ministry Environment and Energy Malé, Maldives Tel: +960 3004319 Mob: +960 7930403 Email: Hassan.azhar@environment.gov.mv
Nepal Mr. Ramesh Sthapit Joint Secretary-Tech. Department of Environment Ministry of Science Technology and Environment Singha Durbar, Kathmandu Nepal Tel: +977-9843-069689 Email: rameshsthapit@yahoo.com	 Mr. Teeka Ram Pokhrel Senior Divisional Chemist (Under-Secretary, Tech) Department of Environment Ministry of Science Technology and Environment, Nepal Tel: +977-9841-318052 Email: pokhrelteeka@gmail.com
Pakistan Mr. M. Ahsan Rafi Kiani Deputy Director Pakistan Environment Protection Agency (Pak-EPA) 44-E, 3rd Floor, Office Tower, Blue Area, Islamabad, Pakistan Email: ahsanrafi2002@yahoo.com	 Mr. Dilshad Babur, Joint Secretary, Ministry of Climate Change Pakistan Phone: 0519245548, Fax: 0519245549 Email: dilshadbabar@hotmail.com
Mr. Ijlal Hussain, DPM, Pakistan Environment Protection Agency Pakistan Phone: 0519267632 Email: ijlaldpm@gmail.com	
Sri Lanka Mr. Ruwan Weerasooriya Air Resource Management & International Relations Division Ministry of Environment & Renewable Energy Sri Lanka Email: dammika100@yahoo.com	 Mr. Rasnayake Mudiyanselage Kulasena Deputy Director, Air Quality Monitoring Central Environmental Authority 104, Parisara Piyasa, Baththaramulla Sri Lanka Tel: +94 0117877282 Fax: +94 0112872605 Mobile: +94 0718188652 Email: kulelab@cea.lk

International Resource Persons

Mr. Mylvakanam Iyngararasan Project Coordinator UNEP Headquarters P.O. Box 30552 (00100), Nairobi, Kenya Tel: +254-20-762-6730 Fax: +254-20-762-3918 Email: Iyngararasan.Mylvakanam@unep.org	Mr. S.M.D.P. Anura Jayatilake Director General South Asia Cooperative Environment Programme (SACEP) #10, Anderson Road, Off Dickman's Road Colombo 05, Sri Lanka Tel: +94-11-255-2761 / 258-9787 Fax: +94-11-258-9369 Email: dg_sacep@eol.lk
Mr. Frank Murray Associate Professor School of Environmental Science Murdoch University Murdoch WA 6150, Australia Tel: +61 8 9360 2501 Email: f.murray@murdoch.edu.au	Dr. Kevin Hicks Senior Research Fellow Stockholm Environment Institute at York Grimston House (2nd floor) Environment Department University of York, Heslington, United Kingdom Tel +44 (0) 1904 432896 Fax +44 (0) 1904 432898 Email: kevin.hicks@york.ac.uk
Dr. Parwana Harjinder Kaur, H.No. - 514, SSST Nagar, Rajpura Road Patiala Pb - 147003, India Tel: +91 99 9997 1482 Email: hkparwana@yahoo.com	Mr. Sagar Dhara Cerana Foundation D-101 Highrise Apartments Lower Tank Bund Road, Hyderabad AP 500 080 India Tel: +91 40 2753 6128 Email: sagdhara@gmail.com
Dr. Ram Lal Verma, Program Officer ABC-Asia Secretariat, Regional Resources Centre for Asia and the Pacific (RRC.AP) 3rd Floor, Outreach Building, P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand Tele: +66 2524 6163, 2516-0110 ext. 6163, Fax: +66 2516-2125 Email: Ramlal.Verma@rrcap.ait.asia	Ms. Suwimol Wattanawiroon Programme Officer EANET Secretariat Regional Resource Centre for Asia and the Pacific (RRC.AP) c/o Asian Institute of Technology 3rd Floor, Outreach Bldg. P.O. Box 4, Klong Luang Pathumthani 12120, Thailand Tel: +66 2 524 6244 Fax: +66 2 516 2125 Email: Suwimol.Wattanawiroon@rrcap.ait.asia

Local Resource Persons

Dr. Bilkis A. Begum Atomic Energy Centre Dhaka, Bangladesh	Dr.Abdus Salam Department of Chemistry University of Dhaka Dhaka, Bangladesh

Prof. Ashraf Ali,Civil Engineering Department Bangladesh University of Engineering & Technology(BUET) Dhaka, Bangladesh	Mr.Golam Soroar CASE Project Department of Environment
Mr. Md Anisur Rahman, PD,CASE Project DTCA	

RRC.AP

Dr. Jonathan Shaw Deputy Director Regional Resource Centre for Asia and the Pacific c/o Asian Institute of Technology, P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand Tel. no. +662-524-5365 Fax no. +662-516-2125 Email: Jonathan.Shaw@rrcap.ait.asia	Ms. Adelaida B. Roman Head, Network Support Component Regional Resource Center for Asia and the Pacific (RRC.AP) c/o Asian Institute of Technology, P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand Tel. no. +662-524-5366 Fax no. +662-516-2125 Email: Adelaida.Roman@rrcap.ait.asia
Ms. Charina May Lepiten Programme Officer Regional Resource Centre for Asia and the Pacific c/o Asian Institute of Technology P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand Tel: +66 2 516 2124 Fax: +66 2 516 2125 Email: Charina.Lepiten@rrcap.ait.asia	Mr. Ahmed Iftekhar Khan Programme Officer Regional Resource Centre for Asia and the Pacific c/o Asian Institute of Technology, P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand Tel: +66 2 524 6494 Fax: +66 2 516 2125 Email: Ahmed.Khan@rrcap.ait.asia
Ms. Woralac Rodsum-ang Administrative Assistant Associate Administrative Regional Resource Centre for Asia and the Pacific (RRC.AP) c/o Asian Institute of Technology P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand Tel: +662-524-5389, Fax: +662-516-2125 Email: bew@rrcap.ait.asia	

Local Participants

Mr. Md. Shahjahan Additional Director General Department of Environment, Dhaka.	Mr. Alamgir Mohammed Monsurul Alam Director (Climate Change & Administration) Department of Environment, Dhaka.
Md. Jafar Siddique Director (Law) Department of Environment, Dhaka.	Dr. Nurul Quadir Deputy Secretary (Environment-I) Ministry of Environment & Forests
Dr. Md. Afzal Hossain Deputy Secretary (Env.-2) Ministry of Environment & Forests	Md. Towfiqul Arif Director (IT) Department of Environment, Dhaka.
Mr. Mahmood Hasan Khan Director (Air Quality Management) Department of Environment, Dhaka.	Dr. Tarun Kanti Shikder Director Khulna Division Office Department of Environment, Khulna.
Representative from Ministry of Foreign Affairs	Mirza Shawkat Ali Deputy Director(Int. Convension) Department of Environment, Dhaka.
Mr. Md. Ziaul Haque Deputy Director(Law) Department of Environment, Dhaka.	Mr. Abu Nayeem Md. Maruf Khan Senior Assistant Secretary (Env.-1) Ministry of Environment & Forests
Mr. Syed Ahmed Kabir Senior Chemist & Incharge Malé Monitoring Station Khulna Division Office Department of Environment, Khulna.	
DOE, Local Secretariat	
Mr. Md. Khaled Hasan Deputy Director(Planning) Department of Environment, Dhaka.	Mr. Hasan Hasibur Rahman R.O. & Asstt. Coordinator-Admin Department of Environment, Dhaka.
Mr. Md. Shah Alam SC & Asstt. Coordinator-Finance Department of Environment, Dhaka	

I. Meeting Documents

Seventh Regional Stakeholders cum Coordination Meeting (RSC7)
18-19 May 2013, Dhaka, Bangladesh

Tentative Agenda

Day 1, 18 May 2013

Inaugural Session

09:00-10:00	Registration
10:00-10:10	Welcome Address by Mr.Aparup Chowdhury, Additional Secretary, Ministry of Environment and Forests
10:10-10:20	Introduction and Overview of the Meeting by the Secretariat
10:20-10:30	Opening Remarks by Dr. Jonathan Shaw, Deputy Director Regional Resource Centre for Asia and the Pacific, AIT, Thailand
10:30-10:40	Opening Remarks by Mr. S.M.D.P. Anura Jayatilake, Director General, SACEP
10:40-10:50	Address by the Special Guest, Dr. Qazi Kholiquzzaman Ahmad, Chairman, PKSF
10:50-11:10	Address by the Chief Guest, Dr. Hasan Mahmud, Minister, Ministry of Environment and Forests
11:10-11:20	Address by the Chair, Mr. Md. Shafiqur Rahman Patwari, Secretary, Ministry of Environment and Forests
11:20-11:50	*Coffee/Tea Break*
11:50-12:20	Review of the progress of MD activities in 2010- 2012, By: The Secretariat
12:20-13:00	Overview of national level implementation of the Malé Declaration ▪ National Implementing Agencies (Bangladesh, Bhutan, India)
13.00-14:00	*Lunch*
14:00-15:00	Overview of national level implementation of the Malé Declaration (continue) ▪ National Implementing Agencies (Iran, Maldives, Nepal, Pakistan, Sri Lanka)
15:00-15:30	Presentation and Review of the Data Analysis Report 2012 By: Dr. Parwana
15:30-16:00	*Coffee/ Tea break*
16:00-16:30	Presentation on the Final Report on Health Impact Assessment Studies By: Mr. Frank Murray
16:30-17:00	Presentation on Final Report on Crop Impact Assessment Studies By: SEI
19:30	*Reception dinner*

Seventh Regional Stakeholders cum Coordination Meeting (RSC7)
18-19 May 2013, Dhaka, Bangladesh

Day 2, 19 May 2013	
09:00-10:30	Updates on air pollution from national stakeholders initiatives (some presentations from national stakeholders participants) ▪ Identification of haze creating sources from fine particulate matter in Dhaka aerosol using carbon fractions By**:** Dr. Bilkis A. Begum, Atomic Energy Centre, Dhaka, Bangladesh ▪ Aerosol Optical Depth (AOD) Measurements from a Newly Established NASA-AERONET Station in Dhaka, Bangladesh By: Dr.Abdus Salam, Associate Professor, Department of Chemistry, and University of Dhaka. ▪ CASE project-a national initiative to reduce air pollution in Bangladesh By: Mr.Golam Soroar,CASE Project.
10:30-11:00	*Coffee/ Tea break*
11:00-12:30	Updates on air pollution from national stakeholders initiatives (continue) ▪ Dhaka Bus Network and Regulatory Reform By: Mr.Md Anisur Rahman,PD,CASE Project,DTCA. ▪ National Air Pollution Reduction Strategy By: Prof.Ashraf Ali,Civil Engg. Department, Bangladesh University of Engineering & Technology (BUET),Dhaka.
12.30-14:00	*Lunch*
14:00-15:30	Updates from initiatives focusing on air pollution at regional and sub-regional level ▪ Acid Deposition Monitoring Network in East Asia ▪ Atmospheric Brown Cloud Project ▪ Other Regional and Global Initiatives on Air Pollution
15:30-16:00	Updates on air pollution related activities in the member countries of MD ▪ (some presentations by international participants)
16:00-16:30	*Coffee/Tea Break*
16:30-17:00	Summing Up and Closing

Seventh Regional Stakeholders cum Coordination Meeting on
Malé Declaration on Control and Prevention of Air Pollution and
Its Likely Transboundary Effects for South Asia (Malé Declaration)
18-19 May 2013, Dhaka, Bangladesh

Report on the Progress of Malé Declaration after the Twelfth Session of the Intergovernmental Meeting (IG12)

I. INTRODUCTION

1. This report presents and reviews the progress of Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia (Malé Declaration) activities after the Twelfth Session of the Intergovernmental Meeting (IG12) held in Delhi, India on 30 June 2011.

2. The review is based on the 6 objectives of the Phase IV implementation of the Malé Declaration:

- Strengthen Regional Cooperation for addressing air pollution issues in South Asia;
- Strengthen the air pollution monitoring network and conduct regular monitoring of high quality;
- Enhance the impact assessment capacity of the national institutions and assess the impacts of air pollution and their socio-economic implications in the participating countries;
- Enhance the capacity of National Implementation Agencies (NIAs) to undertake emission inventory and scenario development, atmospheric transfer of pollutants and Integrated Assessment Modelling;
- Assist the member countries of Malé Declaration with the developing air pollution reduction policies and development of a regional framework; and
- Raise awareness for action on air pollution issues through targeted information dissemination.

II. STRENGTHEN REGIONAL COOPERATION AND STAKEHOLDER'S PARTICIPATION UNDER THE MALÉ DECLARATION

II-1 Intergovernmental meeting

3. The IG12 of the Malé Declaration in June 2011 was attended by the representatives of the participating counties, namely: Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan, and Sri Lanka. Experts from the following organizations: South Asia Cooperative Environment Programme (SACEP), Stockholm Environment Institute (SEI), United Nations

Environment Program (UNEP) Headquarters and Regional Resource Centre for Asia and the Pacific (RRCAP), and an independent facilitator also attended the Session.

4. The IG12 adopted, with modifications the Report of the Task Force for Future Development (TFFD), and its Annexes which include the Draft Resolutions for Consideration of the Ministerial Level Meeting, the Report on the Sustainable Financial Mechanism, the Feasibility Report on the Establishment of Regional Centres, and the Feasibility Report on Strengthening the Regional Framework on Air Pollution Reduction in South Asia. The Workplan 2012 for Malé Declaration was also adopted by the IG12.

II-2 Ensure Stakeholders Engagement with Intergovernmental Process

5. The Sixth Regional Stakeholders cum Coordination Meeting (RSC6) of the Malé Declaration was held back to back with the IG12 in Delhi, India on 28-29 June 2011 and the Meeting Report was transmitted to all participants after the IG12. The meeting was attended by the Malé Declaration National Focal Points (NFPs) and National Implementing Agencies (NIAs) of the participating countries which include: Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan, and Sri Lanka. Experts from South Asia Cooperative Environment Programme (SACEP), Stockholm Environment Institute (SEI), United Nations Environment Programme (UNEP), UNEP Regional Resource Centre for Asia and the Pacific (UNEP RRC.AP), a resource person from Murdoch University Australia, expert from Swedish Environmental Research Institute Ltd (IVL), Technical Committee Member of the Malé Declaration and an independent facilitator also attended in the meeting.

6. The National Implementing Agencies (NIAs) of the Malé Declaration presented the progress during the Phase IV implementation in their respective countries. Presentations focused on the institutional arrangement under the Malé Declaration, monitoring activities, impact assessment activities, recent measures to control air pollution emissions in the country and the plan for the next 2 years.

II-3 Task Force on Future Development (TFFD) of Malé Declaration

7. The Ninth Session of the Intergovernmental Meeting (IG9) held in 2007 decided the establishment of the Task Force for Future Development of Malé Declaration (TFFD). The TFFD which was established to consider the expansion of the Malé Declaration, submitted to the IG12 its Report on Future Development which included: 1) Draft Resolutions for Consideration of the Ministerial Level Meeting; 2) Report on the Sustainable Financial Mechanism, 3) Feasibility Report on the Establishment of Regional Centres; and 4) Feasibility Report on Strengthening the Regional Framework on Air Pollution Reduction in South Asia. The Report of the TFFD was discussed, reviewed and adopted, with modifications during the IG12.

8. The Third Meeting of the Task Force Task was held on 9-10 August 2012 in Chonburi, Thailand. The objectives of the meeting include, among others, the presentations and discussions on the following guidelines, for submission to the Thirteenth Session of the Intergovernmental Meeting for its review and guidance: 1) Draft guidelines for implementation of the sustainable financial mechanism of the Malé Declaration; 2) Draft guidelines for the next steps of implementation on strengthening the framework on air pollution reduction in South Asia; 3) Draft guidelines for the operation of the regional centres; 4) Terms of Reference for the Synthesis Report, Plan; 5) Plan for Phase V; and 6) Work Programme in 2013 for the Malé Declaration.

III. STRENGTHEN CAPACITY BUILDING PROGRAMMES INITIATED DURING PHASE IV ON MONITORING

III-1 Continue operation of the monitoring stations

9. NIAs continued the operation of the monitoring sites during the phase IV. The Malé Declaration monitoring network has been strengthened through the addition of new sites in India (4 new sites) and Iran (1 site), which have been mostly funded by in-kind contributions from those countries. Training for the enhancement of capacity for technicians in charge of the monitoring site/s in each of the member countries is being continued. The results will be presented and discussed during the 9th Refresher Training to be held in India in October 2012. The Malé Declaration had improved the operation of the established monitoring stations by site audits and on- site training.

III-2 Implementation of inter-laboratory comparison

10. Dr. Nguyen Thi Kim Oanh, Asian Institute of Technology, Thailand submitted to the Secretariat the "Draft Report of the Inter Laboratory Comparison of Precipitation Chemistry Analyses of the Malé Declaration" in May 2012. The report was based on the analytical results of the artificial rain water samples from the NIAs. This is the third attempt of the inter-laboratory comparison project which involves a round-robin analysis of uniformly prepared artificial rainwater samples by the NIA laboratories of the Malé Declaration. The result of the third inter-laboratory comparison was presented to the 9th Refresher Workshop held in New Delhi, India and to be submitted to the the IG13 for its review, guidance or endorsement.

11. The overall objective of the inter-laboratory comparison is to recognize the analytical precision and accuracy of the data in each participating NIA laboratory and consequently to provide an opportunity to improve data reliability/quality. The protocol highlighting the methodology of this inter-laboratory comparison has been developed based on Quality Assurance/Quality Control (QA/QC) procedure for Malé Declaration network with reference to the inter-laboratory comparison reports of the EANET project. The sample preparation, distribution and analysis with necessary QA/QC are included in the protocol which was

circulated and agreed upon by all NIAs in September 2007, i.e. before the inter-laboratory exercise started.

III-3 Regional training programme

12. The 9th Refresher Training on Monitoring Transboundary Air Pollution was held on 10-12 December 2012 in New Delhi, India. The training was organized by the Central Pollution Control Board (CPCB), India which is designated as the Regional Centre on Wet and Dry Deposition Monitoring of the Malé Declaration, in collaboration with the Secreatraiat. The capacity building events initiated in the previous implementation phase of the Malé Declaration are being continued during the Phase IV implementation. Included in the priority areas for capacity building is the Refresher Training on monitoring transboundary air pollution programme which is being held every year.

13. The objectives of this workshop included: to provide hands-on-training on the use of different monitoring and laboratory equipment and enhance knowledge on quality assurance/ quality control aspects; to discuss the progress of the implementation of Malé Declaration monitoring activities during Phase IV; to discuss the plan for Phase V implementation of the Malé Declaration; and to discuss the data submitted by the member countries.

III-4 Central compilation, evaluation, and storage of data

14. Some of the participating countries have submitted their data and related information obtained through the monitoring activities in 2010-2012 to the Secretariat. The Data Analysis Report during Phase IV will be developed based on the data and monitoring information provided by the participating countries. After quality check by the MoC, the data will added to the regional database. The regional database is available online for the NIAs at: http://www.rrcap.unep.org/male/.

IV. ENHANCE THE CAPACITY OF NIAs ON EMISSION INVENTORY, SCENARIO DEVELOPMENT AND INTEGRATED ASSESSMENT MODELING

15. The 5th Regional Training on Emission Inventory and the National Training on Emission Inventory were held in Colombo, Sri Lanka on 23-25 May 2012 and 21-22 May 2012, respectively. The trainings were organized by the Central Environment Authority (CEA), Sri Lanka which serves as the Regional Center on Emission Inventory of the Malé Declaration, and co-organized by the Secretariat.The objective of the trainings were to enhance the capacity and capability of National Implementing Agencies (NIAs) and those involved in the participating countries to undertake emission inventory and scenario development, and integrated assessment modeling.

V. ENHANCE THE ANALYTICAL AND IMPACT ASSESSMENT CAPABILITY AT THE NATIONAL LEVEL

V-1 Assess the socio-economic impact of air pollution on the health of people

16. During the Phase IV implementation of the Malé Declaration, the health impact assessment study which was conducted in Dhaka, Bangladesh during the Phase III implementation was replicated in selected schools in Kathmandu, Nepal and in Islamabad, Pakistan. The objectives of the study are: to a) determine whether there is an association between daily mean PM10 and PM2.5 concentrations and respiratory health and lung function in children in a the selected city; b) quantify the relationship; and c) assess the scale and severity of impacts of air pollutants. This assessment can address the need for information on the effects of air pollutants on health in South Asia at the high concentrations commonly found in large cities, and provide locally-gathered evidence to support actions by governments to control particulate emissions.

17. In order to review the results of the study, the Workshop on Health Impact Assessment was held in Dhaka, Bangladesh on 9 January 2012. The training was attended by health and air quality experts from Nepal, Pakistan and Bangladesh who are involved in health impact studies and air pollution related activities, a resource person from Murdoch University, Australia and representatives from the Malé Declaration Secretariat from the Asian Institute of Technology (AIT) United Nations Environment Programme (UNEP) Regional Resource Center for Asia and the Pacific (RRC.AP).

18. The training was hosted by the National Institute for Preventive and Social Occupational Medicine (NIPSOM), the selected regional center on Health Impact Assessment for South Asia under the Malé Declaration.

19. The Final Health Impact Studies conducted by Bangladesh, Nepal and Pakistan will be presented to IG13 for its review and endorsement.

V-2 Crop Impact Assessment Studies

20. Nepal has conducted the crop impact study titled **“** *Assessing The Impact Of Ambient Ozone On Growth And Yield Of Mungbean Under Rampur, Chitwan Condition”*. The experiment was carried out at the Institute of Agriculture and Animal Science (IAAS) Rampur, Chitwan. The location falls in inner Terai region of Nepal. The study was conducted from April, 2012 to July 2012.

21. Bhutan also conducted the cop impact study titled “Quantifying the impact of tropospheric ozone on spinach using protective chemical (EDU), Kanglung Bhutan*”*. The main objective

of the study was to qualitatively and quantitatively assess the impact of ozone, expressed as foliar injury and biomass reduction, on **spinach** using the anti-ozonant ethylenediurea (EDU).

VI. PROVIDE DECISION SUPPORT INFORMATION FOR POLICY FORMULATION AND AIR POLLUTION PREVENTION

22. In response to a call by the Department of Environment (DOE) of the Government of Bangladesh, the "Final Report on Air Pollution Reduction Strategy for Bangladesh' was completed by Bangladesh in April 2012. The report describes the current state of air quality, major sources of air pollution, past policies implemented and suggests future strategies to reduce air pollution in Bangladesh. Around 50 strategies were initially selected, of which 26 are finally recommended after evaluation of the strategies. The criteria for evaluation were likely impact, time to introduce, time to benefits, technical and implementation effectiveness, cost effectiveness and co-benefits. The recommended strategies are presented in the report. The strategy choices were based on a *qualitative* multi-criteria evaluation because of lack of information for quantitative benefit-cost modeling.

23. The publication on "Rapid Urban Assessment of Air Quality for Katmandu, Nepal" was completed by ICIMOD, NIA, Nepal in 2012. This publication provides a detailed account of the pollution hotspot areas in Kathmandu. This is the first study done using quantitative data to get an overall picture of the major pollutants. Population density and pollution concentration data are overlaid to provide easily understood maps that will be of particular relevance to policy makers. This study provides an example that can be replicated for other cities.

VII. RAISE AWARENESS FOR ACTION THROUGH TARGETED DISSEMINATION

24. The Report on Compendium of Good Practices on Prevention and Control of Air Pollution (first report) was compiled by Prof. Ram M. Shrestha, in collaboration with Malé Secretariat as part of the phase III implementation of the Malé Declaration. This report has been updated by the Centre for Environment Education in collaboration with the Secretariat as part of the phase IV implementation of the Male' Declaration.

25. Raising the awareness of youth on air pollution issues is continued through the activities of the South Asia Youth Environment Network (SAYEN). A national "Youth for Clean Air Awareness Workshop" was held in January 2012 in Dhaka, Bangladesh and the Regional Workshop on "Youth for Clean Air" was held in February 2012 in Ahmedabad, India.

Report on the Progress of

Malé Declaration Activities

in 2010-2012

The Secretariat

Malé Declaration: Phase IV Objectives

1. Strengthen **Regional Cooperation** for addressing air pollution issues in South Asia

2. Strengthen the **air pollution monitoring network** and conduct regular **monitoring of high quality**

3. Enhance the **impact assessment** capacity of the national institutions and assess the impacts of air pollution and their socio-economic implications in the participating countries

4. Enhance the capacity of National Implementing Agencies (NIAs) to undertake **emission inventory and scenario** development, atmospheric transfer of pollutants and Integrated Assessment Modelling

5. Assist the member countries of the Malé Declaration with developing **air pollution reduction policies** and development of a **regional framework**

6. Raise **awareness** for action through targeted information dissemination

Goal: Strengthen Regional Cooperation and Stakeholders' Participation

Activities:

- **12th Session of Intergovernmental Meeting (June 2011)**
- **6th Regional Stakeholder-cum-Coordination Meeting (June 2011)**
- **3rd Meeting of the Task Force on Future Development of MD (August 2012)**

The IG12 adopted (with modifications) the Report of the Task Force for Future Development (TFFD), and its Annexes which included:

- **Draft Resolutions for Consideration of the Ministerial Level Meeting**
- **Report on the Sustainable Financial Mechanism**
- **Feasibility Report on the Establishment of Regional Centres**
- **Feasibility Report on Strengthening the Regional Framework on Air Pollution Reduction in South Asia.**

Goal: Strengthen the air pollution monitoring network and conduct regular monitoring of high quality

Activities:

- **Continued operation of the monitoring stations**
  - **Additional stations: (India (4 new sites) and Iran (1 site)**
- **Implementation of inter-laboratory comparison**
  - **to recognize the analytical precision and accuracy of data and consequently improve data reliability/quality**
- **9th Refresher Training on Monitoring Transboundary Air Pollution (December 2012)**
- **Central compilation, evaluation, and storage of data**

Goal: Enhance capacity on Emission inventory, scenario development and Integrated Assessment Modelling

Activities:

- **5th Regional Training on Emission Inventory**
  (Sri Lanka, May 2012)
- **National Training on Emission Inventory**
  (Sri Lanka, May 2012)
  The objective of the trainings were to enhance the capacity and capability of NIAs and those involved in the participating countries to undertake emission inventory and scenario development, and integrated assessment modeling.

Goal: Enhance analytical and impact assessment capability

Activities:

- **Health Impact Assessment**
  - The epidemiological study undertaken in Bangladesh investigating the impact of air pollution on school children was expanded to Nepal and Pakistan
  - *The objectives of the study are to: a) determine whether there is an association between daily mean PM10 and PM2.5 concentrations and respiratory health of children; b) quantify the relationship; and c) assess the scale and severity of impacts of air pollutants.*
  - In order to review the results of the study, the **Workshop on Health Impact Assessment** was held in Dhaka, Bangladesh on 9 January 2012.

Goal: Enhance analytical and impact assessment capability

Activities:

➢**Crop Impact Assessment**

- ❖ Nepal: "Assessing the Impact of Ambient Ozone on Growth and Yield of Mungbean under Rampur, Chitwan Condition".
  - o *The study was conducted by the Institute of Agriculture ans Animal Science (IAAS) from April 2012 to July 2012 at the inner Tersi region of Nepal.*
- ❖ Bhutan study: "Quantifying the impact of tropospheric ozone on spinach using protective chemical (EDU), Kanglung, Bhutan"
  - o *The objectives of the study was to qualitatively and quantitatively assess the impact of ozone, expressed as foliar injury and biomass reduction, on spinach using the anti-ozonant ethylenediurea (EDU)..*

Goal: Provide decision support information for policy formulation and air pollution prevention

Activities:

➢**"Final Report on Air Pollution Reduction Strategy for Bangladesh" was completed in April 2012.**

- ❖ *The report describes the current state of air quality, major sources of air pollution, past policies implemented and suggests future strategies to reduce air pollution in Bangladesh*

➢**Publication on "Rapid Urban Assessment of Air Quality for Kathmandu, Nepal" completed in 2012 by ICIMOD.**

- ❖ *The publication provides detailed account of the pollution hotspot areas in Kathmandu.*

Goal: Raise awareness

Activities:

➢The **Report on Compendium of Good Practices on Prevention and Control of Air Pollution** (first report) compiled since phase III implementation of the MD has been updated by the Centre for Environment Education in collaboration with the Secretariat as part of the phase IV implementation of the MD.

➢**Networking with youth**

- ❖ Raising the awareness of youth on air pollution issues is continued through the South Asia Youth Environment Network (SAYEN).
- ❖ A national "Youth for Clean Air Awareness Workshop" was held in January 2012 in Dhaka, Bangladesh and the Regional Workshop on "Youth for Clean Air" was held in February 2012n Ahmedabad, India.

Thank you !!!

Overview of the national level implementation of the Malé Declaration

Presentation

on

Overview of national level implementation of the Malé Declaration in Bangladesh

Presented By:
Quazi Sarwar Imtiaz Hashmi
Director (Planning)
Department of Environment and PD, Phase IV
Implementation of Male' Declaration in Bangladesh
&
Syed Ahmmad Kabir, Sr. Chemist in Charge of Male' Monitoring Activities

Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Outline of the Presentation

- Institutional Arrangement
- Location of Trans-boundary Air Pollution Monitoring Station
- Monitoring activities-Dry and wet deposition
- Emission inventory and modeling
- Impact Assessment Activities
- Air Pollution Reduction Strategy for Bangladesh
- Awareness Activities
- .ure Plan.

Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Institutional Arrangement

Ministry of Environment and Forests (NFP)

National Advisory Committee

Department of Occupational & Environmental Health (DOEH),NIPSOM

Department of Environment (NIA)

Environmental Science Department, Bangladesh Agricultural University

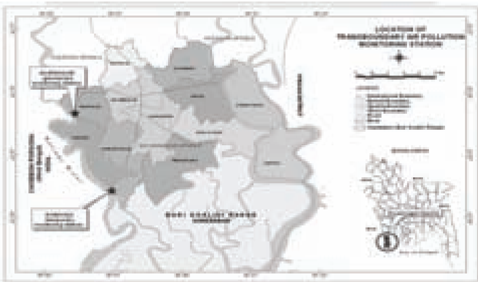
Dept. of Civil Engineering. BUET

Monitoring Station, Sathkhira

Khulna Divisional Lab of DOE

Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Location of Transboundary Air Pollution Monitoring Station

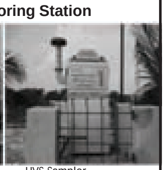


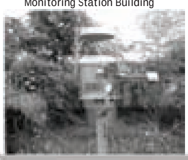
Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

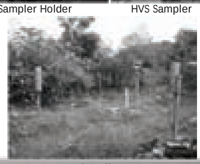
Location of Transboundary Air Pollution Monitoring Station


Monitoring Station Building


Passive Sampler Holder

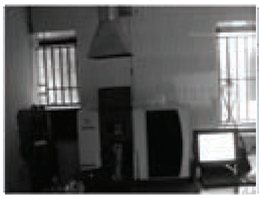

HVS Sampler


Wet only collector


Rain collector

Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Malé Declaration Lab Instruments in Khulna DOE


Atomic Absorption Spectrophotometer


Spectrophotometer

Monitoring activities

- Analysis Concentration of Air Pollutants (Dry Deposition)
  - By High Volume samplers (Particulate Matter- PM_{10}) and Diffusive samplers (SO_X, NO_X and O_3).
- Rain water Analysis (Wet Deposition)
  - Sample Collection By Bulk Collector and Wet only Collector).
  - P^H, EC, Anions (Sulfate, Nitrate, Chloride, Bicarbonate), Cations (Sodium, Potassium, Calcium, Magnesium, Ammonium).
  - Analyze by using P^H, EC meter, Spectrophotometer and Atomic Absorption Spectrophotometer.
- Metrological Parameter
  - Data Collected from Metrological dept. of Shatkhira.

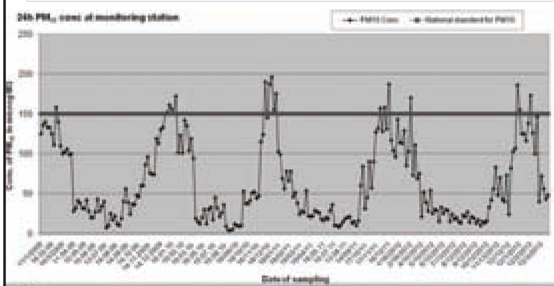
Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Monitoring activities

- Standard Operating Procedure (SOP) has been translated in local language.
- Participation of inter Laboratory Comparison programme by UNEP/AIT.
- National Advisory Committee has been formed and this committee is having meeting in every three months .
- High Volume sampler for PM_{10} Monitoring has been started from July'2008.
- Passive sampler for SO_2 and NO_2 Monitoring have been stared from July'2004.
- Passive Sampler for O_3 Monitoring has been started from July'2006
- Rain water Sampling has been started from 2007.

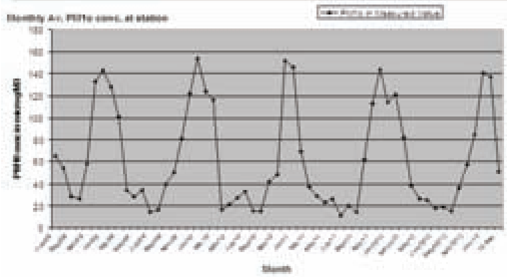
Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Monitoring activities-PM_{10} Conc. of Ambient Air (24hrs Av. Data) at monitoring station



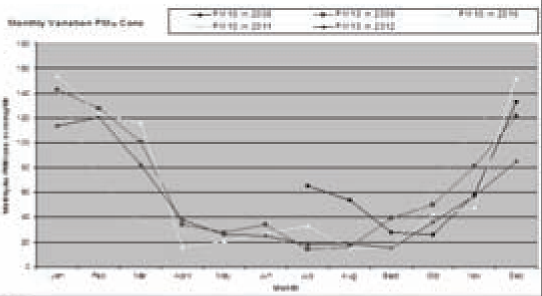
Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Monitoring Activities-Monthly Av. Particulate Matter (PM_{10}) Conc.



Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Season Variation of Monthly Av. PM_{10} Conc.



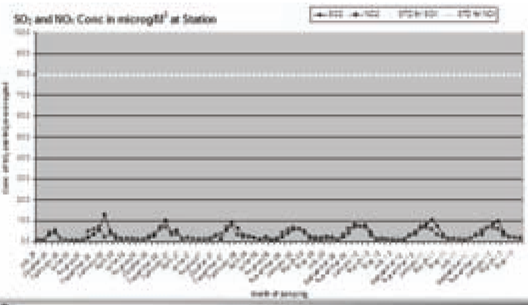
Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Annual Average of PM10

Year	PM_{10}	Nation standard
2009	68	50
2010	66	50
2011	58	50
2012	51	50

Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Ambient Conc. of SO_X and NO_X in air by Passive Sampler



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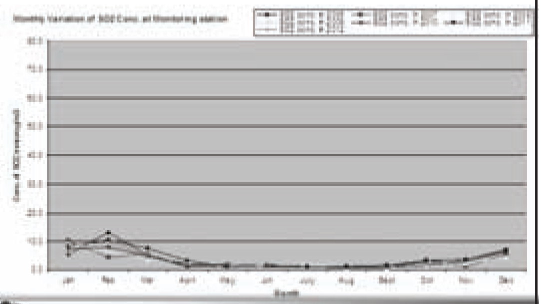
Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Monthly Variation SO_2 and NO_2 Conc. From 2006 to 2012



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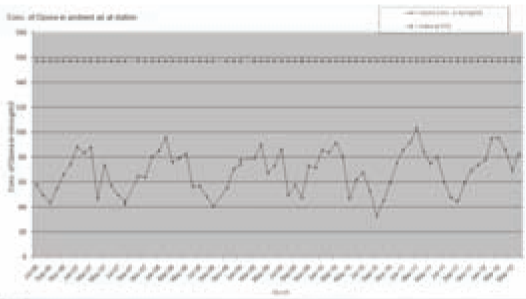
Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Ozone Conc. In microgm/M3 in Ambient air at station



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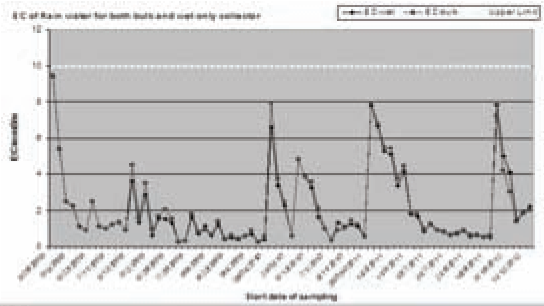
Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

EC of Rain water (bulk and wet only collector) in mS/m



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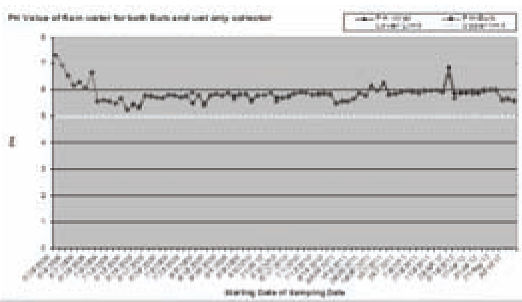
Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

P^H of Rain water (bulk and wet only collector)



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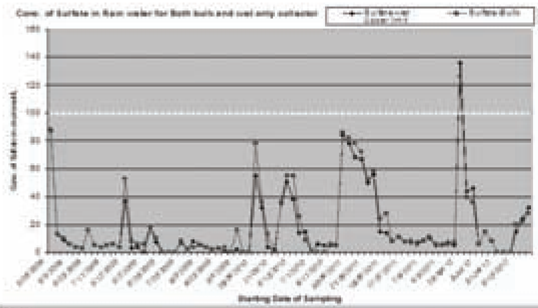
Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Sulfate con. of Rain water (bulk and wet only collector) in µmol/L



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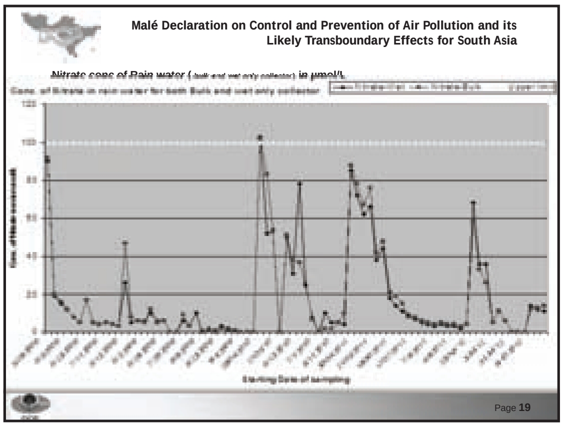
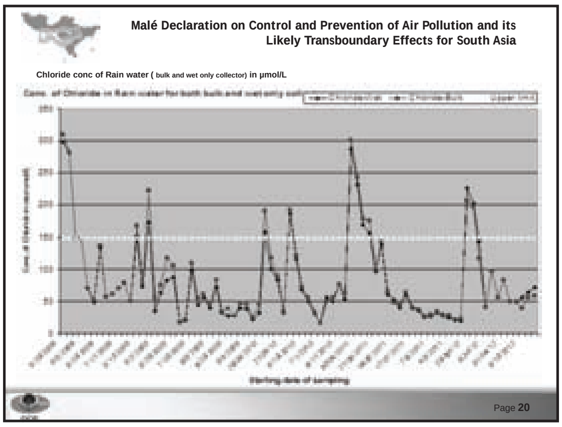
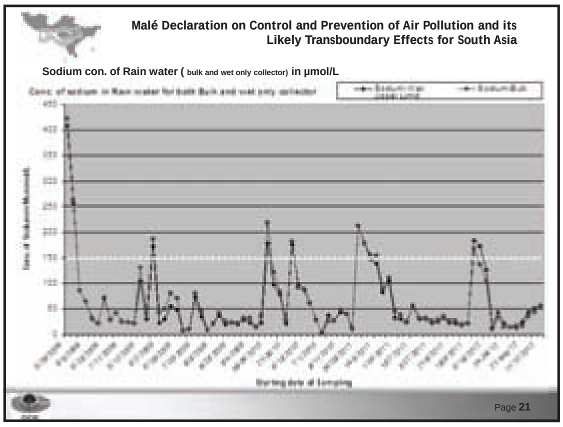
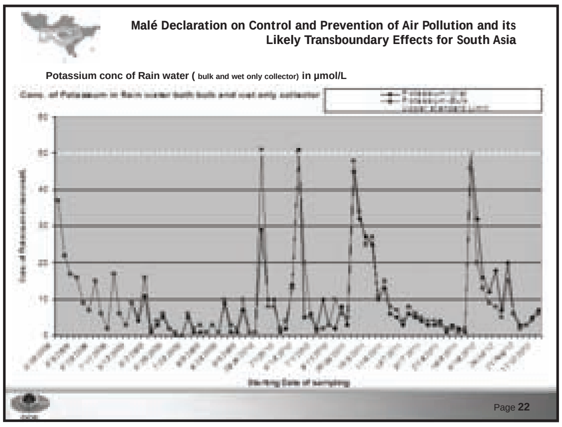
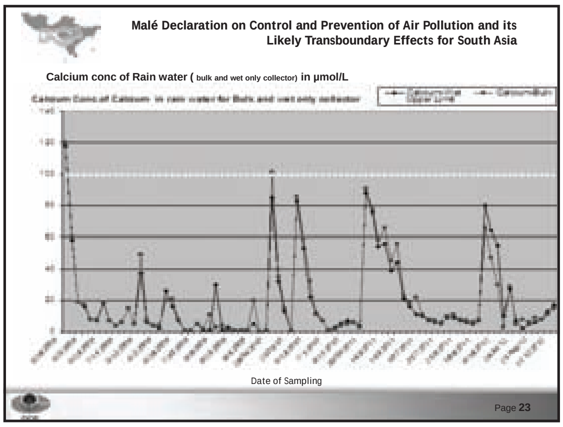
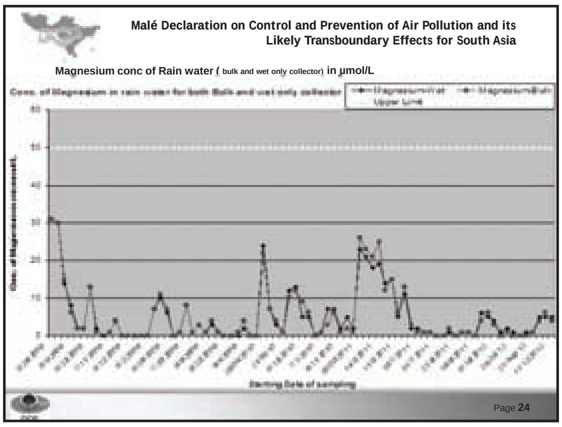

Malé Declaration on Control and Prevention of Air Pollution and its
Likely Transboundary Effects for South Asia
Nitrate conc of Rain water (bulk and wet only collector) in µmol/L
Starting Date of sampling
Page 19


Malé Declaration on Control and Prevention of Air Pollution and its
Likely Transboundary Effects for South Asia
Chloride conc of Rain water (bulk and wet only collector) in µmol/L
Starting date of sampling
Page 20


Malé Declaration on Control and Prevention of Air Pollution and its
Likely Transboundary Effects for South Asia
Sodium con. of Rain water (bulk and wet only collector) in µmol/L
Starting date of Sampling
Page 21


Malé Declaration on Control and Prevention of Air Pollution and its
Likely Transboundary Effects for South Asia
Potassium conc of Rain water (bulk and wet only collector) in µmol/L
Starting Date of sampling
Page 22


Malé Declaration on Control and Prevention of Air Pollution and its
Likely Transboundary Effects for South Asia
Calcium conc of Rain water (bulk and wet only collector) in µmol/L
Date of Sampling
Page 23


Malé Declaration on Control and Prevention of Air Pollution and its
Likely Transboundary Effects for South Asia
Magnesium conc of Rain water (bulk and wet only collector) in µmol/L
Starting Date of sampling
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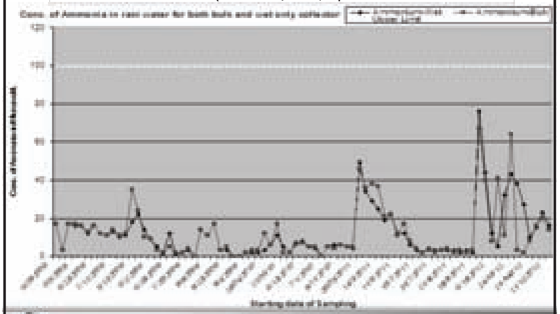
Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Ammonium conc of Rain water (bulk and wet only collector) in µmol/L



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Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Observation about Dry deposition Monitoring

- Same trend of PM conc. Variation like previous years
- PM Conc. Observed higher value during Dec, Jan and Feb
- SO_2 and NO_2 conc. at station observed much lower than national standard
- SO_2 and NO_2 conc. Observed higher Value during Dec, Jan and Feb
- Annual Average of PM_{10} is decreasing trend.
- Ozone conc. Relatively higher than others gaseous substances.
- All Rain water samples analyzed data have been checked QC and QA by R_1 and R_2 Calculation.

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Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Emission inventory and modeling

- **Emission Inventory, Emission Scenario and Modeling under Malé Declaration on Control and Prevention of Air Pollution And Its Likely Transboundary Effects for South Asia**

The emissions inventory under the current exercise is based on a common methodology developed by the Swedish Environmental Institute (SEI) for countries in South Asia - itself derived from various inventory approaches used in other regions of the world using 2005 data. According to the SEI approach, sources of air emissions are categorized into ten sectors.

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Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Emission inventory and modeling

1. Combustion in the energy industries,
2. Combustion in the manufacturing industries and construction,
3. Transport,
4. Combustion in other sectors
5. Fugitive emissions from fuels
6. Industrial processes
7. Solvent and other product use
8. Agriculture,
9. Vegetation fires and forestry, and
10. Waste

Each sector has several sub sectors. For each sector the basic approach for calculating emissions of a particular pollutant is simple in concept.

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Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Emission inventory and modeling

DIFFICULTIES

- **Data are not available in all sectors.**
- **Data are not in same time frame.**
- **Incomplete data**

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Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Health Impact Assessment

Assessment of Impact of Air Pollution among School Children of selected school of Dhaka City

3 schools of Dhaka City
Survey:1680 Students (Class V-IX),
Duration: 7 Days
Main Study:180 Students(120 Asthma=60 Non-Asthma),
Duration:42 Days

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Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Assessment of Impact of Air Pollution among School Children of selected school of Dhaka City

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Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Assessment of Impact of Air Pollution among School Children of selected school of Dhaka City

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Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Assessment of Impact of Air Pollution among School Children of selected school of Dhaka City

Findings:

- The study was concluded with that the air pollution especially the particulate matter (PM_{10} and $PM_{2.5}$) are causing respiratory health problems particularly of the children in Dhaka, who are suffering from asthma.
- The air pollution is not only affecting the health of the children but also causing adverse economic implication in the family and as well as in the nation

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Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Air Pollution Impact on crop

- Study 1: Biomonitoring study using white clover in relation to tropospheric ozone concentrations
- Study 2: Chemical protectant study using EDU in Potato, Munbean, wheat and spinach.
- Findings-The prevailing O3 concentrations at Bangladesh Agricultural University Campus area led to a decrease in biomass of the O3-sensitive clover genotype and also in local cultivars, which indicates that sensitive crop cultivars might be at risk in the farming areas of Mymensingh District.

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Air Pollution Impact on crop

Fig. Ozone resistant white clover plants cultivated in Mymensingh

Fig. White clover plants suffering with air pollutant (tropospheric ozone)

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Fig. A

Fig. B

Fig. A. Wheat plant cultivated with EDU

Fig. B. Wheat plant suffering with tropospheric ozone

Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Air Pollution Reduction Strategy for Bangladesh

- Prepared by Department of Civil Engineering, Bangladesh University of Engineering and Technology with the financial help of UNEP.
- Major features -
  - Analyze the air pollution status of Bangladesh.
  - National Air Quality Management and standard
  - Sources of Air pollution in Bangladesh
  - Effects of Air Pollution
  - Past Air Quality strategies of Bangladesh.
  - Air Pollution Control Approaches
  - Evaluation of Past Air Quality strategies
  - Recommended Strategies for Air Pollution Reduction
  - Other policy issues

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Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Awareness Activities

Awareness material for print and electronic media developed

Print Material:

a .Posters-20,000

b. Leaflets-20,000

c. Stickers-10,000

Electronic Media Material:

a. TV spots- 4 Nos.

b.Docodramas-3 Nos.

C. Folksongs- 2 Nos.

Bus Sticker- 6 Nos.

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Awareness Activities

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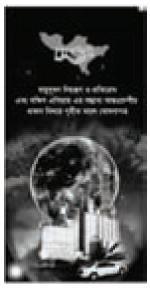
Awareness Activities



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Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Future Plan

- All parameters will be monitored as usual.
- 2nd monitoring station may be set up, if fund is made available.
- $PM_{2.5}$ may measured ,if it is included as a parameter in *Male Declaration*.

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Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Thank you…..

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Overview of implementation of Malé Declaration in Bhutan

Seventh Regional Stakeholders cum Coordination Meeting (RSC7) ,18 May 2013
Dhaka, Bangladesh

Sonam Dagay
National Environment Commission
Royal Government of Bhutan

Implementation

- Completed implementation of 3 Phases of declaration in last 11 years
- 1st Phase : for baseline study
- Phase II & III, ended in 2008 for capacity building
- Phase IV commenced from 2010
- A station at Bhur, Gelephu was established as a male network to monitor transboundary pollution
- Support from Male has been instrumental to start air quality monitoring
- Regular passive sampling exposure was initiated in Phase III, and still continuing
- Network of air quality monitoring stations set up

Contd…implementation

- Total of USD 10,000 has been sanctioned by the male secretariat for Phase IV
- Task Force formed to future development of Male
- Crop impact assessment completed by Sherubtse College
- Update of inventory will be initiated soon
- SOP not required (translation not required since English is widely used in the country): use SOP developed by Male secretariat

TASHI DELEK

Malé Declaration on Control & Prevention of Air Pollution and its Likely Trans boundary Effects for the South Asia

Seventh Regional Stake Holders cum Coordination Meeting (RSC-7)

Dhaka
May 18-19, 2013

RSC-7, Dhaka 1

WELCOME DELEGATES
& COUNTRY REPRESENTATVES

A SHORT COUNTRY PRESENTATION BY CENTRAL POLLUTION CONTROL BOARD, DELHI
WWW.NIC.IN

9/5/2013 RSC-7, Dhaka 2 2

Air Pollution Prevention, Monitoring & Implementation of Activities in India

National Implementation Agency: Central Pollution Control Board
National Focal Point: Ministry of Environment & Forests, Govt. of India

RSC-7, Dhaka 3

Institutional Arrangement-India

National Focal Point:
Ministry of Environment and Forests
Government of India

National Implementing Agency:
Central Pollution Control Board

RSC-7, Dhaka 4

Implementation Status (Phase-IV)

S. No.	Activity	Summary Status
1	Ambient Air Quality Monitoring and wet deposition monitoring	• Ambient air quality monitoring and wet deposition monitoring is being carried out at Sunderban bordering Kolkata. • Discussions initiated with concerned SPCBs/PCCs to set up monitoring stations in other bordering areas. • 6 Transboundary Monitoring are in operation
2	Corrosion Study	• Corrosion study has been completed at TajMahal, Agra • Awarded one project to National Metallurgical Laboratory at Jamshedpur for carrying impact on materials at 9 cities in India including one virgin area
3	Health Impact Study	• Two studies completed through Chittaranjan National Cancer Institute (CNCI), Kolkata. A report has been brought out. • Impact on Benzene exposure on Petrol pump workers has been initiated • Development of Protocol Monitoring & Instrumentation is in progress.
4	Crop Impact Study	• We have intimated approved list Research Institute to Male Secretariat • Male Secretariat is dealing this activity directly and has not involved NIA
5	Emission Inventory	• Completed National Emission Inventory in 2009 and is being regularly up-dated.
6	Advisory committee	• Advisory committee is being revised
7	Awareness	• CPCB is maintaining a very dynamic website along with list of publications, soft copy of almost all documents, online air quality data, data of Environmental Data Bank including Trans-boundary ambient air quality stations.
8	Other activities	• Trajectory analysis of Sunderban stations is proposed for Sunderbans Ambient Air Quality Monitoring Station.

RSC-7, Dhaka 5

Additional Activities (Routine)

- **Source Apportionment study in six cities**
- **Emission inventory in six cities & initiation for other cities**
- **Emission factors for vehicles and Implementation of Euro Norms**
- **Source profile for vehicular sources**
- **Source profiles for non-vehicular sources**
- **Development of Emission Standards & Revision of Standards**
- **Introduction of IS 17025/IS 9000 & OHSAS for all Environmental Laboratories**
- **Initiation for Pilot Project on Emission Trading Scheme for Particulate Matter in Stationary Sources (Stack)**

RSC-7, Dhaka 6

Additional Activities (1)

- **Organization of various programs for the successful Implantation of the Declaration. Some of them are as under:**
  - 5 Regional Refresher Courses / workshops): organized ;
  - 3 Stake-holders meeting ;
  - 3 Inter-governmental meetings ;
  - Capacity building programs on Health Impact Assessment, Emission Inventory, crop Impact Assessment etc.)
  - Series of Hands on Training programs, refresher courses, workshops for dry & wet deposition towards uniformity in sampling and data generation, etc.
  - Participation of Task Force Committee
- **The Present program has the following focus:**
  - To update the implementation activities under Male' Declaration
  - Formulation of future Development Plans
  - Sustainability

RSC-7, Dhaka 7

Additional Activities (2)

- **Revision of National Ambient Air Quality Standards (November 2009)**
  - **Uniform ambient air quality for all**
  - **Special monitoring for Ecologically sensitive areas**
  - **Consideration of health related parameters viz. $PM_{2.5}$, Benzene, Bezo(a)Pyrene.**
  - **Consideration of Signature metal analyses like Nickel, Arsenic and lead**
  - **537 ambient air quality stations are in operation. The data generated in these stations are regularly analyzed for Trend Analyses, special attention area, problem area**

RSC-7, Dhaka 8

- **Criteria for Comprehensive Environmental Assessment for Industrial Clusters**
  - **Rational to characterize the environmental quality at a given location by means of algorithm of source, pathway and receptor.**
- **Regional Cooperation**
  - **Signed MoU with Royal Government of Bhutan & CPCB for capacity building, demonstration & training (completed six years of Cooperation)**
  - **Similar MoU may be signed with other**

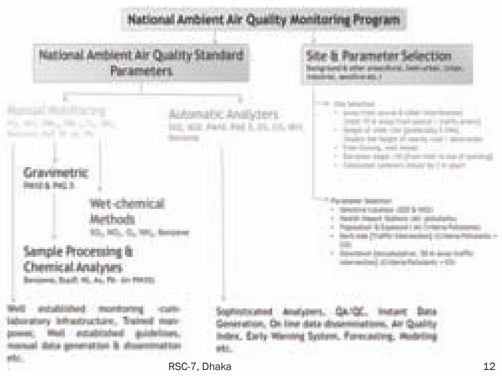
RSC-7, Dhaka 9

NATIONAL AMBIENT AIR QUALITY STANDARDS (2009)

Pollutants	Time Weighted Average	Concentration in Ambient Air		Methods of Measurement
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (Notified by Central Government)	
Sulphur Dioxide (SO_2), µg/m³	Annual * 24 Hours **	50 80	20 80	-Improved West and Gaeke Method -Ultraviolet Fluorescence
Nitrogen Dioxide (NO_2), µg/m³	Annual * 24 Hours **	40 80	30 80	-Jacob & Hochheiser modified ($NaOH-NaAsO_2$) Method -Gas Phase Chemiluminescence
Particulate Matter (Size less than 10µm) or PM_{10}, µg/m³	Annual * 24 Hours **	60 100	60 100	-Gravimetric -TEOM -Beta attenuation
Particulate Matter (Size less than 2.5µm) or $PM_{2.5}$, µg/m³	Annual * 24 Hours **	40 60	40 60	-Gravimetric -TEOM -Beta attenuation
Ozone (O_3) µg/m³	8 Hours * 1 Hour **	100 180	100 180	-UV Photometric -Chemiluminescence -Chemical Method
Lead (Pb) µg/m³	Annual * 24 Hours **	0.50 1.0	0.50 1.0	-AAS/ICP Method after sampling on EPM 2000 or equivalent filter paper -ED-XRF using Teflon filter
Carbon Monoxide (CO), mg/m³	8 Hours ** 1 Hour **	02 04	02 04	-Non dispersive Infrared (NDIR) Spectroscopy
Ammonia (NH_3), µg/m³	Annual * 24 Hours **	100 400	100 400	-Chemiluminescence -Indophenol blue method
Benzene (C_6H_6), µg/m³	Annual *	05	05	-Gas Chromatography (GC) based continuous analyzer -Adsorption and desorption followed by GC analysis
Benzo(a)Pyrene (BaP) Particulate phase only, ng/m³	Annual *	01	01	-Solvent extraction followed by HPLC/GC analysis
Arsenic (As), ng/m³	Annual *	06	06	-AAS/ICP Method after sampling on EPM 2000 or equivalent filter paper
Nickel (Ni), ng/m³	**Annual ***	**20**	**20**	-AAS/ICP Method after sampling on EPM 2000 or equivalent filter paper

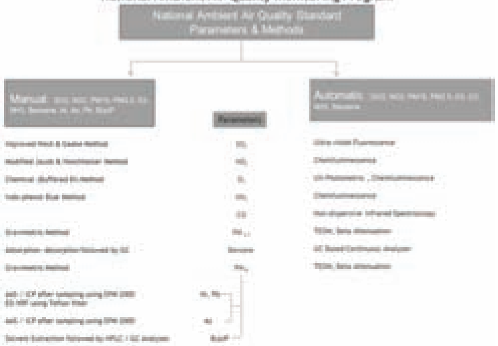
Review of the National Ambient Air Quality Guidelines

RSC-7, Dhaka 11

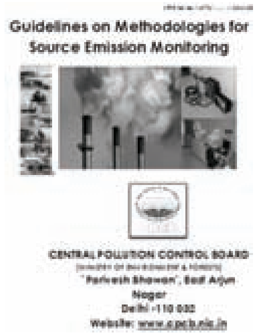


RSC-7, Dhaka 12

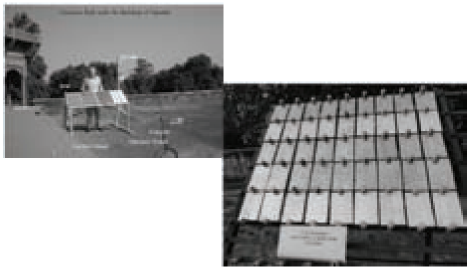
National Ambient Air Quality Monitoring Program



Source Monitoring



Corrosion Studies



METHODOLOGY
(Corrosion Investigation)

•Exposure of the specimens of the appropriate sizes as per ASTM specification . G50-76 at the chosen sites, on the steel racks installed at appropriate places.

•The corrosion i.e. the deterioration of the materials is affected by (1) rain fall, (2) temperature, (3) salinity, (4) acidic gases and humidity surrounding the area besides collection of meteorological data for all selected location.

•Similarly dust collectors will be installed at different locations to collect the data for:

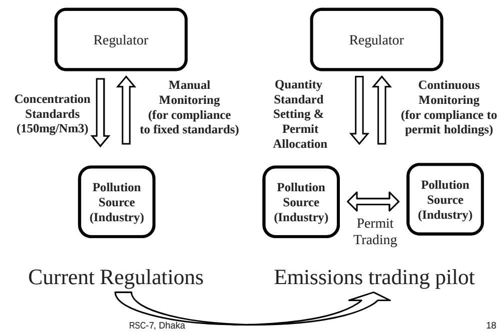
a) Falling of dust per unit area
b) Presence of heavy metals
c) Analysis of components in dust
d) pH of dust

•Finally the evaluation of the corrosion products formed on different samples exposed at various locations using various analytical techniques such as: XRD, Raman Spectroscopy, Scanning electron microscopy, X-ray photoelectron spectroscopy, etc. ; study the kinetics and mechanism of the degradation of materials.

Impact of air pollution in India on deterioration of metals and materials

Material	Corrosion rate (μm/year)			
	Locations			
	Jamshedpur	New Delhi	Lucknow	Mumbai
Weathering steel	24.96	18.57	11.68	26.19
Brass	1.07	4.19	1.40	3.76
Bronze	2.91	3.32	1.22	3.80
Copper	3.40	4.35	2.56	4.58
Aluminium	0	1.28	0	0.38
Zinc	1.53	1.70	-	2.62

Market-based Scheme Reduces Compliance Cost by Giving Industry More Flexibility in Abatement



Phases of Pilot ETS

- **Design Phase (Phase-I)**
  - Understanding the activity
  - Identification of project sites,
  - CEMS draft standards,
  - Data Transmission standards,
  - Training and workshops
  - Synchronization
- **Baseline Survey (Phase-II)**
  - Baseline survey of industry and associated research
  - Care Center setup in SPCBs and CPCB
  - CEMs installation in industry and connection to CARE centers
  - ETS Implementation Phase
- **Implementation Phase (Phase-III)**
  - Implementation of pilot emissions trading regime and associated evaluation

Trans-boundary Ambient Air Quality Monitoring

Establishment & operation of Trans-boundary Ambient monitoring stations, viz.;

1.Port Canning-West Bengal (India & Bangladesh);

2.Dera Baba Nanak ,Pathankot-Punjab (India & Pakistan);

3.Lakshadweep (India & Maldives);

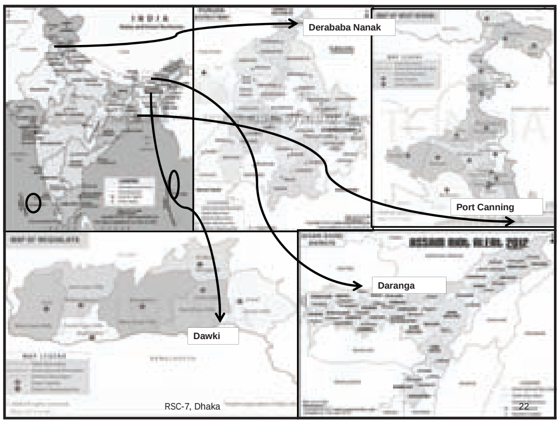
4.Daranga-Assam (India & Bhutan) and

5.Dawki-Meghalaya (India & Bangladesh)

6.Andaman & Nicobar

Status of ambient air quality monitoring stations in Male' Declaration under NAMP

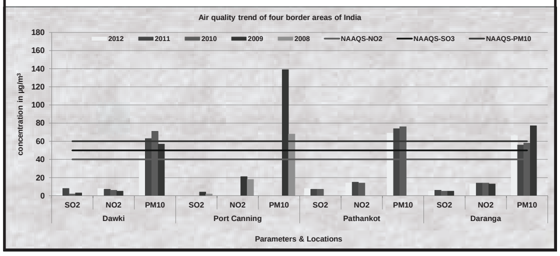
	Monitoring stations at (city)					
	Dawki	Port Canning	/Pathankot	Daranga	Kavaratti	Andaman & Nicobar
State	Meghalaya	West Bengal	Punjab	Assam	Lakshadweep	Andaman & Nicobar Islands
No. of stations	1	1	1	1	2	5
Name of monitoring station	Terrace Building, Dawki, Jaintia Hills District	Port Canning, Sunderban	C-PYTE Building, Dera Baba Nanak	BATAD, Baska district,	Kavaratti	Port Blair, Brookshabd, Rangat, Campbell Bay
Bodering	Bangladesh	Bangladesh	Pakistan	Bhutan	Maldives	South East Asia
Lat & long	26°47´06″ N	22°19´8″ N	32°1´60″ N 75°1´0″	26°48´ N	10° 0´ N 73° 0´	
Sanction date	23.06.2008	2004	23.06.2008	August 2008	10.09.2010	10.09.2010
Operating since ------*Yet to operate*	August 2009	2004. Stopped monitoring from December 2011	January 2010	January 2009	Yet to operate	Yet to operate



Status of ambient air quality in Male' Declaration under NAMP

	Monitoring stations											
	Dawki (Bangladesh border)			Port Canning (Bangladesh border)			Pathankot (Pakistan border)			Daranga (Bhutan border)		
	SO_2	NO_2	PM_{10}	SO_2	NO_2	PM_{10}	SO_2	NO_2	PM_{10}	SO_2	NO_2	PM_{10}
2012	2	8	44	-	-	-	8	14	69	5	13	66
2011	8	7	63	-	-	-	7	15	74	6	14	56
2010	2	6	71	-	-	-	7	14	76	5	14	58
2009	3	5	57	4	21	139	-	-	-	5	13	77
2008	-	-	-	2	18	68	-	-	-	-	-	-

NB. Port Canning-Jan & Feb data 2009; Daranga-Jan-Feb 2012; Dawki-Jan-Oct data 2012; all values are in microgram per meter cube



Thank you all

MALE' DECLARATION ON CONTROL AND PREVENTION OF AIR POLLUTION AND ITS LIKELY TRANSBOUNDARY EFFECTS FOR SOUTH ASIA

Progresses in Iran

(COUNTRY REPORT)

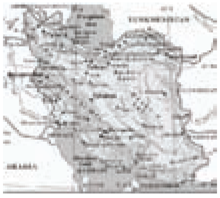
Bangladesh

28-30 May-2013

Masood zandi

1

IRAN (Islamic Republic)



Location: 26 - 38 N, 44 - 63 E

Population> 70 million

165,000,000 ha Total Area:

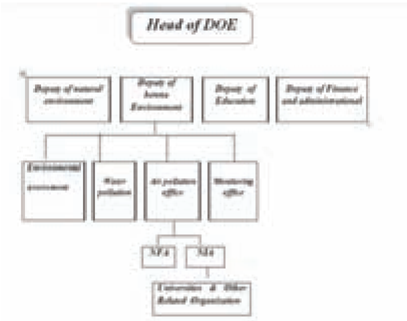
-26.6m ≤ Altitude ≤ 5671m MSL

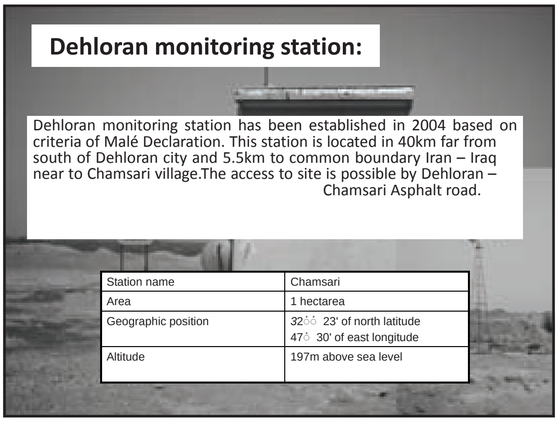
0 ≤ Precipitation ≤ 1800mm

Coastline length: 3500 km

2

Institutional arrangement



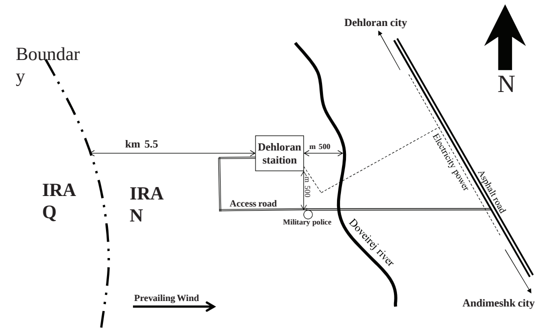


Dehloran monitoring station:

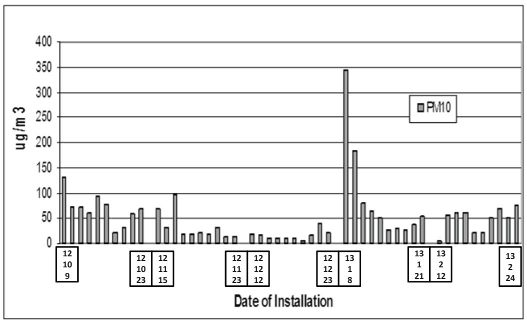
Dehloran monitoring station has been established in 2004 based on criteria of Malé Declaration. This station is located in 40km far from south of Dehloran city and 5.5km to common boundary Iran – Iraq near to Chamsari village.The access to site is possible by Dehloran – Chamsari Asphalt road.

Station name	Chamsari
Area	1 hectarea
Geographic position	32°° 23' of north latitude 47° 30' of east longitude
Altitude	197m above sea level

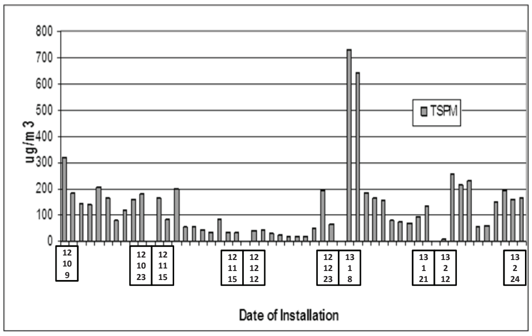
DEHLORAN Transboundary Station



Concentration of PM10 from 9 OCT 2012 to 24 FEB 2013

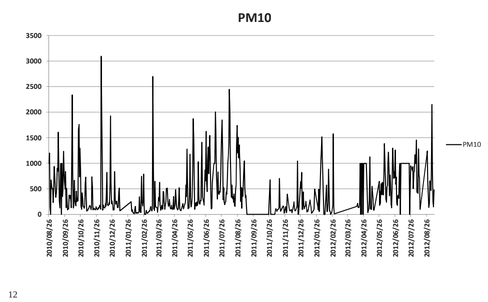


Concentration of TSPM from 9 OCT 2012 to 24 FEB 2013



Hamoun Transboundary Station

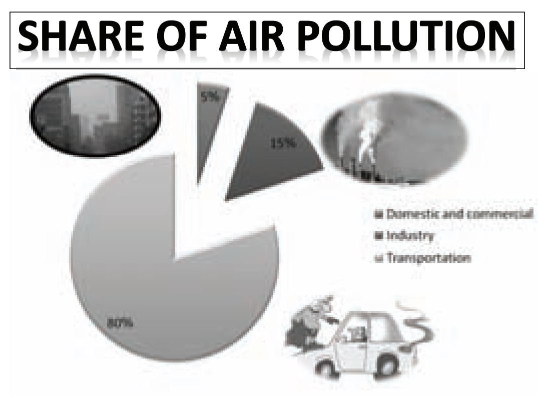
Data Report

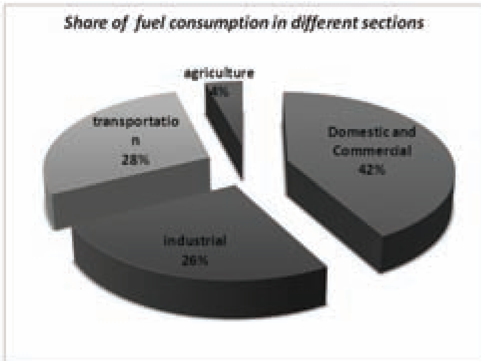


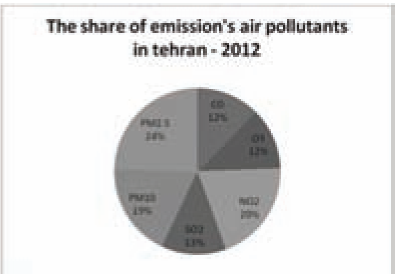
Major Sources of air pollution in Country

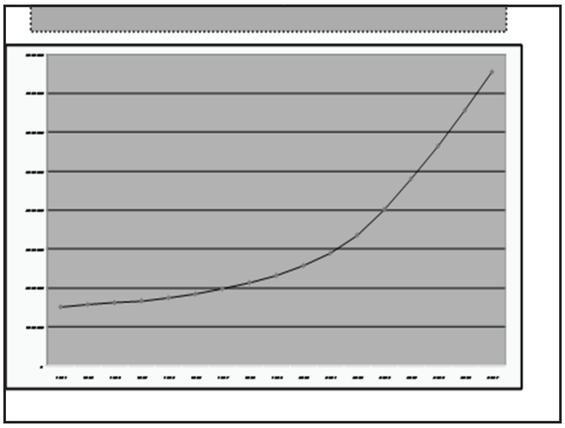
Mobile sources. •
Stationary sources: •
large and small industrial processes.
Power Refinery and petrochemical industries. -
-Dust storm

- •









Policies

Decreasing of air pollution in process of ♀♀♀♀ industrial Improvement of fuel quality

Improvement of vehicles standards

Setting of required laws and regulation

combating with the phenomenon of dust storm

Measures

Master plan for decreasing of air pollution in country has revised and contain :

Standardization of new vehicles : Standard of vehicles is Euro4

Old vehicles:
phasing out of 1500000 vehicles from fleet of vehicle .we can reduce up to 20 percent of air pollution in cities.

Fuel : Improvement of fuel quality to Euro 4&5

Improvement and developing of public transportation

Increasing the green spaces

Increasing the number of measurement of air pollution station

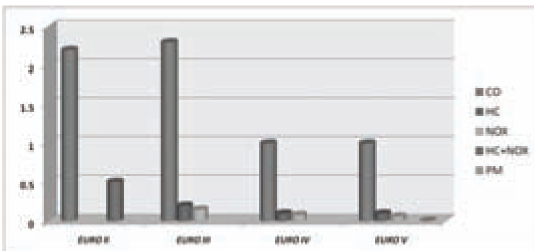
Improvement of Environmental Industrial management

Extension of Tune up center for vehicles

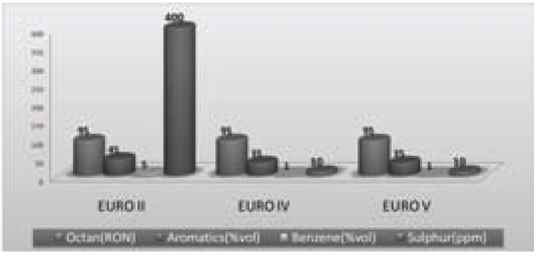
Traffic management:
Improvement of traffic management in mega cities.

ON - line monitoring system for industries :
installing on-line monitoring system on exhaust of industries

comparing emissions from gasoline-powered vehicles based on environmental standards EuroIV and EuroV



Gasoline chart comparison with standard EURO II and EURO IV and EURO V



Ambient air quality

Gholhak station

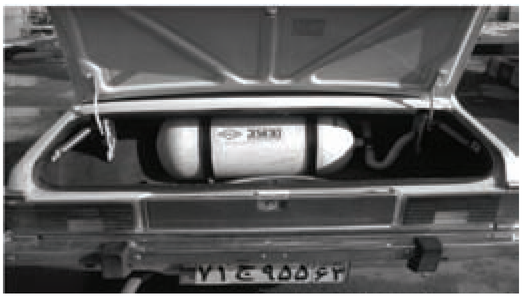
The Parameters that are Measuring

- CO
- NO2
- NO
- NOx
- O3
- PM2.5
- PM10
- SO2
- HC
- THC

Emission Inventory

1. Try to Collect The Update Data
2. Complete Some Sheet
3. Check the Error
4. Negotiation with Mr.Vallack for better doing of project

DUAL-FUEL SYSTEM IN PAYKAN VEHICLE AND REPLACING GASOLIN WITH CNG IN VEHICLES



REPLACING OLD TAXIES WITH NEW SAMAND VEHICLES

Storms Dust
(south & west)

Dust storm

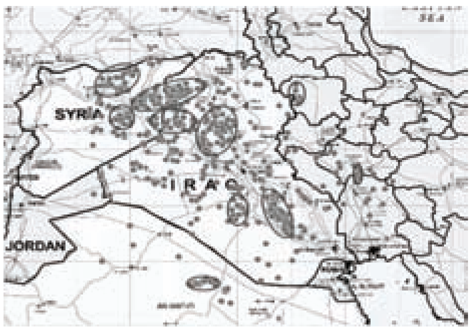
Occurrence of Sever Dust Phenomenon with Different Specialties and its Gradual Development to South West, West, North West and Central Provinces of Iran from 2004

Activities

- The establishment of a regional secretariat in Tehran on dust & sandstorm management
- The national committee in Iraqi government to combat drought and desertification
- Planning an Action Plan to combat desertification in Iraq by Iran
- Preparation of a national strategic plan to combat desertification and drought action plan by the Ministry of Environment in Iraq
- Special Workshop on dust management for Iraqi and Syrian experts in Ahvaz
- Planning an air quality workshop for environmental experts of Iraq
- Collaboration with international organizations, UNAMI &UNEP

Dust Storm in Iraq

Regional dust sources (2008)

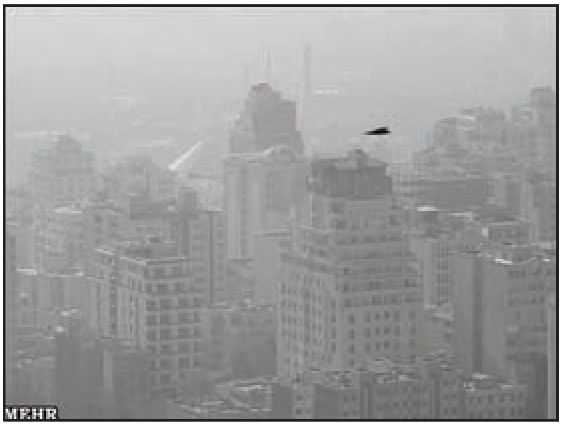


Transboundary Origins of Dust Storms in I.R. Iran from 2001-2010 (IRIMO,2010)

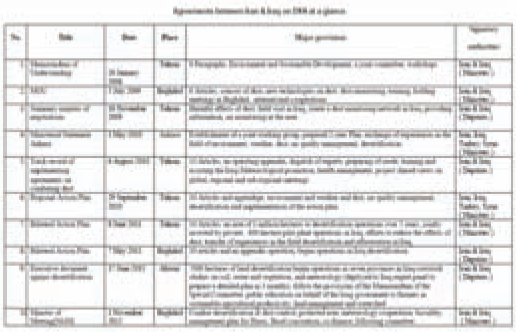
224 Sources are identified

529 Dust storms are detected

- ❖Harsh dust storms: 143
- ❖Mild dust storms: 172
- ❖Weak dust storms: 214



An Overview on agreements between Iran & Iraq on DSS



7th Regional Stakeholder meeting and 13th intergovernmental meeting of Male' Declaration on the control and prevention of trans boundary air pollution and its likely effects

Bangladesh, Dhaka

18-21 May 2013

Ibrahim Mohamed, EPA Maldives

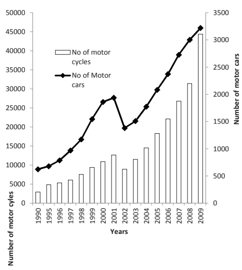
Hasan Azhar, MEE Maldives

Over view

- **Introduction**
- **Status of implementation**
- **Future plan**

Monitoring Station

BACKGROUND



- The total numbers of vehicles registered in Male' from Jan 2006 to Dec 2010 is 19,767
- Vehicles are primary source of air pollution

ACTIVITIES UNDERTAKEN

Party to Male' Declaration on control and prevention of air pollution and its likely Transboundary effects for South Asia
Also party to UNEP/ABC project and has one of the ABC super observatories.

EPA began collecting air quality monitoring data on December 2011
PM 10 is the only parameter monitored, due to unavailability of consumables and chemicals.
Data collection stopped due to mechanical failure of high volume sampler

Member of Clean Air Coalition on SLCPs

POLICIES AND STRATEGIES

- Ministry of Environment and Energy
  - develops policies and strategies pertaining to Air quality management
- Regulatory authorities
  - EPA, implementing agency for Male' Declaration since 2010
  - Transport Authority

Planned and completed projects

- Vehicular emission standard gazetted
- Develop Emission Regulation
- Develop Emission standards for vehicles and ambient air
- Develop Maldives National Emission inventory

Status of Implementation

- High Volume sampler is not in operation due to a mechanical failure in the equipment
- No consumables and chemicals available for analysis
- Laboratory facility is not adequate for conducting chemical analysis
- Passive sampler data collection is not regular due to lack of proper supervision

PM Data

Month	PM10	NRSPM	TSPM
Sep-11			
Oct-11			

Challenges

- Air pollution is not given a high priority at national level due to other pressing environmental issues in the country
- No adequate finance available to carry out the activities
- Delays in signing of MOU which resulted in not being able to access the funds to implement monitoring activities in a timely manner

Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Thirteen Session of the Intergovernmental Meeting and Seventh Regional Stakeholders cum Coordination Meeting (RSC7)

18-19 May 2013
Dhaka, BANGLADESH

Teeka Ram Pokhrel
Senior Divisional Chemist (Under-Secretary, Tech)
Department of Environment
Ministry of Science, Technology and Environment (MoSTE)
Kathmandu, Nepal

Ministry of Science, Technology and Environment
Government of Nepal

ICIMOD

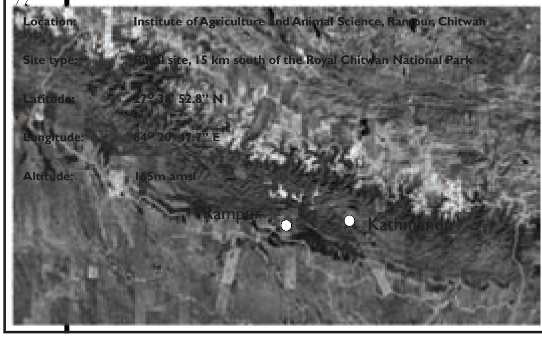
Organizations involved in Air Quality in Nepal

- Ministry of Science, Technology and Environment, lead organization and national focal point of Male Declaration.
- Department of Environment, implementing agency of MoSTE in all environmental issues
- ICIMOD, (International Centre for Integrated Mountain Development) national implementation agency for Male Declaration

Members:

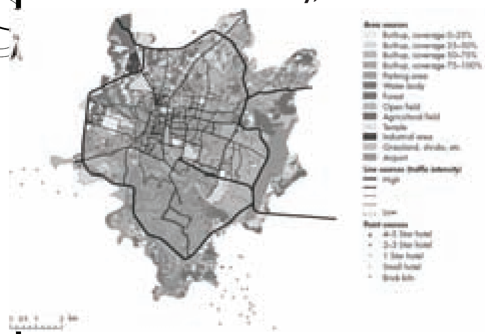
- Institute of Agriculture and Animal Science (IAAS) TU, Chitwan
- Clean Air Network Nepal-representing from NGOs
- Center for Pollution Studies, Institute of Engineering (IoE-TU) representing from academic institutions
- Department of Hydrology & Meteorology, GoN

Monitoring Station



Achievements

1. RUA Kathmandu Study, Publication



Achievements

Huge Media Attention/Coverage

2. Health Study

In collaboration with Nepal Health Research Council (NHRC)

Correlation of Peak Expiratory Flow Rate (PEFR) and PM 2.5 for St. Xavier's (Urban roadside school)

3.Crop Study –IAAS, Rampur

Experimental site

- Institute of Agriculture and Animal Science (IAAS) Rampur, Chitwan
- Latitude - 27⁰37' North
- Longitude - 84⁰25' East
- Altitude - 165 m above mean sea level.
- Inner Terai region of Nepal.

Duration of the study

- April, 2012 to July, 2012.

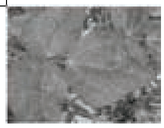
Ambient ozone conc. and meteorological recordings during experimental period

Date	Max.Temp.⁰C	Min.Temp.⁰C	Avg. Rainfall mm	Avg RH %	Sunshine(hrs)	Ozone level μg/m³
3 April-3May	34.04	16.58	4.32		8.53	79.2
5 May-30 May	37.4	22.92	1.96	81.0	8.96	99.0
30May-30 June	35.1	25.22	8.2	87.5	6.20	65.5
30 June-29 July	33.3	23.17	16.5		2.22	34.5

Measurements of yield attributing parameters of mungbean during experimental period

Yield parameters	Mean(control)	Mean(EDU treated)
Pod length/plant	7.20	7.39
Mature pod weight (gm)	34.42	36.97
Immature pod weight (gm)	16.90	12.10
N0. of mature pods/plant	74.40	97.65
No of immature pods/plant	25.15	16.10
No of seeds/pod	4.22	4.51
No of seeds/plant	307	425
Seed dry weight/plant (gm)	7.90	10.31
Test weight of seed/plant	38.24	40.49
Above ground biomass (gm)	35.34	36.22
Shelling %	23.24	28.65

- No significant difference in plant height and branch per plant
- Number of leaves significantly higher in EDU treated
- Number of seeds per plant was significantly higher in EDU



Issues about current monitoring station

- ✓ Long hours of power outage – hamper in sample collection from High volume sampler
- ✓ IAAS is in transition to become a separate campus from Tribhuvan University
- ✓ Modality will have to change
- ✓ Transfer of the personnel who was looking after the monitoring activities

Existing Legal Framework on Air Quality

- ✓ Interim Constitution of Nepal, 2007
- ✓ Nepal Environmental Policy and Action Plan (NEPAP I), 1993
- ✓ National Transport Policy, 2002
- ✓ Environment Protection Policy, 1987
- ✓ Industrial Policy, 1992
- ✓ Environment Protection Act and Rule, 1997
- ✓ Ozone Depleting Substances Consumption (Control) Rules, 2001
- ✓ Industrial Enterprises Act, 1992
- ✓ Transport Management Act, 1992 and Regulation 1997

Existing Legal Framework on Air Quality

- ➢ National Ambient Air Quality Standard, 2012
- ➢ Nepal Vehicle Mass Emission Standard, 2012
- ➢ Standard on Emission and Chimney Height for Industrial Boiler, 2012
- ➢ Standard on Emission for Diesel Generator, 2012
- ➢ Standard on Emission for Cement and Crusher Industries, 2012
- ➢ National Indoor Air Quality Standard and Implementation Guidelines, 2009
- ➢ Standard on Emission and Chimney Height for Brick Kilns, 2008

Recent Activities of Ministry of Science, Technology and Environment

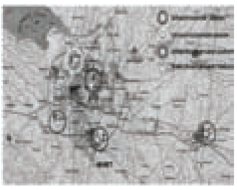
- **Department of Environment has been established**
- Formulation of new standards
- Environmental Policy (Draft)
- Running 4 air quality monitoring stations in Kathmandu valley
- Planning to measure other parameters related with air quality from next fiscal year
- Planning to establish 6 air quality monitoring stations out of Kathmandu valley in coming fiscal years (Pokhara, Birgunj, Butwal, Bharatpur and Nepalgunj)

Recent Activities of Ministry of Science, Technology and Environment

6 stations in the Katmandu Valley:

- ➢Putalisadak & Patan (Urban Traffic Roadside station)
- ➢Thamel (Residential station)
- ➢Bhaktapur & Kirtipur (Urban Background)
- ➢Matsyagaon (Valley Background)

Measured Parameter: PM10



Issues on Air Pollution

- Rapid Urbanization
- Brick kilns in operation in Kathmandu Valley
- Growing Numbers of Vehicles
- Traffic Congestion and Increasing Demand of Fossil Fuel
- Industrialization

Challenges on Air Quality

- To regulate the fuel quality for vehicle
- On road monitoring of the vehicle mass emission
- Protest (Burning of tire)
- Rapid and haphazard urbanization
- Maintaining the rule of law
- Sustainability of program
- Issue on climate change
- Public health

Major other Studies Related to Air Pollution

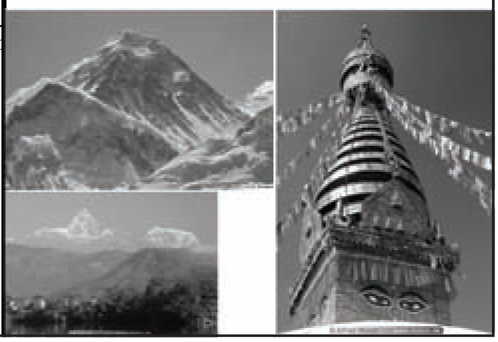
Government announcement of **"Clean Cooking Solution for All by 2017 (CCS 2017)" thereby ensuring Indoor Air Pollution free Nepal. (AEPC)**

Reducing Impact of Black Carbon & other Short Lived Climate Pollutants (ICIMOD)

- Improving the science of SLCP in the Himalaya
- Knowledge dissemination
- Analysis of mitigation options
- Contribution to policy development

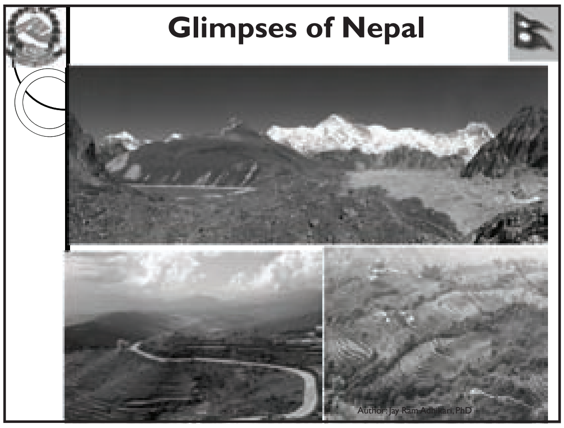
Emission Inventory of Diesel Gensets (CANN)

Glimpses of Nepal

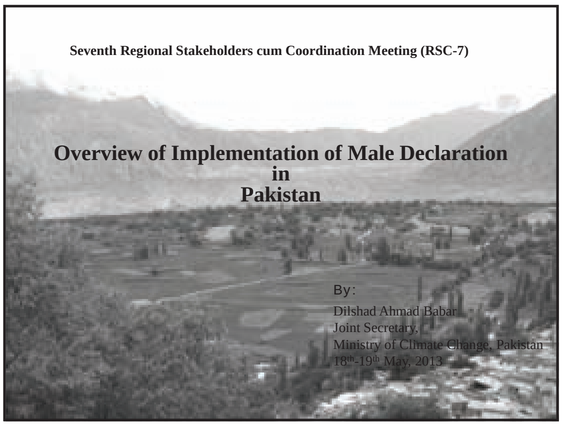


Glimpses of Nepal

18


Glimpses of Nepal


Thank You !



Seventh Regional Stakeholders cum Coordination Meeting (RSC-7)

Overview of Implementation of Male Declaration in Pakistan

By:
Dilshad Ahmad Babar
Joint Secretary,
Ministry of Climate Change, Pakistan
18th-19th May, 2013

"Malé Declaration on Control and Prevention of Air Pollution and Its Likely Trans-boundary Effects for South Asia"

MAIN OBJECTIVES

- To promote the establishment of a scientific base for prevention and control of Transboundary air pollution in South Asia to encourage and facilitate coordinated interventions of all the stakeholders on Transboundary and shared air pollution problems at national and regional levels.

IMPLEMENTATION IN FOUR PHASES

- Phase I (1999 - 2000) – Baseline information on air pollution and awareness raising
- Phase II (2001 - 2004) – Capacity building
- Phase III (2005 - 2009) – Tackling air pollution problems
- Phase IV (2010-) – Enhance Regional Cooperation

Tasks for Phase-I

The Tasks Assigned to the NIAs under Phase–I of the Malé Declaration (July 1998 to February 2000) are given below:

- To Carry out a Baseline Study
- Compilation of Expert's Database
- Create a Database on Air Pollution
- Formulation of a National Action Plan to Cope with the Air Pollution.

Implementation Status Phase-I

- A Country Report Containing the Baseline Report, National Action Plan, Database, Maps and National Emission Inventory was compiled in July, 2000 and forwarded to UNEP
- A Network of Institutions establishment, baseline studies and action plans were coordinated by Regional Resource Centre for Asia and the Pacific (RRC-AP) of UNEP, Bangkok in collaboration with all member countries of SACEP.
- Baseline studies and action plans (including Pakistan) were reviewed in year 2000 at Bangkok and agreement reached on the Phase-II of the project.

Tasks for Phase-II

- Selection of sites for setting up monitoring stations.
- Provision of required equipment by UNEP-AP.
- To Install the Monitoring Stations by February, 2004.
- To organize a one week in-country training programme for all the technicians supposed to carry out the installation of monitoring equipment.
- Monitoring results of the air may be reported to RRC.AP on monthly basis from March, 2004.
- To organize a national stakeholders meeting in Pakistan by February, 2004.

Implementation Status Phase -II

- Monitoring Station has been Installed at Bahawalnagar
- Ambient Air Monitoring Equipment installed for Particulate Matter (PM10 & TSPM)
- Wet Deposition Monitoring Bulk Collector was Installed of
- Wet Only Collector was Installed
- Diffusive Samplers (for NO_2, SO_2 & O_3) installed according to the Monitoring Protocol
- Established Laboratory for Analysis of Basic Parameters of Field Samples Collected from Dry & Wet-Only Collectors

Visit of Monitoring Station at Bahawalnagar

Fixing of Wet-Only Collector

Fixing of Bulk Collector

Fixing of High Volume Air Sampler

Fixing of Diffusive Sampler

Training Imparted to Meteorological Officials

- Basic Training was Imparted to PMD Officials Second Time at Bahawalnagar (Punjab Province) to Improve their Skills & Expertise for the Following Aspects:
  - Wet Deposition Monitoring
  - High Volume Air Sampler (HVAS) Operation & Calibration
  - Bulk Collector Sampling
  - Diffusive Samples Monitoring
  - Monitoring Intervals & Data Reporting
  - Good Laboratory Practices
  - Equipment Calibration
  - Water Distillation Preparation & Usage

Training on Air Sampler

Training on Air Sampler

Training in Laboratory

Training on Wet-Only Collector

Tasks under Phase-III

- Continue to promote the establishment of scientific base for prevention and control Transboundary air pollution in Pakistan as part of regional initiative in South Asia.
- The National Advisory Committee (Ac) established during Phase II implementation will meet, at least once in a year, at national level and advise NIA and other organization involved in monitoring exercise.
- Participate by the NIA project Coordinator of the Male Declaration Secretariat
- Regularly report the monitoring results in digital format to RCC.Ap for the centralized database, which is maintained at Secretariat.

Task under Phase III…..Cont.

- Provide guidance and nominate an expert institution for the development of regional integrated modeling and atmospheric transport capabilities.
- Nominate an expert institution for the crop impact assessment and conduct rapid integrated assessment.
- Provide guidance and nominate an expert institution to conduct the corrosion impact assessment programme.

Implementation Status Phase-III

- Participated in capacity building programmes at National and Regional Level on Monitoring.
- A study on impacts of particulate air pollution on the respiratory health of school children was carried out in Pakistan.
- Established continuous air quality monitoring system in federal and provincial capitals and upgraded EPAs laboratories with collaboration of JICA

Phase III ….Continued

- About 2.5 million vehicles converted to CNG and 3,331 CNG stations were set up in the country.
- The largest number of CNG stations in the world
- Reduction of Sulphur in diesel from 1% to 0.5% and further reduction to 0.05% by 2012.
- Adaptation of EURO-II Emission standards for new vehicles effective from 2009 for gasoline vehicles and 2012 for diesel vehicles (delayed till 2014 due to non-availability of Euro-II compliant diesel).

Tasks under Phase-IV

- Phase IV will continue to assist the member countries enhance their regional cooperation, monitoring, impact assessment; strengthen the initiatives started in the first three phases and to initiate new ones. A Task Force is proposed, to plan the future of the MD to consider the expanding network.

Implementation Status Phase-IV

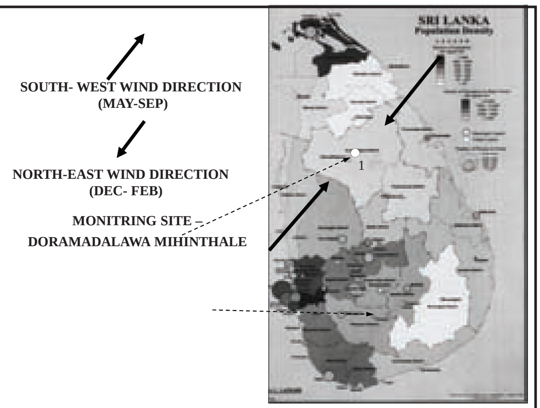
- Government of Pakistan in collaboration with IUCN established Pakistan Clean Air Network (PCAN) in 2005 with the assistance of ADB in 2005. It aims to address air quality issues in Pakistan and promote better air quality management (AQM) practices in urban centers by awareness raising, capacity building and provision of a broad knowledge base for AQM.
- Pakistan is actively working with "Partnership for Clean Fuels and Vehicles (PCFV)" and "Clean Air Initiative for Asian Cities (CAI-Asia) Center", Manila to promotes better air quality and reducing air pollution and greenhouse gas emissions from transport, energy and other sectors.

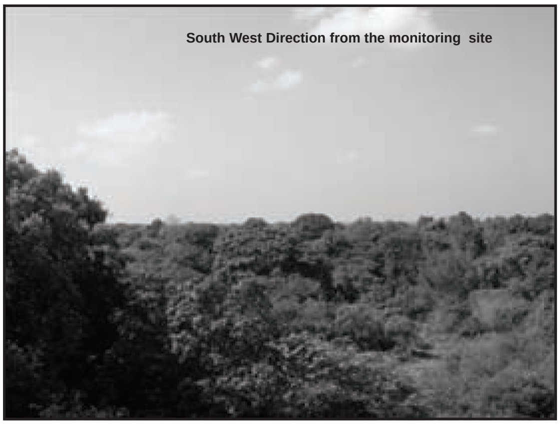
Thanks

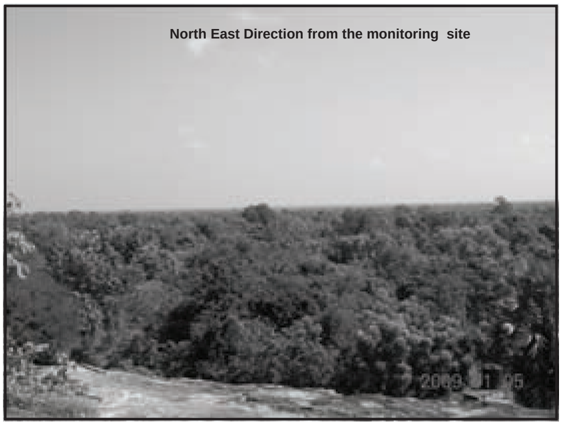
Contact # +92-51-9245548
Fax # +92-51- 92645549
Email: dilshadbabar@hotmail.com
Website: www.mocc.gov.pk

OVERVIEW OF NATIONAL LEVEL IMPLEMENTATION OF MALE DECLEARATION IN SRI LANKA

BY
R.M. KULASENA
CENTRAL ENVIRONMENTAL AUTHORTIY
SRI LANKA



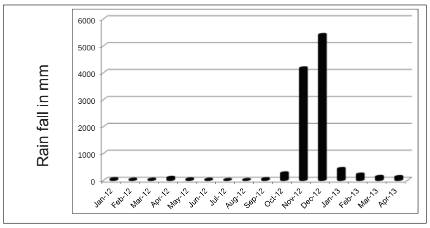




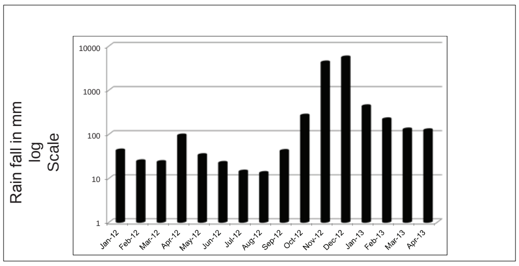
WET DEPOSITION MONITORING

- **Bulk Collector**
  - Rain water collects once in every week
  - pH and EC onsite measurements
  - Transport to the Colombo Central Laboratory
  - Analyze for cations and anions
- **Wet only collector is not working since October 2011**
  - Repaired locally and samples collected for 2 months
  - Permanently damaged in December 2001

Variation of monthly total rain fall at monitoring site in 2012- Bulk collector



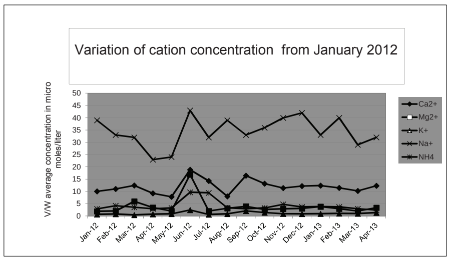
Variation of monthly total rain fall in mm



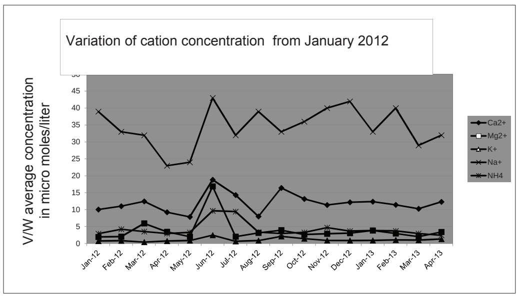
Dionex Model ISC900 Cation and Anion Analysis system

To generate accurate data and to avoid contamination with other environmental analysis

Wet deposition monitoring data



Wet deposition monitoring data

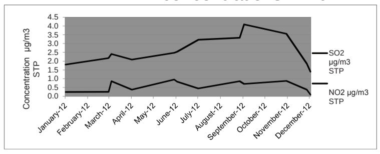


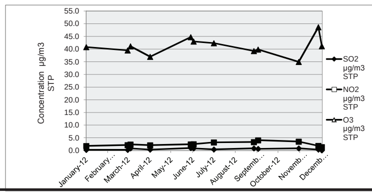
Monitoring of SO_2, NO_2 & O_3 using Passive Samplers

Ambient air quality monitoring activities at Doramadalawa site

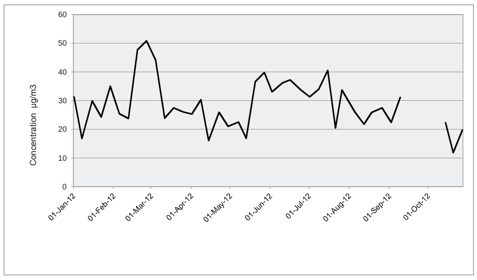
- *SO2, NO2 and ground level ozone concentrations were continuously monitored using passive samplers received from IVL .*
- *Exposed samplers were dispatched to IVL for analysis.*
- *Samples were analyzed and results have been transferred to the NIA.*

Variation of SO2, NO2 and O3 concentrations in 2012

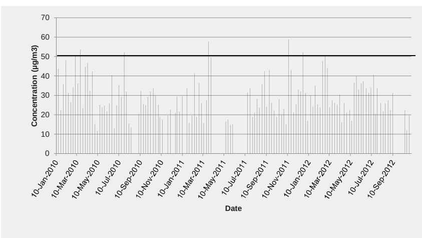




PM10 concentration variations in 2012



PM10 Exceedences in last two years reference to National Standard



Status of Impact Assessment

- New study area has been selected for crop impact assessment for the second time 2012
- Location in Mihintale close to Doramadalawa monitoring site .
- New researcher has been identified in Rajarata University of Sri Lanka.
- MoU has been signed with Rajarata University and CEA with the approval of Male Secretariat.
- Initial payment as mobilization advance has been paid to start the study in July, 2012.
- As per the agreement, study will be continued to January 2013.
- Deliverables were due in April 2013.

Re-planning of the impact assessment activity

- Rajarata University appointed new researcher to continue this activity
- Students who were involved in this research are still working with new member to complete the study in the university .

Emission Inventory Preparation

Training program for local stake holders in Sri Lanka

Emission inventory training workshop for local stake holders

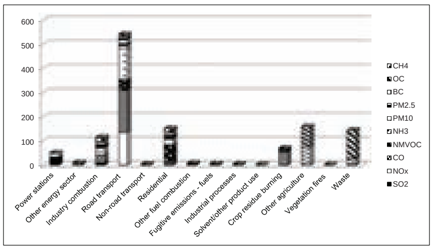
5th international Training on Emission inventory preparation Colombo - 2012

Experts delivering remarks!

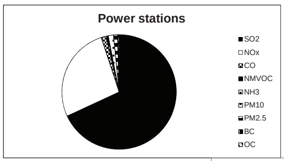
Emission Inventory 2005 - Sri Lanka

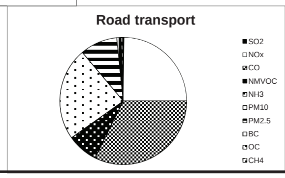
- Major problem in completion of the emission inventory is data collection and data gaps
- After training is given to the responsible officers of other stake holder organizations, this problem is solved.
- Continuous data collection network has been established.
- Data collection format is also highly important in compilation of a emission inventory
- 2005 emission inventory is completed.
- Planning to initiate 2010 emission inventory.

Emission loads from each subsector in kT/year



Emissions from transport sector and power generation





Remaining data gaps

- Vegetation/forest fires
- Evaporation of solvents and other products use
- Industrial fugitive emissions /process emissions

- Quality control/quality assurance

  - Default emission factors have been used in many sectors
  - development of country specific emission factors are highly important

Thank you

Malé Declaration - UNEP

Data Reporting

H K Parwana

MAY 2013

Lay Out of the Draft Report

(2009-2011)

- **Chapter 1 : Introduction**
- **Chapter 2 : Monitoring Program**
- **Chapter 3 : Results**
- **Conclusions**
- **Recommendations**

Chapter 1 Introduction

1.1 Background and Objective

- Introducing the Malé Declaration and its objectives
- Global and Regional concerns of Air Pollution

1.2 Air Quality in Asian Cities

- Sources of Air Pollution
- Types of pollutants

Chapter 2 Monitoring Program

2.1 The Malé Network monitoring programme

2.2 Parameters and Methodologies

2.3 Monitoring Locations

Chapter 3 Results

- **AQ Standards**

(WHO and country standards where available**)**

- **QA/QC**

- **Countrywise Data Analysis**

Countries Participating

- Bangladesh
- Bhutan
- India
- Iran
- Maldives
- Nepal
- Pakistan
- Sri Lanka

Air Quality in Asian Cities

Asian cities are exposed to PM10, which is relatively higher than other cities in the world. Sumber:Cohen **et. al. 2005**

Main Driving Forces

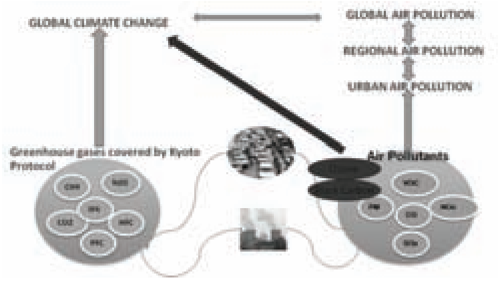
- **Population growth and urbanization**

- **Economic development**

Global Concerns

- **Climate Change**
- **Ozone depletion**
- **Acid Rain**

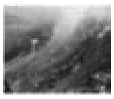
Co-benefits: GHGs and Air Pollutant Reduction



Sources of Air Pollution

- Industry

- Open burning of Garbage



- Agricultural residue burning in fields

Sources of Air Pollution

- Vehicular Pollution – a major source in most of the countries, e.g.,

Sri Lanka

Iran

Monitoring Locations

- Bangladesh – Rural – Kulna
- Bhutan – Remote - Gelephu or Thimphu
- India – Rural - Port Canning
- Iran – Rural – Chamsari
- Maldives – Remote – Hanimaadhoo
- Nepal – Rural – Rampur
- Pakistan – Rural – Bahawalnagar
- Sri Lanka – Rural - Doramadalawa

AAQ Standards

Country	PM_{10}		$PM_{2.5}$		SO_2		NO_2		O_3	
	24 hrs	Annual	24 hrs	Annual	24hrs	Annual	24hrs	Annual	1hr	8hrs
WHO	50	20	25	10	20	--	--	40	--	100
Bangladesh	150	50	65	15	365	80	--	100	235	157
		60* 120**								
India(residential, rural and other areas)	100	60	60	40	80	50 20***	80	40 30***	180	100
Iran										
Nepal	120				70	50	80	40		
Pakistan										
Sri Lanka	100	50	50	25	120	80	100		200	

Status of Data Reporting

S. No	Country	Year	Months	Parameters
1	Bangladesh	2009	Jan - Dec	PM_{10}, SPM[1]
		2010	Jan - Dec	PM_{10}
		2011	Jan - Dec	PM_{10}
2		2009	Feb-July , Dec	PM_{10}
		2010	Jan –Oct,Dec	PM_{10}
		2011	Jan-Jun ,Oct – Dec	PM_{10}
3	India		--	--
4	Maldives		--	--
5	Nepal	2009	Jun-Aug, Nov, Dec	PM_{10}
6	Pakistan		--	--
7	Sri Lanka	2009	--	--
		2010	Jan - Dec	PM_{10}
		2011	Jan - Dec	PM_{10}
8	Iran	2009	Jan - Dec	PM_{10}, SPM
		2010	Jan –Sep, Dec	PM_{10}, SPM
		2011	Jan – Jul	PM_{10}, SPM

passive

S. No	Country	Year	Months	Parameters
1	Bangladesh	2009	Jan - Dec	SO_2,NO_2,O_3
		2010	Jan - Apr	SO_2,NO_2,O_3
2		2009	Bhur: Feb – Dec Serpang Dzong : Jan – Mar, May - Nov	SO_2,NO_2,O_3
		2010	Bhur : Jan – May	SO_2,NO_2,O_3
3	India		--	--
4	Iran	2009	Jan – Dec	SO_2,NO_2,O_3
		2010	Jan (15 days)	SO_2,NO_2,O_3
5	Maldives	2009	Jan – Nov	SO_2,NO_2,O_3
6	Nepal	2009	Jan – Dec	SO_2,NO_2,O_3
		2010	Jan , Feb	SO_2,NO_2,O_3
7	Pakistan		--	--
8	Sri Lanka	2009	Duttuwewa: Jan - Aug, Nov, Dec	SO_2,NO_2,O_3
		2010	Duttuwewa: Feb	SO_2,NO_2,O_3
		2009	Doramadalawa : Jan - Aug, Nov, Dec	SO_2,NO_2,O_3
		2010	Doramadalawa: Jan – Feb	SO_2,NO_2,O_3

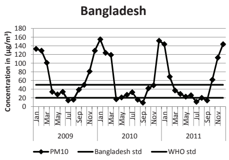
Wet (W)

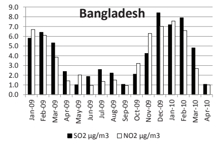
S. No	Country	Y	Months	Parameters
1	Bangladesh	2009	May-Sep	Ec, pH, NH_4^{+}, Na^{+}, K^{+}, Mg^{2+}, Ca^{2+},SO_4^{2-}, Cl^{-}
		2010	Apr-Aug	Ec, pH, NH_4^{+}, Na^{+}, K^{+}, Mg^{2+}, Ca^{2+},SO_4^{2-}, Cl^{-}
2	Bhutan		--	--
3	India		--	--
4	Maldives		--	--
5	Nepal		--	--
6	Pakistan		--	--
7	Sri Lanka	2010	Jan, Mar - May,Jul, Sep-Dec	Ec, pH, NH_4^{+}, Na^{+}, K^{+}, Mg^{2+}, Ca^{2+},SO_4^{2-}, Cl^{-}
		2011	Jan-Mar,May,Aug	Ec, pH, NH_4^{+}, Na^{+}, K^{+}, Mg^{2+}, Ca^{2+},SO_4^{2-}, Cl^{-}
8	Iran		--	--

Wet (B)

S. No	Country	Year	Months	Parameters
1	Bangladesh	2009	May - Sep	Ec, pH, NH_4^{+}, Na^{+}, K^{+}, Mg^{2+}, Ca^{2+},SO_4^{2-}, Cl^{-}
		2010	Apr - Aug	Ec, pH, NH_4^{+}, Na^{+}, K^{+}, Mg^{2+}, Ca^{2+},SO_4^{2-}, Cl^{-}
2	Bhutan	2009	May – Sep, Nov	Ec, pH
		2010	Sep -Dec	Ec, pH
		2011	Jan – Sep	Ec, pH
3	India		--	--
4	Maldives		--	--
5	Nepal	2009	Feb-Dec	Ec, pH, NH_4^{+}, Na^{+}, K^{+}, Mg^{2+}, Ca^{2+},SO_4^{2-}, Cl^{-}
		2010	Jan-Oct	Ec, pH, NH_4^{+}, Na^{+}, K^{+}, Mg^{2+}, Ca^{2+},SO_4^{2-}, Cl^{-}
		2011	Apr-Dec	Ec, pH, NH_4^{+}, Na^{+}, K^{+}, Mg^{2+}, Ca^{2+},SO_4^{2-}, Cl^{-}
6	Pakistan		--	
7	Sri Lanka	2009	Mar-May , Aug,Oct-Dec	Ec, pH, NH_4^{+}, Na^{+}, K^{+}, Mg^{2+}, Ca^{2+},SO_4^{2-}, Cl^{-}
		2010	Jan,Mar-May,Sep-Nov	Ec, pH, NH_4^{+}, Na^{+}, K^{+}, Mg^{2+}, Ca^{2+},SO_4^{2-}, Cl^{-}
		2011	Aug,Oct-Dec	Ec, pH, NH_4^{+}, Na^{+}, K^{+}, Mg^{2+}, Ca^{2+},SO_4^{2-}, Cl^{-}
8	Iran	2009	Apr, Dec	Ec, pH, NH_4^{+}, Na^{+}, K^{+}, Mg^{2+}, Ca^{2+},SO_4^{2-}, Cl^{-}
		2010	Feb, Dec	Ec, pH, NH_4^{+}, Na^{+}, K^{+}, Mg^{2+}, Ca^{2+},SO_4^{2-}, Cl^{-}
		2011	Jan, Feb	Ec, pH, NH_4^{+}, Na^{+}, K^{+}, Mg^{2+}, Ca^{2+},SO_4^{2-}, Cl^{-}

Bangladesh





Sources of Pollution – B'desh

- Major source of PM10 : Brick Kilns using wood/low grade coal
- Manufacturing : October to March. Peak Dec/Jan
- Other Sources : Road dust, construction sites, industry

Monsoon : June to October

(some in March/April & Dec/Jan)

Predominant Wind direction : ??????

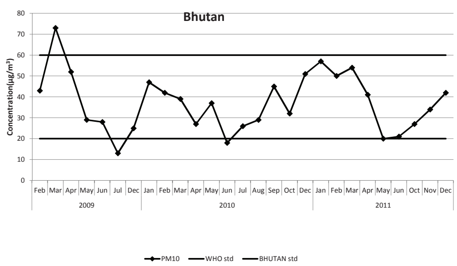
Wet(W) & Wet(B)

- Monitored for about six months in a year
- High conductance values correspond with the high concentration of sodium and chloride ions
- pH generally remains around 6
- No specific trends

Additional Information-B'desh

- General information of area/country
- Photographs brick kiln in operation – old/new technology
- Agriculture residue burning if there - period?
- Use of low quality diesel(freight vehicles not meeting standards) ?
- Can the results be correlated to emission inventory/other sources?
- Windrose/met data to be provided
- Map with emission sources(brick kilns) if possible
- SO_2 monitoring important in case coal is being used

Bhutan



Sources of Pollution -Bhutan

Major Sources :

- industrialization,
- rapid urbanization,
- Emission from motor vehicles
- loss of vegetation to infrastructure development,
- forest fires

Monsoon : May to September

Windy-Dusty : March to May

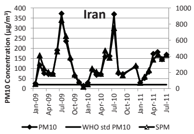
Additional Information-Bhutan

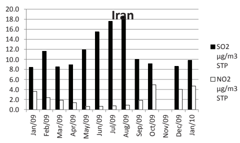
- Gelephu or Thimpu – location ?
- General information of area/country
- Discarded stray values e.g., 663/425/352(µg m3) for calculating average(– may be there is an explanation)
- Major crop – maize/rice – residue burning/months?
- Status of freight (trans border trade) ?
- Windrose/met data
- Low pH in precipitation– probable cause ?
- Tenfold increase in EC in 2010? – reason(calculation?)
- Windrose/met data to be provided

India

Data to be received

Iran





Sources of Pollution - Iran

Major Sources

- Vehicular Emissions
- large and small industrial processes.
- Power Refinery and petrochemical industries. plant industries
- Oil Wells ?
- **Dust Storms** ⟹

Driest months : July to September
Wettest month: January

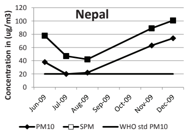
Additional Information - Iran

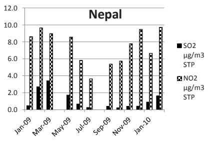
- General information of area/country
- Activities in Chamsari and Dehlaran(40km)
- Predominant wind direction
- Monsoon pattern
- Sources of PM10 other than natural
- Reasons for exceptionally high results not always given (discarded very high values- PM10 above 600; SPM above
- The oil wells of Iraq are 12-15km from the site(continuous flare reported)-do they influence the results ?
- Has the PM10/SPM been analysed at any time
- Correlation to emission inventory
- Windrose/met data

Maldives

Data to be received
(except some of diffusive for 2009)

Nepal





Sources of Pollution -Nepal

Major Sources

- Forest Fires
- Vehicular emissions ?
- Construction activity
- Agricultural residue burning – Nov-Dec & April-May
- Industry – Distillery, pharmaceutical, animal feed

Monsoon : End of June to September(80% of total rainfall)

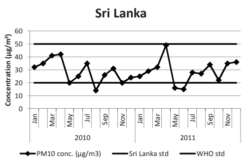
Additional Information - Nepal

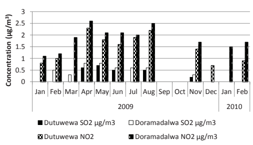
- General information of area/country
- Correlation to emission inventory
- Windrose/met data

Pakistan

Data to be Received

Sri Lanka





Sources of Pollution – Sri Lanka

- Vehicular Emissions
- Agriculture Residue Burning
- Construction Activities

Additional Information – Sri Lanka

- Activities in the area
- Anuradhapura activities – emission sources – transport – etc
- Tourism months ?
- Villages around the site – population/activity?
- Month with maximum agricultural residue burning in fields
- How far are the highways
- Met data during sampling days ?
- Dec PPT – PM2.5 measurement –location ?

Major Sources

- Vehicular Emissions
- Tourism?
- Agricultural Residue burning
- Construction Activities

Monsoon months :

Wind direction: SW from May to Sept. and NE from Dec. to Feb.

Additional Information/clarification

- Activities in the area
- Anuradhapura activities – emission sources – transport – etc
- Tourism months ?
- Villages around the site ?
- Month with maximum agricultural residue burning in fields
- How far are the highways
- Met data during sampling days ?
- Dec PPT – PM2.5 measurement –location ?

Limitations

- **Insufficient Data –e.g., only a few days in a month / a few months in a year**
- **Remarks related to site conditions not given to explain the odd/exceptionally high results**
- **Field blanks not being run in parallel or not being run.**
- **Very high values of field blanks.**
- **Contamination of field blank.**
- **Improper labeling of samples.**
- **Samples sent to IVL after long gaps.**
- **Temperature generally missing**
- **Frequency 24 hrs to three months exposure.**
- **Results and trends not correlated to sources of emission/emission inventory**

Recommendations

- Activities in and around monitoring location
- General information on sources of Air Pollution in the country
- Correlation to meteorological data
- Correlation of data generated by different methods or from other monitoring locations
- Correlation with emission sources
- Explaining trends if any
- Discarding/explaining stray values
- Regular monitoring

Thank You

The effects of $PM_{2.5}$ on health of children in Dhaka, Islamabad and Kathmandu

Assoc. Professor Frank Murray
Murdoch University
Perth, Australia

Seventh Regional Stakeholders cum Coordination Meeting (RSC7), 18-19 May 2013

Presentation based on the following reports

- NIPSOM and Department of Environment 2008. Final Report: Assessment of Impact of Air Pollution among School Children in Selected Schools of Dhaka City, Bangladesh. National Institute of Preventive and Social Medicine and Department of Environment, Dhaka, Bangladesh.
- PakEPA and PMRC 2013. Final Report: Impacts of Particulate Air Pollution on the Respiratory Health of Schoolchildren in Pakistan. Pakistan Environmental Protection Agency, and Pakistan Medical Research Council, Islamabad, Pakistan.
- NHRC and ICIMOD 2013, Assessment of Impacts of Particulate Air Pollutants on Respiratory Health of School Children in Kathmandu Valley. Nepal Health Research Council and International Center for Integrated Mountain Development, Kathmandu, Nepal.

Project

What are the effects of air pollution on health of children in large cities in South Asia?

If actions are taken to reduce air pollution, what will be the health benefits?

The project aimed to test the relationship in school children between:

- Daily particle concentrations measured in Dhaka, Islamabad and Kathmandu

and

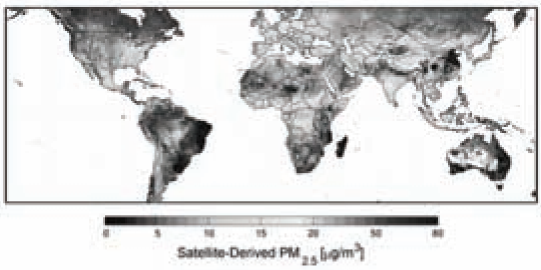
- Peak expiratory flow (as an indicator of lung function)

How high are PM levels in Dhaka, Islamabad and Kathmandu?

Concentrations of $PM_{2.5}$ during these studies in Dhaka, Islamabad and Kathmandu (NHRC & ICIMOD, 2013; NIPSOM & Department of Environment 2008; PakEPA & PMRC 2013)

Concentrations of $PM_{2.5}$ (in µg/m^3)	Dhaka	Islamabad	Kathmandu Urban school	Kathmandu Semi-urban school
Mean concentration	67	81	203	137
Maximum concentration	233	142	337	231
Minimum concentration	18	25	102	76
Air quality national standard	65	40	40	40

Comparison of $PM_{2.5}$ around the world (soil dust and emissions)



Global satellite-derived map of $PM_{2.5}$ averaged over 2001-2006. Credit: Dalhousie University, Aaron van Donkelaa

Regional Particles in Air

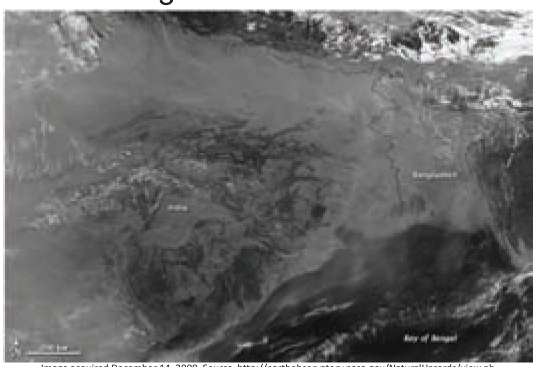


Image acquired December 14, 2009. Source http://earthobservatory.nasa.gov/NaturalHazards/view.ph

Two Phases

- The studies had two components: Phase 1: a baseline survey and Phase 2: a health impact assessment.
- The baseline survey used a structured questionnaire developed for international use by the International Study of Asthma and Allergies in Childhood.
- The baseline surveys were conducted based on 1618 children in Dhaka, 801 children in Kathmandu and 328 children in Islamabad.

Results of the Phase 1 questionnaire

- These studies in Dhaka, Kathmandu and Islamabad showed a high level of respiratory illnesses not associated with colds or flu.
- Nearly 30% of children had respiratory symptoms such as sneezing, running nose or nasal blockage without common cold or flu.
- About 25% of them had symptoms that hampered their studies and activities.
- About 30% of all children with respiratory health issues visited a doctor or other health facility.
- Due to these respiratory health issues in Kathmandu 43% of the children missed school for one or two days, 42 % of their guardians missed their work due to these illnesses in children

Phase 2

- Phase 2 assessed the impact on respiratory health of fine particles in air ($PM_{2.5}$), among 180 children in Dhaka, 137 children in Kathmandu and 132 children in Islamabad.
- Children of age between 9-16 years in Dhaka, 10-15 years in Kathmandu and 9-14 years in Islamabad were assessed for their lung function by measuring morning peak expiratory flow rate (PEFR).

Phase 2

- Measurements of $PM_{2.5}$ were recorded daily in in Dhaka and Kathmandu and weekly in Islamabad. Weather data were also recorded.
- PEFR and $PM_{2.5}$ measurements were conducted for 35 days in Dhaka, 31 days in Kathmandu and a total of six weeks in Islamabad.

$PM_{2.5}$ in Dhaka

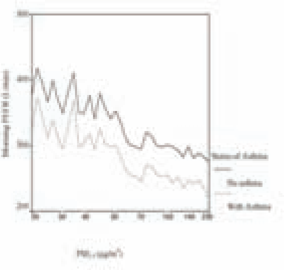
The daily mean concentrations of $PM_{2.5}$ varied from 18 to 233 µg/m^3 with a mean of 67 µg/m^3. It exceeded the Bangladesh daily $PM_{2.5}$ standard of 65 µg/m^3 on 13 of the 42 days of health data collection.

Major findings of the Dhaka study

The results in Dhaka show that there is a relationship between Peak Expiratory Flow Rate a measure of lung function, in both asthmatic and non-asthmatic children and $PM_{2.5}$ concentrations.

.

PEFR decreased when $PM_{2.5}$ increased



PEFR in Dhaka decreased by about 30% in both asthmatic and non-asthmatic children when $PM_{2.5}$ increased from its lowest level of 18 $\mu g/m^3$ to its highest daily mean of 233 $\mu g/m^3$

Comparison with adult female smokers and non-smokers - only 16% reduction

	PEFR L/min	
Non-smokers	Range Mean	330-340 332
Heavy smokers	Range Mean	270-300 280

Both groups were 100 women, 30-40 years old of similar height and weight from Nepal

Source: Prasad et al, 2003

Additional expenditure

- Total annual expenditure for respiratory illnesses of asthmatic children (6918 Taka, about 100 USD) was twice that of non-asthmatic children.
- Of about 2.37 million children of school age in Dhaka, 25.8% have clinical symptoms of asthma, about 0.61 million children.
- The additional expenditure on respiratory illnesses for children with asthma in Dhaka is about USD 30 million per year.

The results are consistent with other studies

- The finding that increases in $PM_{2.5}$ levels are associated with impaired lung function in children with and without asthma is in agreement with studies in Mexico City, the Netherlands, Bangkok and studies in the USA
- The severity of the changes in PEFR with increases in PM is an important new finding

Impacts on children with asthma

Although data from Dhaka are not readily available, based on data from the USA and assuming the same health outcome ratios apply to Dhaka, the 0.61 million children in Dhaka with asthma will have

- 12 million restricted activity days,
- 1.5 million school absence days, (2.48 days per child with asthma), and
- 51 school age children each year will die of asthma.

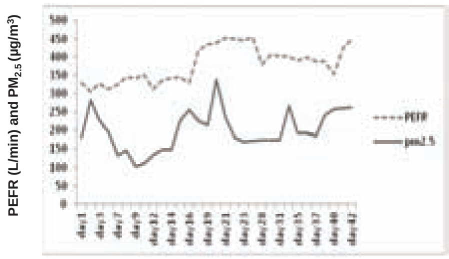
Results in Kathmandu

- The study in Kathmandu contrasted an urban roadside school with a semi-urban school in a residential area.
- The 24 hour mean concentration of $PM_{2.5}$ was 203 $\mu g/m^3$ in the urban school and 137 $\mu g/m^3$ in the semi-urban school.
- These concentrations exceeded the Nepal daily $PM_{2.5}$ standard of 40 $\mu g/m^3$.

Results in Kathmandu

- The PEFR level of the students at the urban school varies with the changing levels of $PM_{2.5}$ concentration which ranged between 100 µg/m^3 and nearly 340 µg/m^3.
- The PEFR levels of younger (10-12 years) children seem to be correlated with the changes in $PM_{2.5}$ concentrations in the initial days and later days of the assessment.
- The PEFR levels of female children also seem to be associated with the variation in daily $PM_{2.5}$ concentrations on a few days.

The relationship between peak expiratory flow rate (PEFR) (L/min) of 10 to 12 year old children and $PM_{2.5}$ (µg/m^3) concentration at the urban roadside school in Kathmandu (NHRC and ICIMOD 2013)

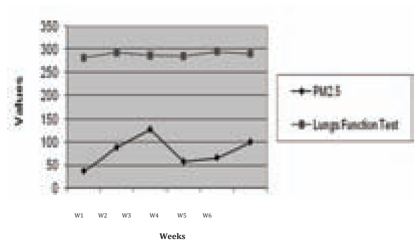


Days from the commencement of monitoring

Results in Islamabad

- The mean concentration of $PM_{2.5}$ in Islamabad was 81 µg/m^3 with a range of 25-142 µg/m^3
- Measurements frequently exceeded the 24 hour air quality standard in Pakistan of 40 µg/m^3.
- The peak expiratory flow rate (PEFR) ranged from 120 L/min to 420 L/min, with a mean of 287 L/min.

Results in Islamabad



Weekly average PM2.5 and PEFR in Islamabad. The vertical axis refers to both PEFR in L/minute and $PM_{2.5}$ in µg/m^3

Social and Economic Impacts

These and other studies suggest that $PM_{2.5}$ concentrations in ambient air have a significant adverse economic impact on the families of affected children.

It has been estimated that the reduction of PM_{10} concentration by 20% - 80% in Dhaka could allow for:

- avoidance of 1,200 to 3,500 deaths,
- 80 to 235 million cases of sickness, and
- a saving of US$ 169 to 492 million equivalent to 0.34 – 1.0 % of Gross National Income (World Bank, 2006).

Further steps

- A regional study should be considered to quantify the health, social and economic costs of ambient health damaging $PM_{2.5}$ particles in Malé Declaration countries, reporting to the Governments.
- The aim is to enable more thorough national assessments of impacts, policy options, costs and health benefits of key options to reduce the burden of disease caused by air pollution.
- This could be conducted by a team nominated by governments of Malé Declaration countries using national data and working to a common methodology.

Conclusion

If emissions of $PM_{2.5}$ in Dhaka, Islamabad, Kathmandu and similar cities could be reduced the harmful impacts on the respiratory health of children could be substantially decreased with social and economic benefits

Thank you

Assessment of Impacts of Air Pollution on Crops in South Asia with a focus on Tropospheric Ozone

Patrick Büker, Lisa Emberson, Kevin Hicks
Stockholm Environment Institute/University of York

Aim of crop impact assessment study

- To identify agricultural areas in South Asia at risk from ozone (O_3)
- To quantify – based on field experiments across the region - the effect of ambient O_3 on crop yields in South Asia
- To identify the sensitivity of important South Asian crops to O_3
- To inform model-based regional crop impact assessment studies
- To increase awareness of O_3 effects on agricultural among policy makers, scientists and the interested public
- To build capacity in South Asia in application of risk assessment methods
- To establish a global network of crop effect scientists

→ To gain knowledge of threat O_3 poses on food security in South Asia

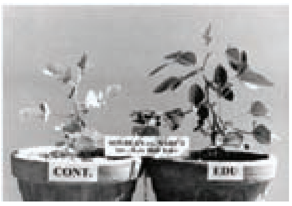
Methodology

Chemical protectant study using EDU

EDU suppresses acute and chronic ozone injury on a variety of crop plants (e.g. Mung bean, wheat, potato, spinach, tobacco) under ambient O_3 conditions (Godzik & Manning, 1998)

Structural formula for N-(2-(2-oxo-1-imadazolidinyl)ethyl)-N'-phenylurea

abbreviated as EDU for ethylenediurea

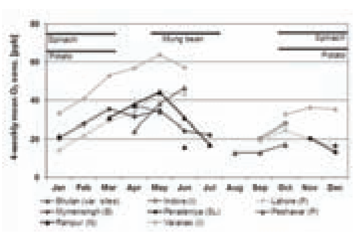


Pakistan soybean cv. NARC-1 showing protective effect of EDU at a roadside rural site in Lahore, Pakistan (photo courtesy of A. Wahid)

Overview of sites and crops used

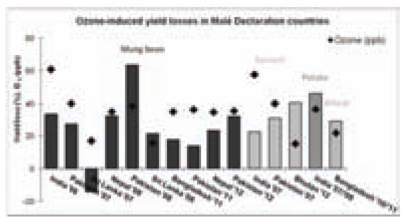
Country	Site	Scientist in charge	Crop
Bangladesh	Mymensingh	Prof. M. A. Sattar, Dr. T. Islam	Mung bean, Wheat
Bhutan	Kanglung	Dr. K. Tshering, Dr. M. Pelmo	Spinach
India	Varanasi	Prof. M. Agrawal	Mung bean, Spinach, Potato
Nepal	Rampur	Prof. N. Chaudhary, Mr. L. Amgain, Ms. M. Bhattarai	Mung bean
Pakistan	Lahore, Peshawar	Prof. S.R.A. Shamsi, Dr. M.N. Ahmad	Mung bean, Spinach
Sri Lanka	Peradenyia	Dr. A. Perera	Mung bean

Ozone concentrations in South Asia



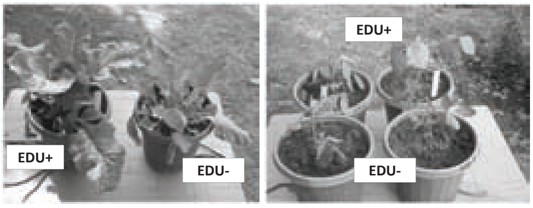
Four-weekly mean ambient ozone concentration monitored using passive samplers at various sites across the South Asian region.

Yield losses in South Asia



Ozone-induced yield losses for Mung bean, spinach, potato and wheat in various South Asian countries as recorded during field experiments conducted between 2006 and 2012.

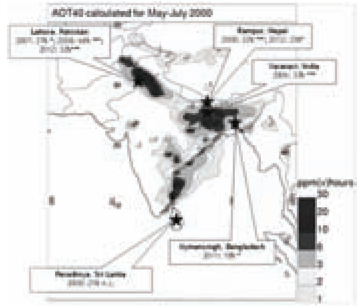
Visible evidence of O_3 effect



Example shown from Lahore, Pakistan (Photos courtesy of Prof. Shamsi).
Left photo: Spinach; right photo: Mung bean

Beside obvious difference in growth and hence yield, ozone-induced leaf injury (depending on crop varying between brown, yellow or whitish stipples of various sizes) makes it more difficult to sell leafy crops on market; customers prefer healthy looking, bright green leaves!

Modelled O_3 concentrations *vs*. field-based evidence



MATCH-modelled O_3 concentrations for year 2000 (as 3-month AOT40 values for May – July) and results of EDU chemical protectant study for mung bean (% yield loss) conducted at South Asian experimental sites (blue stars) during equivalent months. The significance of the experimental results is presented (n.s. = not significant; * moderately significant and *** highly significant).

Establishment of Air Pollution Crop Effect Network (APCEN)

- To facilitate communication between air quality stakeholders concerned with assessing risk posed by air pollution to agriculture
- To provide technical support to the experimental campaigns of Malé Declaration crop impact assessment studies
- 70+ network members (mainly air pollution effects scientists, modellers and policy makers) are located across the globe

Region	Network Members	Countries / regions represented
Africa	14	Egypt, Kenya, Mozambique, South Africa, Zimbabwe, Zambia, Tanzania, Botswana
Asia	55	India, Japan, Nepal, Pakistan, P.R. China, Philippines, South Korea, Sri Lanka, Taiwan, Thailand, Bangladesh
The Americas, Europe and Australia	18	Australia, Chile, Sweden, UK, USA, Brazil, Germany

Summary of achievements

- New large-scale experimental evidence of effects of O_3 on yield of important South Asian crops (e.g. Mung bean, spinach, wheat and potato); evidence fits well with modelling-based regional prediction of O_3 concentration fields;
- Wide-spread evidence of plant-damaging concentration levels of O_3 during main growing seasons of important South Asian crops;
- Development of standardised risk assessment methodologies that have been evaluated for application across South Asian region;
- Increased awareness of yield-damaging effect of O_3 among policy makers, scientific community and general public through seminars, training workshops and information material (e.g. policy briefs);

Summary of achievements (cont.)

- Successful capacity building in region due to training of numerous junior and senior scientists in application of risk assessment methods;
- Enhanced, institutionalized (e.g. via APCEN network and GAP Forum) cooperation between South Asian, European and North American scientists with active mutual exchange of knowledge and skills;
- A Regional Centre of Crop Impact Assessment is currently being established in Pakistan to oversee coordination, harmonization, quality control and reporting of the Malé Declaration crop impact activities.

Future challenges – knowledge gaps

- Better estimation of extent of yield losses of staple crops due to air pollution across entire South Asian region → link to food security!
- Identification of differing O_3 sensitivity of common crop cultivars cultivated in region;
- Effect of changing climate (temperature, rain fall) on crop growth and yield
- Robust estimation of extent of socio-economic effects of O_3 and climate change on crop yields for small- to large-scale farmers in region.

Suggested future steps

- Modelling studies to enable derivation of dose-response relationships for crops in South Asia;
- Pan-Asian Open Top Chamber (OTC) study;
- Crop impact studies that account for changing climate (temperature rise, change in rainfall patterns and hence shift of growing seasons).

→ this will require strong joint proposal writing efforts of Asian, European and North American scientists, a clear political will in South Asian region and potent donors.

National Initiatives on Air Pollution in Bangladesh

7th Regional Stakeholders Meeting Cum Coordination Meeting Presented by Dr. Bilkis A. Begum

19 May 2013

Impact of air pollution on visibility

The Great Smog of 1952 darkened the streets of London and killed approximately 4,000 people in the short time of 4 days (a further 8,000 died from its effects in the following weeks and months)
Smog is a mixture of Gaseous SO2 and Particulate Aerosols
If Smog is a yellowish or blackish fog, it would be formed by a mixture of particulates and ground level ozone.

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Impact of air pollution on visibility

Smog in New York City as viewed from the World Trade Center in 1988

Beijing air on a day after rain (left) and a smoggy day (right)

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Impact of air pollution on visibility

- **The visibility worsens during winter months.**
- **Almost in every winter months, we saw a dense smog episode that contributed to flight delays and a virtual halt of steamer movement in the rivers surrounding Dhaka.**

Reduced visibility due to smog in Dhaka during winter (left picture) compared to clear visibility during monsoon (right picture)

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Identification of Haze Creating Sources from Fine Particulate Matter in Dhaka Aerosol using Carbon Fractions Data

Bilkis A. Begum
Atomic Energy centre, Dhaka
Bangladesh Atomic Energy Commission

19 May 2013

Air Quality Parameters

- **PM (PM_{10}, $PM_{2.5}$)**
- **SO_x**
- **NO_x**
- **CO**
- **Ozone**
- **Trace elements in PM's etc.**

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Impact of Air Pollution

-Health Effect
-Visibility
-Production of crops
-Climate change

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National Ambient Air Quality Standards for Bangladesh

Pollutant	Objective	Average
CO	10 mg/m^3(9 ppm)	8 hours
	40 mg/m^3(35 ppm)	1 hours
Pb	0.5 µg/m^3	Annual
NO_2	100 µg/m^3	Annual
PM_{10}	50 µg/m^3	Annual
	150 µg/m^3	24 hours
$PM_{2.5}$	15 µg/m^3	Annual
	65 µg/m^3	24 hours
O_3	235 µg/m^3	1 hours (d)
	157 µg/m^3	8 hours
SO_2	80 µg/m^3	Annual
	365 µg/m^3	24 hours

- ***The most serious pollutant of concern in Bangladesh, especially in cities, is the particulate matter (PM)***

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- ***Experience in Dhaka, Bangladesh***

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Air quality status in Dhaka

- Assessment of impact of different policy interventions (such as, unleaded gasoline, banning of two-stroke baby taxis, CNG adaptation)
- Assessment of ambient air quality particularly PM in Dhaka city
- Identification of potential sources, source locations
- Identification of haze creating sources from FPM
- Evidence of long range transport

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Adaptation of policies taken by the Government to reduce the PM emission from motor vehicle

These are

- **banning of use leaded gasoline from July 1999**
- **improved training of engine mechanics, import and marketing of mineral oil without additives and set minimal standards for lubricants**
- **banning of two-stroke three-wheel taxis from January 2003 and removal of trucks and buses that were more than 20 years old**
- **a phased reduction of gasoline-powered by introducing CNG, &**
- **electronic traffic signals to increase the mobility of vehicles**.

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Sample collection (*Research*)

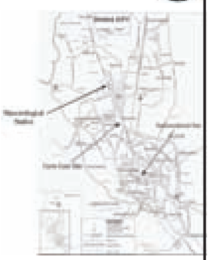
Sampling locations

CAMS-2: Farm Gate area in Dhaka, a hot spot with very high pollutant concentrations because of the proximity of major roadways, latitude 22.22N, longitude 91.47E), 2000

SR: Semi-residential (AECD) area, which is located within the Atomic Energy Centre, Dhaka University Campus with relatively less traffic, latitude 23.73N, longitude 90.38E, 1996

Sampler: **Air Metrics and GENT** type sampler

Method of Analysis
Mass by weighing
BC by Reflectance measurement
Carbon fraction analysis by carbon analyzer
Elemental Concentration by PIXE & XRF



Location of sampling site at Dhaka

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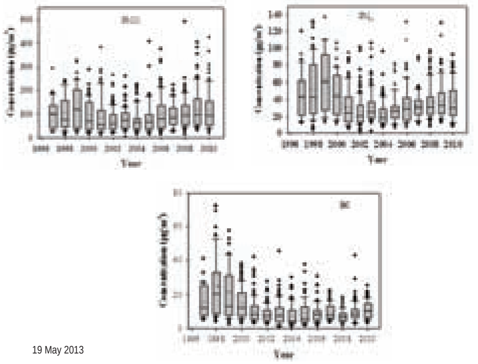
Variation of concentration with time



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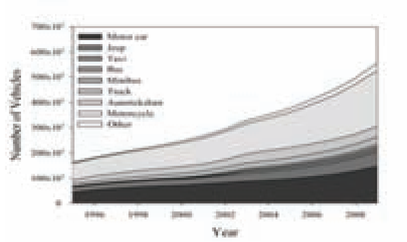
Year-by-year registration of vehicles in Dhaka City (Source: Bangladesh Road Transport Authority, 2010)



Truck & Motor cycles = 54% of the total fleet

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Brick Industry

Brick Production
15 billion bricks per year with an annual growth of about 7-8% & contributes 1% of the GDP. It consumes 2.2 million tons of coal and 1.9 million tons of fire wood.

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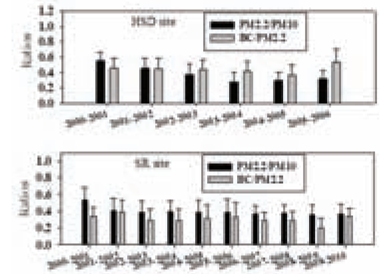
Ratios of PM2.2/PM10 and BC/PM2.2 over the collection periods from April 2000 to March 2006 and April 2000 to March 2010 at HS and SR sites



Hence, control of emission from the combustion sources is good achievement of policies adaptation

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Average source contributions derived from the PMF modeling

Source	Fine PM samples (μg/m³)					
	2001-2002		2005-2006		2007-2009	
	Mass	BC	Mass	BC	Mass	BC
Motor vehicle	*7.16*	*2.50*	*5.62*	*0.38*	*12.1*	*0.02*
Brick kiln	*2.23*	*1.37*	*11.1*	*4.14*	*7.59*	*7.41*
Metal smelter	1.87	0.00	1.94	0.53	-	-
Sea salt	0.19	0.00	0.60	0.00	2.12	0.00
Two Stroke/Zn	*1.75*	*1.11*	1.94	1.07	*1.49*	*0.62*
Soil dust	1.92	0.0	2.74	0.18	3.21	0.02
Road dust	3.63	1.63	5.14	1.09	4.97	0.57
Fugitive Pb			-	-	2.22	0.01
RM	*18.7*	*6.61*	*29.1*	*7.38*	*33.7*	*8.12*
MM	*22.1*	*7.90*	*30.5*	*9.23*	*37.3*	*8.21*

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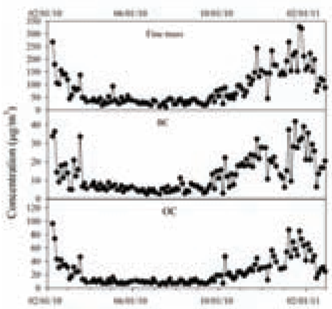
Variation of PM fraction (FPM), black carbon (BC) and organic carbon (OC) during 2010-2011 period



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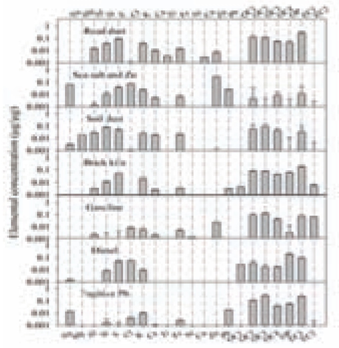
Source composition profiles for fine particulate matter using fractions of OC and EC



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Average source contributions (μg/m3)derived from the PMF modeling

Source	Modeling with OC & EC			Modeling with fraction of OC &EC		
	Mass	OC	EC	Mass	OC	EC
Road dust	3.34	0.57	0.50	6.59	1.91	1.92
Sea salt & Zn	3.21	0.00	0.00	4.42	0.26	0.05
Soil dust	14.5	4.40	2.39	4.03	0.78	0.14
Motor vehicle	36.0	9.28	3.01			
Brick kiln	24.5	7.95	6.29	31.2	7.91	5.99
Gasoline				5.39	1.40	0.75
Diesel				16.8	4.73	1.54
Fugitive Pb				7.9	3.77	1.98

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Which sources are related to worsen the Visibility

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Aerosol Extinction coefficient from visibility observations

- ***According to the Koschmieder (1926) theory, the visual range of an object viewed against the horizon sky, VR (km), is inversely proportional to the horizontal extinction coefficient, B_{ext}(km^{-1}),***
  B_{ext}=K/VR.
- ***Where K=Koschmieder constant which is equal to 3.92 (real target is not black, small, angular in size)***

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Visibility

- **Particle size depends on**
  -Particle composition
  -Relative humidity
- **Reflective Index**
  -Particle composition

Thus, particle composition is a key determinant of extinction

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Means and standard deviations of visibility, and extinction efficient in different season during study period

Season	Visibility	B_{ext}
	Km	Km^{-1}
Pre-monsoon	5.14±0.45	0.76 ±0.07
Monsoon	5.46±0.38	0.72 ±0.05
Post-monsoon	4.93±0.68	0.81 ±0.11
Winter	3.34±0.01	1.34 ±0.70

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Results of the Stepwise Multiple Linear Regression Analyses

Source	Coefficient Estimate (m^2/g)	Standard Error (m^2/g)	T Statistic	P-Value
Road dust	62.1	10.1	6.18	0.00
Brick kilns	6.60	1.00	6.42	0.00
Gasoline	27.2	5.60	4.88	0.00
Diesel	6.80	1.10	6.11	0.00
Pb	7.80	3.20	2.39	0.02

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Long Range Transport

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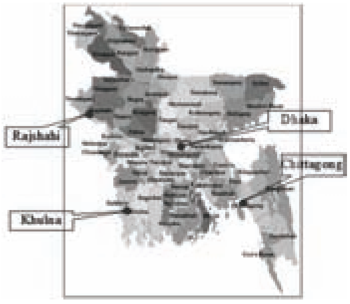
Map of sampling locations in Bangladesh



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Seasonal variation of $PM_{2.5}$ (µg/m3) in four stations

Year	Season	Rajshahi	Dhaka	Khulna	Chittagong
		Mean±STD	Mean±STD	Mean±STD	Mean±STD
2010-11	Monsoon	-	**30.3 ±11.6**	-	-
	Post-monsoon	127 ±66.4	68.6 ±32.7	51.3 ±29.3	-
	Winter	**277 ±94.0**	**104 ±49.8**	**120 ±72.9**	**113 ±47.4**
2011-12	Pre-monsoon	143 ±79.6	50.0 ±35.5	42.5 ±28.9	56.6 ±39.4
	Monsoon	**55.4 ±26.5**	**26.8 ±10.5**	**19.6 ±11.8**	**11.7 ±2.32**
	Post-monsoon	109 ±31.8	65.8 ±21.4	63.1 ±37.8	60.5 ±45.9
	Winter	**271 ±140**	**101 ±23.6**	**84.6 ±52.6**	**33.7 ±0.71**
2012	Pre-monsoon	151 ±77.5	39.1 ±23.1	-	-
	Monsoon	**100 ±28.2**	**41.3 ±11.1**	-	-

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The mean, standard deviation and threshold value of fine PM and BC concentrations (µg/m3) during sampling period

Parameter	Statistics	Rajshahi	Dhaka	Khulna	Chittagong
Fine PM	Mean	155	65.1	64.7	73.3
	Median	121	56.0	52.0	74.2
	STD	112	41.2	56.8	50.7
	Threshold Value	379	147	178	175
BC	Mean	13.1	7.20	5.84	4.32
	Median	10.8	7.40	5.20	3.32
	STD	7.05	3.31	3.58	2.67
	Threshold Value	27.2	13.8	13.0	9.66

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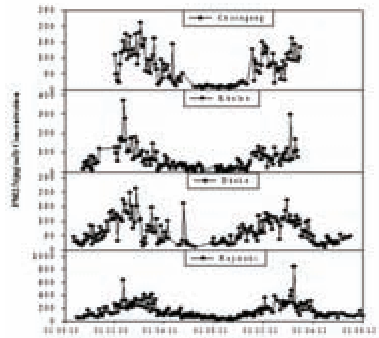
Variation of PM2.5 concentrations with time in four cities



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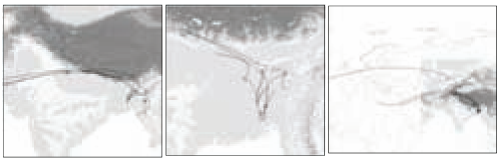
Air parcel movement (Backward trajectory)



*Typical wind directional pattern during December, January and February respectively (*During the winter time wind mainly comes from northwest direction, e.g. Dhaka)

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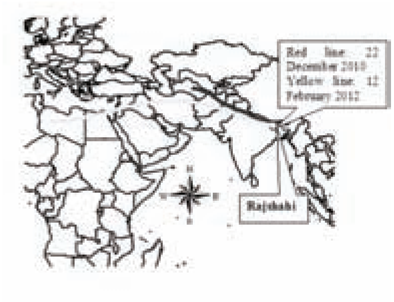
Air parcel backward trajectories showing the long range transport of fine PM



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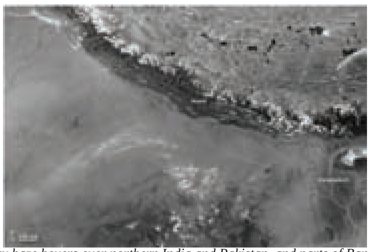
Pollution and fog mixed at the base of the Himalayas in India in early December 2010
http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=47742



Dull gray haze hovers over northern India and Pakistan, and parts of Bangladesh which results from a combination of agricultural fires, urban and industrial pollution, and a regional temperature inversion.

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Dust storm over the Arabian Peninsula
http://thewatchers.adorraeli.com/2012/02/06/dust-storm-in-saudi-arabia

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Transboundary Evidence

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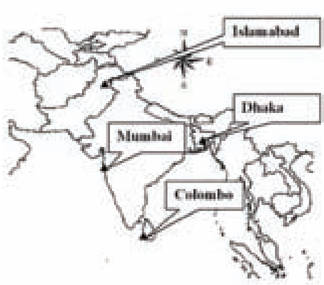
Sampling sites of Neighboring Countries



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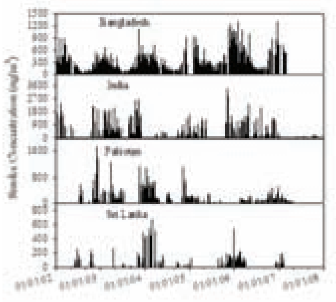
Time series plots of fine Smoke contribution



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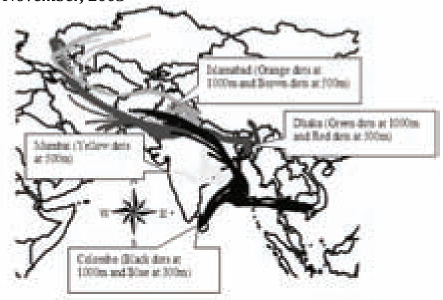
Air parcel back trajectories showing the likely sources areas for smoke

3 to 15 November, 2003



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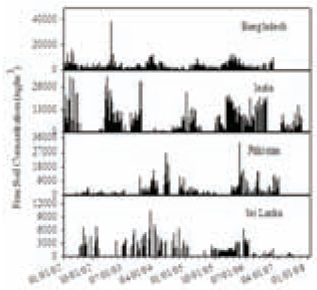
Time series plots of fine soil concentrations in Bangladesh, India, Pakistan and Sri Lanka



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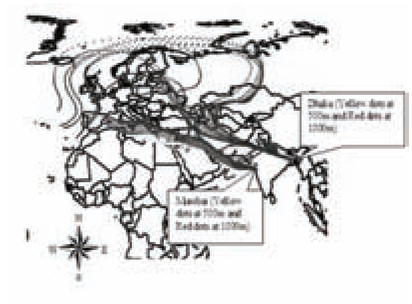
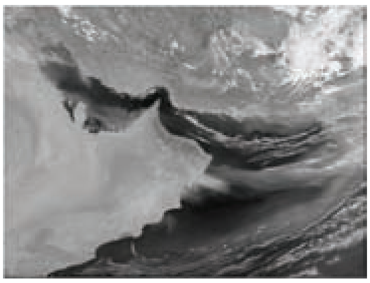
Air parcel back trajectories showing long range transport of soil dust in Bangladesh and India in February 2003



19 May 2013

Thick plumes of desert dust blew over Oman and across the Gulf of Oman toward Iran and Pakistan on February 18 2003. (http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=10917)



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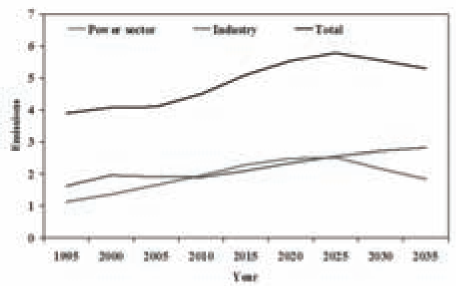
HAZE OCCURRED IN SINGAPORE IN OCTOBER 2006, AND WAS CAUSED BY SMOKE FROM FIRES IN INDONESIA BEING BLOWN BY SOUTH-WESTERLY WINDS.

19 May 2013

SO_2 Emissions (Million Tons) (India)



Ref: 7th AIM International Workshop, NIES, Tsukuba, Japan, March 15-17, 2002

19 May 2013

Conclusions

To address the air pollution issues locally

a) Emission from Motor vehicles
b) Reduction of soil dust including road dust from road and
c) Replacement of existing brick kiln with energy efficient and environment friendly brick production technology, cook stove and rice parboiling system.

It is also necessary to address the air pollution issues regionally due to Transboundary Effect which increase local air pollution

a) Coal-fired power plants in India using high S coal in India
b) Similar problem with BC, biomass/agricultural waste

19 May 2013

Thank You

END

19 May 2013

Aerosol Optical Depth (AOD) Measurements from a Newly Established NASA-AERONET Station in Dhaka, Bangladesh

Abdus Salam*, M. Arifur Rahman, M. Ashaduzzaman, A. Rahman
Department of Chemistry, University of Dhaka, Bangladesh
&
Brent Holben
NASA Goddard Space Flight Center, Greenbelt, Maryland, USA

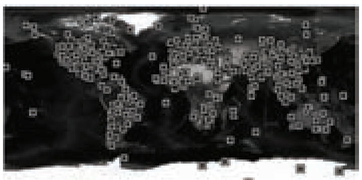
7th Regional Stakeholders cum Coordination Meeting (RSC7), 18-19 May 2013, Dhaka, Bangladesh

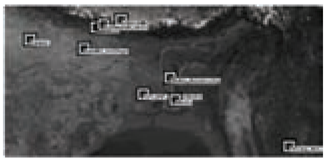
Overview

- The NASA AERONET (AErosol RObotic NETwork) program is a federation of ground-based remote sensing aerosol networks.
- The program provides a long-term, continuous and readily accessible public domain database of aerosol optical, microphysical and radiative properties for aerosol research and characterization, validation of satellite retrievals, and synergism with other databases.
- NASA has about 400 AERONET stations in all over the World. We have two AERONET stations in Bangladesh.
  - Chemistry Department (MHSB), Dhaka University
  - Island of the Bay of Bengal (Bhola), Bangladesh
- CIMEL Sunphotometer can measure the sun and sky radiances at seven different wavelengths within the visible and near-infra red spectrum (340, 380, 440, 500, 675, 870 to 1020nm).

2

Map of the AERosol RObotic NETwork (AERONET)





3

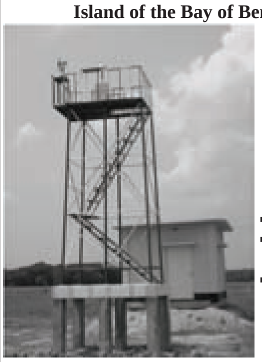
Sunphotometer on the roof of the Chemistry Department (Khondhakar Mukaram Hossain Building), Dhaka University

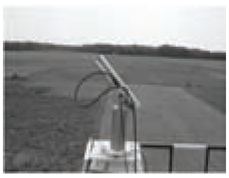
Sources of air pollutants: Traffic emissions, Industries, Brick kilns, Construction activities, Cooking, and Long range transport, etc.

Latitude: N 23° 43'40", Longitude: E 90°23'52, Elevation: 34.0 meters

4

Island of the Bay of Bengal (Bhola) Observatory

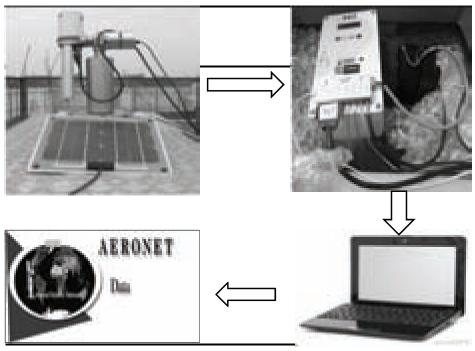




- About 1 km far from nearby habitants.
- No industrial and very low traffic emission
- Biomass burning for cooking and agricultural activities, and also long range transport are the main sources of pollution.

Latitude: N 22°10'01", Longitude: E 90°45' 00", Elevation: 10.0 meters

5



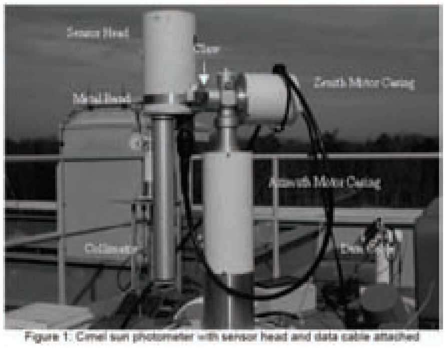


Figure 1: Cimel sun photometer with sensor head and data cable attached

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We need to give input to the Sunphotometer the exact latitude and longitude and also the GMT of the sampling location. Then it starts measuring from sun rise to sunset.

Basically, it measures the intensity of sunlight arriving directly from the Sun. The collimator are directly pointed at the Sun and measure direct sunlight.

Since haze and aerosols block some direct sunlight, a sun-photometer is an ideal instrument for measuring haze.

A hazy sky would read a lower intensity of sunlight and give a lower voltage reading on the Sunphotometer.

A clear blue sky would result in a greater intensity and a higher voltage reading on the sunphotometer.

8

The following information can be obtained from Sunphotometer

- Aerosol optical depth (AOD)
- Single scattering albedo (SSA)
- Aerosol particle size distribution
- Contribution of fine and coarse particles
- Water content
- Angstrom parameters
- Brown carbon and black carbon

9

Aerosol Optical Depth (AOD)

- Optical depth is defined as the negative natural logarithm of the fraction of radiation that is not scattered or absorbed on a path. It is dimensionless.
- Aerosol optical thickness is the degree to which aerosols prevent the transmission of light by absorption or scattering of light.
- Aerosol optical depth or optical thickness (τ) is defined as the integrated extinction coefficient over a vertical column of unit cross section.
- Extinction coefficient is the fractional depletion of radiance per unit path length (also called attenuation). The optical thickness along the vertical direction is also called normal optical thickness (compared to optical thickness along slant path length).

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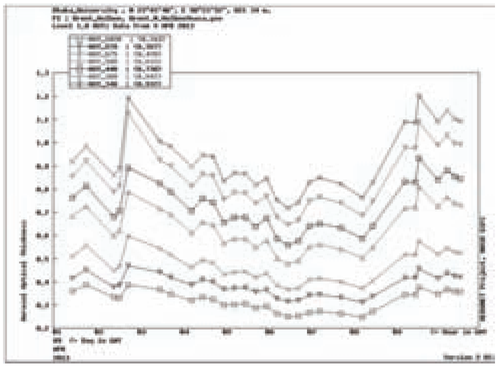
Applications of AOD

- Air Quality
- Health and environment
- Climate change
- Monitoring of sources and sinks of aerosols
- Satellite data verification
- Monitoring of the volcanic eruptions and forest fire
- Radiative transfer model
- Energy radiation budget

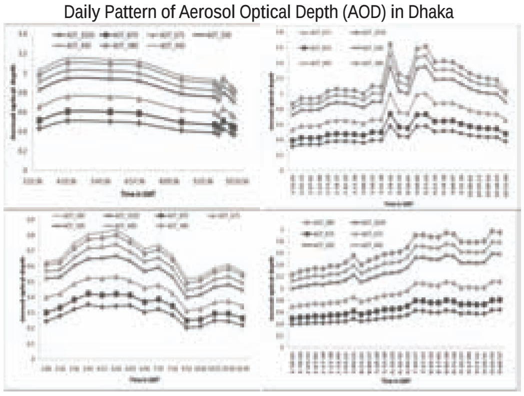
11

Typical Daily Aerosol Optical Depth (AOD) Variation in Dhaka with Sunphotometer

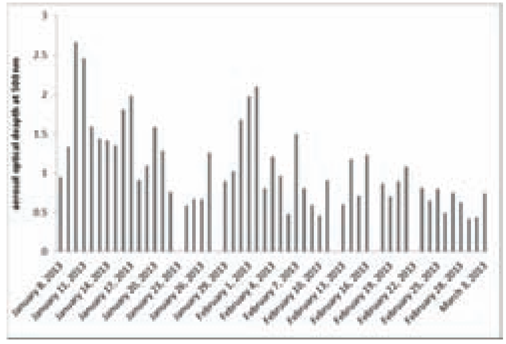


12

Daily Pattern of Aerosol Optical Depth (AOD) in Dhaka



Variation of AOD at 500 nm in Dhaka, BD



Monthly Average of Aerosol Optical Depth (AOD) at Seven Wavelengths in Dhaka

Wavelength	340	380	440	500	675	870	1020
Jun-12	1.464	1.401	**1.271**	**1.175**	0.947	**0.83**	0.756
Jul-12	0.557	0.534	**0.489**	**0.467**	0.39	**0.362**	0.333
Aug-12	0.579	0.557	**0.518**	**0.487**	0.426	**0.405**	0.381
Sept-12	0.906	0.875	**0.812**	**0.748**	0.625	**0.559**	0.511
Oct-12	0.84	0.798	**0.71**	**0.623**	0.446	**0.336**	0.267
Nov-12	1.021	0.983	**0.885**	**0.78**	0.551	**0.396**	0.309
Dec-12	0.872	0.853	**0.778**	**0.69**	0.496	**0.365**	0.295
Jan-13	1.238	1.21	**1.115**	**1.008**	0.76	**0.572**	0.464
Feb-13	0.905	0.856	**0.757**	**0.659**	0.472	**0.357**	0.287
Mar-13	1.137	1.063	**0.93**	**0.806**	0.571	**0.431**	0.344
Apr-13	1.145	1.061	**0.922**	**0.802**	0.582	**0.462**	0.386
May-13	1.201	1.111	**0.971**	**0.854**	0.635	**0.52**	0.447
Ave	**0.989**	**0.942**	**0.847**	**0.758**	**0.575**	**0.466**	**0.398**

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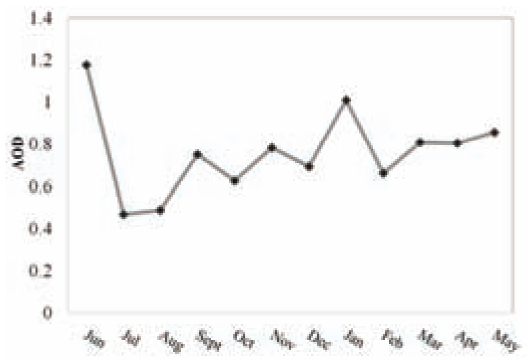
One year monthly Average AOD in Dhaka, BD at 500 nm



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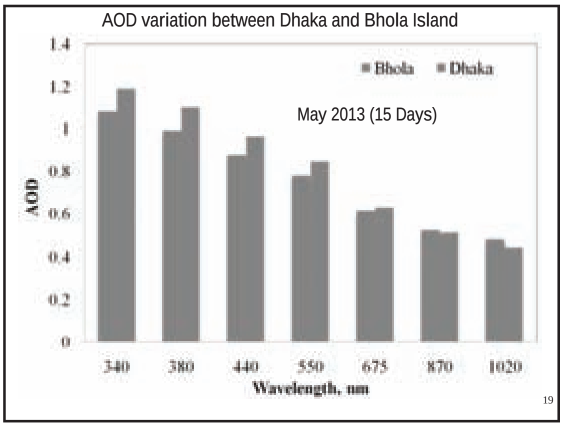
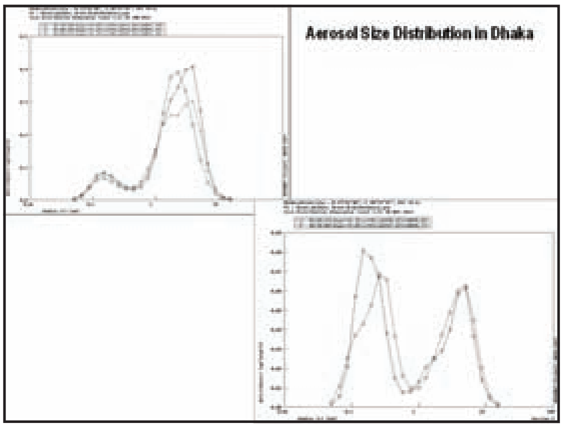
AOD values at 500 nm for the year of 2012 at Different Locations

	Dhaka	Kanpur	Lahore	Halifax	Hanimadho	Kathmundhu-bode
Jun-12	**1.175**	**0.871**	**0.690**	**0.200**		
Jul-12	**0.467**	**0.866**	**0.682**	**0.188**	**0.441**	
Aug-12	**0.487**	**0.849**	**1.004**	**0.220**	**0.609**	
Sept-12	**0.748**	**0.671**	**1.092**	**0.138**	**1.395**	
Oct-12	**0.623**	**0.771**	**0.549**	**0.138**	**1.913**	
Nov-12	**0.780**	**0.932**	**0.734**	**0.089**		
Dec-12	**0.69**	**0.705**	**0.431**	**0.137**	**0.482**	**0.256**
Jan-13	**1.008**	**0.903**	**0.733**	**0.083**	**0.451**	**0.381**
Feb-13	**0.659**	**0.565**	**0.488**	**0.115**	**0.369**	**0.363**
Mar-13	**0.806**	**0.367**	**0.478**	**0.259**	**0.438**	**0.598**
Apr-13	**0.802**	**0.623**	**0.629**	**0.186**		**0.757**
May-13	**0.854**	**0.679**	**0.629**	**0.117**		**0.565**
average	**0.758**	**0.734**	**0.678**	**0.156**	**0.762**	**0.487**

18





Single Scattering Albedo (SSA)

Definition:

Single scattering albedo is the ratio of scattering optical depth to the total optical depth (scattering+extinction) of the atmosphere. It is a dimensionless quantity and ranges from 0 to 1.

Applications:

- ❑ Computation of scattering phase function
- ❑ Characteristics of the aerosol particles
- ❑ Radiative transfer model
- ❑ Earth radiation budget study

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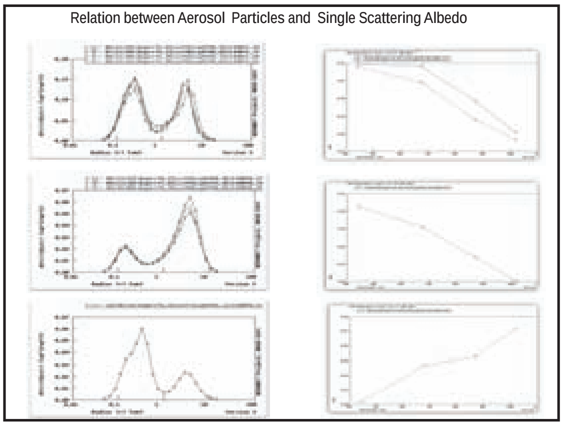
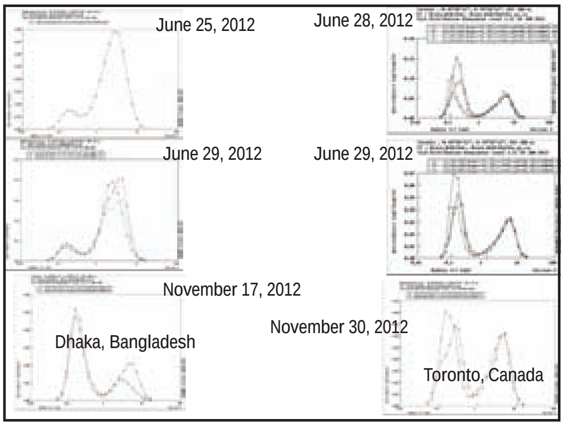
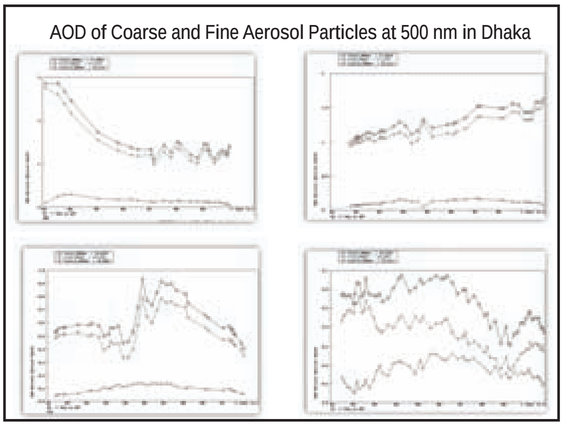
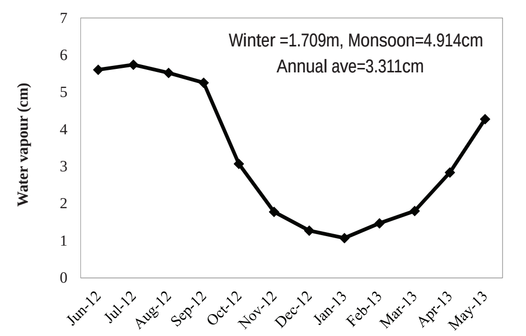






Water vapour in Dhaka, BD



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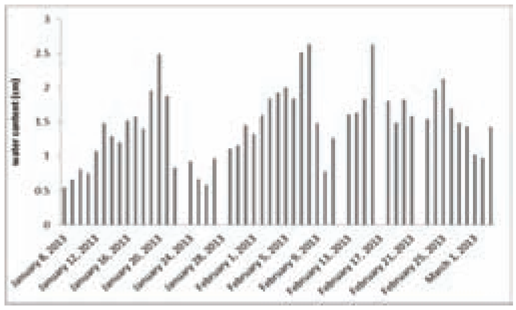
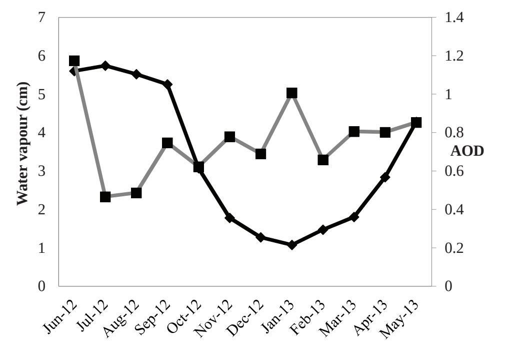
Daily variation of water vapor content (cm) in Dhaka, BD



Monthly average AOD and Water Vapour (cm)



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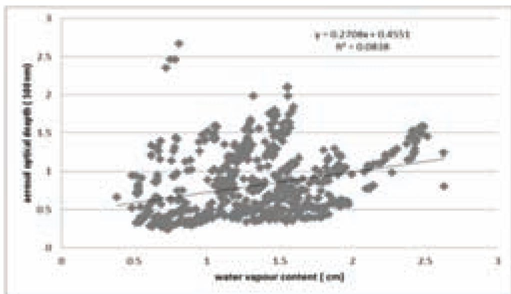
Relationship between water vapor (cm) and AOD (500 nm) in Dhaka, BD



Angstrom exponent

Ångström exponent is an exponent in a formula that is usually used to describe the dependency of the aerosol optical thickness or aerosol extinction coefficient on wavelength. The spectral dependence of the aerosol optical thickness depending on particle size distribution is given by

$$\frac{\tau_\lambda}{\tau_{\lambda_0}} = \left(\frac{\lambda}{\lambda_0}\right)^{-\alpha}$$

Where, T_λ is the optical thickness at wavelength **λ**, and $T_{\lambda o}$ is the optical thickness at the reference wavelength λ_o.

For measurements of optical thickness $T_{\lambda 1}$ and $T_{\lambda 2}$ at two different wavelengths λ_1 and λ_2 respective ponent is given by

$$\alpha = -\frac{\log \frac{\tau_{\lambda_1}}{\tau_{\lambda_2}}}{\log \frac{\lambda_1}{\lambda_2}}$$

29

- The Ångström exponent is inversely related to the average size of the particles in the aerosol: the smaller the particles, the larger the exponent.
- Ångström exponent is a useful quantity to assess the particle size of atmospheric aerosols/clouds, and the wavelength dependence of the aerosol/cloud optical properties.
- This exponent is now routinely estimated by analysing radiation measurements acquired on earth observatory through AERONET.

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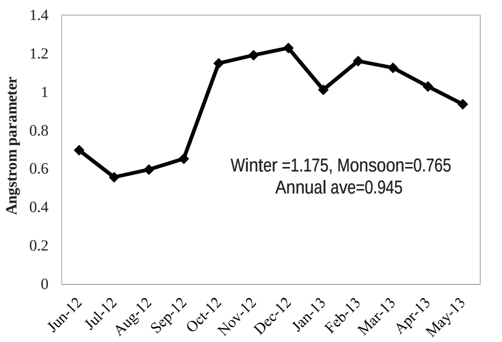
Angstrom Parameter in Dhaka, BD



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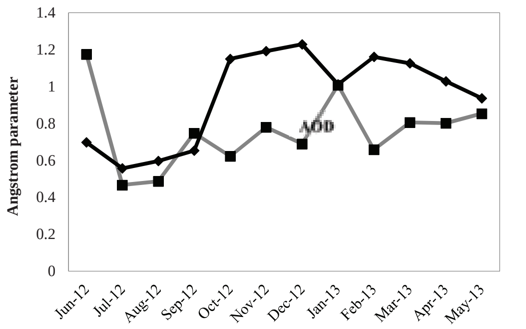
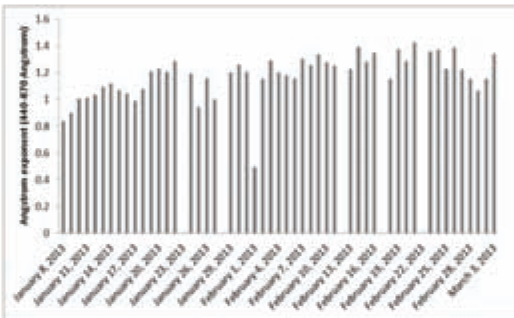
Relation between angstrom exponent and AOD (monthly average)



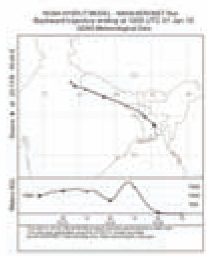
32

Variation of the Angstrom exponent in Dhaka, BD

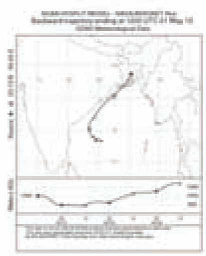


Information Regarding Trans Boundary Pollution from AOD Measurements

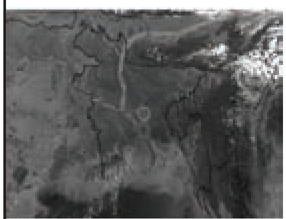
AOD at 500nm: 1.223



AOD at 500nm: 0.893



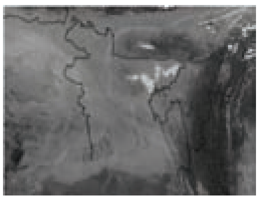
Distinguish between Clear and Hazy day



TERRA-MODIS Pictures

Clear Day

AOD at 500nm on March 19, 2013: 0.522



AOD at 500nm on January 12, 2013: 1.255

Hazy day

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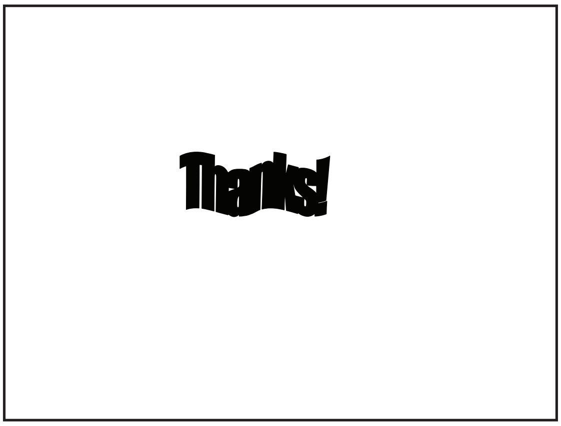
Conclusion

- Very high AOD values were observed in Dhaka. Dhaka AOD is slightly higher compared than other south Asian locations, but much higher compared to North Armenian site
- Bimodal size distributions were observed in most of the cases. Coarse particles are dominating in monsoon months.
- Clear and Hazy Day can be distinguish from AOD measurements
- AOD measurements showed that Dhaka aerosol has a significant contribution from Trans boundary pollution.


Thanks!

Clean Air and Sustainable Environment (CASE) Project

a national initiative to reduce air pollution in Bangladesh

Md.Golam Saroar
Scientific Officer (Modelling)
CASE Project

Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

Air Quality Scenario in Bangladesh

- Major cities are highly polluted despite major efforts to date.
- PM is the the significant pollutant, especially during the winter season.
- Known sources of pollution:
  - Older, smoke-emitting diesel buses and trucks
  - Dense, congested traffic that is growing worst.
  - Industrial emission sources including brick kilns (uncontrolled)
  - Many area sources of open burning, dust and small industries

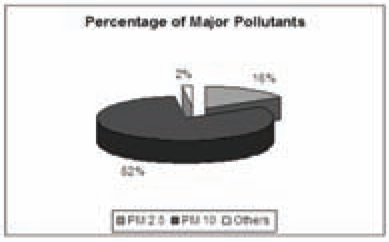
Nature of Pollutants

Key pollutant
-*PM, SO_x, NO_x, CO, O_3 and Pb*
Sources specific Pollutants
-Motorized vehicles
visible smoke, PM, SO_x, NO_x,& toxic hydrocarbon
-Brick kilns
PM, SO_x,CO
- Soil dust including road dust
PM
- Industry (Pb based battery factory, re-rolling mills, cement factory, Galvanizing factory, etc)

Control of PM is important for protection of human health and climate

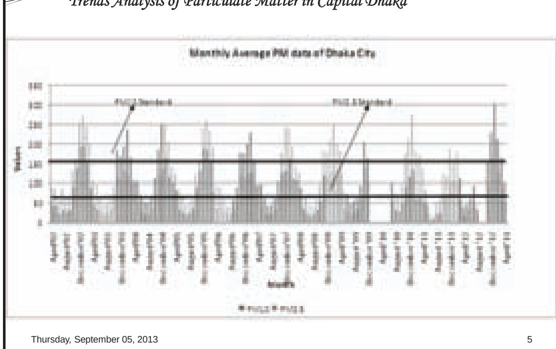
5 September 2013 3

Pollutants of concern for Bangladesh

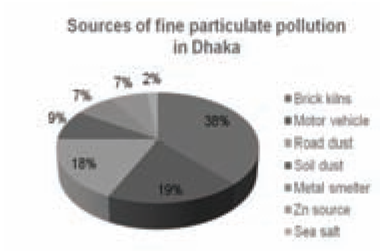


Thursday, September 05, 2013 4

Trends Analysis of Particulate Matter in Capital Dhaka



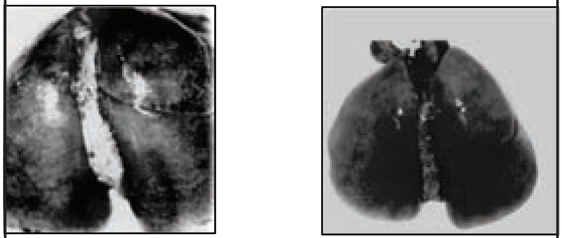
Thursday, September 05, 2013 5



Source: Begum, B.A., Biswas S.K. and Hopke, P.K. 2010, Key issues in controlling air pollutants in Dhaka, Bangladesh. Atmospheric Environment. In press.

Lung of a rat after exposure to Polluted Air

Exposed to Polluted Air | **Expose to Clean Air**



Compared to the normal pink lung, it has been blackened by soot

National Institute for Environmental Studies, Japan

Clean Air and Sustainable Environment (CASE) Project

Project Cost : 44501.64 (In Lakh Taka)
Project Duration : July-2009 to June-2014.
*Lead Agency : **MOEF***
www.case-moef.gov.bd

CASE Builds on Two World Bank Supported Projects: AQMP and DUTP

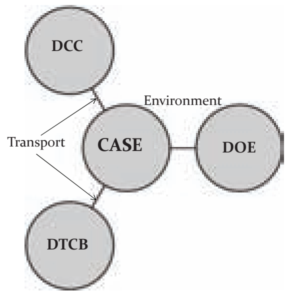
- *The project builds on the experiences and lessons of two past Bank-supported projects in Bangladesh, namely the Air Quality Management Project (AQMP), and the Dhaka Urban Transport Project (DUTP).*
- *The project will address **air pollution abatement and improved mobility in Dhaka.***
- ***CASE project integrates Environment and Transport** to deliver "co-benefits" by reducing health costs due to air pollution exposure and improving safe mobility as well as lowering energy consumption in brick industries and GHG emissions.*

Project Overview

1 Project

2 Components

3Implementing Agencies



Objectives of the Project

- *Strengthen capacity to plan, monitor, regulate and implement sustainable environmental initiatives in transport and brick sector.*
- *Greening the brick making industry.*
- *Increase pedestrian mobility.*
- *Reduce congestion by improving traffic flows*
- *Enhance the institutional capacity of multi-sector players to abate air pollution.*

Environment Component

Three Sub Components:

- ***Capacity Building for Air Quality Management (AQM)***
- ***Brick Kilns Emission Management***
- ***Communication campaign and Clean air initiatives facility***

Sub Component 1: Capacity Building for AQM

- *Expansion of air quality monitoring network*
- *Establishment of central instrument Lab*
  - *Equip with simple repair facility and spare parts*
  - *Filter weighing laboratory*
- *Emission Inventory and modeling*
- *Source Apportionment studies*
- *Human Resources Development*

Thursday, September 05, 2013

Cont'd

- *Revision of vehicle emission standards*
- *Revision of national ambient air quality standard and air quality index (AQI) categories*
- *Development of auto fuel policy*
- *Enhanced Vehicle Inspection Program*
- *Industrial emission control (stricter standard and enforcement)*

Thursday, September 05, 2013

Sub Component 2: Brick Kilns Emission Management

Institutional, Legal and regulatory aspects

- Review and update regulatory framework (including emission standards)
- Pilot demonstration of energy efficient and cleaner brick making technology and practices
- Technical assistance for enhancing skills of brick workers towards & the industry as a whole.
- Competence building of various Govt. officials

Sub Component 3: Communication campaign and Clean air initiatives facility

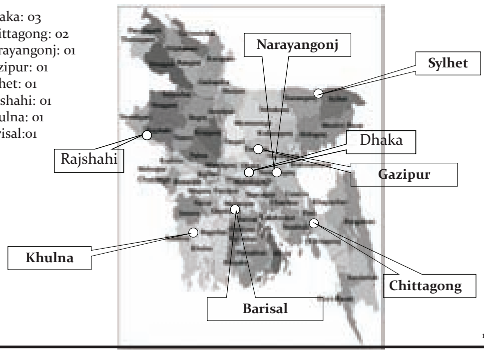
Awareness building on air quality, health impact and remedies among public

Thursday, September 05, 2013

Expansion of Air Monitoring Network already been established

Location of all CAMS sites in Bangladesh

Dhaka: 03
Chittagong: 02
Narayangonj: 01
Gazipur: 01
Sylhet: 01
Rajshahi: 01
Khulna: 01
Barisal:01



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Analytical Studies: Emission Inventory, Dispersion Modeling, Source Apportionment, Dust Control and Industrial Emission

- *TASK 1: Emission Inventory (Dhaka and Chittagong) – NILU with assistance from BUET and CU*
- *TASK2: Pollution Dispersion Modeling (Dhaka and Chittagong) – NILU*
- *TASK3: Source Apportionment (Dhaka, Chittagong, Rajshahi and Khulna) – NILU with assistance from independent consultants from BAEC.*
- *TASK4: Dust Control Measure Assessment (Dhaka) – NILU with assistance from BUET*
- *TASK5: Industrial Emission Estimates (Dhaka and Chittagong) – NILU with assistance from BUET*

Collaboration with Norwegian Institute for Air Research (NILU) – BAPMAN project

- Established bilateral collaboration with NILU under financial assistance from NORAD in 2010
- NILU provided AIRQuis system including a server and two client for enhancing AQM capacity within DoE
- Provided training (home and abroad) on using AIRQuis system for AQM
  - Emission inventory
  - Dispersion modeling
  - AQ data quality control and quality assurance
  - CAMS operation and maintenance

Number of both DoE and CASE officials were trained

Vehicle and Industrial Inspection Program

Vehicle Emission

- *Expand VIP Program to Chittagong and other cities.*

Industrial Emissions

- *Existing Sources & Proposed New Sources*
- *Survey of Current Emission Controls by Industry*
- *Estimate Emission Reductions with Controls*

Thursday, September 05, 2013

Introducing cleaner technologies & practices through pilots & technical services development in Brick Sector

The project will support

• *Introducing cleaner technologies and practices through demonstration initiatives and technical service development*

• *Pilot demonstration to introduce new cleaner technology (proven in other countries) along with alternative building materials.*

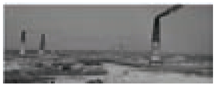
• *Established Training Institute for Capacity development.*

Thursday, September 05, 2013

Potential for Energy Efficiency Gain and Emission Reduction

All Improved Technologies show considerable Energy Efficiency gain and emission reduction

- Energy Efficiency 40% or better possible
- Emission Reduction better than 50%possible.



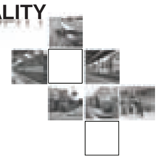
•Conversion of one Fixed Chimney (FCK) to Converted Zig-Zag kiln Including back process completed.
•Initial assessment showed reduction of coal consumption and 70-80% reduction in respect of emission.

Thursday, September 05, 2013 21

Seventh Regional Stakeholders cum Coordination Meeting (RSC7)

IMPROVING URBAN AIR QUALITY

Role of Dhaka Bus Network and Regulatory Reform



Md Anisur Rahman
Project Director CASE-DTCA

Controlling air quality in cities needs more than testing motor vehicle emissions- or even controlling them

» In parallel, cities must reduce dependence on cars and make a fundamental shift into mainstream use of more efficient public transport
» Not only to improve air quality, but to:

- Reduce congestion and improve mobility
- Restore productivity (less wasted time) and improve economic performance
- Improve quality of life through a more liveable city

2

Many people equate improved public transport with MRT rail systems, ignoring the essential role of buses

- MRT is very expensive to build and operate
- A few kilometres or a single corridor of MRT will not solve the cities problems

Bangkok's BTS *SKYTRAIN* corridor - an excellent public transport alternative
- But did not solve 'on-ground' problems & traffic congestion
- Rail carries 5% of all public transport trips (2005)
- Buses are stuck in traffic

3

MRT rail has a role to play in high volume corridors

Bus systems are also a viable option and are sometimes better placed to address the problems

- Bus Rapid Transit (BRT) systems offers:
  - A high capacity corridor system
  - Is able to be well-integrated into the city providing a full network
  - At a far lower cost
- The challenge cities face, is how to manage bus reform, and make it financially sustainable

4

An affordable and efficient public transport is vital for the development of Dhaka, given the current socioeconomic framework

- The current population in DMA is estimated at over 11 million people, expected to grow significantly in the coming years (over 3% annually)
- Around 30% of this population lives in poor conditions; the average income per capita is only 550 USD/year
- Population densities are very high, reaching over 45,000 persons/km^2 in the downtown area
- **High mobility needs: over 21 million trips per day inside DMA only**

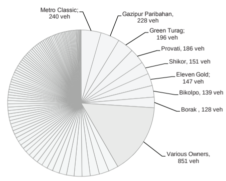
There is a need for an efficient and affordable public transport system in order to support the future development of Dhaka

5

The bus industry is extremely fragmented and the vehicle fleet in operation is not suitable for a megacity such as Dhaka

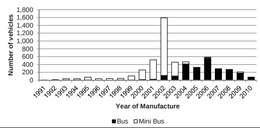
Fragmented bus operation:

- **137** companies are currently operating in the network
- The **8** biggest companies only account for **26%** of the fleet
- 73 companies have less than 50 vehicles
- In addition, there are several individual owners operating
- Often various operators share the same route



Vehicle fleet issues:

- Private operators: 7,053 buses or minibuses
- BRTC: 974 buses
- 50% of the vehicle fleet has already reached its service life (10 years)
- Low vehicle maintenance standards are common
- Authorities wish to gradually phase out minibuses, but it has not always been possible due to pressure from the operators



6

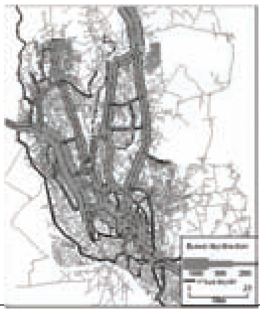
The current bus network provides low coverage, has several route overlaps and does not meet passenger trip patterns

Issues of the existing route network:

- 152 bus routes
- They are basically distributed in 40 different corridors, having long and frequent overlaps
- Several areas have a low coverage (especially in Old Dhaka and the suburbs)
- Buses pile up in the arterials, with combined frequencies that even reach 9 buses per minute in the same direction
- For 22% of users, the travel distance using public transport is over 2 times the travel distance using a car
- The passengers most affected are those making east-west trips, given that most routes are north-south

The current road network is a big part of the public transport problem:

- 88% of the roads are local streets, which are normally too narrow to host bus services
- There is a lack of east-west arterials



7

Furthermore, road congestion is creating excessive pollution in Dhaka. Improving bus capacity and design standards should alleviate the problem

- There are around 250 μg/m^3 of suspended particulate matter in Dhaka air (5 times the acceptable limit)
- Congestion increases the average trip times and, hence, fuel consumption

The current bus fleet is not environmentally friendly:

- Excessive vehicle age (50% of the fleet over the service life)
- Inadequate maintenance status
- 55% of the fleet are minibuses, with more emissions per passenger than standard buses

Need for improvements in the current fleet and its management:

- Use vehicles with higher passenger capacities and lower levels of emissions
- Improve levels of maintenance
- Scrap the vehicles that exceed the recommended service life

8

The current network is not profitable, which means that the service quality could further decrease and/or fare prices would rise

The profitability of each route has been assessed considering: vehicle type, age, number, fare levels and operating costs

Results are very negative

Average profitability: - 31%
Some routes would loose as much as 92%
Only 12 routes would be profitable, from 0 to 12%

Main reason

- Very low commercial speeds that increase operating costs and reduce passenger capacity

Likely consequences

A. Increased fare prices → **Negative social impacts**

B. Reduction of:
- Wages
- Maintenance levels
- Vehicle frequencies
- Hours of operation

Reassignment of vehicles to other routes → **Reduced level of service**

9

The existing public transport culture creates a low quality service, adds to road congestion and has negative social impacts

Unsuitable public transport culture:

- Competition between operators for passengers
- Reckless and untrained bus drivers
- Long pedestrian queues in ticket booths
- Lack of use of designated stopping locations
- Buses laying over at the road sides
- No seats available for women

Core problems behind these issues:

- Multiple, uncoordinated and weakly regulated bus operators
- Inadequate level of training among their employees
- Significant disregard for passenger safety
- Lack of respect for female passengers
- Inefficient and unintegrated fare payment methods
- Inexistence of adequate infrastructure (bus stops, lanes, depots)

10

In Dhaka, the DTCA is undertaking major efforts at bus system reform

1. Infrastructure (high capacity BRT system along main corridors) and priority bus routes as feeders
2. The Management Model : Public- Private Partnership
3. The Business Model - sustainable

11

The strategies to address the issues detected will imply a deep restructuration of the sector, based in 6 macro actions

Strategies

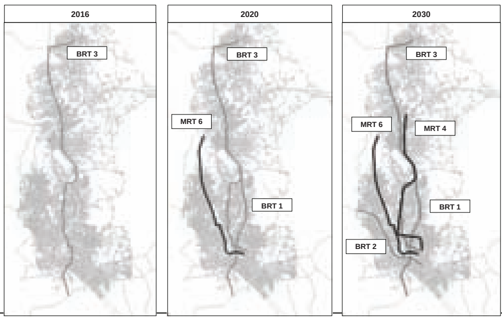
- **Vision of an Integrated Transport System**
- **Institutional and Entrepreneurship Strengthening**
- **Fleet Renewal**
- **Quality of Service**
- **Awareness**

Macro Actions

- **Routes/Itineraries**
- **Operation/Services**
- **Organization**
- **Fleet**
- **Fares**
- **Safeguards**

12

The implementation of new mass transit systems is an opportunity to restructure the bus network



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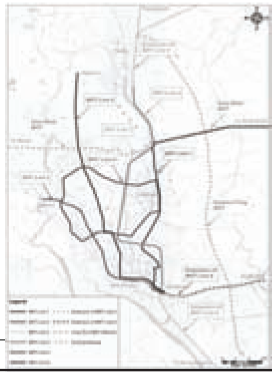
Proposed Mass Transit Network Towards-2050



14

Bus Network restructuring needs to be implemented in parallel to the implementation of mass transit corridors and other mobility strategies

2011
Base Scenario
Status Quo

2016
Implementation of
- BRT Line 3

- First phase of route rationalization
- Intermodal Terminal
- Pedestrian area
- Shopping Mall
- Relocation of Inter City (IC) Mohakhali Terminal to Airport

2020
Implementation of
- BRT Line 1 and
- MRT Line 6

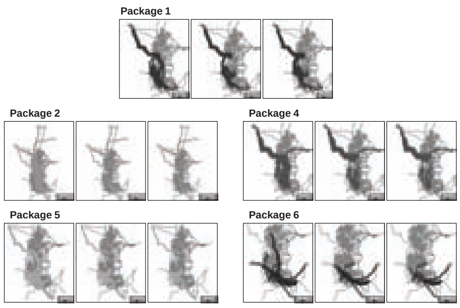
- 2nd phase of route rationalization
- Realignment of L3 to Kamalapur
- Interchange station L1-L3 in Kakrail
- First stage of DEE (Airport-Tejgaon)
- New IC terminal in Jodeybpur

2030
Implementation of
- BRT Line 2
- MRT Line 4
- BRT L3 connection with MRT Line 6

- 3rd phase of rationalization
- Cargo logistics center in Kampur
  - Railway ringroad
  - Logistics platform
- Relocation of Sadar Ghat terminal close to Buriganga River bridge 2
- Second stage DEE

15

Geographic distribution of routes plays a role in route packaging



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Business Model

- *FOR THE NETWORK MANAGER (Bus Agency)*
  - A commercial business model – business like, offering good customer service to 'win the market
  - No operational subsidy – survives on revenue
- *FOR THE BUS OPERATORS*
  - Paid commercial rates to provide km of service
  - Quality defined and enforced by contract
  - Develops a win –win partnership between the bus agency and the private sector with risk assigned to where it can be best managed
  - Managed risk will attract investment / greater sustainability

17

Why it works:

Now

Government Regulation

Weak hand of regulation against the forces of operator's survival instinct

Bus Operators
Carries 100% risk
SURVIVAL BEHAVIOUR
No investment

Future

DTCA
sets goals & Strategic Transport Policy

Coordinated approach / shares risk

TransDhaka
BRT Management Co.

Commercial , with incentive to make the business work
(Takes business risk but can manage the risk)

Bus Operators
Incentive to operate efficiently under sustainable business model

Paid by km - Fully funded to provide specified LOS and quality

18

Business Model

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  - A commercial business model – business like, offering good customer service to 'win the market
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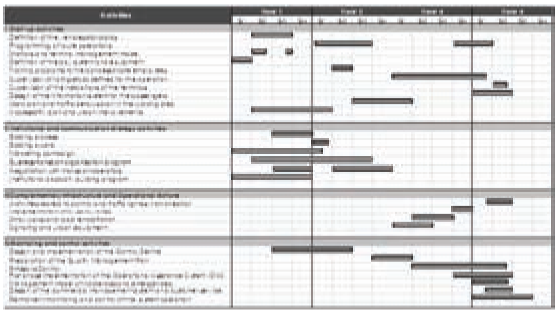
19

Actions associated with the implementation of the first phase are anticipated to occur over a period of 3-4 years



20

Major Challenges for Bus Reform

- Political support
- Funding
- Negotiation of routes packages for contract operations(6 packages) with the operators

21

Thanks

22

Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia
Seventh Regional Stakeholders cum Coordination Meeting (RSC7)
18-19 May, Dhaka, Banglaesh

Air Pollution Reduction Strategy for Bangladesh

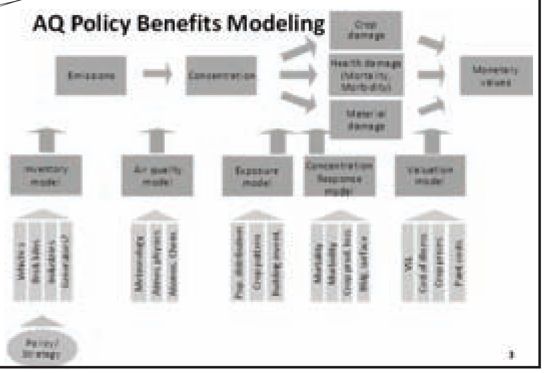
Zia Wadud and M Ashraf Ali
Department of Civil Engineering, BUET, Dhaka

Background

- Implementation of Male Declaration – DoE to develop AP reduction strategy for Bangladesh
- BUET would assist in developing the strategy
- Draft strategy presented to Stakeholders in January and March 2012
- After receiving comments from peer review, Final Draft submitted in December 2012

2

AQ Policy Benefits Modeling



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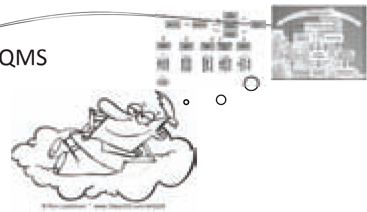
AQMS



4

Work Breakdown

- Current status/Monitoring data
- Emissions inventory by the DoE/ Others
- Identify key pollutants
- Existing strategies, laws, standards
- Literature review on control strategies and policies and their effectiveness and efficiency
- Review of evidence in Bangladesh
- Identify key control strategies and potential policies
- Feedback from stakeholders
- Draft report

5

Structure of Report

- **Chapter 1:** Background, objectives, scope
- **Chapter 2:** Current status of pollution
- **Chapter 3:** Emission sources
- **Chapter 4:** Air pollution impacts in Bangladesh; Key pollutants and sources
- **Chapter 5:** Past measures, successes and failures
- **Chapter 6:** Approaches to air pollution control (CAC, MBI), International case studies
- **Chapter 7:** Potential and recommended strategies to reduce air pollution, incorporating stakeholders suggestions
- **Chapter 8:** Other relevant issues
- **Chapter 9:** Conclusions

6

Work Breakdown

- **Current status/Monitoring data**
- Emissions Sources
- Air Pollution Impacts
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- Literature review on control strategies and policies and their effectiveness and efficiency
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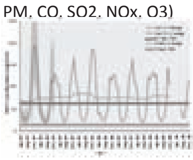
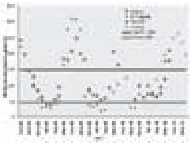
- Draft report

7

Work Breakdown

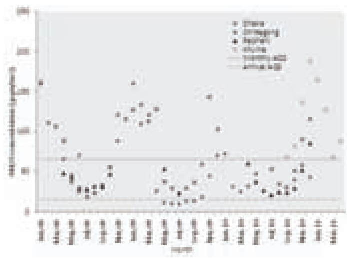
- **Current status/Monitoring data**
  (Pb, PM, CO, SO2, NOx, O3)

- Dhaka, Khulna, Chittagong, Rajshahi – CAMS
- BAEC, BUET, Others

8

CAMS data for $PM_{2.5}$ at 4 major cities, along with AQS



9

Work Breakdown

- Current status/Monitoring data
- **Emissions Sources**
- Air Pollution Impacts
- Existing strategies, laws, standards
- Literature review on control strategies and policies and their effectiveness and efficiency
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10

Work Breakdown: Emission Sources

- **Emissions inventory by the DoE**

- Under Male Declaration Work plan
  Year 2000 available (have major limitations)
- Emission inventory being developed for Dhaka and Chittagong under CASE project

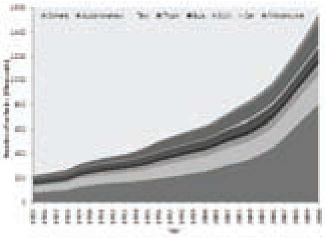
11

Work Breakdown: Emission Sources

- **Source Apportionment and Trends of Emissions Sources**:
  - Vehicles
  - Brick kilns (technologies being used)
  - Industries
  - Biomass burning (including indoor)
  - Construction activities
  - Power sector

12

Vehicle growth in Bangladesh during 1985-2010



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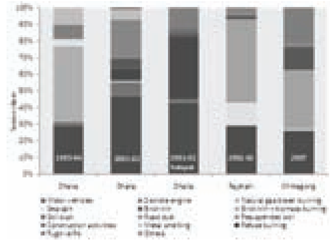
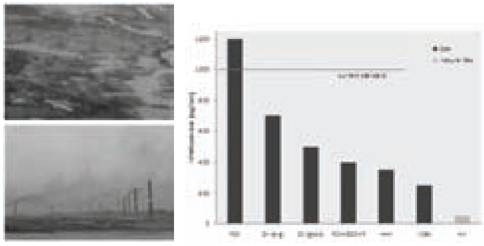
Source apportionment for $PM_{2.5}$ at various locations in Bangladesh



14

Suspended particulates emissions performance of different types of brick kilns



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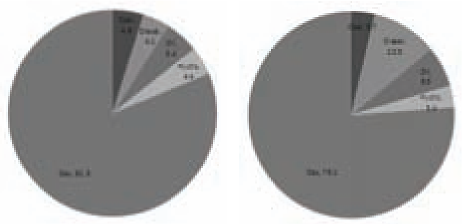
Percentage share of fuels used for power generation in (a) 2006 and (b) 2011



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Work Breakdown

- Current status/Monitoring data
- Emissions Sources
- **Air pollution impacts**
- Existing strategies, laws, standards
- Literature review on control strategies and policies and their effectiveness and efficiency
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- Draft report

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Work Breakdown: Air Pollution Impacts

- Documented impacts of air pollution
  - Epidemiological/ toxicological studies in developed countries relate elevated PM ($PM_{2.5}$) with increased risk of premature mortality
  - SLCPs, particularly BC, also identified as a major health concern
- Social costs of air pollution (Table 4.3 of Report)

18

Work Breakdown: Key Pollutants and Sources

- Based on Emissions, Ambient concentration, and Impacts
- PM and its precursors (NO_2, SO_2) - most harmful + exceeds standards (by up to five times for $PM_{2.5}$)
- NO_x- slightly elevated; SO_2/CO/O_3 meets standards
- Most important sources of ambient air pollution:

  Vehicles, brick kilns, cement factories, open burning, metal smelters, glass factories, power plants and re-suspended soil or dust
- Indoor air pollutants PM, Soot (BC) - from cooking stoves using solid fuels and kerosene

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Work Breakdown

- Current status/Monitoring data
- Emissions Sources
- Air pollution impacts
- **Existing strategies, laws, standards**
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Work Breakdown

- **Existing strategies, laws, standards, policies**

- Ambient AQ standards
- Vehicle emissions standards (being updated under CASE project)
- Industrial emissions standards

21

Work Breakdown

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Work Breakdown

- **Past Air Quality Strategies in Bangladesh**

  - Lead Phase Out from Petrol
  - Ban on Two-Stroke Three-Wheelers in Dhaka
  - Promoting CNG Conversion of Vehicles
  - Ban on Older Vehicles
  - Policies on Import of Personal Vehicles
  - Vehicle Emissions Standards
  - Policies to Reduce Emissions from Brick Kilns
  - Ban on High Sulfur Coal

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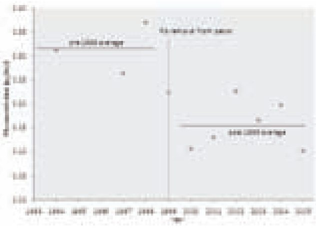
Past Air Quality Strategies in Bangladesh: Lessons

Policy/ Strategy	Policy	Year	Result	Lessons learnt
Lead phase out from Petrol	CAC	1999	Success	Media and public support allows easy implementation, implementation quick and easy if few, government run bodies are targeted
Vehicle emissions Standard	CAC	1997, Update 2005	Failure	There is limited testing facilities for monitoring vehicle emissions during certification, poor institutional capacity and enforcement hinder implementation
Brick kiln stack height	CAC		Success	Benefit to the owners (more efficient burning, better quality bricks) is good for policy implementation, ease of monitoring is also important
Ban on older vehicle import	CAC		Success	Small number of vehicle importers, no significant losses to businesses (increased cost of vehicles passed on to buyers) allow easier implementation, somewhat covers vehicle emissions standard initially
Differentiated vehicle import tariff	MBI		Success	Although not a perfect MBI, strong public support, smaller points of regulation means easier implementation
Ban on driving older vehicles in Dhaka	CAC	2010	Repeated failure	CAC did not work when many polluters are financially affected, especially when they have a strong lobby. MBI instruments with active stakeholder engagement during policymaking can be useful

Ambient Concentration of Pb in Dhaka

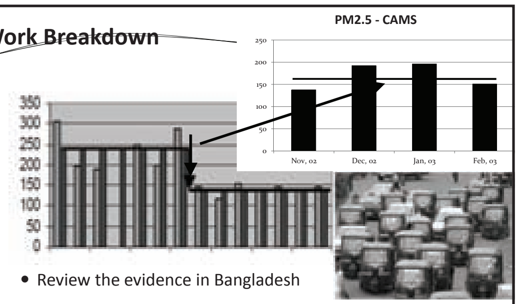


25

Policy/ Strategy	Policy	Year	Result	Lessons learnt
Ban two stroke three wheelers	CAC	2002	Success	Extensive public support allows easy implementation, unforeseen practices (smaller diesel vehicles) can erase the benefits, monopoly in new CNG three wheeler supply can make a good policy costlier than necessary, multiple benefits
Promotion of CNG vehicles	MBI	2002	Success	Extensive public support, good pricing policy, good incentive to private sector, multiple benefits – all are important for a functioning MBI
Ban on use of wood in brick kilns	CAC		Success – qualified	Fuel choice primarily governed by economics – low sulfur coal is generally cheaper than wood currently (unless in remote areas), monitoring and enforcement lax in rural areas
Lane based traffic	CAC	2010	Failure	Not practical
Carpooling	CAC			Unrealistic proposal, met with ridicule by the citizens
Colored kerosene	CAC		Failure	Price is an important issue
Ban on import of high Sulfur coal	CAC		Failure	CAC did not work when many polluters are financially affected (fuel choice governed by economics), especially when they have a strong lobby to overturn the ban

26

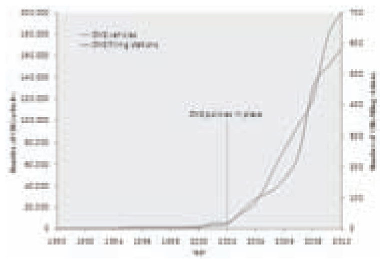
Work Breakdown



- Review the evidence in Bangladesh
- 2 stroke 3 wheeler ban – visible changes in PM2.5

27

Evolution of CNG vehicles and CNG filling stations in Bangladesh



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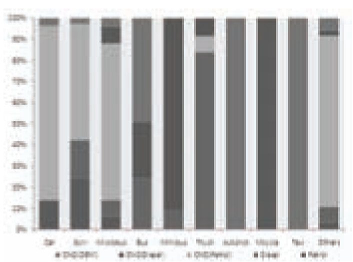
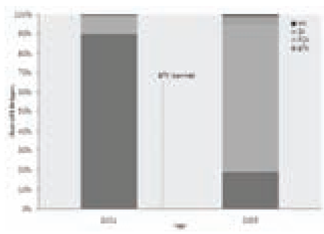
Share of different vehicles running of different fuels in Dhaka in 2010



29

Share of different brick kilns before and few years after BTK are banned (source: Gomes and Hossain 2003 and UNEP-GEF 2006)



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Work Breakdown

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- from stakeholders
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Work Breakdown

- **Pollution Control Approaches**
  - Command and Control (CAC)
  - Market Based Instruments (MBI)

International Case Studies:

- Mexico City Car Rationing
- Vehicle Inspection and Maintenance
- Shift to Electric Vehicles in Nepal
- Vertical Shaft Brick Kilns in India, Nepal and Vietnam
- Diesel Vehicle Retrofit in Hong Kong

32

Comparison of CAC and MBI Approaches

	Command and Control	Market Based Instruments	Comment
Effectiveness	Can achieve goals quickly, with greater certainty	May take longer to achieve goals, not always effective	MBI may not be effective in a weak institutional framework
Efficiency	Total cost of abatement is high	Theoretically, abatement is done at least cost to economy	MBI preferred, but if information unavailable, enforcement costly, then costs could be high in MBI too
Equity	Can put excessive burden to some firms or users	Marginal burden is equal across firms or users	MBI preferred
Ease of policy	Widely understood	Relatively new concept	Lack of capacity in Bangladesh – MBI could be difficult to design/ implement
Administration, monitoring and enforcement	Relatively easier	Requires more administrative efforts	Administration, monitoring and enforcement is weak in Bangladesh – MBI may be ineffective
Market requirement	Does not require a competitive market	Requires a properly functioning competitive market	Potential collusion among polluters, a real possibility in Bangladesh, can render MBI ineffective
Further emission reduction , innovation	No such incentives	Large incentive for reduction , innovation	MBI preferred as every unit of reduction has a financial benefit
Evolution with time	Less flexible	More flexible	Regulation is often slow to catch up with technology

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Strategies Considered: Motor Vehicles

- Stringent emissions standards: new
- Differentiated emissions standards: existing
- Diesel to CNG switch
- Discourage diesel: how to differentiate with agri use?
- Retrofit diesel catalytic converters, particulate filters
- Cleaner fuel, reduce fuel sulfur content
- Inspection & maintenance of vehicles
- Emissions based registration fee
- Enforce old vehicle bans

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Strategies Considered: Motor Vehicles

- Electric vehicles
- Electric motor cycles
- Hybrid vehicles
- Traffic flow management
- Odd/even vehicle days
- Improve public transport
- Discourage vehicle use
- Encourage walking

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Strategies Considered: Brick Kilns

- Ban on upstream locations
- Cleaner technology
- Ban on clusters
- Clusters based on technology
- Retrofitting new technology
- Cleaner coal
- Alternative Construction Materials

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Strategies Considered: Power plants

- Emissions standards for diesel generators
- Inspection and maintenance of diesel generators
- Emissions standards
- Emission-based tariff
- Technology specification
- Ban on upstream location

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Strategies Considered: Industries

- Cleaner technology & fuel
- Particulate control measures: cement
- Physical shifting of industries
- Industrial emission standards
- Enforcement of emissions standards

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Strategies Considered: Dust sources

- Better construction practices
- Construction ambient standards
- Wall to wall paving of roads
- Timely road maintenances
- Regular sweeping and watering
- Landscaping and gardening

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Strategies Considered: Indoor sources

- Domestic fuel switch (e.g., biogas)
- Improved cooking stoves (ICS)

Strategies Considered: Open burning

- Ban open burning of refuse
- Ban open asphalt burning
- Awareness on open buring
- Ban slash and burn practice

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Work Breakdown

Evaluation of Air Quality Strategies
(Qualitative)

- Evaluation Criteria:
  - Impact
  - Time to introduction
  - Technical effectiveness
  - Implementation effectiveness
  - Costs
  - Co-benefits

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Work Breakdown

- Current status/Monitoring data
- Emissions inventory by the DoE
- Identify key pollutants
- Existing strategies, laws, standards
- Future growth and strategies
- Literature review on control strategies and policies and their effectiveness and efficiency
- Review the evidence in Bangladesh
- Identify key control strategies and potential policies
- **Feedback from stakeholders**
- Draft report

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Proposed strategies to reduce air pollution from different sectors

Control Sectors		Strategy	Area of application	Priority
A. TRANSPORT				
Vehicle use	A	Improve public transport	Large cities	High
Existing vehicles	B	Strengthen vehicle inspection and maintenance	All, especially large cities	High
	C	Ban vehicles older than 20 years	Commercial vehicles, large cities	High
	D	Encourage Diesel to CNG switch through incentives	All diesel vehicles, especially commercial in large cities	High
	E	Emissions based annual registration fees	All vehicles	Medium
New vehicles	F	Stringent emissions standards	All new vehicles	High
	G	Emissions based import tariff	All new vehicles	High

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Control Sectors		Strategy	Area of application	Priority
B. INDUSTRIES				
All industries	H	Comprehensive land use plan for industry locations	All industries, especially new ones	High
	I	Cluster management	Cluster of highly polluting industries	High
Brick kilns	J	Emissions based license fee	All kilns	High
	K	Technology standards	All kilns	Medium
	L	Alternate construction material	All country, especially large cites	Medium
Power industries	M	Ensure adequate power supply	-	High
	N	Emissions standards	All new plants	High
	O	Emissions standard for diesel generators	All new generators	High
	P	Inspection & maintenance of diesel generators	All existing generators	High
Other industries	Q	Technology specification	Existing steel mills, cement and glass factories	High
	R	Inspection and maintenance	Existing steel mills, cement and glass factories	High
	S	Emissions standards	All new and existing plants	High

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Control Sectors		Strategy	Area of application	Priority
C. FUEL				
Coal	T	Import control for quality of coal	Whole country, primarily brick and power industries	High
D. DUST				
Construction	U	Better construction practices on site and during transportation	All construction sites	High
	V	Air pollution mitigation plan and its enforcement	Large construction projects	Medium
Road	W	Timely road maintenance	All roads	High
Land use	X	Landscaping and gardening	All exposed soil in urban areas	Medium
E. INDOOR				
Fuel	Y	Encourage fuel switch	Urban slums and rural areas	High
Technology	Z	Improved cooking stoves	Rural areas	High

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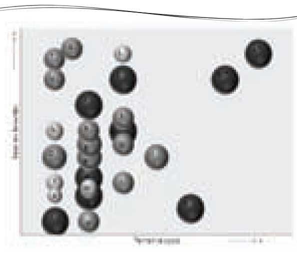

Qualitative comparison of different strategies with respect to tentative costs, time to benefits realization and potential benefits. Bubble size reflects benefits – qualitatively; Benefit code: Red ++++, Blue +++, Green ++, Yellow +. *very large co-benefits

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Other Policy relevant Issues:

- Regulatory and fiscal reform to implement strategies effectively
- Awareness and motivation across sectors
- Research and development to address knowledge and information gaps, so that future strategies can be based on quantitative modeling
- Co-operation and coordination among various stakeholders (regulators-businesses-general public)
- Capacity building and knowledge retention
- Institutional set up and governance

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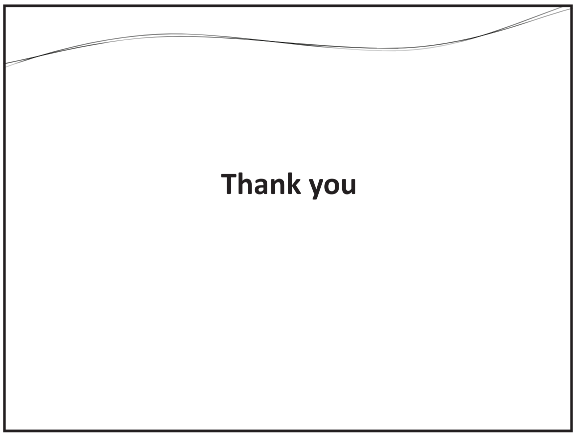

Thank you

Regional Initiatives on Air Pollution in Asia

Regional Cooperation Mechanisms for Air Quality Management in East Asia

Instrument for Strengthening the Acid Deposition Monitoring in East Asia (EANET) and Updates Activities

Presented by
Suwimol Wattanawiroon
EANET Secretariat

18-19 May 2013,
Dhaka, Bangladesh

at
The Seventh Regional Stakeholders Meeting cum Coordination Meeting (RSC7)

13 EANET Participating Countries

Cambodia, China, Indonesia, Japan, Lao PDR, Malaysia, Mongolia, Myanmar, Philippines, Russia, Republic of Korea, Thailand, and Vietnam.

History of Implementation Phases of Activities of the EANET

- Expert Meetings during 1993-1997 : agreed on a regional collaborative monitoring network in order to have the aligned monitoring methodologies and techniques and be able to compare data and evaluate the state of acid deposition across the East Asian region.
  - Developed manuals and guidelines for monitoring acid deposition
    - Wet Deposition
    - Dry Deposition
    - Soil and Vegetation
    - Inland Aquatic Environment (Water and Sediment)
  - Design of the Acid Deposition Monitoring Network in East Asia (EANET)
  - Preparation for the Implementation of Preparatory-Phase Activities

The participating member countries were 10 countries: China, Indonesia, Japan, the Republic of Korea, Malaysia, Mongolia, Philippines, the Russian Federation, Thailand, and Vietnam.

History of Implementation Phases of Activities of the EANET

- Preparatory Phase (1998-2000) : Meeting of IG1 to develop Design of Acid Dep. Monitoring in East Asia. Participated by 9 East Asian countries, i.e. Indonesia, Japan, the Republic of Korea, Malaysia, Mongolia, the Philippines, the Russian Federation, Thailand, and Vietnam. China was considering whether to join or not.
- Regular Phase (Since 2001) : IG2 **(**2000**)**, 10 East Asian participating countries issued the Joint Announcement on the Implementation of the EANET to cooperatively start the activities of the EANET on a Regular Basis starting from January 2001.

History of Implementation Phases of Activities of the EANET

- Instrument for Strengthening the Acid Deposition Monitoring Networks in East Asia (EANET) : IG12 (2010) meeting in Niigata, Japan, adopted the Instrument and 7 participating countries signed the Instrument. And LAST YEAR (2012) 12 of 13 participating countries have signed the Instrument which has been in operation since 1st January 2012.

Instrument for Strengthening the Acid Deposition Monitoring Network in East Asia (EANET)

Objectives :

Same as when the EANET was established.

- to create a common understanding of the state of the acid deposition problems in East Asian region.
- to provide useful inputs for decision-making at local, national and regional levels aimed at preventing or reducing adverse impacts on human health and the environment due to acid deposition.
- to contribute to cooperation on the issues related to acid deposition among the participating countries.

Instrument for Strengthening the Acid Deposition Monitoring Network in East Asia (EANET)

Scope of the Instrument **:**

- Acid deposition monitoring;
- Compilation, evaluation of data, storage and provision of data;
- Promotion of quality assurance and quality control (QA/QC) activities;
- Implementation of technical support and capacity building activities;
- Promotion of research and studies related to acid deposition problems; and
- Promotion of public awareness activities.

Extension subjected to the decision of IG

Regional Resource Centre for Asia and the Pacific; RRC.AP 7

Instrument for Strengthening the Acid Deposition Monitoring Network in East Asia (EANET)

The EANET monitoring activities covers five environmental media

- Wet deposition
- Dry deposition
- Soil and vegetation
- Inland aquatic environment
- Catchment

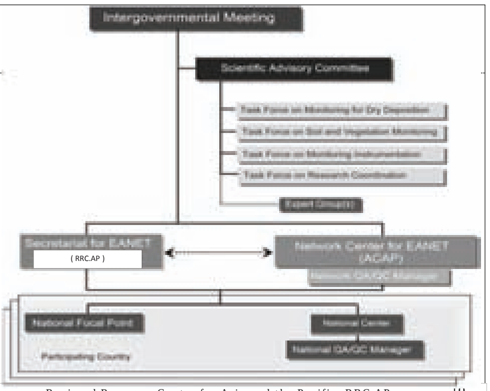
Regional Resource Centre for Asia and the Pacific; RRC.AP 8

Instrument for Strengthening the Acid Deposition Monitoring Network in East Asia (EANET)

Institutional Arrangement of the EANET

- Intergovernmental Meeting (IG) : decision-making body
- Scientific Advisory Committee (SAC) : providing advices and assisting the IG with various scientific and technical matters related to the EANET activities.
- Secretariat : providing administrative and coordinative supports to the EANET such as organizing and conducting the meetings, preparing the reports and proceedings and coordinating among the network and outside, etc with UNEP designated as the Secretariat under which RRC.AP at AIT in Pathumthani, Thailand is the implementing Secretariat.
- Network Center : providing scientific and technical supports to the EANET members thru trainings, capacity building programs, technical dispatches, public awareness workshops and many research programs in various air pollution schemes such as impact assessment, modeling, emission inventory, laboratory set up, QAQC program, etc. with Asia Center for Air Pollution Research (ACAP) in Niigata, Japan designated as the Network Center.

Regional Resource Centre for Asia and the Pacific; RRC.AP 9



Regional Resource Centre for Asia and the Pacific; RRC.AP 10

Instrument for Strengthening the Acid Deposition Monitoring Network in East Asia (EANET)

Financial Arrangement of the EANET

- Based on voluntary financial contributions from the participating countries and burden sharing practices in the United Nations system.
- EANET is also open to more financial and in-kind contributions from participating countries and other sources including international and regional organizations and non-governmental organizations (NGOs).

Regional Resource Centre for Asia and the Pacific; RRC.AP 11

Voluntary Contribution among Participating Countries to Secretariat budget

Country	UN scale of assessment 2013-2015 (%)	Scale of EANET burden sharing (%)	Estimated flat rate contribution in 2014-2015 (US $)
Cambodia	0.004	0.019	91
China	5.148	23.951	114,891
Indonesia	0.346	1.610	7,723
Japan	10.833	50.400	241,765
Lao PDR	0.002	0.009	43*
Malaysia	0.281	1.307	6,270
Mongolia	0.003	0.014	67
Myanmar	0.010	0.047	226
Philippines	0.154	0.716	3,435
Republic of Korea	1.994	9.277	44,501
Russia	2.438	11.343	54,412
Thailand	0.239	1.112	5,334
Vietnam	0.042	0.195	935
Total	21.494	100	479,693**

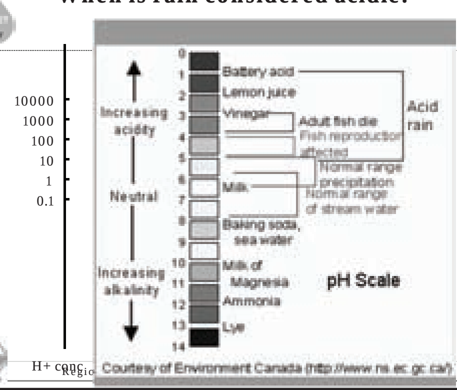
Regional Resource Centre for Asia and the Pacific; RRC.AP 12

Voluntary Contribution among Participating Countries to the Network Center budget

Country	UN scale of assessment 2013-2015 (%)	Scale of EANET burden sharing (%)	Estimated flat rate contribution in 2014-2015 (US $)
Cambodia	0.004	0.019	75
China	5.148	23.951	94,846
Indonesia	0.346	1.610	6,376
Japan	10.833	50.400	199,584
Lao PDR	0.002	0.009	36*
Malaysia	0.281	1.307	5,176
Mongolia	0.003	0.014	55
Myanmar	0.010	0.047	186
Philippines	0.154	0.716	2,835
Republic of Korea	1.994	9.277	36,737
Russia	2.438	11.343	44,918
Thailand	0.239	1.112	4,404
Vietnam	0.042	0.195	772
Total	21.494	100	396,000**

Regional Resource Centre for Asia and the Pacific; RRC.AP 13

When is rain considered acidic?



Regional Resource Centre for Asia and the Pacific; RRC.AP 14

EANET Monitoring Sites

The EANET monitoring activities covers five environmental media

- Wet deposition
- Dry deposition
- Soil and vegetation
- Inland aquatic environment (water and sediment)
- Catchment

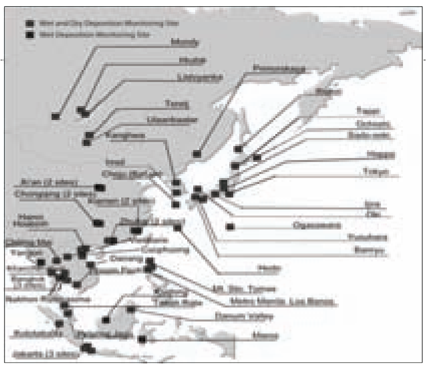
Regional Resource Centre for Asia and the Pacific; RRC.AP 15

EANET Monitoring Sites

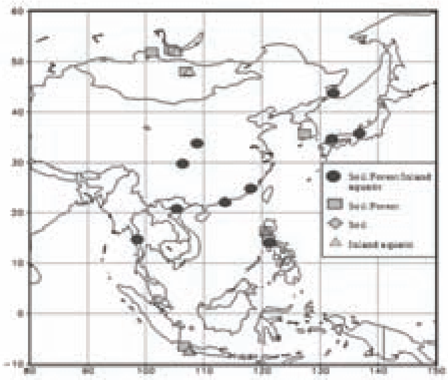
EANET monitoring sites classified by types of environmental media.

- Deposition monitoring sites :
  - 54 wet deposition sites
  - 45 dry deposition sites
- Ecological survey sites :
  - 20 soil survey sites
  - 18 forest/vegetation survey sites
  - 18 inland aquatic environment (lakes/rivers) sites
- Catchment scale monitoring sites : 2 sites

Regional Resource Centre for Asia and the Pacific; RRC.AP 16



Regional Resource Centre for Asia and the Pacific; RRC.AP 17



Regional Resource Centre for Asia and the Pacific; RRC.AP 18

Inland Aquatic Environment (IEA) Monitoring Sites

Catchment Scale Monitoring Sites

EANET Monitoring Sites

EANET monitoring sites classified by type of area of the monitoring sites

• **Urban sites**	**23 sites**
• **Rural sites**	**14 sites**
• **Remote sites**	**17 sites**
Total	**54 sites**

● Urban
■ Rural
♦ Remote

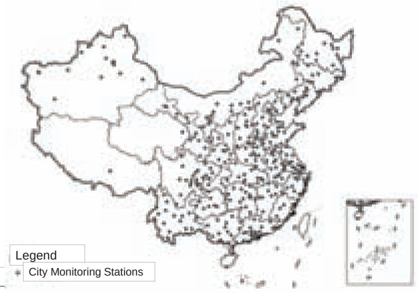
● Daily (33 sites)
■ Weekly (14 sites)
♦ Remote (2 sites)
+ Event base (5 sites)

● Automatic (AT) (3 sites)
■ Filter-pack (FP) (14 sites)
♦ Passive (3 sites)
+ AT & FP (19 sites)

- Daily (18 sites)
- Weekly (14 sites)

Air Monitoring Network in China

- Distribution of city monitoring stations(338 cities)



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Various instruments used to monitor wet deposition

Regional Resource Centre for Asia and the Pacific; RRC.AP 27

2

Methods used to monitor dry deposition

Regional Resource Centre fo

Filterpack

Most monitoring requires precise chemical analysis of the samples at a central laboratory

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Instrument for Strengthening the Acid Deposition Monitoring Network in East Asia (EANET)

Resposibilities : Participating Countries

- Monitoring
- Reporting
- QA/QC program
- Promote research activities, education and training program, public awareness, exchange information
- With in close communication, coordination and collaboration with the Secretariat and the Network Center through the National Focal Points (NFPs), National Centers, and National Quality Assurance and Quality Control (QA/QC) Managers.
- Voluntary financial contribution to support the EANET activities of the Secretariat and the Network Center.

Regional Resource Centre for Asia and the Pacific; RRC.AP 30

Current State of Acid Deposition in East Asia

The 2nd Periodic Report on the State of Acid Deposition in East Asia (PRSAD2) published by the EANET in March 2012 indicated that

- EANET Data compilation from 2005-2009
- Acid rain remains prevalent across East Asia.
- The annual average pH of rainwater is lower than 5.0 (the threshold for acid rain) at 60% of monitoring sites, and values of less than 4.6 have been recorded in several locations while in some locations the higher than pH 6 have been seen due to the contribution of alkaline species such as NH3 from agriculture and calcium carbonate in soil dust.
- H_2SO_4 remains the primary contributor to acid rain across the region, therefore, the regional sulphur emission control is still needed to be improved.

Regional Resource Centre for Asia and the Pacific; RRC.AP 31

Current State of Acid Deposition in East Asia

- Contribution of HNO_3 to acid rain is almost equal to that of H_2SO_4, the control of nitrogen emission is also important in the region.
- However, despite continued acidification in the region, the impact of acid deposition on eco-system functions still appears limited.
- No decline in tree growth nor in the number of species in vegetation has been observed during monitoring, and overall forest functions and structures apparently remain sound.
- Tree decline symptoms observed at some sites were generally considered to stem from pest infestation as a direct cause.
- Declining trend in lake/stream water pH with corresponding increase in sulphate concentration was also observed at several sites during the same period.

Regional Resource Centre for Asia and the Pacific; RRC.AP 32

Current State of Acid Deposition in East Asia

- Results of soil and inland water monitoring in some parts of the region showed symptoms of nitrogen saturation/eutrophication due to excess deposition of nitrogen species (nitrate and ammonium). Deposition loads of S and N were very high in these areas.
- O_3 concentrations monitored in Japan, Korea, Thailand and Russia demonstrated common seasonal variations – highest in spring, lowest in summer, and second-highest in autumn. Monthly average O_3 concentrations from 2005-2009 were higher than those for the previous 5-year period (2000-2004).

Regional Resource Centre for Asia and the Pacific; RRC.AP 33

Future Development of the EANET

Rationale for Future Expansion of the Scope of the EANET

- Acid deposition may have been marginalized these days because the impacts of acid deposition to human health and ecosystems have not become so clear yet in East Asia.
- It may not be of interest of financial authorities in some participating countries for only acid deposition issue and in other outside financial support funds.
- Some other air pollution problems, i.e. O_3 and PM2.5, have been highlighted as either a domestic, regional, or hemispherical problem.
- Integrated (co-benefit/co-control) approach for mitigating air pollution and climate change will yield more efficient mitigation & measures policy.

Regional Resource Centre for Asia and the Pacific; RRC.AP 34

Future Development of the EANET

Possible Future Expansion of the Scope of the EANET

- The Instrument for Strengthening the EANET is allowed for its extended scope.
- The present scope of the EANET covers monitoring of major acidifying species and related chemical substances.
- The 13th Session of the IG on the EANET in 2011 suggested to take the Recommendations of Executive Summary of the 2nd Periodic Report on the State of Acid Deposition Monitoring in East Asia (PRSAD2) related to the future development of the EANET into the discussions of the next Sessions of Working Group of Future Development and Scientific Advisory Committee for the EANET.

Regional Resource Centre for Asia and the Pacific; RRC.AP 35

Future EXPANSION of the EANET

Possible Future Expansion of the Scope of the EANET

Recommendations Expansion of Scope from PRSAD2

- Continue an ongoing monitoring regarding the deposition of acid and other related atmospheric air pollutants, and extending to include relevant components i.e. O_3 and particulate matter (PM).
- Strong links between acid deposition and climate change.
  Air pollutants causing acid deposition (such as O_3 and aerosols) contribute to climate change, while climate change affects acid deposition through influences such as precipitation variations.
- Extending the assessment of acid deposition to include other relevant air pollutants and climate change should be coordinated in order to improve the EANET's treatment of emerging issues.

Regional Resource Centre for Asia and the Pacific; RRC.AP 36

Future Development of the EANET

Possible Future Expansion of the Scope of the EANET

- to address the origins of harmful emissions by reaching out to policy developers and decision makers with scientific knowledge and policy advice.
- to support information to the policy development toward environmental sustainability in the future.
- promotion of research activities on modeling and emission inventories.

Regional Resource Centre for Asia and the Pacific; RRC.AP 37

On-going Discussion on the Future Development of the EANET

- Future development of the EANET should be in a stepwise manner.
- O_3 and PM2.5 monitoring should be added to the monitoring items at the EANET sites with high priority within the present scope of EANET.
- Technical support and capacity building for air concentration monitoring including O_3 and PM2.5 should be strengthened.
- Inter-linkage between acid deposition, air pollution, climate change, and co-benefits/co-control approach should be investigated. As such, monitoring of black carbon may also be considered for connecting acid deposition, air pollution, and climate change.
- Extended assessment of the state of acid deposition and air pollution should be made with the aid of modeling and emission inventories.

Regional Resource Centre for Asia and the Pacific; RRC.AP 38

On-going Discussion on the Future Development of the EANET

- Assessment of the impact on human health by O_3 and PM2.5 in combination with monitoring, modeling, and emission inventory should be considered.
- Public awareness activities and the establishment of epistemic community, including information dissemination should be promoted in order to achieve a common understanding on acid deposition and its inter-linkage with other atmospheric pollution and climate change among different stakeholders.
- Relevance to climate impact of monitoring species may also be considered in the expanded scope.
- New expertise associated with mitigation measures may need to be addressed under the EANET, which will require the expansion of the scope as well as institutional reform in some countries.

Regional Resource Centre for Asia and the Pacific; RRC.AP 39

Future Development of the EANET

Challenges for Future Expansion of the Scope of the EANET

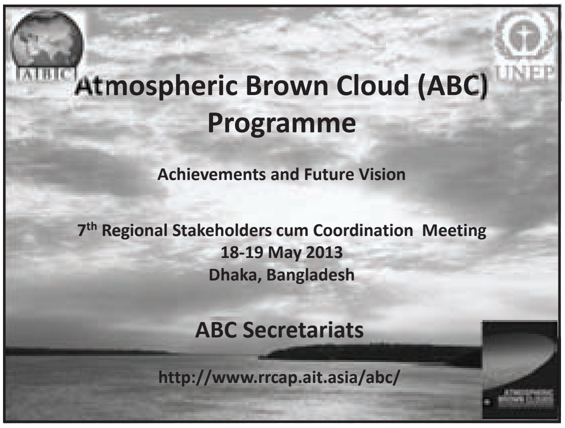
- Some agreed only monitoring of O_3 and PM.
- Expansion could mean burdens technically and financially
- Revision of the Instrument needed.
- The EANET title changed.

Regional Resource Centre for Asia and the Pacific; RRC.AP 40

Thank you for your attention

More information: www.eanet.asia
Secretariat: www. rrcap.ait.asia
Network Center : www.acap.asia

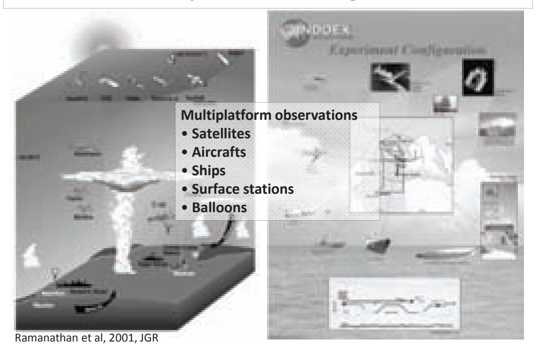
Regional Resource Centre for Asia and the Pacific; RRC.AP 41



Outline

- **Background**
- **Achievements**
- **Ongoing activities**
  - ➢ **Observation and capacity**
  - ➢ **Impact assessment**
  - ➢ **Mitigation**
    - ✓ **Project Surya**
    - ✓ **ABC precursor emission inventory of Nepal**
- **Future plan**
  - ✓ **National mitigation programme**

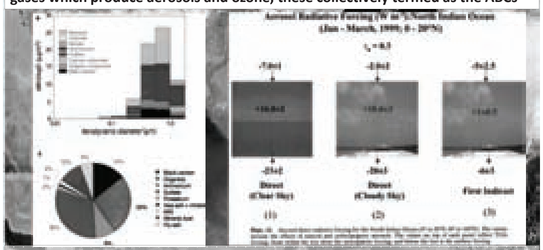
Indian Ocean Experiment (INDOEX, 1999) - an inception of ABC Programme



Ramanathan et al, 2001, JGR

Atmospheric Brown Clouds (ABCs) over South Asia

Widespread layers of brownish haze of regional scale plumes of air pollutants, consisting of mainly the aerosol particles (such as black carbon) and precursor gases which produce aerosols and ozone, these collectively termed as the ABCs



10-20 % reduction in the solar radiation reaching to earth resulting the significant heating of the atmosphere

Ramanathan et al, 2001, JGR

Atmospheric Brown Cloud (ABC) Programme

Following the INDEOX results, UNEP the commissioned the ABC Programme in 2001:

- To further investigate the impacts of ABCs on climate, precipitation, agriculture, and health.
- To equip the policy makers with science-based information for reducing the emissions of ABCs to tackle climate issues.

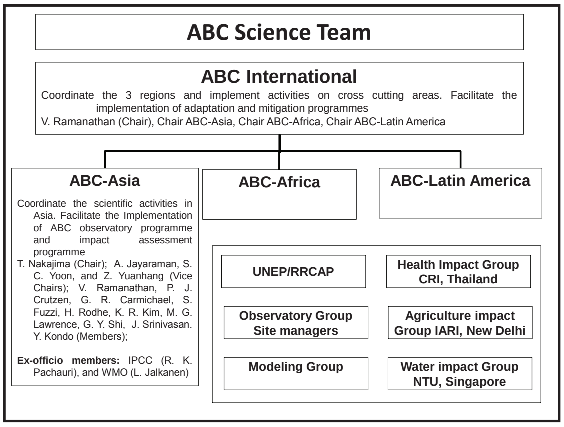
Objectives

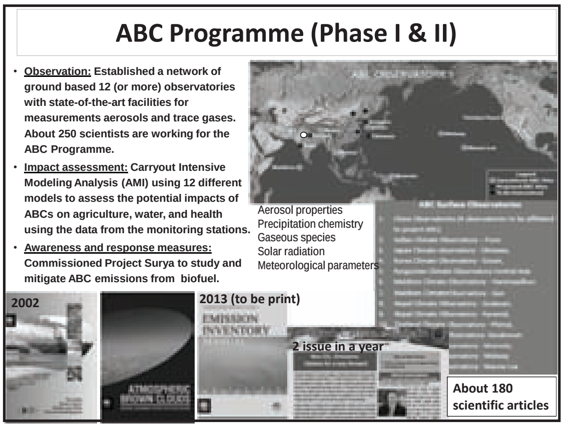
- **Observations:** Establishment of a network of ground based observatories equipped with advanced measured facilities across the Asia-Pacific for data collection.
- **Impact assessment:** Assessment of the impacts of ABCs on climate, agriculture, water, and health using the observed data and models.
- **Awareness and mitigation:** Provide science-based information to policy makers for the reduction of emissions of ABCs.

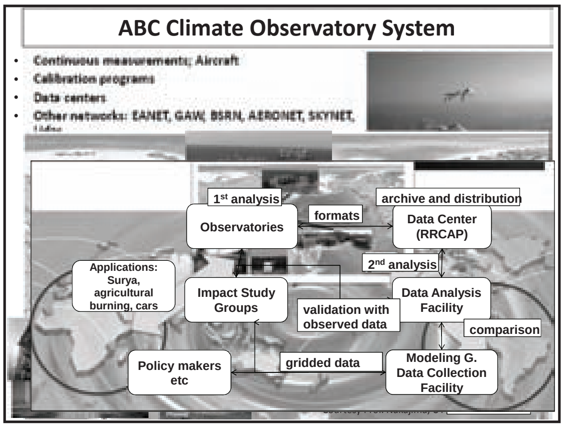
ABC Programme

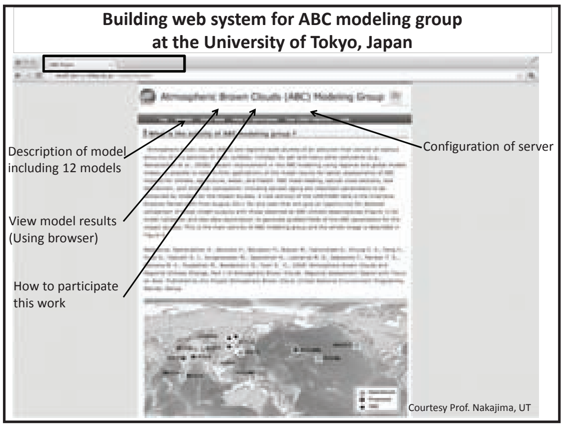
ABC-Asia	ABC-Africa	ABC-Latin America
• Observatories • Impact Assessment • Mitigation • Knowledge Management • Awareness and Consensus on Policies	Whitepaper containing detail plan drafted • Identified potential observation sites. • Mitigation programme started	Whitepaper containing detail plan drafted

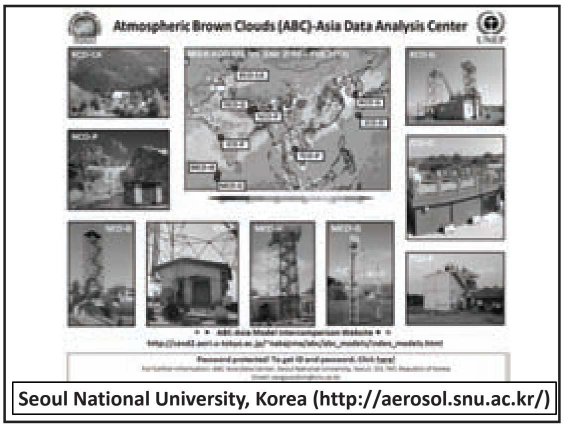
- **ABC Steering Committee**
- **ABC-International Science Team**
- **ABC-Asia Science Team**
- **ABC-Africa Science Team (yet to form)**
- **ABC-Latin America (yet to form)**

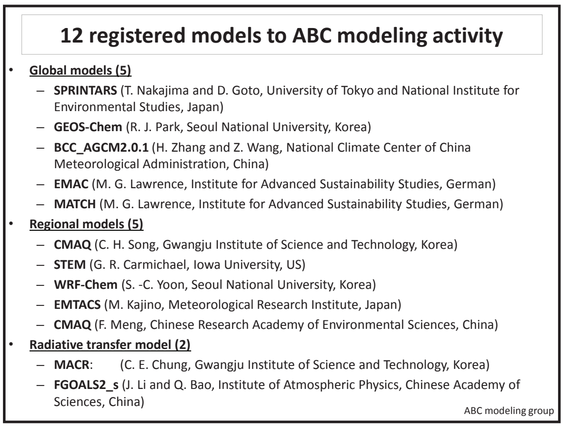

ABC Science Team
ABC International
Coordinate the 3 regions and implement activities on cross cutting areas. Facilitate the implementation of adaptation and mitigation programmes
V. Ramanathan (Chair), Chair ABC-Asia, Chair ABC-Africa, Chair ABC-Latin America
ABC-Asia
Coordinate the scientific activities in Asia. Facilitate the Implementation of ABC observatory programme and impact assessment programme
T. Nakajima (Chair); A. Jayaraman, S. C. Yoon, and Z. Yuanhang (Vice Chairs); V. Ramanathan, P. J. Crutzen, G. R. Carmichael, S. Fuzzi, H. Rodhe, K. R. Kim, M. G. Lawrence, G. Y. Shi, J. Srinivasan. Y. Kondo (Members);
Ex-officio members: IPCC (R. K. Pachauri), and WMO (L. Jalkanen)
ABC-Africa
ABC-Latin America
UNEP/RRCAP
Health Impact Group CRI, Thailand
Observatory Group Site managers
Agriculture impact Group IARI, New Delhi
Modeling Group
Water impact Group NTU, Singapore

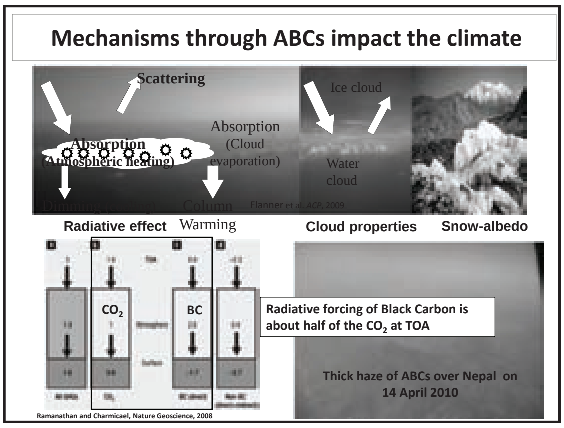

ABC Programme (Phase I & II)
Observation: Established a network of ground based 12 (or more) observatories with state-of-the-art facilities for measurements aerosols and trace gases. About 250 scientists are working for the ABC Programme.
Impact assessment: Carryout Intensive Modeling Analysis (AMI) using 12 different models to assess the potential impacts of ABCs on agriculture, water, and health using the data from the monitoring stations.
Awareness and response measures: Commissioned Project Surya to study and mitigate ABC emissions from biofuel.
Aerosol properties
Precipitation chemistry
Gaseous species
Solar radiation
Meteorological parameters
2002
2013 (to be print)
EMISSION INVENTORY
2 issue in a year
ATMOSPHERIC BROWN CLOUDS
About 180 scientific articles

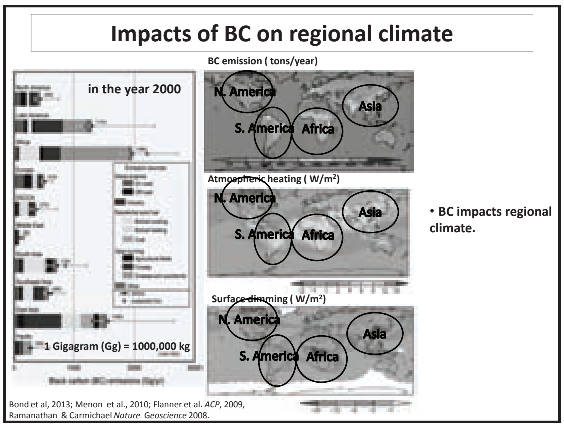

ABC Climate Observatory System
Continuous measurements; Aircraft
Calibration programs
Data centers
Other networks: EANET, GAW, BSRN, AERONET, SKYNET,
1st analysis
archive and distribution
formats
Observatories
Data Center (RRCAP)
2nd analysis
Applications: Surya, agricultural burning, cars
Impact Study Groups
Data Analysis Facility
validation with observed data
comparison
Policy makers etc
gridded data
Modeling G. Data Collection Facility

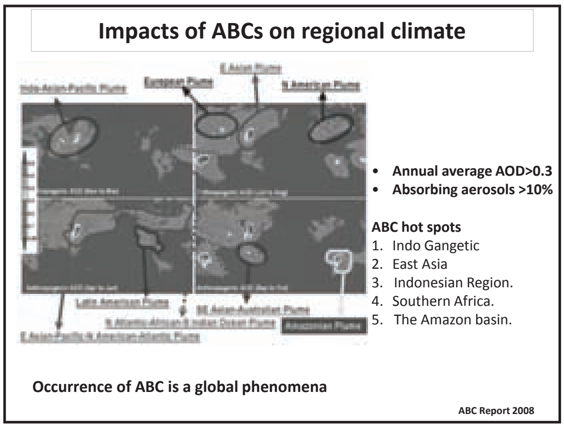

Building web system for ABC modeling group at the University of Tokyo, Japan
Atmospheric Brown Clouds (ABC) Modeling Group
Description of model including 12 models
Configuration of server
View model results (Using browser)
How to participate this work
Courtesy Prof. Nakajima, UT

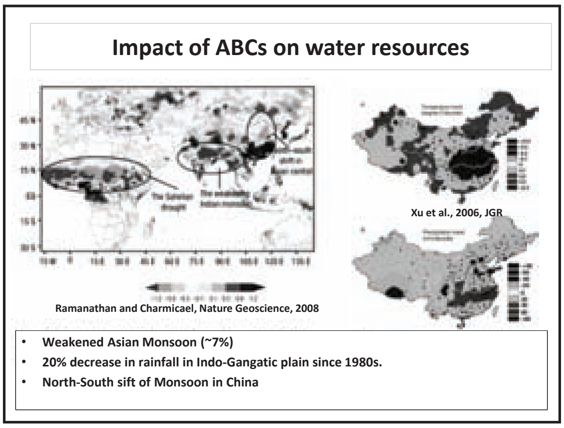

Atmospheric Brown Clouds (ABC)-Asia Data Analysis Center
UNEP
Seoul National University, Korea (http://aerosol.snu.ac.kr/)

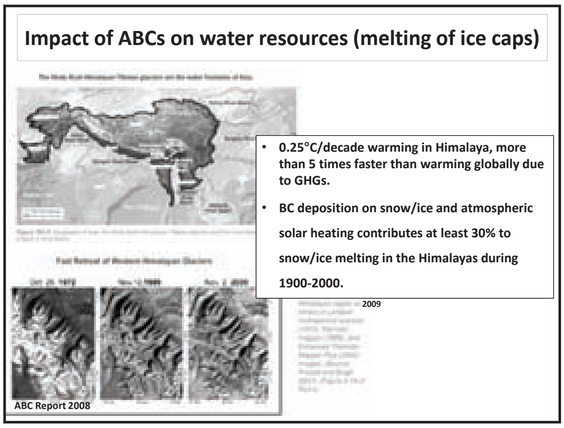

12 registered models to ABC modeling activity
Global models (5)
– SPRINTARS (T. Nakajima and D. Goto, University of Tokyo and National Institute for Environmental Studies, Japan)
– GEOS-Chem (R. J. Park, Seoul National University, Korea)
– BCC_AGCM2.0.1 (H. Zhang and Z. Wang, National Climate Center of China Meteorological Administration, China)
– EMAC (M. G. Lawrence, Institute for Advanced Sustainability Studies, German)
– MATCH (M. G. Lawrence, Institute for Advanced Sustainability Studies, German)
Regional models (5)
– CMAQ (C. H. Song, Gwangju Institute of Science and Technology, Korea)
– STEM (G. R. Carmichael, Iowa University, US)
– WRF-Chem (S. -C. Yoon, Seoul National University, Korea)
– EMTACS (M. Kajino, Meteorological Research Institute, Japan)
– CMAQ (F. Meng, Chinese Research Academy of Environmental Sciences, China)
Radiative transfer model (2)
– MACR: (C. E. Chung, Gwangju Institute of Science and Technology, Korea)
– FGOALS2_s (J. Li and Q. Bao, Institute of Atmospheric Physics, Chinese Academy of Sciences, China)
ABC modeling group

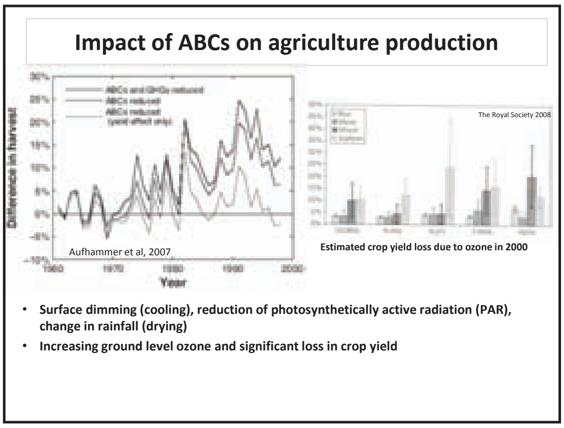

Mechanisms through ABCs impact the climate
Scattering
Absorption (Atmospheric heating)
Absorption (Cloud evaporation)
Ice cloud
Water cloud
Column Warming
Radiative effect
Cloud properties
Snow-albedo
CO2
BC
Radiative forcing of Black Carbon is about half of the CO2 at TOA
Thick haze of ABCs over Nepal on 14 April 2010
Ramanathan and Charmicael, Nature Geoscience, 2008


Impacts of BC on regional climate
BC emission (tons/year)
in the year 2000
N. America
S. America
Africa
Asia
Atmospheric heating (W/m2)
Surface dimming (W/m2)
• BC impacts regional climate.
1 Gigagram (Gg) = 1000,000 kg
Bond et al, 2013; Menon et al., 2010; Flanner et al. ACP, 2009, Ramanathan & Carmichael Nature Geoscience 2008.

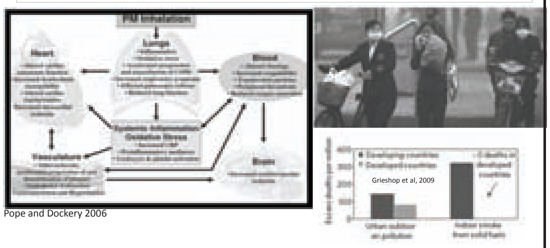

Impacts of ABCs on regional climate
E Asian Plume
European Plume
N American Plume
Indo-Asian-Pacific Plume
Latin American Plume
SE Asian-Australian Plume
Amazonian Plume
• Annual average AOD>0.3
• Absorbing aerosols >10%
ABC hot spots
1. Indo Gangetic
2. East Asia
3. Indonesian Region.
4. Southern Africa.
5. The Amazon basin.
Occurrence of ABC is a global phenomena
ABC Report 2008


Impact of ABCs on water resources
The Sahelian drought
Xu et al., 2006, JGR
Ramanathan and Charmicael, Nature Geoscience, 2008
• Weakened Asian Monsoon (~7%)
• 20% decrease in rainfall in Indo-Gangatic plain since 1980s.
• North-South sift of Monsoon in China


Impact of ABCs on water resources (melting of ice caps)
Fast Retreat of Western Himalayan Glaciers
• 0.25°C/decade warming in Himalaya, more than 5 times faster than warming globally due to GHGs.
• BC deposition on snow/ice and atmospheric solar heating contributes at least 30% to snow/ice melting in the Himalayas during 1900-2000.
2009
ABC Report 2008


Impact of ABCs on agriculture production
ABCs and GHGs reduced
ABCs reduced
Difference in harvest
Year
Aufhammer et al, 2007
The Royal Society 2008
Estimated crop yield loss due to ozone in 2000
• Surface dimming (cooling), reduction of photosynthetically active radiation (PAR), change in rainfall (drying)
• Increasing ground level ozone and significant loss in crop yield

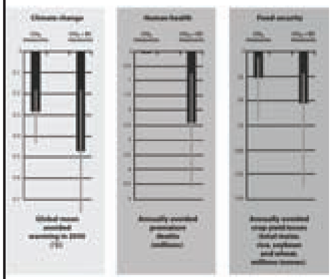
Impact of ABCs on health



Pope and Dockery 2006

- ABC exposure is likely associated with significant health effects, for example, about 400,000 to 500,000 deaths a year in India and China each in indoor and outdoor exposure.
- $PM_{2.5}$ with BC in it is more toxic compared to without BC (smith et al., 2008)

Estimated benefits of BC and CH_4 reduction

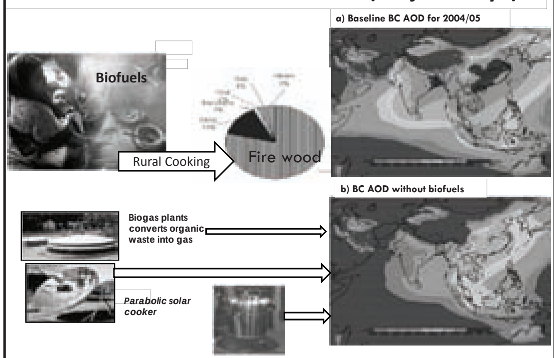


UNEP/WMO (2011)

Benefits from BC the mitigation in 2030 compared to reference scenario.

- If identified measures implemented by 2030, it may reduce global warming by 0.5°C in 2050 half the warming projected and would improve the chance of not exceeding 2°C target, if CO_2 is also aggressively addressed with SLCPs.
- Substantial regional climate benefits, e.g. temperature reduction in Arctic and Himalayas
- Substantial health and crop benefits - avoid 2.4 million premature deaths, mainly in developing countries and loss of 52 million tonnes of maize, rice, wheat and soybean each year

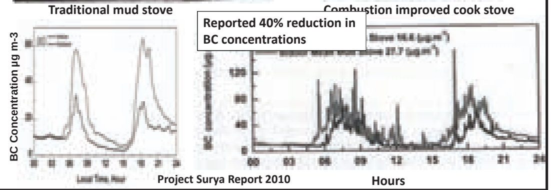
Reduction of ABCs from biofuels (Project Surya)



Romanathan and Balakrishnan, 2007, Romanathan and Carmichael, 2008

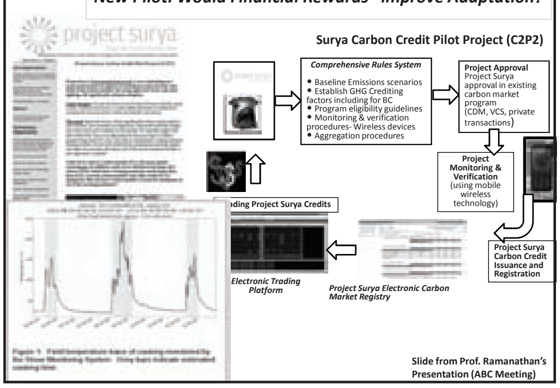
Mitigation of ABCs through improved technology

India: Indo-Gangetic region
Project Surya: Pilot study within the ABC Programme on BC emissions from biofuels



Project Surya Report 2010

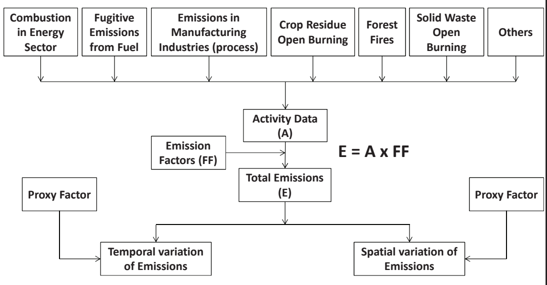
New Pilot: Would Financial Rewards improve Adaptation?



Slide from Prof. Ramanathan's Presentation (ABC Meeting)

Emission Inventory of ABC Precursors of Nepal

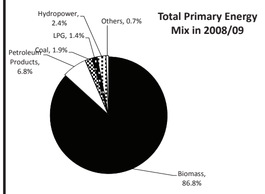
Prepared by Prof. Ram M. Shrestha

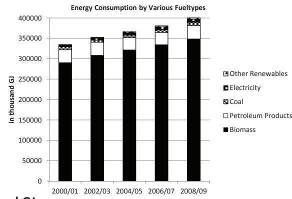


Overall Framework of Emission Inventory in Nepal

Geography of Nepal

Energy consumption in Nepal





Energy Consumption in 2008/09 in thousand GJ

Energy Type	Agriculture	Commercial	Industrial	Residential	Transport
Biomass	0	1842	2071	344956	0
Petroleum Products	3473	427	475	2291	20646
LPG	0	2290	0.0	3201	211
Coal	0	0	7716	35	0
Electricity	174	563	3106	3534	19
Other Renewables	0	0	0	2735	0
Total	3646	5122	13370	356752	20876

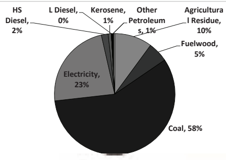
Biomass, which includes fuelwood, agricultural residue and animal waste, is a main source of energy in Nepal

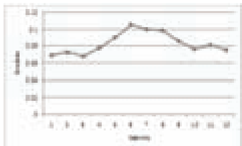
Emissions from industrial sector

Total Industry: 4,552 (as per DOI, 2011)

- Food, beverage and tobacco
- Textiles and leather
- Wood and its products
- Paper and paper products
- Chemicals, rubber and plastic
- Non-metallic mineral
- Iron and steel
- Other manufacturing

Total fuel comsumption : 13.4 million GJ

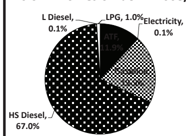


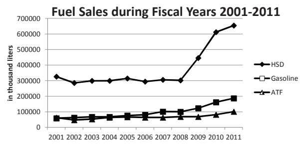


Monthly industrial electricity consumption data has been used as a proxy to estimate the monthly pattern of industrial emissions

Emissions from transport sector (road traffic)

Transport is a second largest energy consuming sector in Nepal with consumption of about 20.9 million GJ of fuel in 2008/09





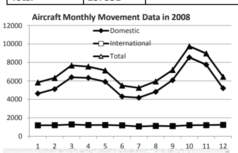
Number of Vehicles in Circulation in 2008/09

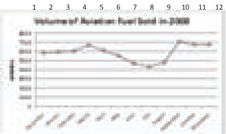
Fuels	Vehicle Class	No. of Vehicles	Average distance travelled (in km/yr.)	Fuel consumption (km/lt.)
Gasoline	Gasoline cars	97590	23624	9.49
	Light-duty vehicles	844	23624	9.49
	Two wheelers (2 & 4 stroke)	573020	10491	46.10
	Three wheelers	4604	12756	5.39
Diesel	Light-duty vehicles	58538	27109	6.52
	Heavy-duty vehicles	67619	47998	6.09
	Three-wheelers	970	27173	9.39
LPG	Light-duty vehicles	633	37125	8.00
	Three wheelers	857	35502	14.70
	Total	805614		

Emissions from transport sector (air traffic)

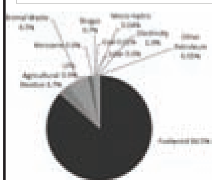
There are 34 domestic and 1 international airports operational in Nepal

Flight Type	Frequency of LTO	Fuel Consumption per LTO (kg/LTO)	Annual Aviation Fuel Sold in 2008, in kt
Domestic	223275	825	65967.8
International	14276	1617	4217.9
Total	237551		70185.7

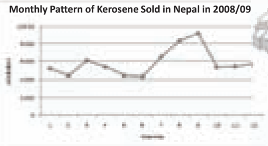


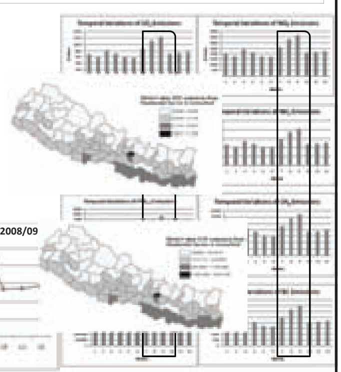


Emissions from residential sector



Energy Consumption by Fuel Type in 2008/09

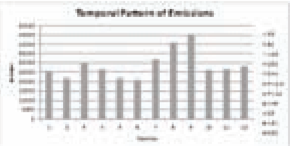


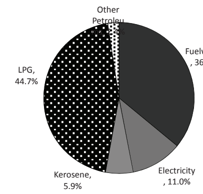


Emissions in power and commercial sectors

2 Power plants in Nepal
- **Sunsari (39 MW)**
- **Makawanpur (14.4 MW)**

District	SO_2	NO_X	CO	NMVOC	CH_4	CO_2	N_2O	BC	OC
Sunsari	12.6	58.0	1.4	0.5	0.3	6796	0.06	0.53	0.002
Makwanpur	4.7	21.5	0.5	0.2	0.1	2511	0.02	0.19	0.001





Commercial Sector

Emissions from manufacturing and process industries

Industrial production in 2008/09

Industry type	Total Production (tonne/year)
Mineral product - cement	71000
Mineral product - limestone	822000
Metal production	-
Pulp and paper industry	34550
Chemical industry	-
Beverage industry*	579609 (hectoliters)
Food industry	446739

Emissions crop residue and open burning

Crop Type	Area (in ha)	Production (in metric ton)	Yield (in kg/ha)
Paddy	1555940	4523693	2907
Maize	875428	1930669	2205
Millet	265889	292683	1101
Wheat	694950	1343862	1934
Barley	25817	23224	900
Oilseed	181361	135494	747
Potato	181900	2424048	13326
Tobacco	2542	2497	982
Sugarcane	58101	2354412	40523
Jute	11678	17658	1512

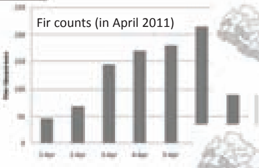
Except mountain region, crop residue and open burning are everywhere in Nepal

Emissions forest fires and municipal solid waste open burning

Forest type and area covered (in km²)	In 1994/95
Shorea Robusta (SAL)	5761
Tropical mixed hardwood	12554
Lower mixed hardwood	7679
Conifer	2567
Upper mixed hardwood	13135
Other forest	992
Shrub	15592
Total (in km²)	58280

Pollutant	At Source (in tonne)	At Disposal Site (in tonne)	Total (in tonne) 2008-09
SO_2	12,582	799	13,381
NO_X	75,493	4,793	80,286
CO	1,056,907	67,105	1,124,012
NMVOC	377,467	23,966	401,433
PM_{10}	201,316	12,782	214,098
CH_4	163,569	10,385	173,954
BC	138,405	8,788	147,193
OC	138,405	8,788	147,193

Pollutants	Forest Fire (in tonnes, 2008-09)
SO_2	16,361
NO_x	70,325
CO	2,985,216
NMVOC	232,502
NH_3	37,315
$PM_{2.5}$	261,206
PM_{10}	301,392
BC	18,945
OC	149,261
CO_2	45,352,320
CH_4	195,187



Summary of Emissions (in Tonnes) in 2008-09

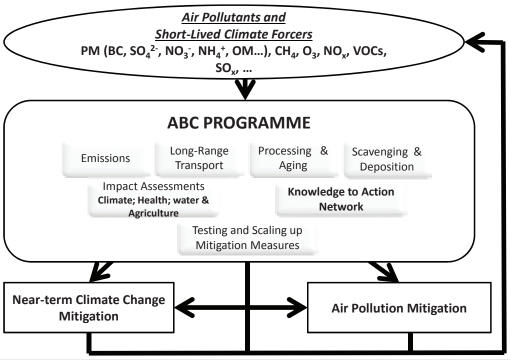
Pollutants	Energy		Manufacturing/Construction		Transport		Residential		Commercial		Agriculture		Fugitive	Process	Crop Res. BB		Forest Fire	Municipal waste BB
	I	II	I	II	I	II	I	II	I	II	I	II			I	II		
SO_2	17.2	31.9	5934	13840	183376	185236	9364	13129	16	16				152	817	489	16361	13381
NO_X	79.4	79.4	3798	859	40494	31020	27795	14925	224	114	300	300		52	4102	2470	70325	80286
CO	1.9	1.9	9117	7132	262941	100008	1670604	2513100	7854	15193	34	34		115328	236515	129701	2985216	1124012
NMVOC	0.6	0.6	346	143	59336	19417	-	-	-	-	11	11	279	1806118	12359	12359	232502	401433
NH_3	-	-	0.2	0.1		3787	15501	15501	142	142					5882	5382	37315	
PM_{10}	1.0	1.0	23540	23419	3787	3787	90725	140321	434	578	12	12	46	1864579	13291	7557	261206	214098
$PM_{2.5}$	0.7	0.7	23469	21502	3770		58081	58081	197	197	16	16	24	5257	12391	7169	301392	
CH_4	0.4	0.4	206	141	2191	552	98140	220190	563	1096					12558	12558	195187	173954
CO_2	9307	9307	1568135	980524	3332873	3332873	30207529	31409183	334052	344826					2929213	2856217	45352320	
N_2O	0.1	0.1	30	20	92	92	1313	1827	8	15								
BC	0.7	1.0	661	30	2185	4792	26848	7728	171	53		13	10		1390	1132	18945	147193
OC	0.003	0.8	662	166	7234	8656	65594	138621	191	860	14	14	7		6787	3986	149261	147193

Forest fires and open biomass burning of municipal solid waste needs attention

Emission estimates for Nepal: key points

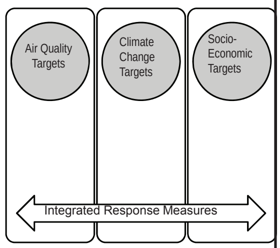
- **Emissions of ABC precursors are estimated for Nepal in 11 sectors for 12 pollutants.**
- **Biomass is a main source of energy in Nepal.**
- **Most of the emissions sources are located in plain (also called, Terai) region.**
- **Emissions from industrial sector are estimated higher in Jun-Jul-Aug, while Aug-Sept from residential sector.**

ABC Programme – A new approach (draft)



Why National Programmes

- Emission reduction measures have been initiated at the local and national level
- Integrated response in the context of sustainable development will improve human health, agriculture production, regional climate, water security, living standards, and economy
- Contributes to global efforts to achieve both the Millennium Development Goals and the Rio+20 Declaration
- Attractive opportunity for donors to invest in projects (international organization, philanthropic groups, etc.)



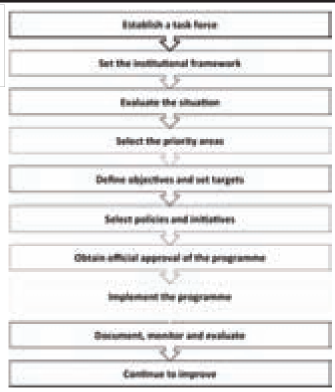
Guidelines

- These guidelines will be designed to specifically address the particular challenges of addressing ABCs at a national level and to spur fast-action to address them.
- The Guidelines will reflect and build upon the growing body of knowledge regarding ABCs and its impacts, sources and response measures, as well as good practice for addressing atmospheric issues.

CONTENTS

The Programme

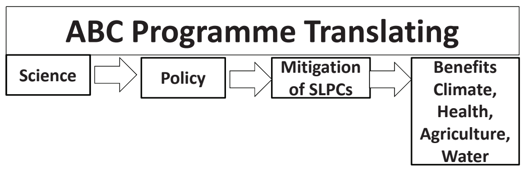
Ten Steps for developing and implementing a national programme



Use of the Guidelines

- Groups and individual trainings
- Through the air pollution networks

Conclusion



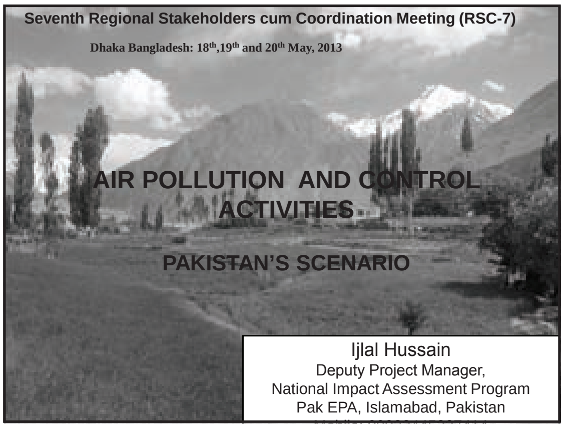
Thank you

Please visit: http://www.rrcap.ait.asia/abc/

Initiatives on Air Pollution in South Asia

Seventh Regional Stakeholders cum Coordination Meeting (RSC-7)

Dhaka Bangladesh: 18th,19th and 20th May, 2013



AIR POLLUTION AND CONTROL ACTIVITIES

PAKISTAN'S SCENARIO

Ijlal Hussain
Deputy Project Manager,
National Impact Assessment Program
Pak EPA, Islamabad, Pakistan

About Pakistan

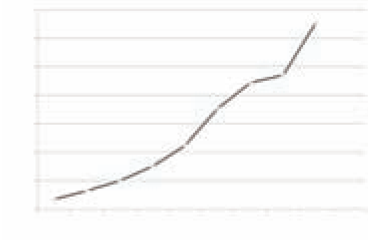
- Location: 23° 73 North & 61° 76 East
- Total Area: 796095 sq km
- Population: 183 million
- Population Density: 225.19 (2010) persons/km2
- Vehicles: 10.9 million
- Climate: Temperate (cold winters and hot summers; Rain Fall 60 mm in South to 1600 mm in North)
- Forest cover: 4.8%
- GDP: Rs. 6.4 trillion
- Per capita income: $ 1372

MAJOR POLLUTION ISSUES OF CONCERN

- High concentration of Particulate Matter (PM10 and PM2.5) is of great concern in the country.
- Haze and Smog formation in urban centers.
- Heavy Fog in winter, adversely affecting communication
- Increasing concentration of Oxides of Nitrogen due to excessive use of CNG
- Increasing use of coal in industry due to shortage of natural gas and high cost of fuel oils .
- Burning of municipal solid waste is significant, almost 57,000 tons of solid waste is generated each day, most of which is either dumped or burnt (incomplete combustion)

Vehicles on Road

	million
1980	**0.682**
1985	**1.288**
1990	**1.990**
1995	**3.000**
2000	**4.471**
2005	**7.084**
2007	**8.878**
2008	**9.413**
2011	**10.90**
2015	**13.127**



QUALITY OF FUEL OIL

	Pakistan	Other Countries of Region
• Gasoline	Unleaded	Unleaded
• Sulphur in Diesel oil	0.05-0.5%	0.05-0.5%
• Sulphur in Furnace oil	3%	0.5-1%

Target for Sulphur Content in Diesel Oil: 0.05% by 2012 Revised 2014

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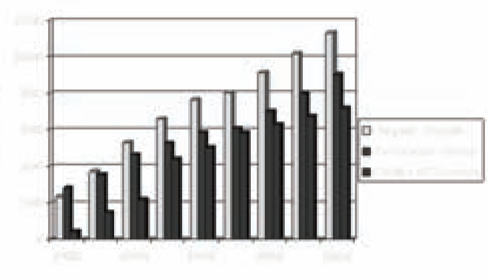
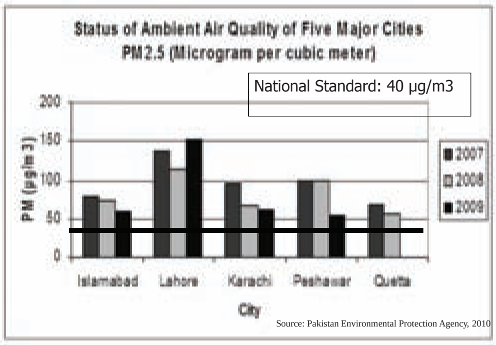
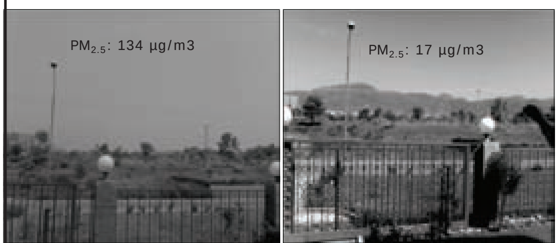
Estimated Emissions
ALL SOURCES



Source:Pak-EPA Estimation based on Emission Factors

Status of Air





Ambient Air Quality In Big Cities Of Punjab, Jan 2010

City	Ozone ug/m³	SO_2 ug/m³	CO mg/m³	NOX ug/m³	PM 2.5 ug/m³
Lahore	32.8	72.8	2.5	164.4	252.3
Faisalabad	31.2	69.7	2.0	170.5	255.2
Rawalpindi	46.0	74.0	2.0	177.0	128.0
Gujranwala	31.5	75.3	2.3	179.2	260.3
Sahiwal	13.2	5.0	0.5	20.3	73.8
Multan	15.0	29.0	1.8	77.0	170.0
Bahawalpur	18.2	38.9	2.0	94.4	209.4
Muzafargarh	36.0	18.0	1.0	62.0	189.0

SO_2: *Sulfur Dioxide,*
CO: *Carbon monoxide,*
NOx: *Nitrogen Oxides,*
PM2.5: *Particulate Matter up to 2.5 micron*

mg/m3: *Milligram Per Cubic Meter,*

*** National Ambient Air Quality Standards (draft)**

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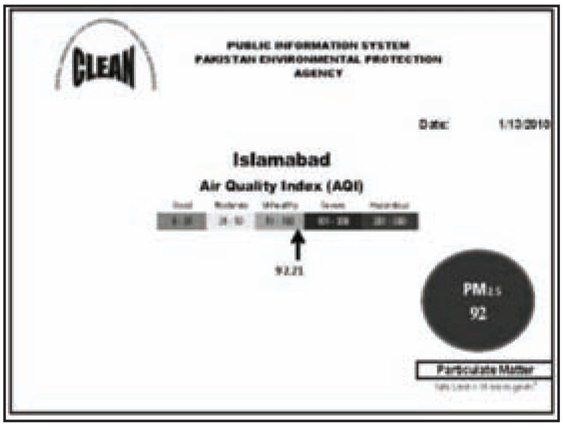
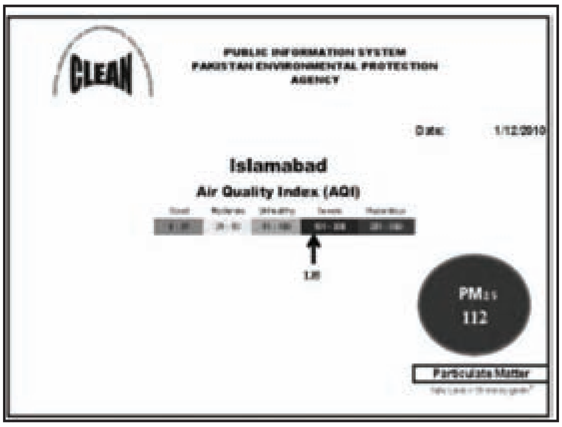
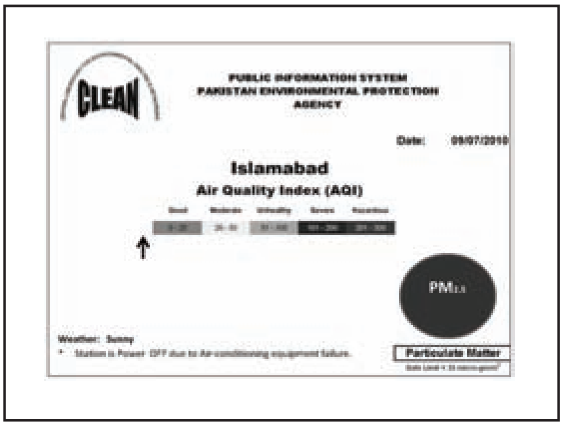
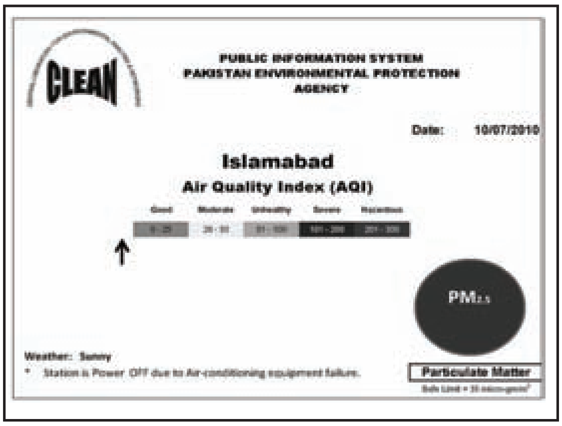
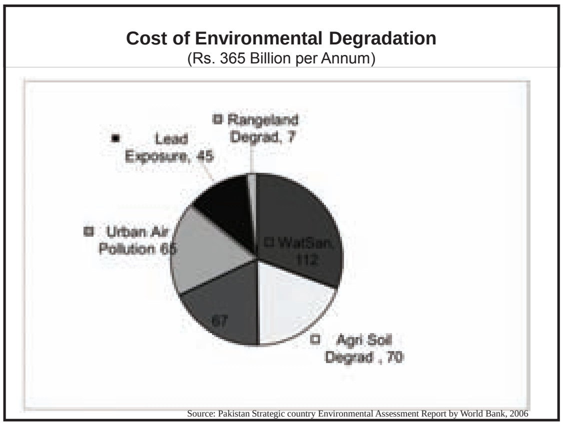










Health Impacts of Particulate Matter in Air

Health End-Points	Attributed Total Cases
Premature mortality adults	21,791
Mortality children under 5yrs	658
Chronic Bronchitis	7,825
Hospital Admissions	81,312
Emergency room visits/ outpatient hospital visits	1,595,080
Restricted activity days	81,541,893
Lower respiratory illness in children	4,924,148
Respiratory symptoms	706,808,732

Source: Pakistan Strategic country Environmental Assessment Report by World Bank, 2006.

Control of Air Pollution
Major Steps Taken

Pakistan Clean Air Program (PCAP) approved by Environment Protection Council

- Clean Fuels
- Unleaded gasoline introduced through out the country
- Phasing out Sulphur in diesel from 1% to 0.5% (achieved) target sulphur 0.05% by 2014 (Euro-II compliant)
- Promotion of CNG in vehicles (more than 2.5 million vehicles converted to CNG) and 3331 CNG stations set up.
- Improved Technology
- Euro II compliant Engines in Vehicles
- Dual Fuel Firing (LPG+ Diesel)
- Phasing out of 2-stroke vehicles

Control of Vehicular Emission….Cont.

- **Vehicle Emission Testing Centers**
  - Pilot Project for improved Motor Vehicle Examination
  - Tune up stations established in different cities with the assistance of UNDP
- **Enforcement of Standards**
  - Various Campaigns were initiated with Traffic Police to check visible smoke of vehicles
  - Environmental squads in Traffic Police.
  - Implementation of National Environmental Quality Standards for industry
- **Establishment of Air Quality Monitoring System**
  - Established continuous Air Quality Monitoring Stations in federal and provincial capitals with the assistance of JICA

Checking of Vehicles

Clean Fuel Program Achievements

2000: Mono grade 87 RON Gasoline introduced in the country by eliminating Super and Regular grades

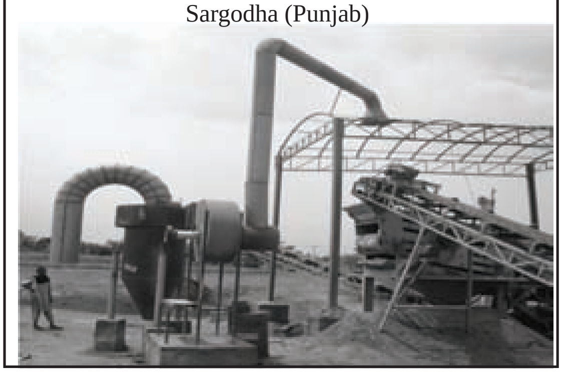
2001: World Bank carried out techno-economic study of clean fuel options

2002: Unleaded gasoline introduced throughout the country

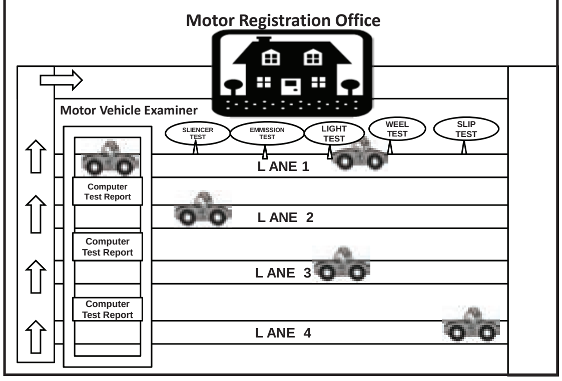
2002: HSD of 0.5 % sulphur was made available

2008: M/o P&NR exercising its power under rule 11 of the Pakistan Petroleum Rules, 1971directed refineries to produce HSD of 0.05% sulphur along with other improved parameters by 1st January, 2011.

Model Dust Control Unit for Stone Crushers in Sargodha (Punjab)



A typical motor vehicle inspection system



Air Quality Monitoring Stations

Challenges & Difficulties

- Communication and Logistical Constraints for Supervising & Monitoring of the Site due to shortage of funds
- Equipment were Showing Sign of Wear – Tear and non-functional.
- High Volume Sampler is not functional due to Unavailability of filter papers.
- Male' station condition was going bad day by day due to unavailability of funds.
- Weak Coordination Among NIA and Expert Institute Nominated for Crop Impact Assessment.

THANK YOU

Air pollutants concentration changes and exposure risk levels in the most important petrochemical complexes zone, Iran

By:
Dr. Mohammad Sadegh Sekhavatjou

Science and Research Branch, Islamic Azad University, Khouzestan
sekhavatjou@gmail.com; m.sekhavatjou@khouzestan.srbiau.ac.ir

Seventh Regional Stakeholders cum Coordination Meeting (RSC7), 18-19 May 2013
Dhaka, Bangladesh

Importance

- Petrochemical industries are the major emission sources of VOCs in the atmosphere.
- It is clear that some of the VOCs have the potential impact on human health and are toxic.
- These pollutants can accumulate in the organisms.
- A lot of petrochemical complexes release high amounts of air pollutants in the atmosphere around the PET Zone, continuously.

Main Goals

- **Determination of Benzene, Hexane, Toluene, Xylene, Phenol, Ethyl Benzene, Ethylene glycol, Formaldehyde, Acetaldehyde concentration in the greatest petrochemical complex zone in Iran (PET Zone)**
- **Determination of Toluene diisosyanate concentration in PET Zone**
- **Determination of Particulate Matter concentration in PET Zone**
- **Determination of Heavy Metals and Hg concentration in PET Zone**
- **Air quality assessment based on results comparison with standard levels**
- **Exposure risk assessment with volatile organic components in this area**

Properties of studied pollutants and their effects

- **Benzene**
- **Toluene**
- **Xylene**
- **Ethyl Benzene**
- **Hexane**
- **Phenol**
- **Trace elements**
- **Ethylene glycol**
- **Formaldehyde**
- **Acetaldehyde**
- **TDI and MDI**
- **Butadiene**
- **PM**
- **Hg**

(Benzene)

- Structural formula: C_6H_6
- Molecular weight: 78.11
- Vapor pressure: 75 mm Hg at 20°C
- Water solubility: 1750 mg/L at 25°C
- Conversion factor:
  1 ppm = 3.24 mg/m3 at 20°C;
  1 mg/m3 = 0.31 ppm;
- Boiling point: 80.1oC at 760 mm Hg
- Taste threshold: 0.5 to 4.5 mg/L
- Odor:
  Lower: 0.84 ppm
  Upper: 53 ppm
- Benzene is rapidly distributed throughout the body after exposure by all routes, and accumulation in fatty tissues is observed
- PEL (permissible exposure limit) TWA = 1 ppm (OSHA, 1987)
- TLV (threshold limit value) TWA = 10 ppm (ACGIH, 1996)

(Toluene)

- Structural formula: C6H5CH3
- Molecular weight: 92.14
- Density: 0.867 g/mL
- Vapor pressure: 28.4 mm Hg at 25 oC
- Water solubility: 0.59 mg/mL at 25 oC
- Conversion factor:
  1 ppm = 3.77 mg/m3,
  1 mg/m3 = 0.265 ppm
  (25 oC, 760 mmHg)
- Chronic inhalation exposure of humans to toluene causes irritation of the upper respiratory tract and eyes, sore throat, dizziness, headache, and difficulty with sleep
- Toluene is absorbed into the blood is distributed throughout the body
- PEL (permissible exposure limit) TWA = 200 ppm (754 mg/m3)
- TLV (threshold limit value) TWA = 50 ppm (189 mg/m3) (ACGIH, 2000)

(Xylene)

- Structural formula: C8H10
- Molecular weight: 106.17
- Vapor pressure: 6–16 mmHg mixtureat 20°C
- Density: 0.864 g/cm3 mixture
- Solubility in water: 130 mg/L mixture
- Conversion factor:
  1 ppm = 4.34 mg/m3; 1 mg/m3 = 0.23 ppm
- Odor threshold in air:
  1.0 ppm mixture
- Xylenes are rapidly absorbed following both inhalation and oral exposure.
- Following absorption, considerable metabolism occurs, with the liver being the primary site of metabolism. Xylenes are distributed throughout the body, but show the greatest affinity for lipid-rich tissues such as the brain.
- Elimination is rapid and occurs primarily in the urine, with the predominant form being the glycine conjugate of methylbenzoic acid (methylhippuric acid).
- PEL (permissible exposure limit) TWA = 100 ppm (OSHA, 2003)

(Ethyl benzene)

- Structural Formula: C_8H_{10}
- Density @ 20 oC (g/mL): 0.867
- Boiling Point (°C): 136.2
- Odor threshold around: 0.5 ppm.
- Possible effects: nearing 100 ppm
- Irritation for 8 hour per day exposures at 100 ppm. Eye irritation at 200 ppm.
- Tolerance can be built at 1000 ppm levels, though first exposure very irritating to eyes.
- Immediate eye irritation at 2000 ppm. 5000 ppm intolerable irritation of eyes, nose and throat, chest constriction, eye irritation, dizziness, effects on blood, liver, and kidneys
- Cancer ranking: EPA does not classify ethyl benzene as a carcinogen
- PEL (permissible exposure limit) TWA = 100 ppm (OSHA, 2003)

(Hexane)

- Structural formula:C_6H_{14}
- Molecular weight: 86.18
- Vapor pressure: 151.3 mm Hg at 20°C
- Water solubility: 1750 mg/L at 25°C
- Boiling point: 68.7°C at 760 mm Hg
- Low level (<50 ppm): Nerve cell death over lifetime exposures.
- Medium level (50 - 500): Evidence of nerve cell death over long term (lifetime) exposures. As concentration increases, less time necessary for nerve cell death to occur. Odor recognition around 130 ppm.
- High level (500 - 1000 ppm): Eye and upper respiratory track irritation. Nerve cell death after a few months exposure.
- Very High level (>1000 ppm): For short time frames (10 minutes) very little effect at 2000 ppm. 5000 ppm for 10 minutes causes dizziness. Some giddiness, nausea, headache, eye and throat irritation. Depression, respiratory arrest, and nerve cell death.
- Cancer ranking: EPA has not classified hexane as a human carcinogen.
- TWA = 50 ppm (NIOSH, 2003)
- TLV (threshold limit value) TWA = 50 ppm (ACGIH, 2003)

(Phenol)

- Structural formula: C6H6O
- Molecular weight: 94.12
- Vapor pressure: 0.3513 mm Hg at 20°C
- Water solubility: 87 mg/L at 25°C
- Conversion factor:
  1 ppm (v/v) = mg/m3 x 0.260
  1 mg/m3 = ppm (v/v) x 3.85
- Boiling point: 181.8oC at 760 mm Hg
- Odor threshold:
  0.047 ppm (0.18 mg/m3) - 100% response
  0.006 ppm (0.02 mg/m3) - sensitive
- Phenol is absorbed by the inhalation, and oral routes. phenol is widely distributed in the body, although the levels in the lung, liver, and kidney are often reported as being higher than in other tissues .
- Elimination from the body is rapid, primarily as sulfate and glucuronide conjugates in the urine.
- Phenol does not appear to accumulate significantly in the body.
- PEL (permissible exposure limit) TWA = 5 ppm (OSHA, 1987)

(Acetaldehyde)

- Structural formula: C2H4O
- Conversion factor:
  1 ppm = 1.80 mg/m3
- Boiling point: 20.8 °C at 760 mm Hg
- Eye contact: Immediately flush the eye with water. Continue for at least ten minutes and call for immediate medical help, since acetaldehyde may burn the eyes.
- Skin contact: Wash off with plenty of water. Remove any contaminated clothing. If the skin reddens or appears damaged, call for medical aid.
- PEL (permissible exposure limit) TWA = 0.75 ppm (OSHA, 1987)
- TLV (threshold limit value) TWA = 0.1 ppm (NIOSH, 2003)

(Formaldehyde)

- Structural formula: H2C=O
- Vapor pressure: 55 mm Hg at 20°C
- Conversion factor:
  1 ppm = 1.23 mg/m3at 20°C;
- Boiling point: 96°C at 760 mm Hg
- TLV (threshold limit value) TWA = 0.3 ppm (ACGIH, 1996)
- Causes burns. Very toxic by inhalation, ingestion and through skin absorption. Readily absorbed through skin. Probable human carcinogen. Mutagen. May cause damage to kidneys, allergic reactions, sensitisation, heritable genetic damage. Lachrymator at levels from less than 20 ppm upwards. Very destructive of mucous membranes and upper respiratory tract, eyes and skin.
- PEL (permissible exposure limit) TWA = 0.75 ppm (OSHA, 1987)

(TDI)

- Structural formula: C9H6N2O2
- Molecular weight: 174.16 g/mol
- Vapor pressure: 0.008 mm Hg at 20°C
- Conversion factor:
  1 ppm = 7.1 mg/m3 at 20°C;
- Boiling point: 251°C at 760 mm Hg
- REL (Reference exposure limit) = 0.07 ppb

- Low level (<0.002 ppm; <0.014 mg/m3) exposures in occupational settings can lead to chronic loss of lung function, including bronchitis or asthma. A higher level (0.002 - 0.02 ppm) of exposure may lead to immune response from repeated exposures. 10 to 20 minute exposures at these concentrations may lead to delayed asthmatic responses in people sensitized to this chemical. Decreased lung function can occur after longer exposures. Even higher exposures, from spills or fires, may lead to neurological problems.
- Cancer ranking: the International Agency for Research on Cancer (IARC) has classified 2,4-toluene diisocyanate as a Group 2B, possible human carcinogen for a variety of tumors.

Material and Methods

- Executive Steps for doing this research
- Determining the sampling stations
- Sampling equipments and necessary materials
- Sampling and analysis methods
- Calculations and exposure risk assessment

Executive Steps for doing research

Site visit of studied area

Executive Steps for doing research

Site visit of studied area

Selection of sampling stations and preparing necessary material and equipments

Executive Steps for doing research

Site visit of studied area

Sampling stations selective and preparing necessary material and equipments

Sampling the ambient air

Executive Steps for doing research

Site visit of studied area

Sampling stations selective and preparing necessary material and equipments

Sampling from air pollutants

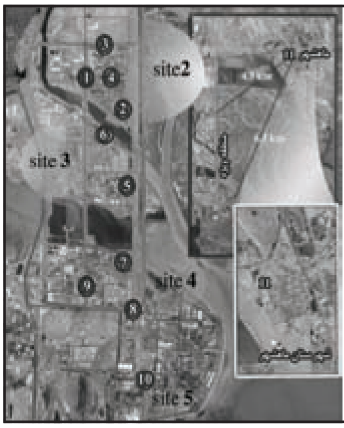
Preparing and extracting the samples

Executive Steps for doing research

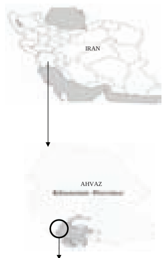
- Site visit of studied area
- Sampling stations selective and preparing necessary material and equipments
- Sampling from air pollutants
- Preparing and extracting of samples
- Determining the air pollutants concentration and comparison with standard levels

Executive Steps for doing research

- Site visit of studied area
- Sampling stations selective and preparing necessary material and equipments
- Sampling from air pollutants
- Preparing and extracting of samples
- Determination of air pollutants concentration and comparison with standard levels
- Exposure risk assessment



Sampling stations in PET Zone along with distance from residential area



PET Zone

2

Sampling stations in PET Zone with distance from emission sources

PET Zone

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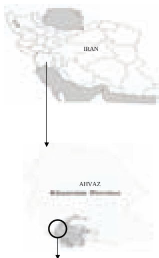
Sampling stations in PET Zone along with distance from emission sources



PET Zone

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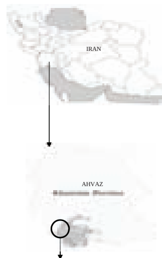
Sampling stations in PET Zone along with distance from emission sources



PET Zone

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Studied parameters

Chemical formula	Pollutant	No.
C_6H_6	Benzene	1
C_7H_8	Toluene	2
C_8H_{10}	Xylene	3
C_6H_{14}	Hexane	4
C_8H_{10}	Ethylbenzene	5
C_2H_6O	Ethylene glycol	6
CH_2O	Formaldehyde	7
C_2H_4O	Acetaldehyde	8
$C_9H_6N_2O_2/CH_3C_6H_3(NCO)_2$	2-4-TDI	9
C_6H_5OH	Phenol	10
$H_2C=CHHC=CH_2$	1-3-Butadieen	11
-	Trace elements	12
Total suspended particle	TSP	13

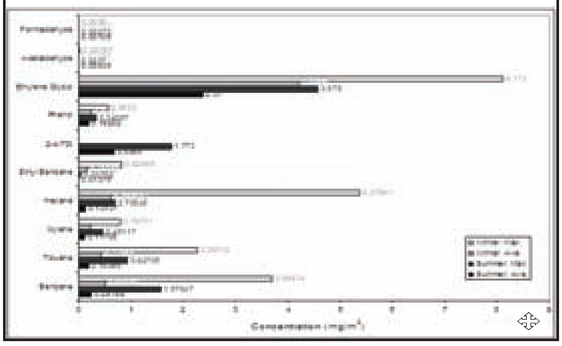
Used sorbents and filters in sampling process

Sampler identification Code	Sampler Type	Pollutant	No.
226-01	Sorbent solid	Benzene	1
226-01	Sorbent solid	Toluene	2
226-01	Sorbent solid	Xylene	3
226-01	Sorbent solid	Hexane	4
226-35-03, 226-57	Sorbent solid	Ethylene glycol	5
226-119	Sorbent solid	Formaldehyde	6
226-119	Sorbent solid	Acetaldehyde	7
225-9002	Coated filter	2-4-TDI	8
226-95, 225-5	Sorbent solid	Phenol	9
226-09	Sorbent solid	1-3-Butadieen	10
-	Filter and on-line system	PM	11

Oven ترازوی دیجیتال

Results

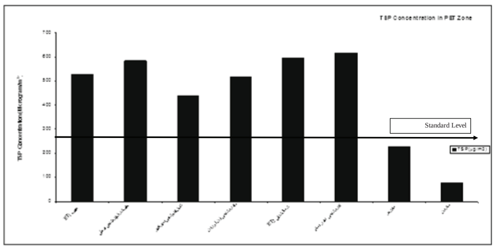
VOCs concentration measurement in PET Zone Results of



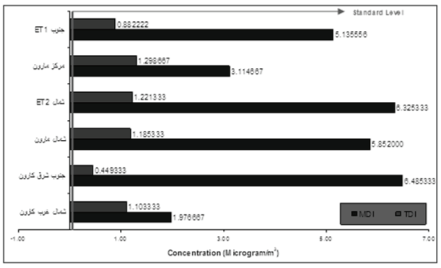
Comparison of the gained results by standard levels (summer 2010)

TDI	Phenol	Ethylbenzene	Xylene	Toluene	Benzene	کد ایستگاه
N.D	0.28341	0.00213	0.00192	0.02167	0.00477	1
1.773	0.34057	0.00235	0.00235	0.02568	0.00588	2
0.666	0.33635	0.02035	0.26705	0.03569	0.05176	3
0.226	0.16875	0.01529	0.04117	0.08253	0.07294	4
0.08	0.094472	0.03759	0.15348	0.34118	0.29411	5
-	0.13659	0.02213	0.46117	0.92705	1.57647	6
-	0.21045	0.01142	0.085314	0.31724	0.23713	7
-	0.08054	0.00505	0.00858	0.00894	0.01176	8
-	0.10421	0.00495	0.01117	0.00423	0.01764	9
-	0.20447	0.00235	0.04117	0.03176	0.05058	10
-	0.16826	0.00729	0.10305	0.05929	0.04480	11
-	0.18864	0.03423	0.22811	0.34638	0.60214	12
0.6866	0.19282	0.01376	0.11705	0.18345	0.24749	Mean
0.00007	0.2	1	0.1	0.3	0.03	Standard

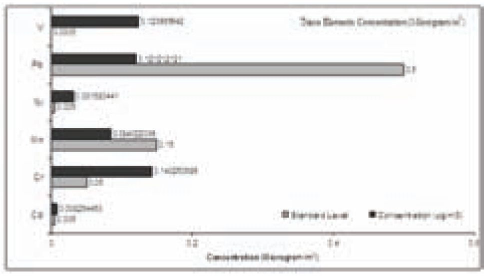
Results of Particulate matter concentration measurement in PET Zone



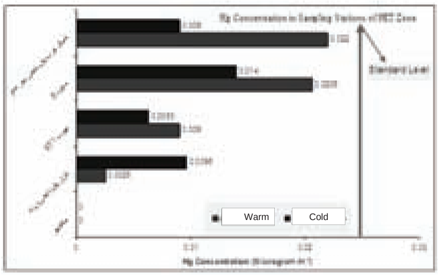
Comparison of the gained results by standard levels



Comparison of the gained results by standard levels



Comparison of the gained results by standard levels



Exposure risk assessment of air pollutants in the studied area

Exposure risk of benzene in the PET zone

Time/Range	Concentration	RFC (mg/m^3)	Current Risk	Allowable risk
Summer, Min	0.00477	0.03	2.69186E-06	1.69299E-05
Summer, Max	1.57647	0.03	0.000889652	1.69299E-05
Summer, Average	0.24749	0.03	0.000139666	1.69299E-05
Winter, Min	0.00723	0.03	3.84011E-06	1.59341E-05
Winter, Max	3.69874	0.03	0.001964532	1.59341E-05
Winter, Average	0.509823333	0.03	0.000270785	1.59341E-05
Total Average	0.378656667	0.03	0.000206628	1.63706E-05

Exposure risk of Ethyle-benzene in the PET zone

Time/Range	Concentration	RFC (mg/m^3)	Current Risk	Allowable risk
Summer, Min	0.00213	1	1.03623E-07	4.86493E-05
Summer, Max	0.03752	1	1.82532E-06	4.86493E-05
Summer, Average	0.013755	1	6.69171E-07	4.86493E-05
Winter, Min	0.00236	1	1.08059E-07	4.57875E-05
Winter, Max	0.82459	1	3.7756E-05	4.57875E-05
Winter, Average	0.159383333	1	7.29777E-06	4.57875E-05
Total Average	0.086569167	1	4.07239E-06	4.7042E-05

Exposure risk of TDI in the PET zone

Time/Range	Concentration	RFC (mg/m³)	Current Risk	Allowable risk
Near Karun Petrochemical	1.22	0.00007	2.61149E-07	1.4984E-11
Near Marun Petrochemical	0.15333	0.00007	3.28213E-08	1.4984E-11
Summer, Average	0.68666	0.00007	1.46984E-07	1.4984E-11

Exposure risk of phenol in the PET zone

Time/Range	Concentration	RFC (mg/m³)	Current Risk	Allowable risk
Summer, Min	0.080548594	0.2	3.1349E-05	7.78388E-05
Summer, Max	0.340573656	0.2	0.000132549	7.78388E-05
Summer, Average	0.192822442	0.2	7.50454E-05	7.78388E-05
Winter, Min	0.062795879	0.2	2.30022E-05	7.32601E-05
Winter, Max	0.562308549	0.2	0.000205974	7.32601E-05
Winter, Average	0.245000511	0.2	8.97438E-05	7.32601E-05
Total Average	0.218911477	0.2	8.23843E-05	7.52672E-05

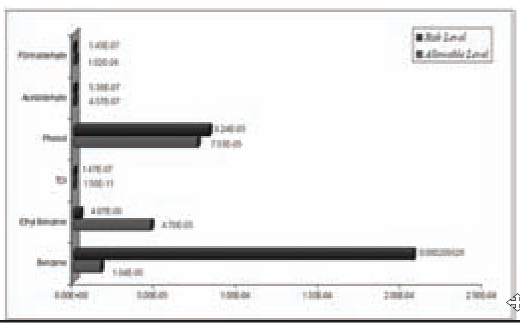
Exposure risk of Acetaldehyde in the PET zone

Time/Range	Concentration	RFC (mg/m³)	Current Risk	Allowable risk
Summer, Min	0.0006	0.009	3.15247E-08	4.72871E-07
Summer, Max	0.021733333	0.009	1.1419E-06	4.72871E-07
Summer, Average	0.008361111	0.009	4.39303E-07	4.72871E-07
Winter, Min	0.000866667	0.009	4.28571E-08	4.45055E-07
Winter, Max	0.027866667	0.009	1.37802E-06	4.45055E-07
Winter, Average	0.012827778	0.009	6.34341E-07	4.45055E-07
Total Average	0.010594444	0.009	5.38255E-07	4.57248E-07

Exposure risk of Formaldehyde in the PET zone

Time/Range	Concentration	RFC (mg/m³)	Current Risk	Allowable risk
Summer, Min	0	0.009	0	1.05082E-06
Summer, Max	0.002733333	0.009	3.19139E-07	1.05082E-06
Summer, Average	0.001059444	0.009	1.23699E-07	1.05082E-06
Winter, Min	0	0.009	0	9.89011E-07
Winter, Max	0.0036	0.009	3.95604E-07	9.89011E-07
Winter, Average	0.001517222	0.009	1.66728E-07	9.89011E-07
Total Average	0.001288333	0.009	1.45454E-07	1.01611E-06

Comparison of studied air pollutants exposure risk by permissible risk levels



Conclusion

It is very important that industrial areas, specially similar to PET - Zone should have comprehensive plan for air pollution control. This plan must include :

- Identification of all emission sources such as stacks, storage tanks, valves, wastewater ponds and etc.
- Measurement of all VOCs and other pollutants such as trace elements and preparing a complete data bank.
- Application of air pollution dispersion and emission modeling in these areas
- Estimating vapor emission from storage tanks and flares.
- Calculation the emission factors for all pollutants from all sources and also determination their emission share.
- Finally, preparing the emission reduction methods for all sources according to each pollutant.

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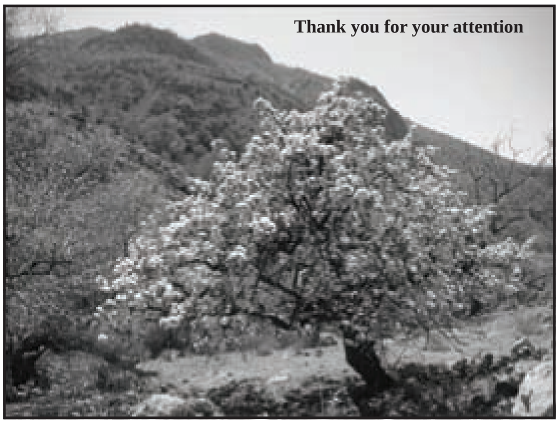

II. Thirteenth Session of the Intergovernmental Meeting

20 May 2013

Thirteenth Session of the Intergovernmental Meeting on the Malé Declaration

REPORT OF THE SESSION

I. INTRODUCTION

1. The Thirteenth Session of the Intergovernmental Meeting (IG13) of the Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia (Malé Declaration) was held in Dhaka, Bangladesh on 20 May 2013.

2. Representatives of the participating counties, namely: Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan, and Sri Lanka participated in the Session. Experts from the following organizations: South Asia Cooperative Environment Programme (SACEP), Stockholm Environment Institute (SEI), United Nations Environment Program (UNEP) Headquarters, Regional Resource Centre for Asia and the Pacific (RRCAP), the regional facilitator and resource persons/experts also attended the Session. The list of the participants is enclosed as Annex I.

Opening of the Session

3. The Session was opened by the Secretariat. Dr. Jonathan Shaw, Deputy Director, RRC.AP delivered the Opening Remarks. He expressed his sincere gratitude to the the Ministry of Environment and Forest (MOEF) and Department of Environment (DOE), Bangladesh for hosting the IG13 and the Seventh Regional Stakeholders cum Coordination Meeting (RSC7). He pointed out that the greatest achievements of the network in 14 years of implementation include: networking, monitoring, emission inventory, impact assessment, regional cooperation, and awareness raising on transboudary air pollution in South Asia.

4. Mr. S.M.D.P. Anura Jayatilake, Director General, South Asia Cooperative Environment Programme (SACEP) delivered the Remarks. He stressed that SACEP will remain a partner and provide continuous support to Malé Declaration. He mentioned that the SACEP Governing Council will push through before the year end and SACEP is preparing for convening the meeting in Pakistan.

5. Mr. Mylvakanam Iyngararasan, Project Coordinator, UNEP Headquarters, in his Opening Remarks, pointed out that the Malé Declaration has already established the foundation for regional cooperation and capacity-building in South Asia. Malé Declaration is one of the few forums that incorporate stakeholders meeting every 2 years to share views and opinions on tackling tranboundary air pollution. He stressed that as per recommendation from the evaluation of the Malé Declaration, the programme should continue. The IG13 will provide guidance on how to proceed. He expressed gratitude to all member countries for their commitments for over a decade and Bangladesh for hosting the IG13 and RSC7.

6. Mr. Raghunathan Rajamani, Regional Facilitator, gave the Introduction and Overview of the Meeting. He briefed the meeting with the Tentative Agenda and the expectation and the outcomes of the meeting. He pointed out that the total ownership of Malé Declaration belongs to the member countries.

7. Mr.Md.Shafiqur Rahman Patwari, Secretary, Ministry of Environment and Forests and chief guest during the opening, welcomed all the participants on behalf of the government of Bangladesh. He commended the progress in four phases of the Malé Declaration and stressed the strong committment of their country in pursuing its success and development. He also mentioned that Bangladesh is a partner to Climate and Clean Air Coaliation (CCAC) and is currently doing the National Action Plan in order to to address the chalenge of Short-Lived Climate Pollutants (SLCPs) issues and problems. In conclusion, he informed that the cabinet of Bangladesh has approved the financial contribution of their government to the Malé Declaration.

8. Mr. Aparup Chowdhury, Additional Secretary, Ministry of Environment and Forests and Chairperson of the IG13, highlighted the outcomes and summary of the RSC7. He pointed out that the Malé Declaration monitoring network has been strengthened in Phase IV. He informed about the inauguration of the Regional Centre on Health Impact Assessment, the National Institute for Preventive and Social Occupational Medicine (NIPSOM), Bangladesh in January 2012.

II. REVIEW OF THE PROGRESS OF MALÉ DECLARATION (Agenda item 1)

9. Ms. Adelaida B. Roman, Head of the Network Component, RRCAP presented the progress under the Phase IV implementation of the Malé Declaration. Summary of the progress under the objectives are as follows:

- *Strengthening regional cooperation:* The Twelfth Session of Intergovernmental Meeting (IG12) and the 6th Regional Stakeholder-cum-Coordination Meeting were held in India in June 2011. The 3rd Meeting of the Task Force on Future Development of MD was held in Thailand in August 2012. The IG12 adopted the Task Force Report on Future Development including its Annexes.
- *Strengthen monitoring capacity:* The 9th Regional Refresher Training Programme was conducted in Delhi, India in December 2012 and provided hands-on training to all participating countries technical staff involved in the programme.
- *Enhance capacity on emission inventory:* The 5thTraining Workshop on Emission Inventory and National Training on Emission Inventory were conducted in Sri Lanka in May 2012.
- *Enhance capacity on air pollution impact assessments*: In order to review the results of the Health Impact Studies in Bangladesh, Nepal and Pakistan, the Workshop on Health Impact Assessment was held in Dhaka, Bangladesh on 9 January 2012. Results of the

Crop Impact Assessment Studies in Nepal and Bhutan were completed in 2012 and presented at IG13.

- *Provide decision support information for policy formulation and air pollution prevention.* "Final Report on Air Pollution Reduction Strategy for Bangladesh" was completed in April 2012. Publication on "Rapid Urban Assessment of Air Quality for Kathmandu, Nepal" was published in 2012 by ICIMOD.
- *Awareness raising*: Issue of newsletter was published in December 2012. The Report on Compendium of Good Practices on Prevention and Control of Air has been updated by the Centre for Environment Education in collaboration with the Secretariat as part of the phase IV implementation of the MD. Regional Workshop on "Youth for Clean Air" was held in February 2012 in Ahmedabad, India.

10. The Session acknowledged the Progress Report as presented (Malé Declaration/IG 13/1). It was concluded that the capacity of member countries to address the transboundary air pollution issues has been improved and enhanced. Member countries were requested to continue the monitoring activities and provide data to the Secretariat for data analysis.

III. REVIEW AND ENDORSEMENT OF THE DATA ANALYSIS REPORT (Agenda item 2)

11. Dr. Parwana Harjinder Kaur, presented the Data Analysis Report in 2012. It focused on data reporting and submission of the monitoring activities of the participating countries for the years 2009-2011. The Data Report Analysis included the following topics: Introduction, Monitoring Program, Results, Conclusions and Recommendations. The monitoring data of India and Pakistan are still to be added in the report.

12. Major discussions included:

- It was pointed out that the countries submission of the data is needed to complete the Data Analysis Report in 2012. Countries that have not submitted the latest monitoring data(including meteorological data) and a brief report explaining the trends and correlating the data to possible emission sources influencing the results, to the Secretariat so far, shall submit the same, right after the meeting.
- Corrective action shall be undertaken so that the report will be comprehensive and complete.
- The representative from Pakistan mentioned that due to amendment in administration, they encountered problems in data collection but positive to submit the data before /by the end of June 2013.
- The representative from Maldives informed that they have not been able to carry out the monitoring during 2009-2011 and thus are unable to submit any data.

- The Draft Data Analysis Report in 2012 will be circulated by the Secretariat to the participating countries to solicit further comments and inputs within the period of two weeks, and not later than the third week of June 2013.

13. Draft Report was endorsed in principle with the suggestion that it will be circulated to the participating countries for further comments.

IV. REVIEW AND DECISION ON THE MALÉ DECLARATION GUIDELINES (Agenda Item 3)

3.1. Draft guidelines for implementation of the sustainable financial mechanism focusing on status of voluntary contribution of member countries

14. The Secretariat presented the Draft guidelines for implementation of the sustainable financial mechanism. The IG13 was requested to discuss, review and provide guidance or make endorsement of the document.

15. Major discussions on the following topics included:

- The voluntary contributions of two member countries (India and Maldives) were fully acknowledged by the meeting. Further, it was mentioned by Indian representative that he will discuss in their Ministry the required contribution amount for India based on UN assessment scale and budget requirements.
- Bangladesh confirmed to give their voluntary contribution to the network as it was already approved by the Bangladesh Cabinet.
- Other countries informed the status of their respective country contribution and will relay further development to the Secretariat.
- It was reiterated that Sida fund was completed in 2012 and countries contribution is crucial for starting next year's implementation of the network activities.
- The meeting expressed gratitude for the countries, which have initiated their voluntary contributions and encouraged others to complete the national process on voluntary contributions. Estimated voluntary contributions are given in the Annex II.

16. The document "Guidelines for implementation of the sustainable financial mechanism" was endorsed by the Session.

3.2. Draft guidelines for the next steps of implementation on strengthening the framework on air pollution reduction in South Asia

17. The Secretariat presented the Draft guidelines for the next steps of implementation on strengthening the framework on air pollution reduction in South Asia. The IG13 was requested to discuss, review and provide guidance or make endorsement of the document.

18. Some major discussions on this topic include:

- There would be some challenging tasks which should be put on the activities, e.g., developing common standards and protocol. Action plan should be considered. Look into available expertise, group and technology, but this could be a long term action.
- Some countries already have standards which are sometimes difficult to implement and enforce, these may be reviewed.
- Suggestion was raised on minimum common standard that could be implemented by the participating countries in a phased manner. Prioritize parameters and make simple standards. Task force will look at this to reach into common standards.
- A country mentioned that they have air quality standards but don't have the capacity to cover all parameters.
- Countries should be grouped and need a substantive roadmap.
- It was also suggested by a country that sea transport has to be included in the priority.
- Standards of countries may vary. It was stressed that it is necessary to select experts to gather data from member countries and reach common standards.
- Common guidelines instead of common standard would be fine as stressed by a country.
- The session agreed to establish an expert group. The expert group will identify key sectors; review exiting guidelines, standards, and available technologies; and propose a roadmap for emission reduction from selective sectors in South Asia.

19. The Session endorsed the "Guidelines for the next steps of implementation on strengthening the framework on air pollution reduction in South Asia", with the understanding that the above agreements will be incorporated in the guidelines.

3.3 Draft guidelines for the operation of the regional centres

20. The Secretariat presented the "Draft guidelines for the operation of the regional centres"**.** The basic function of the regional centre is to exchange knowledge and to support the research and development on air pollution issues in the region on the proposed theme namely: 1) dry and wet deposition monitoring; 2) soil monitoring; 3) vegetation monitoring; 4) corrosion impact assessment; 5) health impact assessment; 6) emission inventory compilation;7) atmospheric transport modeling; and 8) pollution reduction policies/strategies. The IG13 was requested to discuss, review and provide guidance or make endorsement of the document.

21. Major discussions on this topic were as follows:

- A question was raised on the status of other centres since only 3 centres were operational as of this time.
- Regarding the Regional Centre on Pollution Reduction Policies/Strategies (Nepal/Maldives), Maldives informed on lack of expertise on this field but they have interest in joining with Nepal on the activities for this centre.

- Countries were reminded that they shall provide and manage financial support for regional centres and for operation of regional centres, financial support whether from national source or other sources shall be assured and secured.

22. The document "Guidelines for the operation of the regional centres" was endorsed by the Session.

V. REVIEW AND ENDORSEMENT ON THE RESULTS OF THE CROP IMPACT ASSESSMENT STUDIES AND HEALTH IMPACT ASSESSMENT STUDIES (Agenda item 4)

23. Dr. Kevin Hicks, SEI presented the "Assessment of Impacts of Air Pollution on Crops in South Asia with a focus on Tropospheric Ozone". The report has been prepared mostly based on the inputs from the institutes which include: Study in Mymensingh, Bangladesh Agricultural University; Study in Kanglung, Bhutan, Sherubtse College, Royal University of Bhutan; Study in Varanasi, India, Banaras Hindu University; Study in Rampur, Nepal, Institute of Agriculture and Animal Science; Study in Lahore, Pakistan, University of the Punjab; Study in Peshawar, Pakistan, Agricultural University; Study in Peradeniya, Sri Lanka, University of Peradeniya.

24. Major discussions on this topic include:

- It was raised that it could not be induced that only ozone was impacting the study, NOx has also an impact on crop.
- A question was also raised whether the study has incorporated correlation between crop losses and primary production loss which might have impact on local people. It was clarified that there is no correlation.
- Estimate has been done in economic losses.
- It was clarified that for dissemination on the impact study, policy brief/synthesis report which is being developed will cover it.

25. The Session endorsed the report.

VI. GUIDELINES ON THE SYNTHESIS REPORT (Agenda item 5)

26. Dr. Kevin Hicks presented the "Malé Declaration 1998-2013: a Synthesis Progress and Opportunities". This report is being developed by a development team lead by Mr. Lars Nordberg (independent consultant) and comprising the Chair of Task Force on Future Development of Malé Declaration, Regional Facilitator, SEI, UNEP, and Malé Declaration Secretariat with inputs form all the National Implementing Agencies and National Focal Points.

27. Major discussions on the synthesis report include:

a. This is a key report so it should be communicated and disseminated widely.
b. It was suggested to use the recent data.
c. The draft report shall be sent to the member countries for further comments after the meeting. After incorporating the comments, it will be circulated again for approval of the MD countries.

28. The session agreed on the content of the report, in principle with the understanding that the above discussion items will be incorporated.

VII. REVIEW, APPROVAL/ENDORSEMENT OF THE REPORTS DURING THE PHASE IV IMPLEMENTATION ACTIVITIES (Agenda item 6)

6.1 Result of 3rd Inter-laboratory Comparison Programme
6.2 Draft Compendium of Good Practices on Prevention and Control of Air Pollution
6.*3 Standard Operating Procedure Manual*

29. Dr. Sagar Dara presented the Standard Operating Procedures (SOP) Manual for Wet and Dry Deposition Monitoring. This SOP manual has been written to ensure standardization in data collection and handling. This is important as the Malé Declaration Network has eight member nations all with different levels of expertise and capacity. The SOP manual will also ensure QA/QC in the acidic deposition monitoring programme so that it can yield high quality data that are robust enough for policy making.

30. Major discussions include:

a. Countries are requested to look at the 3 draft reports and give comments to the secretariat if there are activities/ which were not reported, etc.
b. The Draft Compendium of Good Practices on Prevention and Control of Air Pollution be available online.
c. There are some discrepancies in the SOP, e.g. on page 25 some parameters should be added.
d. References are necessary in SOP manual.
e. Countries are encouraged to take a careful look at the documents and put all suggestions and submit to secretariat within 2 weeks and will be revised accordingly.

31. The Session endorsed the reports, in principle with the understanding that the above discussion items and further inputs will be incorporated.

VIII. CONSIDERATION OF THE PLAN FOR PHASE V AND THE WORK PROGRAMME OF MD IN 2013 UP TO NEXT IG (Agenda Item 7)

32. Ms. Adelaida B. Roman, RRC.AP presented the Plan for the Phase V Implementation of the Malé Declaration (2014-2016) and the Work Programme in 2013. In her presentation, she slightly briefed the meeting on the result of the evaluation conducted by independent consultant as a requirement by donor agency (Sida).

33. Major discussions on the agenda items include:

a. The meeting acknowledge the satisfactory to highly satisfactory evaluation of the Malé Declaration.
b. On organizational structure, it was confirm by the member countries that the current host of the Secretariat, RRC.AP will continue to function.
c. It was clarified that although funding of the network is from Sida previously, countries had actually guided the functioning of the Malé Declaration. If we need administrative changes, countries have to discuss as the current status is also agreed by countries.
d. There are some queries regarding the Short-lived Climate Pollutants (SLCPs). It was mentioned that on pollutants scope, there will be no change but if it will include SLCPs, it will enable international development to get some funding.
e. A question was raised whether there is there plan of actively involving NGOs, civic organizations, etc. as originally setup.
f. There was a suggestion to include sea transport emission in the future.
g. Some studies like corrosion study, crop study and health impact study were carried out in a few member countries without involvement of scientist from other member countries. Had this been done jointly, more expertise would have been created for regional data collection. This aspect may be considered in future studies.
h. Health impact study for school children needs to be included in the future work plan with enhanced scope covering more cities in the region. Keeping importance of the study, SOP may also be worked out for this activity.
i. There is need to disseminate findings of MD studies to policy makers and general public in member countries through mass awareness activities including organizing targeted seminars/workshops. The MD Secretariat may also publish Synthesis Report for distribution to relevant departments of the member countries
j. Strong linkages need to be established between MD centers and member countries for exchange of information.

34. The Session approved the Plan for Phase V (2014-2016) and the Work Programme in 2013. Table 1- Estimated Countries Contributions for Regional Level Activities in the year 2014-2016 (annual basis), for Phase V implementation was also approved by the Session, attached as Annex II.

IX. SUMMARY AND CLOSING OF THE SESSION

35. Mr. R. Rajamani, the regional facilitator, summed up the session. He expressed his appreciation and personally delighted by the progress and output of the network. He pointed out that the impact studies are very important aspects of implementation of activities. He emphasized that the intention for future plans are already in the right track. He expressed his great satisfaction that countries are slowly internalizing and considering to contribute on the funds for the activities of the Declaration. He expressed appreciation for countries taking deep interest in taking meetings regularly and helped the regional centres and other activities. Finally, he thanked all the participants, Secretariat, all resource persons and especially thanking the local organizer, MOEF and DOE.

36. On behalf of the participants, Mr. J.S. Kamyotra thanked the team from Bangladesh, and Secretariat for promptness and efficient hosting, resource persons for all efforts and sharing their expertise, and all participants for the cooperation. He is positive that all will be able to move forward and he affirmed that activities will be successful.

37. Mr. Chowdhury, Chairperson, gave his final remarks. He expressed his appreciation for the privilege to host the meeting. He especially thanked the regional facilitator, for the efficient conduct of the meeting. The Chairperson closed the Session, thanking all the participants, the Secretariat and the resource persons for the contributions and active participation.

Annex I

List of Participants

Bangladesh Mr. Aparup Chowdhury Additional Secretary Ministry of Environment and Forests Bangladesh Secretariat, Dhaka email: aparup.chy@gmail.com	Mr. Quazi Sarwar Imtiaz Hashmi Director (Planning) & PD, Malé Phase IV Project Department of Environment Paribesh Bhaban Room No. 101, E-16, Agargaon, Sher-E-Bangla Nagar, Dhaka-1207, Bangladesh Fax: 880-2-9118682/ 9113328 (Telefax) Email: quazihashmi@gmail.com
Bhutan Mr. Ugyen Tshering Chief, Adminstrative and finance National Environment Commission Royal Government of Bhutan PO Box 466, Thimphu, Bhutan, Tel: +975-2-323384, 324323 Fax: +975-2-323385 Email: ugyentshering33@yahoo.com	Mr. Sonam Dagay Environment Officer National Environment Commission Royal Government of Bhutan PO Box 466, Thimphu, Bhutan, Tel: +975-2-323384, 324323, 326386 Fax: +975-2-323385 Email: sonamdagay@nec.gov.bt
India Mr. N. A. Siddiqui Under Secretary (CP Division), Ministry of Environment and Forests Lodhi Road, CGO Complex New Delhi-110003, India Email: nasiddiqui@nic.in	Mr. J.S. Kamyotra Member Secretary Central Pollution Control Board Parivesh Bhavan, East Arjun Nagar Delhi 110 032, India Email: jskamyotra.cpcb@nic.in
Iran Mr. Masood Zandi Deputy of Air Pollution Research Bureau Department of Environment Environmental Research Center Hemmat Highway Pardisan Park Tehran, Islamic Republic of Iran Tel: +98-21-8267996 Fax: +98-21-8269920 Email: Zandi740@yahoo.com	Mr. Mohammad Sadegh Sekhavatjou Azad University, Department of Science and Research Group of Engineering Environment Pasdaran Boulevard, Ahvaz City Islamic Republic of Iran Email: sekhavatjou@gmail.com

Maldives Mr Ibrahim Mohamed Deputy Director General Environment Protection Agency P.O Box: 20329, Male', Republic of Maldives. Tel: (960) 333 5949, Fax: (960) 333 5953 Email: Ibrahim.mohamed@epa.gov.mv	 Mr. Hassan Azhar Environment Analyst Environment Department Ministry Environment and Energy Malé, Maldives Tel: +960 3004319 Mob: +960 7930403 Email: Hassan.azhar@environment.gov.mv
Nepal Mr. Teeka Ram Pokhrel Senior Divisional Chemist (Under-Secretary, Tech) Department of Environment Ministry of Science Technology and Environment, Nepal Tel: +977-9841-318052 Email: pokhrelteeka@gmail.com	
Pakistan Mr. Dilshad Babur, Joint Secretary, Ministry of Climate Change Pakistan Phone: 0519245548, Fax: 0519245549 Email: dilshadbabar@hotmail.com	 Mr. Ijlal Hussain, DPM, Pakistan Environment Protection Agency Pakistan Phone: 0519267632 Email: ijlaldpm@gmail.com
Sri Lanka Mr. Ruwan Weerasooriya Air Resource Management & International Relations Division Ministry of Environment & Renewable Energy Sri Lanka Email: dammika100@yahoo.com	 Mr. Rasnayake Mudiyanselage Kulasena Deputy Director, Air Quality Monitoring Central Environmental Authority 104, Parisara Piyasa, Baththaramulla Sri Lanka Tel: +94 0117877282 Fax: +94 0112872605 Mobile: +94 0718188652 Email: kulelab@cea.lk

Resource Persons

Mr. Raghunathan Rajamani Former Secretary, Ministry of Environment & Forestry Government of India 8-2-585/A/1, Road No. 9, Banjara Hills Hyderabad-500034, India Tel: +91-40-2335-8320 Fax: +91-40-2335-5480 Email: 9rajamani@gmail.com	Dr. Kevin Hicks Senior Research Fellow Stockholm Environment Institute at York Grimston House (2nd floor) Environment Department University of York, Heslington, YORK YO10 5DD, United Kingdom Tel +44 (0) 1904 432896 ; Fax +44 (0) 1904 432898 Email: kevin.hicks@york.ac.uk
Mr. Mylvakanam Iyngararasan Project Coordinator UNEP Headquarters P.O. Box 30552 (00100), Nairobi, Kenya Tel: +254-20-762-6730 Fax: +254-20-762-3918 Email: Iyngararasan.Mylvakanam@unep.org	Mr. Frank Murray Associate Professor School of Environmental Science Murdoch University Murdoch WA 6150, Australia Tel: 61 8 9360 2501 Email: f.murray@murdoch.edu.au
Dr. Parwana Harjinder Kaur H.No. - 514, SSST Nagar, Rajpura Road Patiala Pb - 147003, India Tel: +91 99 9997 1482 Email: hkparwana@yahoo.com	Mr. Sagar Dhara Cerana Foundation D-101 Highrise Apartments Lower Tank Bund Road, Hyderabad AP 500 080 India Tel: +91 40 2753 6128 Email: sagdhara@gmail.com
Mr. S.M.D.P. Anura Jayatilake Director General South Asia Cooperative Environment Programme (SACEP) #10, Anderson Road, Off Dickman's Road Colombo 05, Sri Lanka Tel: +94-11-255-2761 / 258-9787 Fax: +94-11-258-9369 Email: dg_sacep@eol.lk	
Dr. Ram Lal Verma, Program Officer ABC-Asia Secretariat, Regional Resources Centre for Asia and the Pacific (RRC.AP) 3rd Floor, Outreach Building, P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand Tele: +66 2524 6163, 2516-0110 ext. 6163, Fax: +66 2516-2125 Email: Ramlal.Verma@rrcap.ait.asia	Ms. Suwimol Wattanawiroon Programme Officer EANET Secretariat Regional Resource Centre for Asia and the Pacific (RRC.AP) c/o Asian Institute of Technology P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand Tel: +66 2 524 6244 Fax: +66 2 516 2125 Email: Suwimol.Wattanawiroon@rrcap.ait.asia

RRC.AP Secretariat

Dr. Jonathan Shaw Deputy Director Regional Resource Centre for Asia and the Pacific c/o Asian Institute of Technology, 3rd Floor, Outreach Bldg. P.O. Box 4, Klong Luang, Pathumthani 12120,Thailand Tel. no. +662-524-5365 ; Fax no. +662-516-2125 Email: Jonathan.Shaw@rrcap.ait.asia	Adelaida B. Roman (Ms.) Head, Network Support Component Regional Resource Center for Asia and the Pacific (RRC.AP) c/o Asian Institute of Technology, 3rd Floor, Outreach Bldg. P.O. Box 4, Klong Luang, Pathumthani 12120,Thailand Tel. no. +662-524-5366 ; Fax no. +662-516-2125 Email: Adelaida.Roman@rrcap.ait.asia
Ms. Charina May Lepiten Programme Officer Regional Resource Centre for Asia and the Pacific c/o Asian Institute of Technology P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand Tel: +66 2 516 2124; Fax: +66 2 516 2125 Email: Charina.Lepiten@rrcap.ait.asia	Mr. Ahmed Iftekhar Khan Programme Officer Regional Resource Centre for Asia and the Pacific c/o Asian Institute of Technology P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand Tel: +66 2 524 6494; Fax: +66 2 516 2125 Email: Ahmed.Khan@rrcap.ait.asia
Ms. Woralac Rodsum-ang Administrative Assistant Associate Administrative Regional Resource Centre for Asia and the Pacific (RRC.AP) c/o Asian Institute of Technology P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand Tel: +662-524-5389; Fax: +662-516-2125 Email: bew@rrcap.ait.asia	

Local Participants

Dr. Nurul Quadir Deputy Secretary (Env.- Pollution Control) Ministry of Environment & Forests	Dr. Tarun Kanti Shikder Director Khulna Division Office Department of Environment, Khulna.
Mr. Mahmood Hasan Khan Director (Air Quality Management) Department of Environment, Dhaka.	Representative from Ministry of Foreign Affairs

Mr. Syed Ahmed Kabir Senior Chemist & Incharge Malé Monitoring Station Khulna Division Office Department of Environment, Khulna.	

Local, DOE Secretariat

Mr. Md. Khaled Hasan Deputy Director(Planning) Department of Environment, Dhaka	Mr. Hasan Hasibur Rahman R.O. & Asstt. Coordinator-Admin Department of Environment, Dhaka
Mr. Md. Shah Alam SC. Asstt. Coordinator-Finance Department of Environment, Dhaka	

Annex II

Table1- Estimated Countries Contributions for Regional Level Activities in the year 2014-2016 (Annual Basis)-for Phase V implementation

No.	Name of Country	% in UN Assessment Scale in 2013	% in Malé Declaration (approximate)	Contribution in US Dollars (USD)
1	Bangladesh	0.01	0.87	1,931
2	Bhutan	0.001	0.087	193
3	India	0.666	57.91	128,542
4	Iran	0.356	30.96	68,701
5	Maldives	0.001	0.087	193
6	Nepal	0.006	0.521	1,156.45
7	Pakistan	0.085	7.4	16,426
8	Sri Lanka	0.025	2.174	4,826
Total		1.15	**100**	**221,968**

II. Meeting Documents

Malé Declaration
on Control and Prevention of Air Pollution
and its Likely Transboundary Effects for South Asia

Thirteenth Session of the Intergovernmental Meeting (IG13)
20 May 2013, Dhaka, Bangladesh

Tentative Agenda

Introduction

09:00-10:00	Registration
10:00-10:40	Opening Session
	Opening Remarks by Dr. Jonathan Shaw, Deputy Director, Regional Resource Centre for Asia and the Pacific
	Address by the Chief Guest,Mr.Md.Shafiqur Rahman Patwari,Secretary,Ministry of Environment and Forests
	Introduction to the meeting by Regional Facilitator,Mr. Raghunathan Rajamani, Former Secretary,MOEF, India
	Address by the Chair , Mr.Aparup Chowdhury, Additional Secretary, Ministry of Environment and Forests

Agenda Item 1: Review of the progress of Malé Declaration

10:40-11:00	Review of the progress of Malé Declaration activities in 2012

Agenda Item 2: Review and endorsement of the Data Analysis Report

11:00-11:20	Facilitate discussion and endorsement of the Data Analysis Report during Phase IV
11:20-11:40	*Coffee/Tea Break*

Agenda Item 3: Review and decision on the Malé Declaration Guidelines

11:40- 12:00	Draft guidelines for implementation of the sustainable financial mechanism focusing on status of voluntary contribution of member countries.
12:00-12:30	Draft guidelines for the next steps of implementation on strengthening the framework on air pollution reduction in South Asia
12:30-13:00	Draft guidelines for the operation of the regional centres
13:00-13:30	*Lunch*

Agenda Item 4: Review and endorsement on the results of the crop impact assessment studies and health impact assessment studies

13:30-14:00	Facilitate discussion and endorsement on the results of the crop impact assessment studies and health impact assessment studies

Thirteenth Session of the Intergovernmental Meeting (IG13)
20 May 2013, Dhaka, Bangladesh

Agenda Item 5:	**Guidance on the Synthesis Report**
14:00-14:30	Facilitate discussion and guidance on the Synthesis Report on Malé Declaration
Agenda Item 6:	**Review, approval/endorsement of the reports during the Phase IV implementation activities**
14:30-15:30	i. Result of 3rd Inter-laboratory Comparison Programme ii. Updated Compendium on Good Practices iii. Revised Standard Operating Procedures (SOP)
15:30-16:00	*Coffee/Tea Break*
Agenda Item 7:	**Consideration of the Plan for Phase V and the Work programme of Malé Declaration in 2013 up to next IG**
16:00-16:20	Facilitate discussion and approval for the Plan for Phase V
16:20-16:50	Facilitate discussion and approval the Work Programme for the Malé Declaration implementation in 2013 up to next IG
16:50-17:00	Other Issues
17:00	Closing - Summing up by Regional Facilitator - Closing of the meeting

Thirteenth Session of the Intergovernmental Meeting on
Malé Declaration on Control and Prevention of Air Pollution and
Its Likely Transboundary Effects for South Asia (Malé Declaration)
20 May 2013, Dhaka, Bangladesh

Report on the Progress of Malé Declaration after the Twelfth Session of the Intergovernmental Meeting (IG12)

I. INTRODUCTION

1. This report presents and reviews the progress of Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia (Malé Declaration) activities after the Twelfth Session of the Intergovernmental Meeting (IG12) held in Delhi, India on 30 June 2011.

2. The review is based on the 6 objectives of the Phase IV implementation of the Malé Declaration:

- Strengthen Regional Cooperation for addressing air pollution issues in South Asia;
- Strengthen the air pollution monitoring network and conduct regular monitoring of high quality;
- Enhance the impact assessment capacity of the national institutions and assess the impacts of air pollution and their socio-economic implications in the participating countries;
- Enhance the capacity of National Implementation Agencies (NIAs) to undertake emission inventory and scenario development, atmospheric transfer of pollutants and Integrated Assessment Modelling;
- Assist the member countries of Malé Declaration with the developing air pollution reduction policies and development of a regional framework; and
- Raise awareness for action on air pollution issues through targeted information dissemination.

II. STRENGTHEN REGIONAL COOPERATION AND STAKEHOLDER'S PARTICIPATION UNDER THE MALÉ DECLARATION

II-1 Intergovernmental meeting

3. The IG12 of the Malé Declaration in June 2011 was attended by the representatives of the participating counties, namely: Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan, and Sri Lanka. Experts from the following organizations: South Asia Cooperative Environment Programme (SACEP), Stockholm Environment Institute (SEI), United Nations Environment Program (UNEP) Headquarters and Regional Resource Centre for Asia and the Pacific (RRCAP), and an independent facilitator also attended the Session.

4. The IG12 adopted, with modifications the Report of the Task Force for Future Development (TFFD), and its Annexes which include the Draft Resolutions for Consideration of the Ministerial Level Meeting, the Report on the Sustainable Financial Mechanism, the Feasibility Report on the Establishment of Regional Centres, and the Feasibility Report on Strengthening the Regional Framework on Air Pollution Reduction in South Asia. The Workplan 2012 for Malé Declaration was also adopted by the IG12.

II-2 Ensure Stakeholders Engagement with Intergovernmental Process

5. The Sixth Regional Stakeholders cum Coordination Meeting (RSC6) of the Malé Declaration was held back to back with the IG12 in Delhi, India on 28-29 June 2011 and the Meeting Report was transmitted to all participants after the IG12. The meeting was attended by the Malé Declaration National Focal Points (NFPs) and National Implementing Agencies (NIAs) of the participating countries which include: Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan, and Sri Lanka. Experts from South Asia Cooperative Environment Programme (SACEP), Stockholm Environment Institute (SEI), United Nations Environment Programme (UNEP), UNEP Regional Resource Centre for Asia and the Pacific (UNEP RRC.AP), a resource person from Murdoch University Australia, expert from Swedish Environmental Research Institute Ltd (IVL), Technical Committee Member of the Malé Declaration and an independent facilitator also attended in the meeting.

6. The National Implementing Agencies (NIAs) of the Malé Declaration presented the progress during the Phase IV implementation in their respective countries. Presentations focused on the institutional arrangement under the Malé Declaration, monitoring activities, impact assessment activities, recent measures to control air pollution emissions in the country and the plan for the next 2 years.

II-3 Task Force on Future Development (TFFD) of Malé Declaration

7. The Ninth Session of the Intergovernmental Meeting (IG9) held in 2007 decided the establishment of the Task Force for Future Development of Malé Declaration (TFFD). The TFFD which was established to consider the expansion of the Malé Declaration, submitted to the IG12 its Report on Future Development which included: 1) Draft Resolutions for Consideration of the Ministerial Level Meeting; 2) Report on the Sustainable Financial Mechanism, 3) Feasibility Report on the Establishment of Regional Centres; and 4) Feasibility Report on Strengthening the Regional Framework on Air Pollution Reduction in South Asia. The Report of the TFFD was discussed, reviewed and adopted, with modifications during the IG12.

8. The Third Meeting of the Task Force Task was held on 9-10 August 2012 in Chonburi, Thailand. The objectives of the meeting include, among others, the presentations and discussions on the following guidelines, for submission to the Thirteenth Session of the

Intergovernmental Meeting for its review and guidance: 1) Draft guidelines for implementation of the sustainable financial mechanism of the Malé Declaration; 2) Draft guidelines for the next steps of implementation on strengthening the framework on air pollution reduction in South Asia; 3) Draft guidelines for the operation of the regional centres; 4) Terms of Reference for the Synthesis Report, Plan; 5) Plan for Phase V; and 6) Work Programme in 2013 for the Malé Declaration.

III. STRENGTHEN CAPACITY BUILDING PROGRAMMES INITIATED DURING PHASE IV ON MONITORING

III-1 Continue operation of the monitoring stations

9. NIAs continued the operation of the monitoring sites during the phase IV. The Malé Declaration monitoring network has been strengthened through the addition of new sites in India (4 new sites) and Iran (1 site), which have been mostly funded by in-kind contributions from those countries. Training for the enhancement of capacity for technicians in charge of the monitoring site/s in each of the member countries is being continued. The results will be presented and discussed during the 9th Refresher Training to be held in India in October 2012. The Malé Declaration had improved the operation of the established monitoring stations by site audits and on- site training.

III-2 Implementation of inter-laboratory comparison

10. Dr. Nguyen Thi Kim Oanh, Asian Institute of Technology, Thailand submitted to the Secretariat the “Draft Report of the Inter Laboratory Comparison of Precipitation Chemistry Analyses of the Malé Declaration” in May 2012. The report was based on the analytical results of the artificial rain water samples from the NIAs. This is the third attempt of the inter-laboratory comparison project which involves a round-robin analysis of uniformly prepared artificial rainwater samples by the NIA laboratories of the Malé Declaration. The result of the third inter-laboratory comparison was presented to the 9th Refresher Workshop held in New Delhi, India and to be submitted to the the IG13 for its review, guidance or endorsement.

11. The overall objective of the inter-laboratory comparison is to recognize the analytical precision and accuracy of the data in each participating NIA laboratory and consequently to provide an opportunity to improve data reliability/quality. The protocol highlighting the methodology of this inter-laboratory comparison has been developed based on Quality Assurance/Quality Control (QA/QC) procedure for Malé Declaration network with reference to the inter-laboratory comparison reports of the EANET project. The sample preparation, distribution and analysis with necessary QA/QC are included in the protocol which was circulated and agreed upon by all NIAs in September 2007, i.e. before the inter-laboratory exercise started.

III-3 Regional training programme

12. The 9th Refresher Training on Monitoring Transboundary Air Pollution was held on 10-12 December 2012 in New Delhi, India. The training was organized by the Central Pollution Control Board (CPCB), India which is designated as the Regional Centre on Wet and Dry Deposition Monitoring of the Malé Declaration, in collaboration with the Secreatraiat. The capacity building events initiated in the previous implementation phase of the Malé Declaration are being continued during the Phase IV implementation. Included in the priority areas for capacity building is the Refresher Training on monitoring transboundary air pollution programme which is being held every year.

13. The objectives of this workshop included: to provide hands-on-training on the use of different monitoring and laboratory equipment and enhance knowledge on quality assurance/ quality control aspects; to discuss the progress of the implementation of Malé Declaration monitoring activities during Phase IV; to discuss the plan for Phase V implementation of the Malé Declaration; and to discuss the data submitted by the member countries.

III-4 Central compilation, evaluation, and storage of data

14. Some of the participating countries have submitted their data and related information obtained through the monitoring activities in 2010-2012 to the Secretariat. The Data Analysis Report during Phase IV will be developed based on the data and monitoring information provided by the participating countries. After quality check by the MoC, the data will added to the regional database. The regional database is available online for the NIAs at: http://www.rrcap.unep.org/male/.

IV. ENHANCE THE CAPACITY OF NIAs ON EMISSION INVENTORY, SCENARIO DEVELOPMENT AND INTEGRATED ASSESSMENT MODELING

15. The 5th Regional Training on Emission Inventory and the National Training on Emission Inventory were held in Colombo, Sri Lanka on 23-25 May 2012 and 21-22 May 2012, respectively. The trainings were organized by the Central Environment Authority (CEA), Sri Lanka which serves as the Regional Center on Emission Inventory of the Malé Declaration, and co-organized by the Secretariat.The objective of the trainings were to enhance the capacity and capability of National Implementing Agencies (NIAs) and those involved in the participating countries to undertake emission inventory and scenario development, and integrated assessment modeling.

V. ENHANCE THE ANALYTICAL AND IMPACT ASSESSMENT CAPABILITY AT THE NATIONAL LEVEL

V-1 Assess the socio-economic impact of air pollution on the health of people

16. During the Phase IV implementation of the Malé Declaration, the health impact assessment study which was conducted in Dhaka, Bangladesh during the Phase III implementation was replicated in selected schools in Kathmandu, Nepal and in Islamabad, Pakistan. The objectives of the study are: to a) determine whether there is an association between daily mean PM10 and PM2.5 concentrations and respiratory health and lung function in children in a the selected city; b) quantify the relationship; and c) assess the scale and severity of impacts of air pollutants. This assessment can address the need for information on the effects of air pollutants on health in South Asia at the high concentrations commonly found in large cities, and provide locally-gathered evidence to support actions by governments to control particulate emissions.

17. In order to review the results of the study, the Workshop on Health Impact Assessment was held in Dhaka, Bangladesh on 9 January 2012. The training was attended by health and air quality experts from Nepal, Pakistan and Bangladesh who are involved in health impact studies and air pollution related activities, a resource person from Murdoch University, Australia and representatives from the Malé Declaration Secretariat from the Asian Institute of Technology (AIT) United Nations Environment Programme (UNEP) Regional Resource Center for Asia and the Pacific (RRC.AP).

18. The training was hosted by the National Institute for Preventive and Social Occupational Medicine (NIPSOM), the selected regional center on Health Impact Assessment for South Asia under the Malé Declaration.

19. The Final Health Impact Studies conducted by Bangladesh, Nepal and Pakistan will be presented to IG13 for its review and endorsement.

V-2 Crop Impact Assessment Studies

20. Nepal has conducted the crop impact study titled **"** *Assessing The Impact Of Ambient Ozone On Growth And Yield Of Mungbean Under Rampur, Chitwan Condition".* The experiment was carried out at the Institute of Agriculture and Animal Science (IAAS) Rampur, Chitwan. The location falls in inner Terai region of Nepal. The study was conducted from April, 2012 to July 2012.

21. Bhutan also conducted the cop impact study titled "Quantifying the impact of tropospheric ozone on spinach using protective chemical (EDU), Kanglung Bhutan*"*. The main objective of the study was to qualitatively and quantitatively assess the impact of ozone, expressed as foliar injury and biomass reduction, on **spinach** using the anti-ozonant ethylenediurea (EDU).

VI. PROVIDE DECISION SUPPORT INFORMATION FOR POLICY FORMULATION AND AIR POLLUTION PREVENTION

22. In response to a call by the Department of Environment (DOE) of the Government of Bangladesh, the "Final Report on Air Pollution Reduction Strategy for Bangladesh' was completed by Bangladesh in April 2012. The report describes the current state of air quality, major sources of air pollution, past policies implemented and suggests future strategies to reduce air pollution in Bangladesh. Around 50 strategies were initially selected, of which 26 are finally recommended after evaluation of the strategies. The criteria for evaluation were likely impact, time to introduce, time to benefits, technical and implementation effectiveness, cost effectiveness and co-benefits. The recommended strategies are presented in the report. The strategy choices were based on a *qualitative* multi-criteria evaluation because of lack of information for quantitative benefit-cost modeling.

23. The publication on "Rapid Urban Assessment of Air Quality for Katmandu, Nepal" was completed by ICIMOD, NIA, Nepal in 2012. This publication provides a detailed account of the pollution hotspot areas in Kathmandu. This is the first study done using quantitative data to get an overall picture of the major pollutants. Population density and pollution concentration data are overlaid to provide easily understood maps that will be of particular relevance to policy makers. This study provides an example that can be replicated for other cities.

VII. RAISE AWARENESS FOR ACTION THROUGH TARGETED DISSEMINATION

24. The Report on Compendium of Good Practices on Prevention and Control of Air Pollution (first report) was compiled by Prof. Ram M. Shrestha, in collaboration with Malé Secretariat as part of the phase III implementation of the Malé Declaration. This report has been updated by the Centre for Environment Education in collaboration with the Secretariat as part of the phase IV implementation of the Male' Declaration.

25. Raising the awareness of youth on air pollution issues is continued through the activities of the South Asia Youth Environment Network (SAYEN). A national "Youth for Clean Air Awareness Workshop" was held in January 2012 in Dhaka, Bangladesh and the Regional Workshop on "Youth for Clean Air" was held in February 2012 in Ahmedabad, India.

Report on the Progress of

Malé Declaration Activities

in 2010-2012

The Secretariat

Malé Declaration: Phase IV Objectives

1. Strengthen **Regional Cooperation** for addressing air pollution issues in South Asia

2. Strengthen the **air pollution monitoring network** and conduct regular **monitoring of high quality**

3. Enhance the **impact assessment** capacity of the national institutions and assess the impacts of air pollution and their socio-economic implications in the participating countries

4. Enhance the capacity of National Implementing Agencies (NIAs) to undertake **emission inventory and scenario** development, atmospheric transfer of pollutants and Integrated Assessment Modelling

5. Assist the member countries of the Malé Declaration with developing **air pollution reduction policies** and development of a **regional framework**

6. Raise **awareness** for action through targeted information dissemination

Goal: Strengthen Regional Cooperation and Stakeholders' Participation

__Activities:__

- **12th Session of Intergovernmental Meeting (June 2011)**
- **6th Regional Stakeholder-cum-Coordination Meeting (June 2011)**
- **3rd Meeting of the Task Force on Future Development of MD (August 2012)**

The IG12 adopted (with modifications) the Report of the Task Force for Future Development (TFFD), and its Annexes which included:

- **Draft Resolutions for Consideration of the Ministerial Level Meeting**
- **Report on the Sustainable Financial Mechanism**
- **Feasibility Report on the Establishment of Regional Centres**
- **Feasibility Report on Strengthening the Regional Framework on Air Pollution Reduction in South Asia.**

Goal: Strengthen the air pollution monitoring network and conduct regular monitoring of high quality

__Activities:__

- **Continued operation of the monitoring stations**
  - **Additional stations: (India (4 new sites) and Iran (1 site)**
- **Implementation of inter-laboratory comparison**
  - **to recognize the analytical precision and accuracy of data and consequently improve data reliability/quality**
- **9th Refresher Training on Monitoring Transboundary Air Pollution (December 2012)**
- **Central compilation, evaluation, and storage of data**

Goal: Enhance capacity on Emission inventory, scenario development and Integrated Assessment Modelling

__Activities:__

- **5th Regional Training on Emission Inventory**
  (Sri Lanka, May 2012)
- **National Training on Emission Inventory**
  (Sri Lanka, May 2012)

The objective of the trainings were to enhance the capacity and capability of NIAs and those involved in the participating countries to undertake emission inventory and scenario development, and integrated assessment modeling.

Goal: Enhance analytical and impact assessment capability

__Activities:__

- **Health Impact Assessment**
  - The epidemiological study undertaken in Bangladesh investigating the impact of air pollution on school children was expanded to Nepal and Pakistan
  - *The objectives of the study are to: a) determine whether there is an association between daily mean PM10 and PM2.5 concentrations and respiratory health of children; b) quantify the relationship; and c) assess the scale and severity of impacts of air pollutants.*
  - In order to review the results of the study, the **Workshop on Health Impact Assessment** was held in Dhaka, Bangladesh on 9 January 2012.

Goal: Enhance analytical and impact assessment capability

Activities:

➢**Crop Impact Assessment**

- ❖ Nepal: "Assessing the Impact of Ambient Ozone on Growth and Yield of Mungbean under Rampur, Chitwan Condition".
  - o *The study was conducted by the Institute of Agriculture ans Animal Science (IAAS) from April 2012 to July 2012 at the inner Tersi region of Nepal.*
- ❖ Bhutan study: "Quantifying the impact of tropospheric ozone on spinach using protective chemical (EDU), Kanglung, Bhutan"
  - o *The objectives of the study was to qualitatively and quantitatively assess the impact of ozone, expressed as foliar injury and biomass reduction, on spinach using the anti-ozonant ethylenediurea (EDU)..*

Goal: Provide decision support information for policy formulation and air pollution prevention

Activities:

➢**"Final Report on Air Pollution Reduction Strategy for Bangladesh" was completed in April 2012.**

- ❖ *The report describes the current state of air quality, major sources of air pollution, past policies implemented and suggests future strategies to reduce air pollution in Bangladesh*

➢**Publication on "Rapid Urban Assessment of Air Quality for Kathmandu, Nepal" completed in 2012 by ICIMOD.**

- ❖ *The publication provides detailed account of the pollution hotspot areas in Kathmandu.*

Goal: Raise awareness

Activities:

➢The **Report on Compendium of Good Practices on Prevention and Control of Air Pollution** (first report) compiled since phase III implementation of the MD has been updated by the Centre for Environment Education in collaboration with the Secretariat as part of the phase IV implementation of the MD.

➢**Networking with youth**

- ❖ Raising the awareness of youth on air pollution issues is continued through the South Asia Youth Environment Network (SAYEN).
- ❖ A national "Youth for Clean Air Awareness Workshop" was held in January 2012 in Dhaka, Bangladesh and the Regional Workshop on "Youth for Clean Air" was held in February 2012n Ahmedabad, India.

Thank you !!!

Thirteenth Session of the Intergovernmental Meeting on
Malé Declaration on Control and Prevention of Air Pollution and
Its Likely Transboundary Effects for South Asia (Malé Declaration)
20 May 2013, Dhaka, Bangladesh

Draft Guidelines for Implementation of the Sustainable Financial Mechanism of the Malé Declaration

I. Introduction

1. In 1998, UNEP together with the Stockholm Environment Institute (SEI) drew attention to the possibility of the impacts of transboundary air pollution in South Asia. This initiative led to the adoption of the Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia (Malé Declaration). The initiative was funded by the Swedish International Development Cooperation Agency (Sida) as part of the Regional Air Pollution in Developing Countries (RAPIDC) Programme. The validity period for the implementation of Phase IV of the Malé Declaration was extended to 30 September 2013 as per "Amendment to the Agreement between Sweden and UNEP RRC.AP on support to Regional Air Pollution in Developing Countries, Phase IV".

2. As the implementation of the Malé Declaration has progressed a lot, greater involvement of the participating countries is required. A regional framework on air pollution reduction in South Asia could be a logical step towards this end. There is also a need to establish a sustainable financing mechanism to continue the implementation process with the ownership of the member countries.

3. The Twelfth Session of the Intergovernmental Meeting (IG12) of the Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia (Malé Declaration) was held in Delhi, India on 30 June 2011. The Session adopted, with modifications the Report of the Task Force for Future Development (TFFD), and its Annexes which include the Draft Resolutions for Consideration of the Ministerial Level Meeting, the Report on the Sustainable Financial Mechanism, the Feasibility Report on the Establishment of Regional Centres, and the Feasibility Report on Strengthening the Regional Framework on Air Pollution Reduction in South Asia. It was suggested that in the budget under regional level activities, the budget for the operation and activities of the regional centres be included.

4. In accordance with the decision by the IG12 on the Report of the Task force, the draft guidelines for implementation of the financial mechanism was prepared by the Secretariat. The Third Session of the TFFD held in Thailand in August 2012 discussed and made comments on the draft guidelines on financial mechanism. This draft will be submitted to the Thirteenth Session of the Intergovernmental Meeting (IG13) for its review and guidance.

II. Previous Discussions

5. Major discussions during TFFD3 were as follows:

- The meeting appreciated the financial contributions from India and Maldives.
- It was suggested that it would be beneficial and helpful in the national process if the financial contribution will be on an annual basis.
- Some countries expressed that if the word "voluntary" in the financial contribution was mentioned, their government would find it difficult to make contribution to the Malé Declaration. It was clarified, however, that the voluntary financial contribution mechanism is one of the principles adopted by the IG12 in the Task Force Report on Future Development.
- It was agreed that the cover letter on financial contribution will be sent to the participating countries considering their needs at the national level.

III. Next steps of Implementation

6. For the next steps of implementation, the following are proposed to be undertaken:

- All the countries are encouraged to make voluntary contributions for the regional core budget for the success of the network and continue the national activities at the countries' expenses. Countries are encouraged to support the operation of the regional centers that they are hosting.

7. Before the transfer of the money by a participating country, a letter requesting for voluntary contribution will be prepared by the Secretariat and send to the participating countries.

8. The participating countries may transfer the money to the Secretariat via electronic transfer to the following bank account:

<u>Bank Details</u>

Account Name:	**Asian Institute of Technology**
Account No :	10492918
Account Type :	Checking Account
Bank Name :	Citibank, NA
Bank Address :	Citicorp Center, 16th floor 153 East 53rd Street, New York, USA10043
Swift Code :	CITIUS33
ABA :	021000089
Detail of payment:	For UNEP RRC.AP / Malé Declaration

9. The Secretariat will inform the National Focal Points (NFPs) of the Malé Declaration as soon as the transfer to the bank account above has been confirmed.

10. The Secretariat calculated the amount of voluntary contribution of the participating countries on an annual basis as agreed by IG12, in accordance with the latest UN assessment scale burden sharing as presented in Table 1. It is proposed that the contribution will continue in the next 3 years.

11. The possibility of introducing minimum contribution amount from the participating countries should also be explored in the future.

IV. Status of Contribution

12. By the step-wise approach, the countries could start the voluntary contribution to the Malé Declaration.

13. Currently, the 2 countries that already contributed to the Malé Declaration include: India which contributed an amount of US $ 19,439.00 on 19 April 2012, and Maldives which contributed an amount of US $ 251.00 on 16 May 2012.

14. In February 2013, the Secretariat requested the voluntary financial contribution to the budget of the Malé Declaration in 2013 to the participating countries. Bangladesh and Nepal informed that their respective government approved the contribution to the programme.

Table 1. Approximate Country Contributions for Regional Level Activities in the year 2014-2016 (Annual Basis)-for Phase V implementation

No.	Country	% in UN Assessment Scale	% in Malé Declaration (approximate)	Approximate Contribution (USD)
1	Bangladesh	0.01	1.13	2,506
2	Bhutan	0.001	0.11	251
3	India	0.534	60.27	133,782
4	Iran	0.233	26.30	58,373
5	Maldives	0.001	0.11	251
6	Nepal	0.006	0.68	1,503
7	Pakistan	0.082	9.26	20,543
8	Sri Lanka	0.019	2.14	4,759
	TOTAL			**221,968**

DRAFT GUIDELINES FOR IMPLEMENTATION OF THE SUSTAINABLE FINANCIAL MECHANISM OF THE MALÉ DECLARATION

THE SECRETARIAT

INTRODUCTION

❖**IG12 adopted the TFFD Report including the sustainable financial mechanism.**

In accordance with the decision by the IG12 on the Report of the Task force, the draft guidelines for implementation of the financial mechanism was prepared by the Secretariat for discussion and comments of the Third Session of the TFFD and subsequently, for submission to the Thirteenth Session of the Intergovernmental Meeting (IG13) for its review and guidance.

DISCUSSION DURING 3RD TASK FORCE MEETING IN AUG. 2012

- **The meeting appreciated the financial contributions from India and Maldives.**
- **It was suggested that it would be beneficial and helpful in the national process if the financial contribution will be on an annual basis.**
- **Some countries expressed that if the word "voluntary" in the financial contribution was mentioned, their government would find it difficult to make contribution to the Malé Declaration. It was clarified, however, that the voluntary financial contribution mechanism is one of the principles adopted by the IG12 in the Task Force Report on Future Development.**
- **It was agreed that the cover letter on financial contribution will be sent to the participating countries considering their needs at the national level.**

NEXT STEPS OF IMPLEMENTATION

All the countries are encouraged to make voluntary contributions for the regional core budget for the success of the network and continue the national activities at the countries' expenses.

Countries are encouraged to support the operation of the regional centers that they are hosting.

Before the transfer of the money by a participating country, a letter requesting for voluntary contribution will be prepared by the Secretariat and send to the participating countries.

The participating countries may transfer the money to the Secretariat via electronic transfer to the following bank account:

BANK DETAILS

Account Name:	**Asian Institute of Technology**
Account No	**: 10492918**
Account Type	**: Checking Account**
Bank Name	**: Citibank, NA**
Bank Address	**: Citicorp Center, 16th floor 153 East 53rd Street, New York, USA10043**
Swift Code	**: CITIUS33**
ABA	**: 021000089**
Detail of payment:	**For UNEP RRC.AP / Malé Declaration**

The Secretariat will inform the National Focal Points (NFPs) of the Malé Declaration as soon as the transfer to the bank account above has been confirmed.

The Secretariat calculated the amount of voluntary contribution of the participating countries on an annual basis as agreed by IG12, in accordance with the latest UN assessment scale burden sharing as presented in Table 1. It is proposed that the contribution will continue in the next 3 years.

The possibility of introducing minimum contribution amount from the participating countries should also be explored in the future.

CONTRIBUTION

The Secretariat calculated the amount of voluntary contribution of the participating countries on an annual basis as agreed by IG12, in accordance with the latest UN assessment scale burden sharing as presented in Table 1.

It is proposed that the contribution will continue in the next 3 years.

It is suggested that new computation based on 2013 UN assessment scale be used.

STATUS OF CONTRIBUTION

By the step-wise approach, the countries could start the voluntary contribution to the Malé Declaration.

Currently, the 2 countries that already contributed to the Malé Declaration include: India which contributed an amount of US $ 19,439.00 on 19 April 2012, and Maldives which contributed an amount of US $ 251.00 on 16 May 2012.

Thank you!

Thirteenth Session of the Intergovernmental Meeting on
Malé Declaration on Control and Prevention of Air Pollution and
Its Likely Transboundary Effects for South Asia (Malé Declaration)
20 May 2013, Dhaka, Bangladesh

Draft guidelines for the next steps of implementation on strengthening the framework on air pollution reduction in South Asia

I. Introduction

1. The objective the Malé Declaration on Control and Prevention of Air Pollution and Its Likely Tranboundary Effects for South Asia (Malé Declaration) is to aid the process of providing a clean environment through clean air. The Declaration calls for the regional cooperation to address shared local air quality problems and the increasing threat of transboundary air pollution and its possible impacts. Through a process of mutual consultation, the Declaration also calls for the continuation of this process in phases, to formulate and implement national and regional action plans and protocols based on a fuller understanding of transboundary air pollution issues. The Malé Declaration has a yearly session of the Intergovernmental Meeting to discuss the ongoing activities and future programmes to implement the Declaration. Its implementation has been in phases since its adoption in 1998.

2. The Phase IV implementation of the Malé Declaration continued to assist the member countries to strengthen the regional cooperation and monitoring, enhance the impact assessment capacity of the national institutions, and also strengthen the initiatives started in the first three phases. The Twelfth Session of the Intergovernmental Meeting (IG12) held in June 2011 adopted, with modifications the "Report of the Task Force on Future Development of Malé Declaration (TFFD)", and its Annexes which include: the Feasibility Report on Strengthening the Regional Framework on Air Pollution Reduction in South Asia.

3. During the IG12, it was stressed that the regional guidelines/standards be developed on air pollution prevention and control in South Asia. It was pointed out that a legally binding instrument will not be applicable at this point in time. It was mentioned that some agreements/frameworks agree on minimum standards on air pollution.

4. This document was discussed at the Third Meeting of the Task Force on Future Development of the Malé Declaration held in Chonburi, Thailand in August 2012, for submission to the Thirteenth Session of the Intergovernmental Meeting (IG13) for its review and guidance. Since the TFFD3, the document was further elaborated as requested by the Task Force members.

II. Previous Discussions

5. On the "Feasibility Study Report on Strengthening the Regional Framework on Air Pollution Reduction in South Asia", the air quality standards exist for all the member states except for the Maldives. Generally, the Ambient Air Quality Standards are defined in all the member states for sulfur dioxide, carbon monoxide, nitrogen oxide, black smoke, hydrocarbons, nitrogen oxides, suspended particulate matter, lead and ammonia. The criteria for categorization of the pollutants are also more or less the same for all the member states industrial, commercial, residential and sensitive areas. Bhutan, Iran, Maldives and Sri Lanka have established specific emission standards for vehicular emissions. Nepal and Pakistan have defined specific standards for extreme winter seasons, atmospheric washout, natural cleansing, poverty level, and institutional capacities.

6. The Annex 1 highlighted key air pollutants of priority concerns to Malé Declaration member states, quoted from Feasibility Study as mentioned above.

7. The Secretariat made a presentation on the draft guidelines for the next steps of implementation on strengthening the framework on air pollution reduction in South Asia during the TFFD3. Major discussions on this topic were as follows:

   - It was stressed that each country has its own air quality standards and developed based on weather conditions and other consideration for setting the standards in a particular country in the region. Standards implementation has a legal backing and it is important to the countries.
   - It was mentioned that countries could have common guidelines but not common standards.

III. Next steps of activities

8. Based on the IG12 decision, the TFFD shall do the next steps of implementation on strengthening the framework on air pollution reduction in South Asia.

   The following are proposed for the activities on this topic:
   1. Identify the key sectors
   2. Establish expert group for each sector
   3. Review existing standards, guidelines and methodologies for emission control
   4. Develop common standards/protocols/guidelines for emission reduction
   5. Consultation with the Task Force for Future Development (TFFD)
   6. Consultation with the Intergovernmental Meeting (IG)

Identify the key sectors

9. On developing guidelines/standards and protocols, there were suggestions to prioritize by sectors, eg. motor vehicles, industrial sector, and dominant industrial pollutants in the South Asian region. The participating countries shall discuss this matter as a first step.

Establish expert group for each sector

10. Expert group for each sector (e.g. motor vehicle, fuel and industries, etc.) would be established to work on air quality standards and protocols.

Review existing standards, guidelines and methodologies for emission control

11. In order to understand the importance of Malé Declaration for reducing air pollution and its likely trans-boundary effects, it is important to review to review existing standards, guidelines and methodologies for emission control. This will be done as the next step on strengthening the framework of the network. Some reviews were done on "Environment Degradation and Air Pollution in Malé Declaration Member States" in the Feasibility Study on Strengthening the Framework, presented in Annex 1. This could be further consulted.

Develop common standards/protocols/guidelines for emission reduction

12. We could have minimum air quality standards, e.g. automobile, brick kiln, fuels, etc. This would be strengthened by technical assistance of experts on standards and thus enable protocols to be drawn up. This will be left to each country to adopt or amend the protocol to make it more stringent based on national requirements.

Consultation with the Task Force for Future Development (TFFD)

13. Task Force for Future Development (TFFD) which was established to consider the expansion of the Malé Declaration could do recommendations for the study and submit it to the Intergovernmental Meeting (IG).

Consultation with the IG

14. The IG will review the report/result of the study on Malé Declaration submitted by the TFFD. It will discuss, review and make decision on the guidelines for implementation on strengthening framework on air pollution reduction in South Asia.

Annex 1

*Quoted from **MD/IG12/3/5***

FEASIBILITY REPORT ON STRENGTHENING THE REGIONAL FRAMEWORK ON AIR POLLUTION REDUCTION IN SOUTH ASIA

MD/IG12/3/5a. Analysis of Gaps and Weaknesses of the Malé Declaration

I. Introduction

1. This feasibility study has been conducted on the "Malé Declaration on Control and Prevention of Air Pollution and its likely Transboundary Effects for South Asia" to assess the socioeconomic situation of South Asia, the existing situation of air pollution in the countries and region, and the responses of countries to air pollution. It makes recommendations for strengthening the framework for air pollution reduction at regional and national levels in South Asia.

2. The Malé Declaration stated the need for countries to carry forward, or initiate, studies and programmes on air pollution in the member states Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan and Sri Lanka.

3. Since its inception over twelve years ago in 1998, the Malé Declaration and its member countries have carried out a number of projects/ activities for the creation of a meaningful framework to limit air pollution.

4. A greater participation of Malé Declaration member states is required as its implementation progresses. A regional framework is needed for better understanding and cooperation among the Malé Declaration member states, on issues related to air pollution and to effectively implement with shared responsibilities, air pollution reduction measures across the member countries for the protection of environment and safeguarding public health, especially of future generations.

II. Socio-Economic Status of Malé Declaration Member States

5. In order to understand the importance of Malé Declaration for reducing air pollution and its likely trans-boundary effects, it is important to first review the socioeconomic situation of the Malé Declaration member states. This section of the report describes the existing socioeconomic situation of the region and provides a review of the same.

6. South Asian countries with a combined population of roughly 1.6 billion people, have adopted the Malé Declaration. As a low-income region, South Asia is home to half of the world's poor. Traditionally, the South Asian economies are centered on agriculture, however recently manufacturing and services have become major contributing sectors as well. The strong recovery in India and the growth in the economies of Bangladesh and Sri Lanka are the

primary reasons for this economic rebound (World Bank, 2010a). India, as an emerging economy of the world is the dominant political power in the region.

7. The state of education and health in the region leave much to be desired. With the worst score on the Global Hunger Index (GHI)[1], South Asia along with Sub-Saharan Africa suffers from the highest level of hunger (International Food Policy Research Institute, 2010).

III. Environment Degradation and Air Pollution in Malé Declaration Member States

8. Environmental degradation remains a challenge in Malé Declaration member countries. With the projected increase in industrial activity, exponential growth in number of vehicles and population, the contribution of each Malé Declaration member country to regional air pollution will increase over time. India is the biggest energy user, followed by Iran and Pakistan (World Bank, 2010). With increasing urbanization and industrialization, air pollution is an increasing concern in South Asia. Sulfur dioxides, nitrogen oxides and particulate matter (PM) emissions have been rising steadily over past few decades. Owing to economic growth and increasing demand, greenhouse gas emissions have risen in South Asia by about 3.3% annually since 1990. Coal is the main source of energy in the region, followed by natural gas (World Bank, 2010c).

9. **Bangladesh**: Air pollution is one of the major sources of environmental degradation in Bangladesh. There are 3 main causes of air pollution in Bangladesh; these are (1) Vehicular emissions (2) Industrial emission (3) Brick kilns (Ministry of Finance - Bangladesh, 2009). In addition, due to the high density of vehicular traffic and industries in the urban areas of Bangladesh, air pollution is a growing concern for the inhabitants of urban areas. The geographic location coupled with low income and over reliance on climate sensitive sectors makes Bangladesh particularly vulnerable to natural disasters.

10. **Bhutan** is one of the few countries in the world where the environment is still protected. Two main reasons behind Bhutan's envious record of environmental protection are (1) Recent start of the development process and (2) Constitutional protection given to environmental sustainability. The constitution of Bhutan specifically states that at least 60% of Bhutan landmass must be under forest cover at all times. Over the years the government has rigorously followed its policy of environmental sustainability and currently almost 51% of Bhutan's land mass falls into the category of protected areas and forests. Forest fires are the biggest sources of air pollution in Bhutan. Constitutional protections and government efforts have allowed Bhutan to limit air pollution to fairly low levels despite steady economic growth over the last few years.

11. **India:** Rapid growth and industrialization over the last few years has led to some major changes in India's environment. More and more cities are experiencing unhealthy levels of air pollution as a direct consequence of unplanned urbanization and growth in population. A number of reasons have contributed to the sharp rise in air pollution and environmental degradation in India. Some of these include (1) Coal, (2) Oil, (3) Process emissions and (4)

[1] Global Hunger Index (GHI) is a multidimensional statistical tool used to describe the state of hunger in countries. The GHI captures three dimensions of hunger: insufficient availability of calories, shortfalls in the nutritional status of children, and child mortality (IFPRI, 2010).

Traditional sources of energy. Coal is India's most abundant source of energy and currently almost 60% of its commercial energy needs are fulfilled by it. Besides having a very high ash content that is responsible for particulate matter emission, coal is also a large source of sulfur dioxide emission in India because of its high sulfur content. Oil is another major source of pollution emissions in India. Lastly, widespread use of traditional sources of energy such as fuel wood and animal dung has also been contributing to air pollution. Estimates indicate that nearly 3 in 4 rural households depend on traditional sources of energy for cooking, heating etc. (Ministry of Enviornment - India, 2010).

12. **Iran:** Environmental and natural resources have been substantially degraded in Iran over the past few decades due to unsustainable development, inadequate enforcement of environment laws, and overpopulation. Urban areas in particular have had to endure exceedingly unhealthy levels of pollution. This is evident by the fact that schools in Tehran are closed occasionally due to dangerously high levels of air pollution (World Bank, 2010).

13. **Maldives:** is at the forefront of efforts to limit climate change impacts. Located in the Indian Ocean, most of the islands that comprise Maldives are between 1 and 1.5 meters above the sea level. Consequently, if global warming continues at its current pace, most of Maldives will be underwater before 2050 (MDEP, 2008B).

14. **Nepal:** Years of unabated population growth and lack of a stringent pollution regulation and management systems has left a deep imprint on the environment in Nepal. Air quality in both urban and rural areas is deteriorating in the country with Kathmandu in particular being at very high levels of risk. The bowl like topography of the Kathmandu valley restricts air movement, thereby accumulating high levels of dangerous pollutants (UNEP2008 D).

15. **Pakistan:** Air pollution is one of the most pressing concerns for environmental protection agencies in Pakistan. Despite having very low energy consumption in comparison to international standards, air pollution in Pakistani cities is soaring (Khwaja & Khan, 2005). Not able to afford gas or electric stoves and heaters, poor people across the country use firewood to cook food and provide heat during the coldest months of winter. Biomass burning is problematic because of the high level of particulate matter produced as well as carbon monoxide and other harmful gases. The level of particulate matter (PM) in major Pakistani cities is almost 2-3.6 times higher than WHO standards (Shigeta, 2000). Environmental challenges facing Pakistan today are the result of a rapidly growing economy, and also unplanned increases in industrialization and urbanization. Increasing economic growth over the years has resulted in overexploitation of natural resources. In addition, unplanned increases in industrialization are leading to air, water and land pollution all across the country (Ministry of Finance - Pakistan, 2009)

16. **Sri Lanka:** Rapid growth over the last few decades has had a massive impact on the environment in Sri Lanka. Years of development with little regard for the environment has resulted in the forest cover decreasing from 70% in 1900 to less than 20% currently (FAO, 1991). Similarly an increase in the GDP per capita over time has resulted in a rapid increase in the number of motor vehicles in Sri Lanka. This in turn has increased the levels of air pollution, especially in the urban areas. Some of the key sources of air pollution aside from motor vehicles include (1) Open burning of domestic and industrial refuse, (2) Combustion of commercial energy and (3) Indoor cooking using fire wood (York University, 2003).

17. Air pollutants can be transported across state and national boundaries covering a distance from about 100s to a few 1000s of kilometers, therefore pollutants produced by one country can have adverse impacts on the environment of neighboring countries as well. Down-wind areas of the countries are likely to be affected more than the up-wind areas. Especially for landlocked cities, trans-boundary air pollution is an issue that demands critical attention. In this context, the Malé Declaration adopted in 1998 provides the basis for a regional framework for air pollution reduction. Some key air pollutant of priority concerns to Malé member states are described below.

IV. Key Air Pollutants of Priority Concerns to Malé Declaration Member States

Particulate Matter:

18. The suspended particulate matter (SPM) is of great concern in Malé Declaration member states. In most of the Malé Deceleration member countries, the levels of SPM exceed the set national standards and cause severe health impacts and environmental damage. WHO guideline levels of particulate matter (SPM) are exceeded in the air of most megacities in South Asia (Asian Development Bank, 2001).

19. The aggravated condition of SPM in Bangladesh, Bhutan, India, Iran and Maldives is no more a myth. In Bangladesh, the commercial sources include the combustion of fuels for power generation in industrial processes and powering motor vehicles. Another important source is different construction and development works (UNEP, 2008 B). 3 wheeler 2 stroke and 2-wheeler 2 stroke are important emission factors, each emitting 0.75 g/km of PM. The main natural sources of particulate matter in Bangladesh are winds blowing over dry soil, and pollen from trees and flowers. In Bhutan, the SPM are usually emitted during the combustion of biomass fuels and responsible for both indoor and outdoor air pollution. In India, the combustion of fuels in the domestic, industrial and transport sector are the major sources of SPM. Due to dry conditions, natural dust is one of the major sources of SPM both for indoor and outdoor air pollution. In industrial sector, cement sector is a major source of SPM besides the small scale industries like foundry, textile etc. The main source of SPM in Iran is incomplete fuel combustion, almost 79.5% of SPM emissions are due to traffic sector. Another important source is chemical reaction during chemical and industrial processes such as sulfuric acid and crude oil. SPM are also dispersed in the air through grinding and crushing of the materials used in construction and agricultural activities (Zandi, 2008). In Maldives, the particulate matters are usually found in the form of soot and coral dust. The main sources of their emission include the land and sea transport, power generation and construction activities (MDEP.2008 B).

20. The situation is no more different in Nepal and Pakistan regarding SPM but slightly better in Sri Lanka. In Nepal, the major source of SPM is vehicles, especially in Katmandu valley. The average values for PM_{10} fall inthe range of 23 to 295μg/m3 in the core areas with the seasonal variation: higher in dry and lower in the rainy season (ADB and ICIMOD, 2006). Other main sources of SPM in urban areas include the industrial emissions. Very high levels of SPM are emitted from cement, brick, tile and textile factories (National Planning Commission Nepal and IUCN, 1992). In Pakistan, the main sources of SPM are vehicles. Dust due to mobile

sources is mainly responsible for air pollution in Sri Lanka. Annual average ambient PM_{10} level in Colombo over the years have remained relatively within the 72 to 82 ug/m3 range, peaking only in 2001. These values, however, consistently exceeded WHO latest annual guidelines value of 20 ug/m3 for PM_{10}, suggesting very unhealthy situation in relation to the PM pollution in Colombo (MDEP, 2008 A).

Sulfur oxides:

21. The sources of sulfur oxides vary from country to country, for instance in case of Bangladesh, Bhutan, India, Iran, Maldives, Nepal and Pakistan these considerably differ from each other. In Bangladesh, the major sources of emissions ofsulfur Dioxide are vehicles, brick kilns, paper and pulp industries, oil refineries and sulfuric acid production plants. The high emission factors of trucks (1.13 g sulfur dioxide/km), followed by minibuses, diesel powered, indicate that substantial sulfur dioxide emissions come from these sources. The estimated emission levels of SO2 in Bhutan have indicated that major source is households. The petroleum refineries, textiles, pulp & paper and industrial chemicals produce about 87% of sulfur emission in India. The main emission factors for sulfur dioxide are coal, oil and industrial process of paper and pulp, copper, zinc and lead smelting, thermal power plants, oil refineries and sulfuric acid. In Iran, sulfur dioxide is mainly emitted from oil refineries during processing. In Maldives, land transport vehicles largely contribute to the air pollution of the country including sulfur dioxide along with carbon dioxide, carbon monoxide, oxides of nitrogen, lead, particulate matters and volatile organic compounds (MDEP, 2008 B). In Nepal, incomplete combustion of fossil fuels, including petrol, diesel, kerosene and coal produce large amounts of carbon monoxide, sulfur dioxide, oxides of nitrogen and hydrocarbons (National Planning Commission, Nepal and IUCN, 1992). Coal consumption in Pakistan is very low as compared to neighboring countries, so the predominant source of Sulfur Dioxide is vehicular emission. (UNDP, 2006). Other sources of SO2 are vehicles, refuse burning, open dump burning, vehicular automobiles and aircrafts (Pak EPA and UNEP, 2004). In Sri Lanka, SO2 emissions are mainly from industrial activities, especially thermal power plants. Unlike ambient PM10, which was fairly stable within a small range of values, SO2 levels in the Colombo air have shown an increasing trend from 1997 to 2000 and then a general decreasing trend from 2003 (MDEP, 2008 A).

Nitrogen oxides:

22. The sources of nitrogen oxides are also different for MD member countries. In Bangladesh, Nitrogen Oxide is mainly emitted during energy consumption including energy transformation industries, transport and biomass burning. Nitrogen Oxide is also emitted during processing of iron and steel industries. Another major source of nitrogen oxide emission is burning of agricultural residues. In Bhutan, the sector wise emissions estimates of nitrogen oxide indicate that domestic sources are responsible for NO emission. In India, sources of nitrogen oxides emissions are vehicles. In India, the road transport is the main source of nitrogen oxide emissions (7.63 Million Tones/Year) as compared to industry and power sector. The number of vehicles, registered in India was 21 millions in 1990-91 which has grown to around 37 millions by 1996-97 (UNEP, 2008 C). Another important source of nitrogen oxide emission is industrial process, especially the production of nitric acid, used in fertilizer manufacturing. In Iran, the major source of nitrogen oxide is transport, followed by

power plants and industries. In Maldives, the domestic combustions are responsible for nitrogen oxide air pollution. In Nepal, the major nitrogen oxide sources are associated with the combustion of fossil fuels and from fuel combustion in industries, especially cement industry.

23. In any preventive pollution control strategy, “Reduction at Source” is considered to be the very first option. The same needs to be considered for air pollution reduction in Malé member states, to minimize the resulting economical, environmental and health impacts in the region.

- **Draft guidelines for the next steps of implementation on strengthening the framework on air pollution reduction in South Asia**

The Secretariat

1

Introduction

- The objective the Malé Declaration is to aid the process of providing a clean environment through clean air.
- The Declaration calls for the regional cooperation to address shared local air quality problems and the increasing threat of transboundary air pollution and its possible impacts.
- Through a process of mutual consultation, the Declaration also calls for the continuation of this process in phases, to formulate and implement national and regional action plans and protocols based on a fuller understanding of transboundary air pollution issues.

2

IG12 held in June 2011

- Adopted, with modifications the "Report of the Task Force on Future Development of Malé Declaration (TFFD)", and its Annexes which include: the Feasibility Report on Strengthening the Regional Framework on Air Pollution Reduction in South Asia.

3

During the IG12

- It was stressed that the regional guidelines/standards be developed on air pollution prevention and control in South Asia. It was pointed out that a legally binding instrument will not be applicable at this point in time.
- It was mentioned that some agreements/frameworks agree on minimum standards on air pollution.

4

Previous Discussions

- On Feasibility Study Report on Strengthening the Regional Framework on Air Pollution Reduction in South Asia", the air quality standards exist for all the member states except for the Maldives.
- Generally, the Ambient Air Quality Standards are defined in all the member states for sulfur dioxide, carbon monoxide, nitrogen oxide, black smoke, hydrocarbons, nitrogen oxides, suspended particulate matter, lead and ammonia.

5

- The criteria for categorization of the pollutants are also more or less the same for all the member states industrial, commercial, residential and sensitive areas.
- Bhutan, Iran, Maldives and Sri Lanka have established specific emission standards for vehicular emissions.
- Nepal and Pakistan have defined specific standards for extreme winter seasons, atmospheric washout, natural cleansing, poverty level, and institutional capacities.
-

6

3rd Task Force on Future Development Meeting in 2012

- It was stressed that each country has its own air quality standards and developed based on weather conditions and other consideration for setting the standards in a particular country in the region. Standards implementation has a legal backing and it is important to the countries.
- It was mentioned that countries could have common guidelines but not common standards.

7

Next steps of activities

Based on the IG12 decision, the TFFD shall do the next steps of implementation on strengthening the framework on air pollution reduction in South Asia.

The following are proposed for the activities on this topic:

- 1. Identify the key sectors
  2. Establish expert group for each sector
  3. Review existing standards, guidelines and methodologies for emission control
  4. Develop common standards/protocols/guidelines for emission reduction
  5. Consultation with the Task Force for Future Development (TFFD)
  6. Consultation with the Intergovernmental Meeting (IG)

8

Identify the key sectors

- On developing guidelines/standards and protocols, there were suggestions to prioritize by sectors, eg. motor vehicles, industrial sector, and dominant industrial pollutants in the South Asian region. The participating countries shall discuss this matter as a first step.

9

Establish expert group for each sector

Expert group for each sector (e.g. motor vehicle, fuel and industries, etc.) would be established to work on air quality standards and protocols.

10

Review existing standards, guidelines and methodologies for emission control

- In order to understand the importance of Malé Declaration for reducing air pollution and its likely trans-boundary effects, it is important to review to review existing standards, guidelines and methodologies for emission control.
- Some reviews were done on "Environment Degradation and Air Pollution in Malé Declaration Member States" in the Feasibility Study on Strengthening the Framework, presented in Annex 1. This could be further consulted.
-

11

Develop common standards/protocols/guidelines for emission reduction

- MD could have minimum air quality standards, e.g. automobile, brick kiln, fuels, etc. This would be strengthened by technical assistance of experts on standards and thus enable protocols to be drawn up.
- This will be left to each country to adopt or amend the protocol to make it more stringent based on national requirements.

12

Consultation with the Task Force for Future Development (TFFD)

Task Force for Future Development (TFFD) which was established to consider the expansion of the Malé Declaration could do recommendations for the study and submit it to the Intergovernmental Meeting (IG).

13

Consultation with the IG

- The IG will review the report/result of the study on Malé Declaration submitted by the TFFD. It will discuss, review and make decision on the guidelines for implementation on strengthening framework on air pollution reduction in South Asia.

14

Thank you for your attention !!!

15

Thirteenth Session of the Intergovernmental Meeting on
Malé Declaration on Control and Prevention of Air Pollution and
Its Likely Transboundary Effects for South Asia (Malé Declaration)
20 May 2013, Dhaka, Bangladesh

Draft Guidelines for the Operation of the Regional Centres

I. Introduction

1. As the implementation of the Malé Declaration has progressed a lot, greater involvement of the participating countries is required. Moreover, establishing centers at regional and national levels is necessary to sustain the capability building in the region and at the national level. The First Meeting of the Task Force on Future Development (TFFD) of the Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia (Malé Declaration) held on 2-3 August 2010 at Pathumthani, Thailand, agreed on the framework and outline of the feasibility report on the establishment of regional centres.

2. During the Second Meeting of the TFFD which was held on 29-30 November 2010 in Colombo, Sri Lanka, the draft feasibility report on the regional centres was discussed and potential regional centres were identified.

3. The Objectives of the Regional Centre:

- The purpose of a regional centre is to advise on any technical problem faced by a country and provide guidance on the smooth operation of Malé Declaration activities and how to maintain high quality data provision. It will also offer training courses to update and enhance the knowledge and capacity in the field.
- The basic function of a regional centre is to exchange knowledge and to support the research and development on air pollution issues in the region on the proposed theme namely: a) dry and wet deposition monitoring; b) soil monitoring c) vegetation monitoring; d) corrosion impact assessment; e) health impact assessment; e) emission inventory compilation f) atmospheric transport modeling; and g) pollution reduction policies/strategies.

4. The Twelfth Session of the Intergovernmental Meeting (IG12) of the Malé Declaration held in Delhi, India on 30 June 2011 adopted, with modifications the “Report of the Task Force for Future Development (TFFD)”, including the Feasibility Report on the Establishment of Regional Centres, among others.

5. This draft document was discussed at the Third Meeting of the Task Force on Future Development (TFFD3), for submission to the Thirteenth Session of the Intergovernmental Meeting (IG13), for its review and guidance.

II. Previous Discussions

6. The Secretariat made a presentation on the draft guidelines for operation of the regional centres during the Third Meeting of the TTFD (TFFD3). Major discussions are as follows:

- It was clarified that the regional centers would be established in a phase-wise manner as decided by the IG12.
- It was suggested that the selected regional centers shall prepare the work program for the regional centers based on the Terms of Reference (TOR), and submit to IG13.
- The Secretariat will prepare and circulate a template for the preparation of work programme for regional centers.
- Based on the suggestion, a template was prepared and circulated to the participating countries for comments on 9 October 2012 by the Secretariat as presented in Annex 1. Comments received from countries are as follows:
    - *Include a tentative timeframe in the work plan and schedule for reporting (quarterly/half yearly/annually).*
    - *Indicate time needed for preparing of work plan.*
    - *Expectation from the Regional Center. What programs should be followed, e.g. training course, guide program on implementation for modeling, etc.?*

III. Next Steps of Implementation

7. For the implementation, the operation of the regional centres will be in accordance with the decision of the IG12, of which the Terms of Reference is herewith attached as Annex 1. The regional centres in each country were identified by National Focal Points (NFPs) and National Implementing Agencies (NIAs) and designated in terms of the existing expertise. It was suggested that each country could have a maximum of two regional centres only. Accordingly, the IG12 adopted and agreed on the location of regional centers as follows:

a. Regional Centre on Wet and Dry Deposition Monitoring - India
b. Regional Centre on Crops and Vegetation Monitoring - Pakistan
c. Regional Centre on Soil Monitoring - Bhutan
d. Regional Centre on Corrosion Impact Assessment - India
e. Regional Centre on Health Impact Assessment - Bangladesh
f. Regional Centre on Emission Inventories – Sri Lanka
g. Regional Centre on Modelling Atmospheric Transport of Air Pollution - Iran
h. Regional Centre on Pollution Reduction Policies/Strategies –Nepal / Maldives

8. Based on the adoption of the IG12, the selected centres were recognized as the Regional Centre’s of the specified area. The regional centre will work in close collaboration with the Malé Declaration Secretariat. The Regional centre’s will coordinate with the NFPs and NIAs of the country to provide technical support, compile data and information and store it and prepare policy briefs. The other member countries in similar modality have to contact these regional centre’s through their respective national focal point or implementing agency for any query or assistance required on the

subject. This will ensure that the NFP and NIAs in each country can monitor the use of the technical centres.

9. Further, the regional centres will support the development and evaluation of new monitoring technologies, and the development and application of quality assurance/quality control guidelines. Annually the regional centres will brief the Intergovernmental Meeting (IG) on progress. The viable technologies will be adopted during the IG meeting and disseminated to the member countries through the NFPs and NIAs.

IV. Status of Implementation

Regional Centre on Wet and Dry Deposition Monitoring – India

10. Enhancing the capacity to monitor and assess air pollution concentrations and wet deposition levels and trends in each country is one of the major activities of the Malé Declaration. Also, the national level capacity building is one of the key objectives of the network. The capacity building events initiated in the previous implementation phase of the Malé Declaration are being continued during the Phase IV implementation. Included in the priority areas for capacity building is the Refresher training on monitoring transboundary air pollution programme are being held every year.

11. The 9th Refresher Training Course on Monitoring Transboundary Air Pollution was held on 8-12 October 2012 in New Delhi, India. The training was organized by the Central Pollution Control Board (CPCB), India which is designated as the Regional Centre on Wet and Dry Deposition Monitoring of the Malé Declaration. This regional center is already operational.

Regional Centre on Health Impact Assessment - Bangladesh

12. During the Phase IV implementation of the Malé Declaration, the health impact assessment study which was conducted in Dhaka, Bangladesh during the Phase III implementation was also conducted in selected schools in Katmandu, Nepal and Islamabad, Pakistan. Objectives of the study is to a) determine whether there is an association between daily mean PM_{10} and $PM_{2.5}$ concentrations and respiratory health and lung function in children in a the selected city, b) quantify the relationship, and c) assess the scale and severity of impacts. This assessment can address the need for information on the effects of air pollutants on health in South Asia at the high concentrations commonly found in large cities, and provide locally-gathered evidence to support actions by governments to control particulate emissions.

13. In order to review the results of the study, the workshop on Health Impact Assessment was held in Dhaka, Bangladesh on 9 January 2012. The training was attended by health and air quality experts from Nepal, Pakistan and Bangladesh who are involved in health impact studies and air pollution related activities, a resource person from Murdoch University, Australia and the Malé Declaration Secretariat. The training was organized and conducted at the National Institute for

Preventive and Social Occupational Medicine (NIPSOM), Bangladesh which was the selected as Regional Center on Health Impact Assessment, and co-organized by the Secretariat.

14. The inauguration of the *Regional Centre on Health Impact Assessment* was also held on the same day of the training.

Regional Center on Emission Inventory- Sri Lanka

15. The 5th Regional Training on Emission Inventory and the National Training on Emission Inventory were held in Colombo, Sri Lanka on 23-25 May 2012 and 21-22 May 2012, respectively. The trainings were organized by the Central Environment Authority (CEA), Sri Lanka which serves as the Regional Center on Emission Inventory of the Malé Declaration, and co-organized by the Secretariat.

16. The objective of the trainings were to enhance the capacity and capability of National Implementing Agencies (NIAs) and those involved in the participating countries to undertake emission inventory and scenario development, and integrated assessment modeling.

V. Financial Arrangement of the Regional Centres

17. During the IG12, it was clarified that the regional centres are institutions in the countries and have their own operational set-ups. Each centre should develop a proposal in order to mobilise resources.

18. Each country is encouraged to support its respective regional centre and should manage its financial resoures/matters.

19. It was suggested that support from outside donors be sought for the initial establishment and/or operation of the regional centres.

Annex 1

Work Plan for 2013-2015

Name of the Regional Centre

1. Problem identification

This introductory section provides description of the problem, examine the cause, need for the changes. Preferably, the arguments could be supported by qualitative information.

Length: approximately half page

2. Goal & Objectives

This section is a statement of the project goals and objectives.

- Goals: statements of what the project will strive to accomplish, but which are not necessarily measurable.
- Objectives: specific, tangible and generally "measurable" targets or achievements that will help achieve the goals.

Length: approximately half page

3. Description

This section lays out how the project will be set to achieve the stated objectives. The content should include major implementation stages (project phases), activities and time frame (in table format). It should also specify who will be involved in these activities and their respective roles.

Length: half page to one page depending on the complexity of the project.

4. Expected outputs

This section will describe, or provide a bullet point listing of the expected outputs and end deliverables that will result from the project. It should be given for each of the stated objectives.

Length: half page to one page depending on the complexity of the project.

5. Budget

This section should tabulate the required resources (major budget items) for the implementation of the project. It should also identify what required resources are available or should be mobilized.

Length: maximum half page

Annex II

MD/IG12/3/4a. Terms of References (TORs) for Regional Centres adopted by the IG12

Terms of References (TORS) for Regional Centres

MD/IG12/3/4a.1. THE REGIONAL CENTRE ON WET AND DRY DEPOSITION MONITORING

Criterion: The regional centre should have the required capacity (technical experts and experience) and the facilities to conduct dry and wet deposition monitoring.

Mission: To ensure and promote accurate procedures and data on dry and wet deposition monitoring for better control and prevention of air pollution and its likely transboundary effects in South Asia.

Mandate: Compile, evaluate and store data; implement and coordinate quality assurance/quality control (QA/QC) activities; and provide technical support on monitoring wet and dry deposition in South Asia.

Networking: The NIAs and NFPs shall nominate the national centre for dry and wet deposition monitoring. The regional centre shall coordinate among the national level technical centres identified for the implementation of the monitoring activities.

Governance: The regional centre will directly report to the IG and make strategic decisions in consultation with the Malé Declaration Monitoring Committee.

1. To further develop and elaborate the strategy for dry and wet deposition evaluation in the region.
2. To discuss on further direction of dry and wet deposition evaluation and provide guidance on relevant activities based on the strategy.
3. To develop the Technical Manual for dry and wet deposition monitoring in the sub-region.
4. To develop a work programme and report to the IG.

Responsibilities of the National Centre

1. To take charge of developing and/or maintaining the monitoring sites.
2. To collect data and liaise with the regional centre for storage and quality control of data.

MD/IG12/3/4a.2. THE REGIONAL CENTRE ON CROPS AND VEGETATION MONITORING

Criterion: The regional centre should have the required capacity (technical experts and experience) and the facilities to conduct crop and vegetation monitoring to assess the effects of air pollution.

Mission: To ensure and promote accurate procedures and data on crop and vegetation monitoring for better control and prevention of air pollution and its likely transboundary effects in South Asia.

Mandate: Compile, evaluate and store data; implement and coordinate (QA/QC) activities; and provide technical support on crops and vegetation monitoring in South Asia.

Networking: The NIAs and NFPs shall nominate the regional centre for crop and vegetation monitoring. The regional centre shall coordinate among the identified national level technical centres for the implementation of the monitoring activities.

Governance: The regional centre will directly report to the IG Meeting and make strategic decisions in consultation with the Malé Declaration Secretariat.

1. To develop manual of methodologies for crop and vegetation monitoring for Malé Declaration.
2. To revise the technical documents on crop and vegetation monitoring as necessary.
3. To develop a work programme for the implementation of activities on crop and vegetation monitoring and report to the IG.
4. To assess the impacts of relevant air pollutants on crop and vegetation based on available data and other information for the Malé Declaration periodic reports.

Responsibilities of the National Centre

1. To take charge of developing and/or maintaining the monitoring sites.
2. To collect data and liaise with the regional centre for storage and quality control of data.

MD/IG12/3/4a.3. THE REGIONAL CENTRE ON SOIL MONITORING

Criterion: The regional centre should have the required capacity (technical experts and experience) and the facilities to conduct soil monitoring.

Mission: To ensure and promote accurate procedures and data on soil monitoring for better control and prevention of air pollution and its likely transboundary effects in South Asia.

Mandate: Compile, evaluate and store data; implement and coordinate (QA/QC) activities; and provide technical support on soil monitoring in South Asia.

Networking: The NIAs and NFPs shall nominate the regional centre for soil monitoring. The regional centre shall coordinate among the identified national level technical centres for the implementation of the monitoring activities.

Governance: The regional centre will directly report to the IG Meeting and make strategic decisions in consultation with the Malé Declaration Secretariat.

1. To develop manual of methodologies for soil monitoring for Malé Declaration.
2. To map the sensitivity of soil in South Asia to acidic deposition.
3. To revise the technical documents on soil monitoring as necessary.
4. To develop a work programme for the implementation of activities on soil monitoring and report to the IG.
5. To assess the impacts of relevant air pollutants on soil based on available data and other information for the Malé Declaration periodic reports.

Responsibilities of the National Centre

1. To take charge of developing and/or maintaining the monitoring sites.
2. To collect data and liaise with the regional centre for storage and quality control of data.

MD/IG12/3/4a.4. THE REGIONAL CENTRE ON CORROSION IMPACT ASSESSMENT

Criterion: The regional centre should have the required capacity (technical experts and experience) and the facilities to conduct corrosion impact assessment.

Mission: To ensure and promote accurate procedures and data to assess the impact of air pollutants on materials and objects of cultural heritage for better control and prevention of air pollution and its likely transboundary effects in South Asia.

Mandate: Compile, evaluate and store data; implement and coordinate (QA/QC) activities; and provide technical support on conducting corrosion impact assessment in South Asia.

Networking: The NIAs and NFPs shall nominate the regional centre for corrosion impact assessment. The regional centre shall coordinate among the identified national level technical centres for the implementation of the monitoring activities.

Governance: The regional centre will directly report to the IG and make strategic decisions in consultation with the Malé Declaration Secretariat.

1. To develop a work programme on corrosion impact assessments and report to the IG.
2. To develop manual of methodologies for corrosion impact assessment for Malé Declaration.
3. To continue developing capacity of Malé Declaration countries in assessing the impacts of air pollutants on materials and objects of cultural heritage.
4. To continue assisting the countries on collecting environmental data at the required period of time.
5. To analyse collected data and transform it into information for policy makers and the community.
6. To develop data & assessment reports based on gathered data.
7. To facilitate the development of awareness materials in the countries based on updates.

Responsibilities of the National Centre

1. To take charge of establishing and/or maintaining the corrosion monitoring sites.
2. To collect data and liaise with the regional centre for storage and quality control of data.

MD/IG12/3/4a.5 THE REGIONAL CENTRE ON HEALTH IMPACT ASSESSMENT

Criterion: The regional centre should have the required capacity (technical experts and experience) and the facilities to conduct health impact assessments.

Mission: To ensure and promote accurate procedures and data on health impact assessments. To develop capacity within NIAs of the Malé Declaration countries to assess the impacts of air pollutants such as particulate matter and ozone on human health.

Mandate: Compile, evaluate and store data; implement and coordinate (QA/QC) activities; and provide technical support on conducting health impact assessment in South Asia.

Networking: The NIAs and NFPs shall nominate the regional centre for health impact assessment. The regional centre shall coordinate among the identified national level technical centres for the implementation of the assessment activities.

Governance: The regional centre will directly report to the IG and make strategic decisions in consultation with the Malé Declaration Secretariat.

1. To develop a work programme and report to the IG.
2. To continue facilitating the development of networks in all Malé Declaration countries with medical or health institutions having expertise on this type of impact assessment.
3. To develop manual of methodologies for health impact assessment for Malé Declaration countries.
4. To continue developing capacity of Malé Declaration countries in assessing the impacts of air pollutants on human health.
5. To develop data and assessment reports based on gathered data.
6. To analyze collected data and transform it into information for policy makers and the community.
7. To facilitate the development of awareness materials in the countries based on updates.

Responsibilities of the National Centre

1. To take charge of developing and conducting the health impact assessment at the national level.
2. To collect data and liaise with the regional centre for storage and quality control of data.

MD/IG12/3/4a.6. THE REGIONAL CENTRE ON EMISSION INVENTORIES

Criterion: The regional centre should have the required capacity (technical experts and experience) and the facilities to conduct emission inventory.

Mission: To ensure and promote accurate procedures and data on emission inventory for better control & prevention of air pollution and its likely transboundary effects in South Asia.

Mandate: Compile, evaluate and store data; implement and coordinate (QA/QC) activities; and provide technical support to carry out emission inventory in South Asia.

Networking: The NIAs and NFPs shall nominate the regional centre for emission inventory. The regional centre shall coordinate among the identified national level technical centres for the implementation of the inventory activities.

Governance: The regional centre will directly report to the IG and make strategic decisions in consultation with the Malé Declaration Secretariat.

1. To develop a work programme and report to the IG.
2. To continue to improve methodologies mentioned in the Malé Declaration Manual for Emission Inventory Compilation.
3. To facilitate good partnerships with governments and academia in all the Malé Declaration countries on emission inventory activities.
4. To continue to assist the countries in conducting emission inventory compilation and develop emission factor suitable for South Asia
5. To conduct QA on the emission inventories submitted to the centre.
6. To develop accurate regional emission inventories
7. To facilitate the development of online real-time emission inventory.

Responsibilities of the National Centre

1. To take charge of developing and/or maintaining emission inventory activities.
2. To collect data and liaise with the regional centre for storage and quality control of data.

MD/IG12/3/4a.7. THE REGIONAL CENTRE ON MODELING ATMOSPHERIC TRANSPORT OF AIR POLLUTION

Criterion: The regional centre should have the required capacity (technical experts and experience) and the facilities to conduct atmospheric transport modeling.

Mission: To ensure and promote accurate procedures and data on atmospheric transport modeling for better control & prevention of air pollution and its likely transboundary effects in South Asia.

Mandate: Compile, evaluate and store data; implement and coordinate (QA/QC) activities; and provide technical support to run atmospheric transport modeling in South Asia.

Networking: The NIAs and NFPs shall nominate the regional centre for atmospheric transport modeling. The regional centre shall coordinate among the identified national level technical centres for the implementation of the modeling activities.

Governance: The regional centre will directly report to the IG and make strategic decisions in consultation with the Malé Declaration Secretariat.

1. To develop a work programme and report to the IG.
2. To continue to improve methodologies for the Malé Declaration atmospheric transport modeling activities.
3. To continue to assist the countries in conducting atmospheric transport modeling activities.
4. To develop accurate regional atmospheric transport models linked to the regional emission inventory compilation activity.
5. To facilitate good links with air pollution monitoring efforts in all the Malé Declaration countries to promote validation of the results of the atmospheric transport models being developed in the region.

Responsibilities of the National Centre

1. To take charge of developing and/or maintaining atmospheric transport modeling activities.
2. To collect data and liaise with the regional centre for storage and quality control of data.

MD/IG12/3/4a. 8. THE REGIONAL CENTREON POLLUTION REDUCTION POLICIES/STRATEGIES

Criterion: The regional centre should have the required capacity (expertise and experience) for developing and implementing pollution reduction policies/strategies.

Mission: To ensure and promote the best pollution reduction practices, policies and strategies for better control & prevention of air pollution and its likely transboundary effects in South Asia.

Mandate: Compile and update good practices on prevention and control of air pollution in South Asia; facilitate update and monitor progress in the implementation of air pollution reduction policies/strategies in South Asia and assist countries in developing and implementing such in their respective nations.

Networking: Work closely with the other regional technical centres, NIAs & NFPs and the Secretariat; assisted by the regional partners and the Regional Stakeholders' Forum.

Governance: The regional centre will directly report to the IG and make strategic decisions in consultation with the Malé Declaration Secretariat.

1. To develop a work programme and report to the IG.
2. To continue updating the compilation on good practices on prevention & control of air pollution for reference of the Malé Declaration countries.
3. To compile pollution reduction/ strategies developed or implemented by the countries.
4. To assist countries in developing and implementing air pollution reduction strategies.

Responsibility of the National Centre

1. Implement and monitor updates on activities on prevention and control of air pollution at the national level.
2. Liaise with the regional centre for information on good practices.

Draft Guidelines for the Operation of the Regional Centers

The Secretariat

I. Introduction

- As the implementation of the Malé Declaration has progressed a lot, greater involvement of the participating countries is required.
- Moreover, establishing centers at regional and national levels is necessary to sustain the capability building in the region and at the national level.
- The First Meeting of the Task Force on Future Development (TFFD) of the Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia (Malé Declaration) held on 2-3 August 2010 at Pathumthani, Thailand, agreed on the framework and outline of the feasibility report on the establishment of regional centres.

The Objectives of the Regional Centre:

- 3. The purpose of a regional centre is to advise on any technical problem faced by a country and provide guidance on the smooth operation of Malé Declaration activities and how to maintain high quality data provision. It will also offer training courses to update and enhance the knowledge and capacity in the field.
- The basic function of a regional centre is to exchange knowledge and to support the research and development on air pollution issues in the region on the proposed theme namely: a) dry and wet deposition monitoring; b) soil monitoring c) vegetation monitoring; d) corrosion impact assessment; e) health impact assessment; e) emission inventory compilation f) atmospheric transport modeling; and g) pollution reduction policies/strategies.

Second Meeting of the TFFD - TFFD2

- Held on 29-30 November 2010 in Colombo, Sri Lanka, the draft feasibility report on the regional centres was discussed and potential regional centres were identfied

IG12

Held in India on 30 June 2011 adopted, with modifications the "Report of the Task Force for Future Development (TFFD)", including the Feasibility Report on the Establishment of Regional Centres, among others.

Previous Discussion at TFFD3

- It was clarified that the regional centers would be established in a phase-wise manner as decided by the IG12.
- It was suggested that the selected regional centers shall prepare the work program for the regional centers based on the Terms of Reference (TOR), and submit to IG13.
- The Secretariat will prepare and circulate a template for the preparation of work programme for regional centers.
- **Based on the suggestion, a template was prepared and circulated to the participating countries for comments on 9 October 2012 by the Secretariat as presented in Annex 1**

Countries comments on the workplan

- Include a tentative timeframe in the work plan and schedule for reporting (quarterly/half yearly/annually).
- Indicate time needed for preparing of work plan.
- Expectation from the Regional Center. What programs should be followed, e.g. training course, guide program on implementation for modeling, etc.?

II. Next Steps of Implementation

- For the implementation, the operation of the regional centres will be in accordance with the decision of the IG12, of which the TOR is herewith attached as Annex 1.
- The regional centres in each country were identified by NFPs and NIAs and designated in terms of the existing expertise. It was suggested that each country could have a maximum of two regional centres only.

IG12 adopted and agreed on the location of regional centers:

- Regional Centre on Wet and Dry Deposition Monitoring - India
- Regional Centre on Crops and Vegetation Monitoring - Pakistan
- Regional Centre on Soil Monitoring - Bhutan
- Regional Centre on Corrosion Impact Assessment - India
- Regional Centre on Health Impact Assessment - Bangladesh
- Regional Centre on Emission Inventories – Sri Lanka
- Regional Centre on Modelling Atmospheric Transport of Air Pollution - Iran
- Regional Centre on Pollution Reduction Policies/Strategies –Nepal / Maldives

III. Status of Implementation

- As agreed by the IG12, the regional centers will be implemented in a step-wise manner.
- Regional centers that are already started functioning are as follows:

1) Regional Centre on Wet and Dry Deposition Monitoring – India

2) Regional Centre on Health Impact Assessment - Bangladesh

3) ***Regional Center on Emission Inventory- Sri Lanka***

IV. Financial Arrangement of the Regional Centres

- During the IG12, it was clarified that the regional centres are institutions in the countries and have their own operational set-ups. Each centre should develop a proposal in order to mobilise resources.
- Each country is encouraged to support its respective regional centre and should manage its financial resources/matters.
- It was suggested that support from outside donors be sought for the initial establishment and/or operation of the regional centres.

- Thank you for your attention!

Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effect for South Asia

Assessment of Impacts of Air Pollution on Crops in South Asia

with a focus on

Tropospheric Ozone

Final Report

Compiled by Patrick Büker, Stockholm Environment Institute, UK

May 2013

This report has been prepared mostly based on the inputs from the following institutes:

Study in Mymensingh, Bangladesh (Prof. M. A. Sattar, Dr. T. Islam)
Bangladesh Agricultural University, Environmental Science Department, Mymensingh-2202, Bangladesh

Study in Kanglung, Bhutan (Dr. K. Tshering, Dr. M. Pelmo)
Sherubtse College, Royal University of Bhutan, Kanglung, Bhutan

Study in Varanasi, India (Prof. M. Agrawal)
Department of Botany, Banaras Hindu University, Varanasi 221005, India

Study in Rampur, Nepal (Prof. N. Chaudhary, Mr. L. Amgain, Ms. M. Bhattarai)
Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan, Nepal

Study in Lahore, Pakistan (Prof. S.R.A. Shamsi)
The University of the Punjab, Dept. Microbiology and Molecular Genetics, **Quaid-e-Azam Campus,** Lahore, Pakistan.

Study in Peshawar, Pakistan (Dr. M.N. Ahmad)
Agricultural University, Khyber Pakhtun Khwah, Department of Chemistry, Peshawar, Pakistan

Study in Peradeniya, Sri Lanka (Dr. A. Perera)
University of Peradeniya, Department of Chemistry, Peradeniya, Sri Lanka

Secretariat

Regional Resource Centre for Asia and the Pacific (RRC.AP)
Outreach Building, Asian Institute of Technology, P.O. Box 4, Klongluang, Pathumthani 12120, Thailand
http://www.rrcap.ait.asia

Technical Support

Stockholm Environment Institute at York
University of York, Heslington, York, YO10 5DD, UK
http://www.york.ac.uk/sei

Funding

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Crop impact assessment

Malé Declaration Achievements

- New large-scale experimental evidence of effects of air pollutant ground-level (or tropospheric) ozone (O_3) on yield of important South Asian crops, such as Mung bean, spinach, wheat and potato; evidence fits well with modelling-based regional prediction of O_3 concentration fields;
- Wide-spread evidence of plant-damaging concentration levels of ground-level O3 during main growing seasons of important South Asian crops;
- Development of standardized risk assessment methodologies that have been evaluated for their application across the region;
- Increased awareness of the yield-damaging effect of ground-level O3 among policy makers, scientific community and general public through seminars, training workshops and information material (e.g. policy briefs);
- Successful capacity building in the region due to training of numerous junior and senior scientists in application of risk assessment methods;
- Enhanced, institutionalized (e.g. via APCEN network and GAP Forum) cooperation between South Asian, European and North American scientists with active mutual exchange of knowledge and skills;
- A Regional Centre of Crop Impact Assessment is currently being established in Pakistan to oversee coordination, harmonization, quality control and reporting of the Malé Declaration crop impact activities.

Setting the scene

Ground level ozone (O_3) is a secondary air pollutant that is formed by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight. Major sources of NOx and VOC are related to the combustion of fossil fuels, such as in industrial facilities, motor vehicle engines or domestic heating and cooking facilities.

O_3 is arguably the most important atmospheric pollutant causing damage to agricultural productivity across the globe. Foliar damage and reduced yields after exposure to ambient levels of O_3 have been widely reported from Europe, North America as well as – to a lesser extent - South Asia. However, unlike in Europe and North America, prior to the RAPIDC project a standardised methodological approach for the assessment of O_3 impacts on crops had never been applied across South Asia. The RAPIDC crop impact studies aimed at developing and applying such a standardised regional approach to be able to a) identify agricultural regions in South Asia that are at risk of experiencing O_3 impacts on crops and b) quantify the extent of this risk. A pre-condition for this approach was to train local scientists in applying these standardised regional risk assessment methods.

These findings will eventually contribute to the assessment of socio-economic effects of air pollution impacts on crop yields for (small- to large-scale) farmers and hence offer policy makers a methodology to assess the risk of food insecurity and the population's susceptibility to poverty.

Methodological approach

Field experiments to quantitatively assess the effect of ambient O_3 on the nutritionally and economically important crops mung bean, spinach, potato and wheat were carried out in Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka between 2006 and 2012. All these field campaigns were carried out according to crop-specific **standardised protocols** that were specifically developed for the application in South Asia. As such, the results between countries are directly comparable and therefore offer interpretations of the **regional extent** of the threat O_3 poses to crop yields. O_3 concentrations were monitored at all field sites using passive samplers, as were the prevailing meteorological conditions using local weather stations or provided data loggers.

The effect of O_3 on the yield of locally grown crops was quantified using the chemical protectant ethylenediurea ((N-[2-(2-oxo-1- imidazolidinyl)ethyl]-N-phenylurea), abbreviated EDU). EDU is an anti-ozonant that has been used successfully throughout the globe; it suppresses typical O_3-induced biomass reductions. Half of the plants exposed to ambient O_3 were treated with EDU. The biomass difference between EDU-treated and non-treated plants at the final harvest can then be directly attributed to O_3. In addition, foliar injury was recorded weekly during the experiment; this parameter is especially important for leafy crops such as spinach, because leaves with clear damage symptoms are less likely to be sold on markets with direct economic effects for farmers.

Evidence of wide-spread impacts of ozone on crops in South Asia

Regional ozone pollution and prevailing meteorological conditions

Ambient four-weekly mean O_3 concentrations at various experimental sites across South Asia as monitored with passive samplers are presented in Fig 1. Since passive samplers capture both night-time (low O_3 concentrations) and day-time (high O_3 concentrations) periods, peak day-time O_3 concentrations during each four-week passive sampler exposure period will have been much higher than the average recorded here. Generally, O_3 concentrations above 40 ppb are considered as being toxic to plants; as such, Fig. 1 indicates that peak O_3 concentrations during the major South Asian crop growing seasons (Nov. – Jan. and March – June) will have almost certainly been at levels that were toxic to plants (i.e. above 40 ppb).

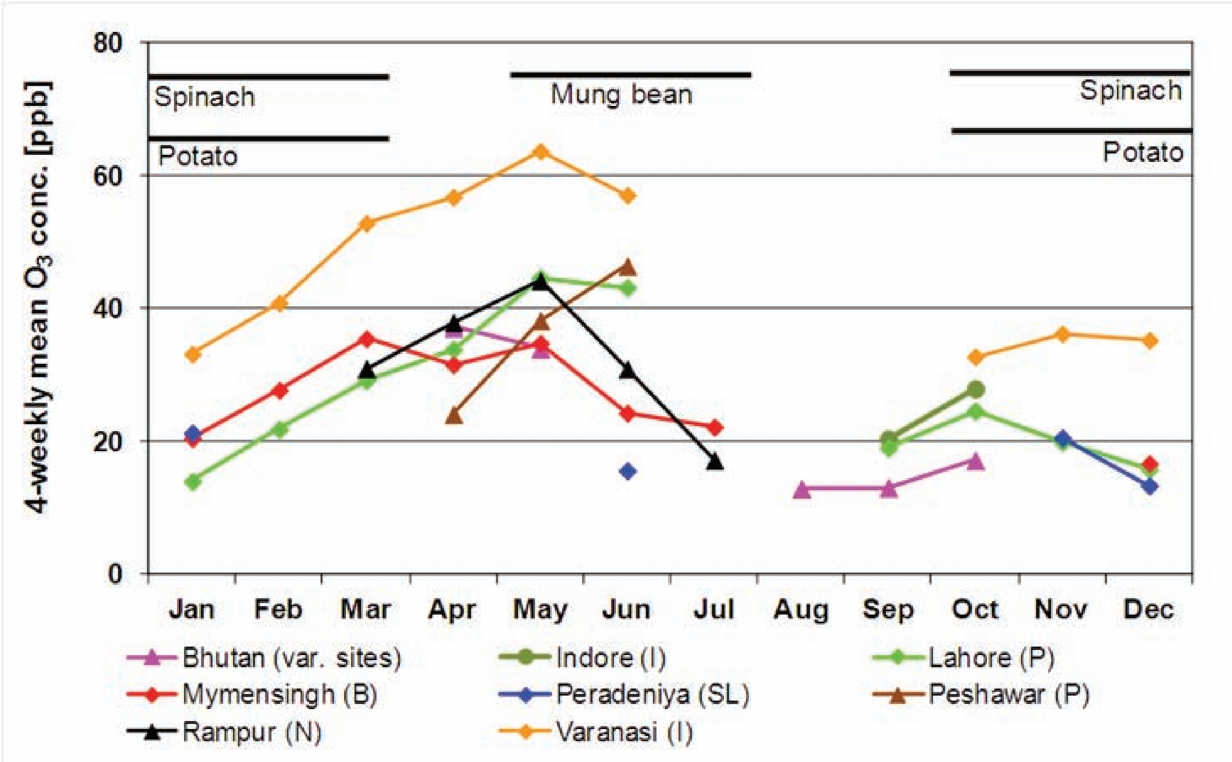

Fig. 1. Four-weekly mean ambient ozone concentration monitored using passive samplers at various sites across the South Asian region.

High air temperatures due to high levels of solar radiation and high levels of air humidity were detected during field campaigns. These meteorological conditions not only favour O_3 formation, but also the plants' uptake of O_3 due to an increased gas exchange at the leaf level in hot and humid conditions. In fact, the experimental sites with the highest temperatures and relative humidity levels experienced the highest levels of O_3 and yield losses (see next section).

Yield losses

Substantial yield losses to mung bean, spinach, potato and wheat were found after exposure of these crops to ambient air at various field sites in six Malé Declaration countries. The extent of these yield losses are presented in Fig. 2 and range from 17 to more than 50% with an average yield loss for mung bean and spinach of 24% and 31% respectively. Please note that with some very few exceptions there is a good match of O_3 concentrations with yield loss levels.

These yield losses are in the range of losses that were reported from other field studies in South Asian countries and that were published in the scientific literature during the last two decades. Yield loss figures of 20 to 30% clearly demonstrate that current ambient levels of O_3 pose already now a threat to crop yields in large parts of South Asia. With O_3 concentrations expected to rise in the region during the next decades, these yield losses might even be higher and more wide-spread in the foreseeable future. Concern also arises from the fact that scientists have found that Asian cultivars of wheat, soybean and rice are in general more sensitive to O_3 as compared to their European and North American counterparts (Emberson et al., 2009),

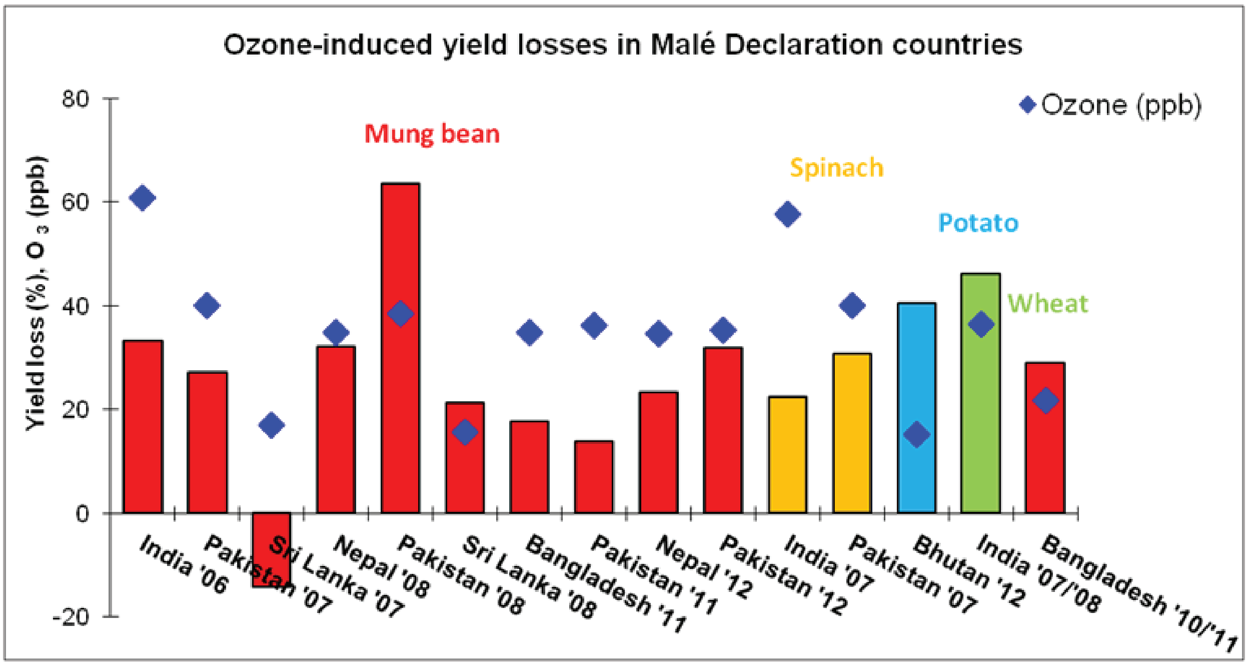

Fig. 2. Ozone-induced yield losses for Mung bean, spinach, potato and wheat in various South Asian countries as recorded during field experiments conducted between 2006 and 2012.

The spatial distribution of yield losses across Malé Declaration countries confirms the results of a modelling-based provisional risk assessment that was performed at an early stage of the RAPIDC programme. Fig. 3 shows the yield losses in relation to O_3 concentrations predicted by the MATCH model and presented as AOT40 (hourly O_3 concentrations Accumulated Over a Threshold of 40 ppb) for the period May, June and July which coincides with the important "pod filling" mung bean growth period. Those areas identified by the modelling study as being at greater risk from prevailing O_3 concentrations correlate well with those sites where statistically significant damage was recorded during the experiments. The sites with the greatest O_3 damage are those in the Indo-Gangetic plain where between 2006 and 2012 robust statistically significant yield losses for mung bean ranged from 23 to 64 %. In contrast, statistically significant yield losses were not recorded in Sri Lanka.

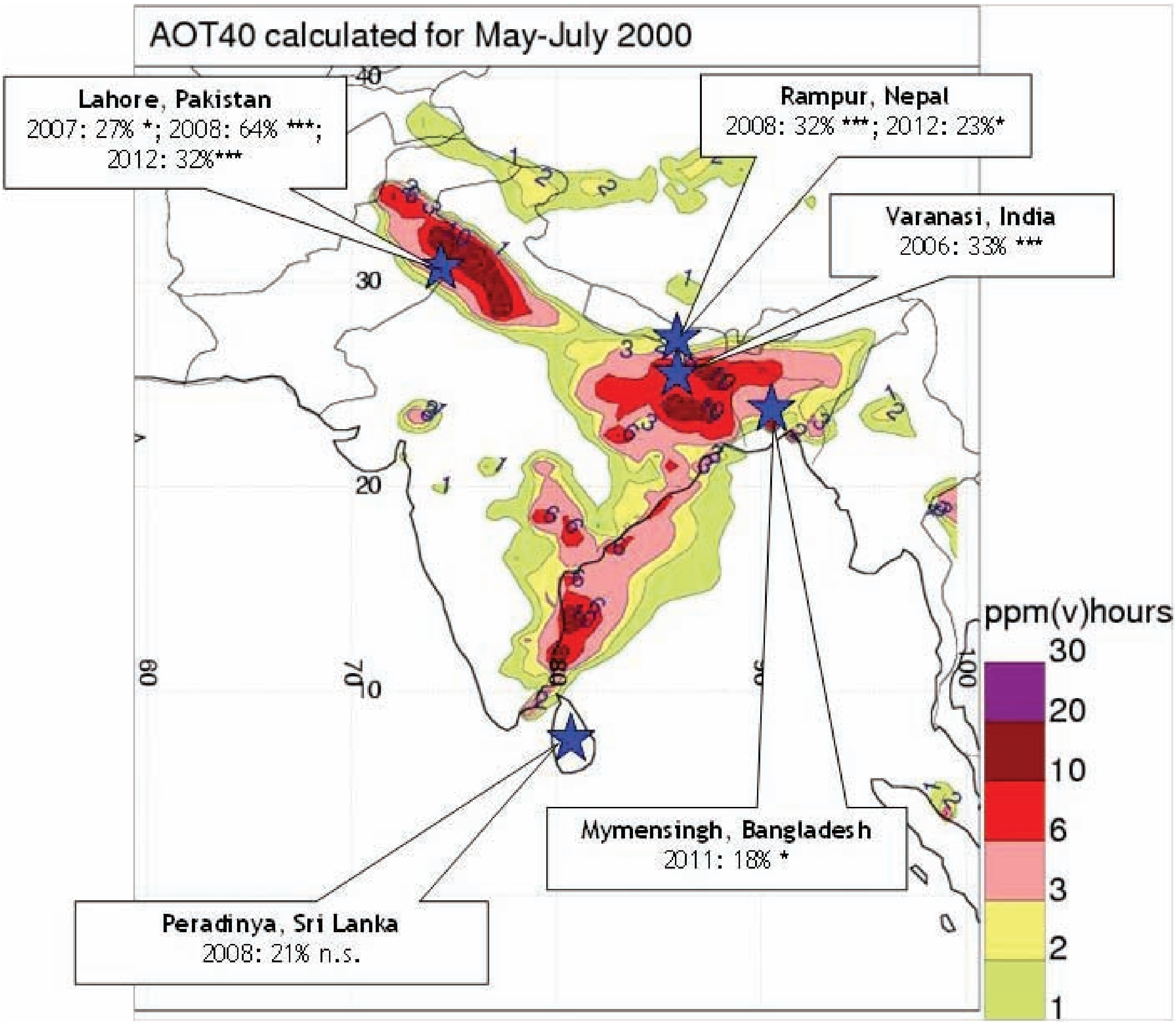

Fig. 3. MATCH modelled O_3 concentrations for the year 2000 presented as 3-month AOT40 values for May to July. Also shown are the results of the EDU chemical protectant study for mung bean (% yield loss) conducted at the South Asian experimental sites (indicated by blue stars) during equivalent months. The significance of the experimental results is presented (n.s. = not significant; * moderately significant and *** highly significant).

Significance of results for Malé Declaration countries

The future sustainability of cereal production in South Asia is rather uncertain. South Asia's Indo-Gangetic Plains benefited from the 1960s Green Revolution. Using improved wheat and rice varieties, irrigation and higher doses of fertilizer, South Asian farmers were able to double rice production and boost wheat output by almost five times in just three decades. However, the area under rice and wheat cultivation has stabilized, and further expansion seems unlikely. In addition, evidence suggests that growth in cereal yields have begun to slow down in many high-potential agricultural areas, with large variability in trends occurring between countries of South Asia. Factors such as soil nutrient mining, declining levels of organic matter, increasing salinity, falling water tables and the build-up of weed, pathogen and pest populations will all have contributed to this decline. Given the magnitude and extent of yield losses found for key crops across the South Asian region in this and other studies, it would seem that O_3 pollution might well be an additional and significant stress on agro-ecosystems. A comprehensive understanding of the relative importance of all stresses facing current and future agricultural production in the South Asian regions is vitally important given the challenge of the region to provide sustainable increases in productivity to balance reduced per capita area harvested.

Global modelling of ground level O3 concentrations (Dentener et al., 2006; Prather et al., 2008) suggests that O_3 concentrations, which are already at concentrations capable of causing yield and productivity losses across many parts of South Asia, will continue to rise over the next decades. This prediction highlights the importance to consider O_3 in future research to assess the effect of multiple-stresses on sustainable crop production across South Asia.

This crop impact assessment programme also provided the Malé Declaration with the opportunity to more closely co-operate with other regional air pollution networks of policy bodies, such as the Global Atmospheric Pollution (GAP) Forum and the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops (ICP Vegetation) of the United Nations Economic Commission for Europe's (UNECE) Convention on Long-Range Transboundary Air Pollution (LRTAP). In fact, an official exchange of letters between the LRTAP Convention and the Malé Declaration on the development of joint programmes and sharing of expertise was initialised in 2007 and further developed ever since. This co-operation for example included the attendance of ICP Vegetation meetings by junior and senior Asian scientists and vice versa to discuss potential future research collaborations.

A substantial number of scientists in the Malé Declaration countries were trained in the application of crop impact assessment at various workshops across the region. Emerging young scientists in all involved countries used the EDU field studies as subject for their MSc and PhD theses and quite a few of them have since pursued a promising career in science. As such, the RAPIDC crop programme has been extremely successful in building capacity in the South Asian region and is expected to benefit from this new capacity in the foreseeable future.

Last but not least, during the RAPIDC programme, the awareness of the threat O_3 poses on crop yields in the South Asian region was raised significantly among policy makers, the scientific community and the general public through public seminars, training workshops and the production of information material (e.g. policy briefs).

Future challenges – knowledge gaps

Although this work has established methods that enable increased understanding of current day air pollution impacts in the Malé Declaration countries, there still remain a large number of future challenges to fill the remaining knowledge gaps, such as a better estimation of the extent of yield losses of staple crops across the entire South Asian region, the differing O_3 sensitivity of common crop cultivars cultivated in the region, the effect of a changing climate on crop growth and eventually a robust estimation of the extent of the socio-economic effects of O_3 and climate change on crop yields for small- to large-scale farmers in the region.

Future assessments related to crop impacts from O_3 would therefore ideally incorporate the effects of climate change, and seek to involve specialists on adaptation options. Ideally, key decision-makers from governments would come together to discuss likely combined impacts, measures to reduce vulnerability of end users, national risk assessments and policy options to reduce the threat from this environmental problem. The opportunity for co-benefits for air pollution and climate change in emission reduction policy is of particular importance in South Asia as well as in other developing regions around the globe.

Future Steps

- Modelling studies to be able to derive dose-response relationships for crops in South Asia.
- Pan-Asian Open Top Chamber (OTC) studies.
- Crop impact studies that account for changing climate (temperature rise and shift of growing seasons).

The Air Pollution Crop Effect Network (APCEN)

During Phase II of the Sida funded Regional Air Pollution in Developing Countries (RAPIDC) Programme the Air Pollution Crop Effect Network (APCEN) network was established to facilitate communication between air quality stakeholders concerned with assessing the risks posed by air pollution to agriculture. The geographical focus of network activities has been developing countries (in particular South Asia and southern Africa), although the 70+ network members (mainly air pollution effects scientists, modellers and policy makers) are located across the globe. The main aims of APCEN are:-

- Capacity building and outreach: Development of experimental protocols for crop impact assessment studies; organisation and facilitation of training workshops; publication of results of impact assessments in reports and peer-reviewed journals.
- Data compilation: Management of data recorded during experimental field campaigns to set RAPIDC work in context of other existing studies.
- Application of modelling methods: Development and test of methodological frameworks for model-based impact assessments.

Three APCEN workshops were held in 2003 (Thailand), 2006 (South Africa) and 2008 (Thailand) to facilitate exchange of information between air pollution effect practitioners and other air pollution stakeholders. In 2010 APCEN co-organised with UNEP and the Global Atmospheric Pollution Forum (GAP Forum) the "Multi-stakeholder policy dialogue: Ground level ozone as a threat to food security in Asia" in Delhi, India. This high-level meeting was attended by ministerial departments (representing the Malé Declaration), science institutes and universities, research funding agencies and UNEP/FAO, and was aimed at assessing the current knowledge on the effect of air pollution on food security in Asia. Detailed seminar conclusions can be found under:
www.sei-international.org/gapforum/reports/Ozone_as_a_threat_to_food_security_seminar_Conclusions.pdf

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Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effect for South Asia

Assessment of Impacts of Particulate Air Pollution on the Respiratory Health of Schoolchildren: Studies in Kathmandu and Islamabad

Frank Murray, Murdoch University, Australia

April 2013

This report has been prepared mostly based on the inputs from the following institutes and the following reports:

PakEPA and PMRC 2013, Final Report: Impacts of Particulate Air Pollution on the Respiratory Health of Schoolchildren in Pakistan. Pakistan Environmental Protection Agency, and Pakistan Medical Research Council, Islamabad, Pakistan.

NHRC and ICIMOD 2013, Assessment of Impacts of Particulate Air Pollutants on Respiratory Health of School Children in Kathmandu Valley. Nepal Health Research Council and International Center for Integrated Mountain Development, Kathmandu, Nepal.

Study in Kathmandu

Expert Institutes

Nepal Health Research Council (NHRC)
Ramshah Path, P.O.Box 7626, Kathmandu, Nepal

http://www.nhrc.org.np

International Centre for Integrated Mountain Development (ICIMOD)
Khumaltar, Lalitpur, G.P.O. Box 3226, , Kathmandu, Nepal

http://www.icimod.org

Study in Islamabad

Expert Institutes

Pakistan Environmental Protection Agency (Pak-EPA)
311, Margalla Road, F-11/3, Islamabad 44000, Pakistan

http://www.environment.gov.pk

Pakistan Medical Research Council (PMRC)

Shahrah-e-Jamhuriat, G-5/2, Islamabad, Pakistan

http://www.pmrc.org.pk

Secretariat

United Nations Environment Programme (UNEP)

Regional Resource Centre for Asia and the Pacific (RRC.AP)

Outreach Building, Asian Institute of Technology, P.O. Box 4, Klongluang, Pathumthani 12120, Thailand

http://www.rrcap.ait.asia

Technical Support

Stockholm Environment Institute at York
University of York, Heslington, York, YO10 5DD, UK
http://www.york.ac.uk/sei

School of Environmental Science

Murdoch University, Murdoch, WA 6150, Australia

http://www.murdoch.edu.au

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Executive Summary

Air quality in large cities is a major health and environmental concern in most countries around the world. As many of the largest cities in developing countries of the Asia-Pacific region have grown, so have emissions of air pollutants. Numerous studies have shown that particulate matter has the greatest impact of all common air pollutants on health (e.g. WHO, 2006, Lim et al, 2012). The World Health Organization (WHO) states that the higher the concentration of particles in air the greater the risk to human health especially risk of respiratory and cardiovascular diseases (WHO, 2006). Recent studies have identified fine particles called $PM_{2.5}$ (particles in air with a mean diameter of 2.5 micrometres or smaller) as being especially harmful because they may reach and persist in the alveolar region of the lungs causing long-term damage.

The WHO Global Burden of Disease identifies especially high health risk threats (Lim et al, 2012). In the large cities of developing countries of Asia where air pollution levels are the highest in the world, outdoor air pollution, mostly due to particulates ranked the sixth highest risk to health in South Asia where it contributed to 712,000 deaths in 2010. The analysis found that reducing the burden of disease attributable to air pollution in Asia will require substantial decreases in the high levels of particulate emissions to air.

Far more studies have been conducted in developed countries than in developing countries. Consequently information is needed to assess the impacts of the high concentrations of fine particles found in the large cities of developing countries in the Asia-Pacific region. This assessment helps to address the need for information on the effects of particles on human health in South Asian cities. It provides locally-gathered evidence to support actions by governments to control particulate emissions. These studies were conducted on the health of children, as the developing lungs of children are more vulnerable to the adverse effects of air pollution than adult lungs. Children are more susceptible to air pollution than adults because of higher ventilation rates and higher levels of physical activity. In addition, adverse impacts in childhood can continue throughout their adult lives with health, social and economic consequences.

The activities of the Malé Declaration have concentrated on enhancing the capacity of key regional stakeholders, including government agencies and health professionals, in this case in health impact assessment methods and helping them to access relevant information. It also provides scientific evidence from South Asian cities to support informed policy decisions on air pollution.

This document reports on two similar studies conducted in different locations (PakEPA and PMRC, 2013; NHRC and ICIMOD, 2013). The objectives of the studies were to assess the impacts of particulate air pollution on the respiratory health of children at selected schools in the Kathmandu Valley, Nepal; and Islamabad, Pakistan and measure the association between the concentration of $PM_{2.5}$ and lung function in selected schoolchildren in these cities.

The studies had two components: Phase 1: a baseline survey and Phase 2: a health impact assessment. Both used quantitative methods and were conducted in 2011 and 2012. The baseline survey used a structured questionnaire, developed for international use by the International Study of Asthma and Allergies in Childhood (ISAAC, 2000). A baseline survey was conducted based on 801 children in Kathmandu and 328 children in Islamabad. The response rate was 68% in Kathmandu and 66% in Islamabad. The results showed a relatively high level of respiratory illnesses not associated with colds or flu in about a third of children in all studies. Children with pre-existing lung diseases,

allergy or other related factors were excluded while a representative sample of the remaining students were selected for Phase 2 of the studies.

A correlational study was conducted in Phase 2 to assess the impact on respiratory health of fine particles in air ($PM_{2.5}$), among 137 students in Kathmandu and 132 children in Islamabad. Children of age between 10-15 years in Kathmandu were assessed daily, and children 9-14 years old in Islamabad were assessed weekly for their lung function by measuring morning peak expiratory flow rate (PEFR). Meanwhile, measurements of $PM_{2.5}$ were recorded daily in Kathmandu and weekly in Islamabad using particulate measurement instruments. Weather data were also recorded. PEFR and $PM_{2.5}$ measurements were conducted simultaneously on a daily basis for a total of 31 days in a period of 42 days in Kathmandu and for a total of six weeks in Islamabad.

Results in Kathmandu, Nepal

The study in Kathmandu contrasted an urban roadside school with a semi-urban school in a residential area. The 24 hour mean concentration of $PM_{2.5}$ was 203 $\mu g/m^3$ (±75) in the urban school and 137 $\mu g/m^3$ (±45) in the semi-urban school and the difference is statistically significant ($p = 0.04$). Measured concentrations usually exceeded the Nepal daily $PM_{2.5}$ standard of 40 $\mu g/m^3$.

The PEFR level of the students at the urban school was found to vary with the changing levels of $PM_{2.5}$ concentration which ranged between 100 $\mu g/m^3$ and nearly 340 $\mu g/m^3$ (Figure 1). The PEFR levels of younger (10-12 years) children seem to be correlating with the changes in $PM_{2.5}$ concentrations in the initial days and later days of the assessment. Also, the PEFR levels of female children also seem to be associated with the variation in daily $PM_{2.5}$ concentrations on a few days. The daily PEFR levels of 20 students at the semi urban school fell with increases in $PM_{2.5}$ concentrations and rose with decreases in $PM_{2.5}$ concentrations for most days in later half of the monitoring period except for few days.

Although the children at the two schools were of very similar age, 13 years old and only 0.3 years difference in mean ages, and similar gender balance between the two schools, the children at the urban school were statistically significantly taller (by 5.6 cm) and heavier (by 9.56 kg) than children attending the semi-urban school. The weight difference was 25% of the mean body weight of the children at the semi-urban school. Unfortunately these differences also affected lung capacity and hence PEFR. The mean PEFR was statistically significantly higher for the urban school ($p < 0.05$, 95% CI 39.61 – 126.17) than the semi-urban school probably because the children were taller and heavier and hence had larger lungs.

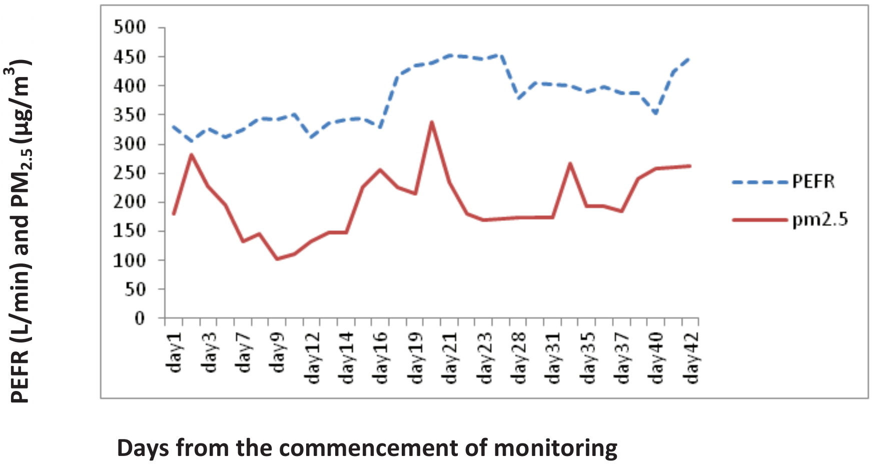

Figure 1: The relationship between peak expiratory flow rate (PEFR) (L/min) of 10 to 12 years old children and $PM_{2.5}$ ($\mu g/m^3$) concentration at the urban roadside school in Kathmandu.

Substantially more children were sampled from the urban roadside school (117 children) than the semi-urban school (20 children). The low numbers sampled at the semi-urban school prevented some statistical analyses and samples could not be pooled due to differences in the lung capacities of the two cohorts of children. It also appears that the data for the two variables, $PM_{2.5}$ and PEFR were not linear and this prevented regression analysis that may have linked them. The data showed some possible associations for some cohorts in some periods

It can be concluded that there may be an association between lung function with the concentration of $PM_{2.5}$ in the atmosphere. However, the relation could not be quantified statistically due to a small number of observations. The data showed some possible associations for some cohorts in some periods. The data may also suggest a lagged response, with PEFR possibly lagging $PM_{2.5}$ by 2 or 3 days in some periods.

The impact of $PM_{2.5}$ appeared to be more pronounced in the younger age groups and female children. Hence, any intervention needs to be focused to protect the most vulnerable groups from the pollutants. Overall the cross sectional component of this study conducted in the larger group as a baseline study before the impact assessment study hints that the burden of fine particles on the respiratory health could be huge and thus requires further investigation.

Results in Islamabad, Pakistan

The mean concentration of $PM_{2.5}$ in Islamabad was 81 $\mu g/m^3$ with a range of 25-142 $\mu g/m^3$. Measurements frequently exceeded the air quality standard in Pakistan of 40 $\mu g/m^3$. The peak expiratory flow rate (PEFR) ranged from 120 L/min to 420 L/min, with a mean of 287 L/min. There was no significant difference in PEFR among children of different schools.

Daily measurements were not taken in Islamabad. When possible associations between PEFR and $PM_{2.5}$ were investigated the study found that over the six weeks of monitoring of $PM_{2.5}$, its concentration started to increase in week 2 and kept on increasing till week 3 and then showed a decline. During this period a drop in PEFR was also observed which reverted to normal at week 4. However this association was not statistically significant.

Conclusions from the studies

Generally the results of these studies showed a surprisingly high level of respiratory illnesses not associated with colds or flu in about a third of children. Many studies have demonstrated increases in respiratory illness, asthma symptoms, medication use, pulmonary function decrements and hospital admissions associated with increases in particulate matter concentrations in air. However, few have been conducted where particulate matter concentrations are at the highest levels found in many large Asian cities such as Islamabad and Kathmandu, making these studies especially important.

The results of the studies show very high levels of particulate pollution in these cities, which consistently exceed the World Health Organization (WHO) Air Quality Guidelines for $PM_{2.5}$ of 25 $\mu g/m^3$ expressed as a 24 hour mean (WHO, 2006). The WHO recommended that countries with areas not meeting the 24-hour guideline values undertake immediate action to achieve these levels in the shortest possible time.

Differences between the studies may be related to the different concentrations of $PM_{2.5}$. Other methodological factors may also have been important. The finding of these studies emphasise the high cost of air pollution to the health of the community and the need to implement cost-effective measures to reduce emissions of health-damaging air pollutants.

Future Steps

The following future steps may be considered:

- Carefully selected technical studies of the health impacts of $PM_{2.5}$ should be established to inform policy, with an emphasis on analysis of social and economic impacts of air pollution on health to enable more thorough national and regional assessments of impacts, policy options, costs and health benefits of key options.

- A regional study should be conducted to quantify and assess the health costs and associated social and economic costs of ambient concentrations of health damaging $PM_{2.5}$ particles in Malé Declaration countries and reporting to the Governments. The aim is to enable more thorough national assessments of impacts, policy options, costs and health benefits of key options to reduce the burden of disease caused by air pollution. This could be conducted by a team nominated by governments of Malé Declaration countries using national data and working to an agreed common methodology.

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Acknowledgements

This report is based on the following two reports of studies conducted in Islamabad and Kathmandu and uses much of the text of these documents.

PakEPA and PMRC 2013, Final Report: Impacts of Particulate Air Pollution on the Respiratory Health of Schoolchildren in Pakistan. Pakistan Environmental Protection Agency, and Pakistan Medical Research Council, Islamabad, Pakistan.

NHRC and ICIMOD 2013, Assessment of Impacts of Particulate Air Pollutants on Respiratory Health of School Children in Kathmandu Valley. Nepal Health Research Council and International Center for Integrated Mountain Development, Kathmandu, Nepal.

The report was prepared by Associate Professor Frank Murray, Murdoch University, Perth, Australia to whom all errors may be attributed.

The study conducted in Islamabad was prepared by the following staff of the Pakistan EPA:

Mrs. Aden Khan, Program Assistant; Mr. Zaigham Abbass, Senior Chemist; and Mr. Asif Khan, Director General.

and the following staff of the Pakistan MRC:

Muhammad Arif Nadeem Saqib, Senior Research Officer; Dr. Faiza Bashir, Medical Officer; Mrs. Sumera Naz, Research Office; and Dr. Huma Qureshi, Executive Director.

The study conducted in Kathmandu was prepared by the following staff of the NHRC:

Prof. Dr. Chop Lal Bhusal, Dr. Shanker Pratap Singh, Dr. Krishna Kumar Aryal, Dr Ajit Rayamajhi, Hari Datt Joshi, Purushottam Dhakal and Bikram Dhimal.

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List of Abbreviations

AQMS	Air Quality Monitoring Station
BS	Black Smoke
CI	Confidence Interval
COPD	Chronic Obstructive Pulmonary Disease
ICIMOD	International Center for Integrated Mountain Development
ISAAC	International Study of Asthma and Allergies in Childhood
m^3	Cubic metres
MD	Mean Difference
$\mu g/m^3$	Microgramme per cubic metre of air
min	minute
MOEST	Ministry of Environment Science and Technology, Kathmandu
NAAQS	National Ambient Air Quality Standard
NHRC	Nepal Health Research Council , Kathmandu
Pak EPA	Pakistan Environmental Protection Agency, Islamabad
PEFR	Peak Expiratory Flow Rate
PM	Particulate Matter
$PM_{2.5}$	particles with a mean aerodynamic diameter of 2.5 micrometres or smaller
PM_{10}	particles with a mean aerodynamic diameter of 10 micrometres or smaller
PMRC	Pakistan Medical Research Council, Islamabad
SD	Standard Deviation
SEI	Stockholm Environment Institute
SIDA	Swedish International Development Cooperation Agency
UNEP	United Nations Environment Programme
RRC-AP	Regional Resource Centre for the Asia Pacific, Bangkok
WHO	World Health Organization

Background

The air quality in large cities is a major health and environmental concern in most countries. As the largest cities in many developing countries in the Asia-Pacific region have grown, so have emissions of air pollutants and air quality is one of the key health and environmental issues in the region. Numerous studies have shown that particles in air have the greatest impact of air pollution on health (UNEP, 2007). The World Health Organization states that the higher the concentration of particles in air the greater the risk to human health especially as they increase the risks of respiratory and cardiovascular diseases (WHO, 2006). The size of particles is important as it determines the extent of penetration of particles into the respiratory system. Recent studies have identified fine particles called $PM_{2.5}$ (particles with a mean aerodynamic diameter of 2.5 micrometres or smaller) as being especially harmful because they may reach and persist in the alveolar region of the lungs (McGranahan and Murray, 2002).

The WHO Global Burden of Disease identifies and ranks relative health risk levels in UN member countries (Lim et al, 2012). The large cities of developing countries of Asia have the highest air pollution levels in the world. Outdoor air pollution, mostly associated with particulates ranked sixth in importance among all health risks in South Asia where it contributed to 712,000 deaths in 2010 (Figure 2). The analysis found that reducing the burden of disease due to air pollution in Asia will require substantial decreases in the high levels of particulate matter pollution. Improved data have resulted in risk estimates substantially higher than assessed in previous analyses (Lim et al, 2012).

Far more studies have been conducted in developed countries than in developing countries. The concentrations of air pollutants in major cities are higher and the sources and chemical composition of particles in cities in developed and developing countries may differ. Consequently information is needed to assess the impacts of the much higher concentrations of PM_{10} (particles with a mean aerodynamic diameter of 10 micrometres or smaller) and $PM_{2.5}$ found in the large cities of developing countries.

Numerous studies suggest that PM_{10} and $PM_{2.5}$ contribute to excess mortality and hospitalizations for cardiac and respiratory tract disease (McGranahan and Murray, 2002). As $PM_{2.5}$ can penetrate into the alveolar regions of the lungs these particles may cause serious damage to developing lungs of children. As most lung alveoli are formed postnatally, changes in the lung continue through adolescence and the developing lungs of children are more vulnerable to the adverse effects of air pollution than adult lungs. Children have more exposure to particles than adults and are more susceptible because of higher ventilation rates and higher levels of physical activity. In addition adverse impacts in childhood can continue throughout their adult lives with considerable social and economic consequences.

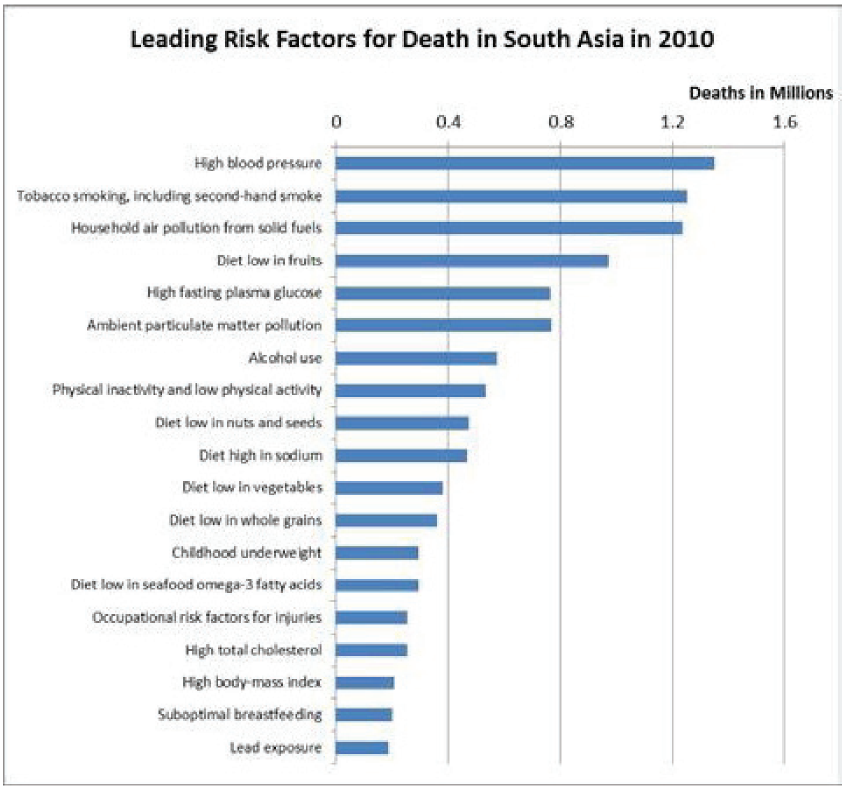

Figure 2: Number of Deaths Attributable to 20 Leading Risks in South Asia in 2010 (Lim et al, 2012)

This assessment helps address the need for information on the effects of air pollutants on health in South Asia at the high concentrations commonly found in large cities in South Asia, and it provides locally-gathered evidence to support actions by governments to control particulate emissions. Studies with similar designs to this have been successfully conducted in Bangkok, Dhaka and other Asian cities.

1.1 Objective of the study

The objective is to determine whether there is an association between daily mean $PM_{2.5}$ or PM_{10} concentrations and lung function in children in a chosen city, quantify the relationship and assess the scale and severity of impacts.

2. Assessment Methodology

2.1. Phase I: Baseline Study

2.1.1. Sampling

The baseline survey was conducted in enough schools with similar socioeconomic populations to obtain adequate questionnaire responses. Students of a suitable age (range from about 9-14 years) were participants for the baseline survey, an age for which it can be assumed and confirmed they are non-smokers yet old enough for them to reliably participate in the study. Ethics approval for the study was obtained.

2.1.2. Data Collection

A survey of the background of the children was completed to enable suitable children to be selected to participate in Phase 2 of the study. The questionnaire of the 'International Study of Asthma and Allergies in Childhood (ISAAC, 2000)' (Appendix 2) was used with modifications to suit local circumstances. The questionnaire was translated into the local languages. A pre-test of the questionnaire was conducted in some participating schools to check that was clearly understood by participants and modified if necessary before being used.

The ISAAC questionnaire has two parts:

Part I has introductory information. *Part II*: includes asthma and respiratory health data to be completed by students themselves or by their parents, and includes questions about respiratory health, asthma, allergy, smoking in the home, fuel use for cooking, etc.

The questionnaire with a request letter was delivered to all the students through their respective class teachers and asked to take it home to complete with the assistance of their parents. The letter contained a request to cooperate in the study, study rationale, study objectives and instruction for completion of the questionnaire.

A separate ***checklist*** (Appendix 3) for recording the present state of respiratory health, relevant medical history and findings of clinical examination of respiratory system of the participating students was prepared.

The baseline survey was conducted at different locations in the Kathmandu valley with completed questionnaires received from 801 children in seven schools, and from 328 children at three schools in Islamabad. The response rate was 68% in Kathmandu and 66% in Islamabad.

2.1.2. Data Analysis

Data obtained in the baseline survey were analysed to identify students with a history of or clinical evidence of asthma. The students were taken as asthmatic subjects if one of the following is reported:

- a history of wheeze at any time in the last year;
- clinician-diagnosed asthma (with or without medication); or,
- an asthma patient identified by the medical examination conducted during the baseline survey.

As the aim was to assess children with healthy respiratory systems, asthmatic children were excluded from Phase 2.

2.2. Phase 2: Health impact study

2.2.1. Sampling

From the healthy subjects identified in the baseline survey, students who satisfied any of the four following exclusion criteria were excluded:

- Use of solid fuel in the home;
- Residing more than 3 km from the air monitoring station;
- Child having asthma or other chronic respiratory illness; or
- A person in the home who is a smoker in the home or who did not provided smoking history.

For the selected participants in Phase 2, a separate *checklist* (Appendix 2) for recording the present state of respiratory health, relevant medical history and findings of clinical examination of respiratory system of the participating students was prepared.

Subsequently each participating student was evaluated by experienced medical practitioners to assess their present state of respiratory health including clinical examination of the respiratory system and history. After exclusions, all the students qualified to be a participant of the study were invited to undertake the Peak Expiratory Flow Rate (PEFR) Test with informed parental consent. Among the healthy subjects who consented to be participants of the study, participating students were selected randomly. Ultimately a total of at least 100 students was the aim for the study to completion.

In Islamabad, 328 students completed questionnaires, 150 fulfilled the inclusion criteria and were subject to medical examination and 132 students were enrolled in Phase 2. In the Kathmandu Valley, 330 students fulfilled the inclusion criteria in the urban school and 150 were randomly selected for Phase 2. At the semi-urban school only 20 students met the inclusion criteria after medical examination and all were selected for Phase 2.

2.2.2 Data Collection

Physical examination

The physical examination was conducted by a pediatrician and cases found to have respiratory or cardiac illness were excluded from the study. During the physical examination, height and weight of the students were measured using a standard measuring tape and weighing scale.

Respiratory Data:

For recording peak expiratory flow rate a Peak Flow Meter was used. Each participating student was provided with a peak flow meter. The use of a peak flow meter was demonstrated to study participants in small groups. Each participant was also trained on an individual basis as to how to use the peak flow meter and how to enter events including taking of any airway medication and respiratory illnesses. PEFR was measured by the student themselves under the supervision of the assigned teachers and technician once per day in Kathmandu and once per week in Islamabad. Each measurement was replicated three times in the standing position, and the highest reading was recorded (Appendix 4). The reading was done by putting a dot mark in the PEFR record sheet and recorded by the teacher. The investigators frequently visited the schools to provide guidance and ensure quality collection of data.

Class teachers of classes with study participants in each school were trained. A teacher ensured collection of data at a specified room each day in Kathmandu and once per week in Islamabad. However, due to practical factors, for example school examinations, national holidays and others, continuous data collection was not always possible. PEFR and $PM_{2.5}$ measurements were conducted simultaneously on a daily basis for 31 days in a period of 42 days in Kathmandu and for a total of six weeks in Islamabad.

For the entire period of data collection, formatted colored Record Sheets for each student were used for recording the PEFR readings (for example Appendix 4). Individual cards contained a unique identification number, school name, class of the school, name and roll number of the student. In addition all the students were provided with a diary to make daily notes of any illness, particularly respiratory symptoms such as sore throat, runny nose, hoarseness, cough, phlegm, wheezing, fever, ear pain or discharge; hospital admission, physician consultation and additional medications if required.

Particulate and Weather Data:

Data for particulates (PM_{10} and $PM_{2.5}$) and other measured air pollutants (eg sulphur dioxide, ozone, nitric oxide, nitrogen dioxide, and/or carbon monoxide if available) were collected on days when the PEFR are measured. Measurements of the $PM_{2.5}$ concentration in Kathmandu used the DustTrak TSI model 8250 recording 24 hour averages. Measurements of these other air pollutants were not available in Kathmandu. Relevant meteorological data (maximum, minimum and average daily temperature, relative humidity and wind speed) for the same period was obtained from relevant meteorology agency.

Other data

Costs of medical supplies and medical support for children participating in the study were recorded in Kathmandu and data on annual expenditure on respiratory illnesses in children were found.

2.2.3 Data analysis:

All the data collected from the questionnaire survey was coded and then entered in Microsoft Excel which was then later transferred to SPSS version 16.0 for further analysis. Once transferred into SPSS the data was thoroughly checked for any discrepancies and any missing entry or faulty entries. The discrepancies found were corrected by cross-checking with the completed questionnaire. The data was decoded and analyzed for frequencies and distribution in different groups. The information thus generated was tabulated, grouping together the related variables.

2.2.3 Data Analysis

The general characteristics such as age, sex, height and weight of the students participating in the lung function assessment were analyzed and described in tabular forms. This information was grouped by school. Similarly the $PM_{2.5}$ concentrations and PEFR readings of the students were interpreted separately and the mean values were compared.

For the study in Kathmandu where there were sufficient numbers of students for statistical power the analysis was further categorized as per the sex and age group (higher – 13 to 15 years and lower – 10 to 12 years) of the students. For comparing the mean $PM_{2.5}$ concentrations, a Mann Whitney U test was used as the data was found not to follow the normal distribution. The mean PEFR readings of two schools as well as two different groups within the urban school were compared using independent samples t test.

The correlation of $PM_{2.5}$ and PEFR readings was done separately for the schools as well as two different groups within the urban school in Kathmandu by using graphical plots. As planned initially for measuring the association and quantifying the relation of $PM_{2.5}$ with PEFR in Kathmandu, the daily average data for PM and PEFR were tested for the linearity to perform multiple linear regressions by taking PEFR as dependent variable and weather data as independent variables along with $PM_{2.5}$. However, the data was not found to be linear and the log conversion, quadratic conversion, cubic conversion and exponential conversion also did not provide the required linear data. Hence, the regression analysis was omitted from the analysis.

Statistical analyses of the relationship between means of air quality parameters, meteorological factors especially daily temperature and humidity, PEFR, school attendance, comparisons between schools and other relevant factors were performed.

Economic assessments were performed in Kathmandu to assess:

- the costs of medical supplies and medical support in relation to daily changes in air quality; and,
- annual expenditure on respiratory illnesses in children.

3. Results

3.1 Phase I: Baseline Survey

3.1.1 Socio-demographic characteristics of school children

The socio-demographic characteristics of the participants in the Phase 1 questionnaire in Islamabad and Kathmandu are summarized by Table 1. The participants consisted of proportionately more males and of similar ages in the two cities. The results showed a relatively high level of respiratory illnesses not associated with colds or flu in about a third of children in both studies. Children with pre-existing lung diseases, allergy or other exclusion factors were excluded while a representative sample of the remaining students were selected for Phase 2 of the study.

Table 2: **Socio-demographic characteristics of school children from results of questionnaires in Phase 1**

	Islamabad	**Kathmandu**
Number of completed questionnaires	328	801
Male (%)	64	58
Female (%)	36	42
Age range (years)	9-14	10-15
Nasal allergy without cold or flu (%)	36	29
Asthma (%)	7	-
Wheeze (%)	14	-
Asthma, wheeze or whistling sound (%)	-	8
Eczema (%)	7	21

Phase 2 included a correlational study to assess the impact on respiratory health of $PM_{2.5}$ in two schools, an urban roadside school and a school in a semi-urban residential area among 137 students in Kathmandu and 132 children from three schools in Islamabad. Children of age between 10-15 years in Kathmandu and 9-14 years in Islamabad were assessed daily in Kathmandu and weekly in Islamabad for their lung function by measuring morning peak expiratory flow rate (PEFR). Meanwhile, measurements of $PM_{2.5}$ were recorded daily in Kathmandu and weekly in Islamabad using particulate measurement instruments. Weather data were also recorded. Lung function tests (PEFR) and $PM_{2.5}$ measurements were conducted simultaneously on a daily basis for 31 days in a period of 42 days in Kathmandu and for a total of six weeks in Islamabad. Diaries of respiratory symptoms were also kept by the participants. To identify the correlation of PM with lung function of children the average PEFR with average $PM_{2.5}$ concentrations for different groups was plotted daily in Kathmandu and weekly in Islamabad.

3.2 Phase 2: Health Impact Studies

Results in Kathmandu

The period of collection of PM and PEFR data was from 25 January 2012 to 06 March 2012 with a total span of 6 weeks. However, the actual number of days of observation of PEFR was 31 days. These data from both the schools are thus taken into consideration for showing the correlation with the changes in the PEFR of children of the same date.

The concentration of $PM_{2.5}$ at the urban roadside school varied between 102 to 337 µg/m^3 with a mean value of 200 µg/m^3 and a standard deviation of 54.39 (Table 2). The concentration of $PM_{2.5}$ at the semi urban school was lower. The mean concentration was 123 µg/m^3 with a standard deviation of 32.75 and values ranging between 76 to 231 µg/m^3.

Table 2: Mean $PM_{2.5}$ (in µg/m^3) measured at the two schools in Kathmandu

School	Number of Observations	Minimum	Maximum	Mean	Standard Deviation
Urban	31	102	337	200	54.39
Semi-urban	31	76.	231	123	32.75

To test the mean difference of $PM_{2.5}$ between these two schools the Mann-Whitney U test was used as the daily data was not found to follow the normal distribution (Table 3). It showed that the mean difference of $PM_{2.5}$ between the urban and semi-urban schools was statistically significant with a Mann-Whitney U test value of 104 and p value less than 0.05.

Table 3: A statistical comparison of the mean $PM_{2.5}$ at the two schools

School	Mean Rank	Mann-Whitney U	P Value
Urban	43.65	104	0.0000
Semi-urban	19.35		

Although the children at the two schools were of very similar age, 13 years old and only 0.3 years difference in mean ages, and similar gender balance between the two schools, the children at the urban school were statistically significantly taller (by 5.6 cm) and heavier (by 9.56 kg) than children attending the semi-urban school (Table 4). The weight difference was 25% of the mean body weight of the children at the semi-urban school.

Table 4: Comparison of age height and weight of participants in the two schools

Variables	School	Mean	SD	t - value	P-Value	Mean Diff	95% CI	
							Lower	Upper
Age of students (years)	Urban	13.15	1.15	-1.12	0.26	-0.30	-0.84	0.23
	Semi-urban	13.45	0.89					
Height of students (cm)	Urban	155.56	9.22	2.56	0.01	5.61	1.27	9.96
	Semi-urban	149.95	8.11					
Weight of students (kg)	Urban	50.31	11.02	3.73	0.00	9.56	4.49	14.63
	Semi-urban	40.75	7.50					

The differences in body height and weight also affected lung capacity and hence PEFR. The mean PEFR was statistically significantly higher for the urban school ($p < 0.05$, 95% CI 39.61 – 126.17) than the semi-urban school probably because the children were taller and heavier (Table 5) and hence had larger lung capacities.

Table 5: A statistical comparison of mean PEFR (L/min) of participants at the two schools

School	N	Minimum	MaxiMum	Mean	SD	t-value	P-value	Mean Diff	95% CI	
									Lower	Upper
Urban	31	357	452	409	28.90	7.88	0.000	50.23	37.47	62.99
Semi-urban	31	314	388	359	20.62					

Table 5 shows that the mean PEFR is higher for the urban school than the semi-urban school. The difference is statistically significant with a 95% CI (37.47– 62.99) and with a p value less than 0.05. The average PEFR of the children ranged from 357 to 452 L/min for the urban school whereas it ranged from 314 to 388 L/min for the semi-urban school.

3.2.3 Correlation of $PM_{2.5}$ and PEFR

The relations between $PM_{2.5}$ and PEFR were analyzed using graphical plots for the two schools separately. In addition the relation between $PM_{2.5}$ and PEFR at the urban school was shown separately for older and younger age groups as well as for male and female children. However, it was not possible to calculate the regression of these two variables as the data were not linear. Attempts to convert the data into linear form by log conversion, quadratic conversion, exponential conversion, and cubic conversion were not successful.

The $PM_{2.5}$ concentration measured at the urban roadside school varied daily between 100 μg/m^3 and nearly 340 μg/m^3 (Figure 3). However, with the changes in PM there appeared to be relatively little fluctuation in the average PEFR of the students.

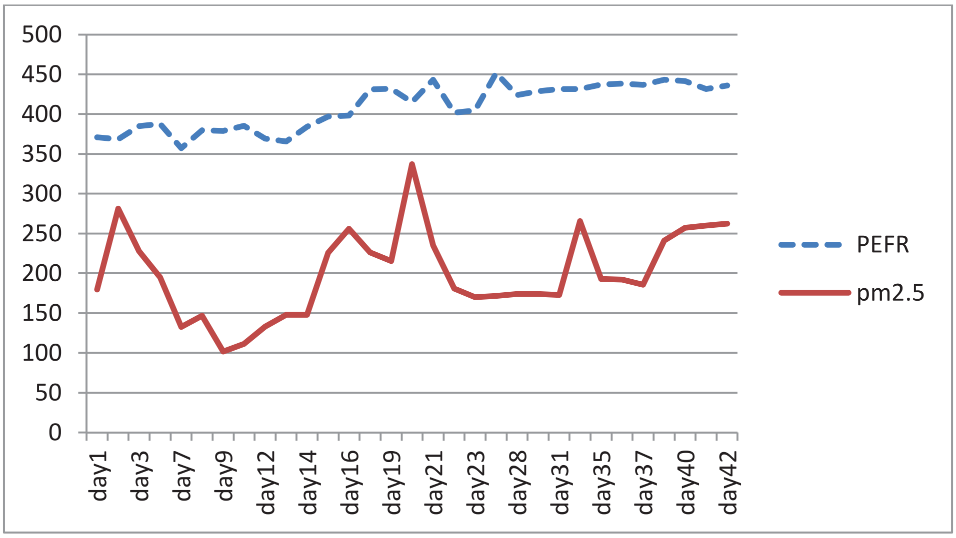

Figure 3: Correlation of PEFR and $PM_{2.5}$ at the urban roadside school. The vertical axis refers to both PEFR in L/min (dotted line) and $PM_{2.5}$ in μg/m^3 (solid line)

There are days when the daily PEFR falls with the rise in the $PM_{2.5}$ concentration, for example day 20 and there is rise in PEFR concentration with the fall in $PM_{2.5}$ concentration around day 28. On other days PEFR does not change with the daily change in $PM_{2.5}$. This suggests that there could be factors besides $PM_{2.5}$ affecting the lung function.

Figure 4 depicts the relation of PEFR with daily averages of $PM_{2.5}$. The PEFR of the older cohort (13 to 15 years) of children appears to vary slightly with the changes in $PM_{2.5}$ concentrations. In the period of day 19 to day 21 the increasing trend of $PM_{2.5}$ matched the decreasing trend in PEFR concentrations. In the days 28 and 29 the daily PEFR increased when the PM level was maintained in low levels. Otherwise, the PEFR of the older children seems to be not affected by daily changes in $PM_{2.5}$ concentrations**.**

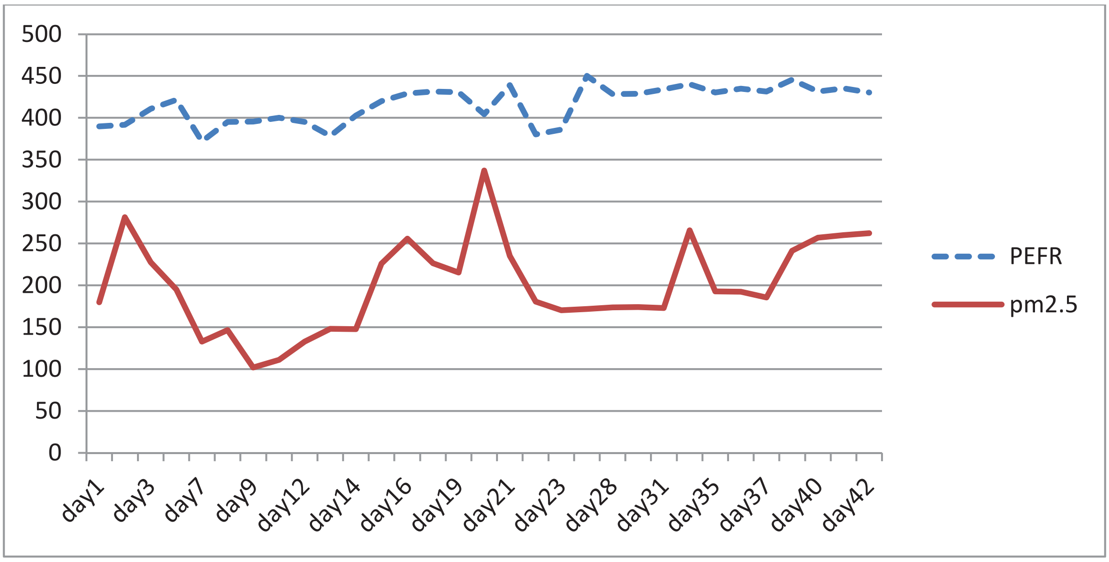

Figure 4: Correlation of PEFR of 13 to 15 years old children and $PM_{2.5}$ at the urban roadside school. The vertical axis refers to both PEFR in L/min (dotted line) and $PM_{2.5}$ in µg/m^3 (solid line)

The PEFR of children in the 10 to 12 year old cohort at the urban roadside school (Figure 5) showed that in the initial days and later days of the assessment there appeared to be a correlation. The PEFR levels appeared to decrease when the $PM_{2.5}$ level increased in the initial days and again around day 16. The daily PEFR level decreased around day 40 when the $PM_{2.5}$ concentration increased.

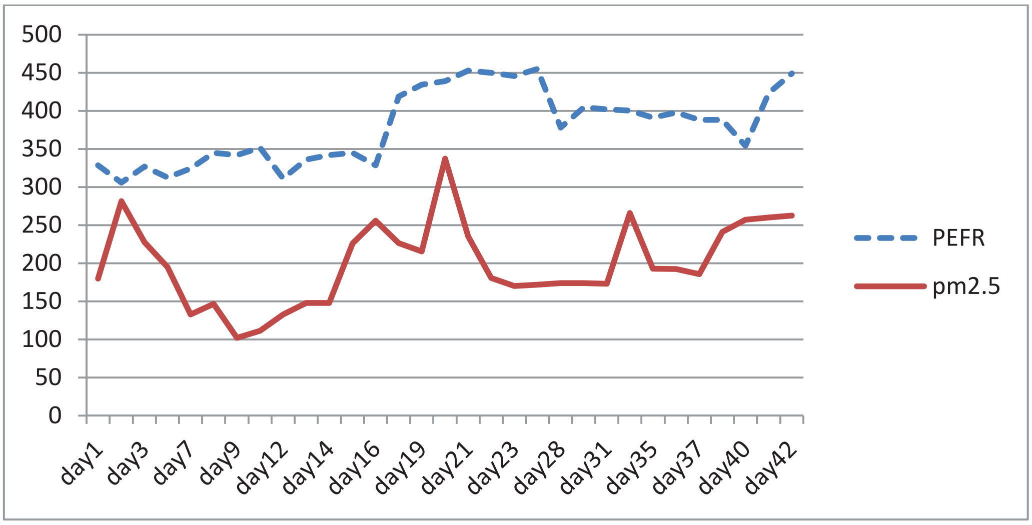

Figure 5: Correlation of PEFR of 10 to 12 year old children and $PM_{2.5}$ at the urban school. The vertical axis refers to both PEFR in L/min (dotted line) and $PM_{2.5}$ in µg/m^3 (solid line)

Figure 6 shows the correlation of daily $PM_{2.5}$ and PEFR of male children at the urban school. The PEFR levels seemed to slightly decrease when the $PM_{2.5}$ concentration rose around day 20. Otherwise there seemed to be little correlation between the daily variation in $PM_{2.5}$ and PEFR levels.

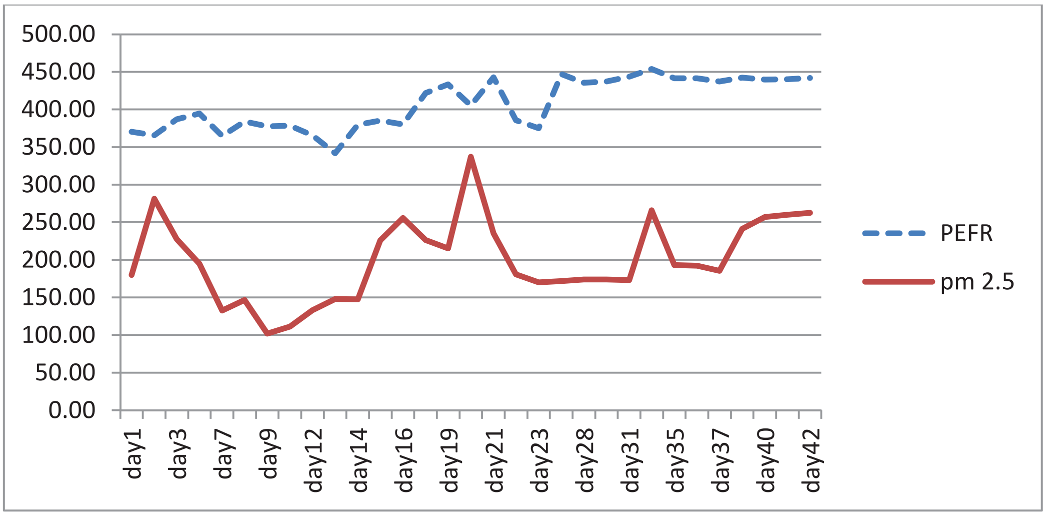

Figure 6: Correlation of PEFR of male children and $PM_{2.5}$ at the urban roadside school. The vertical axis refers to both PEFR in L/min (dotted line) and $PM_{2.5}$ in µg/m^3 (solid line)

The daily PEFR levels and $PM_{2.5}$ concentrations for female children show that there is little variation in the PEFR levels in line with the variation in daily $PM_{2.5}$ concentrations (Figure 7). The change in PEFR level is related with the change in $PM_{2.5}$ levels on most days. Around day 23 to 28 there is rise in the daily PEFR levels when the $PM_{2.5}$ level remained low. In comparison to the plots of male children, the plots of female children show a suggestion of an inverse relationship between $PM_{2.5}$

concentrations and PEFR levels. The PEFR increased on the days $PM_{2.5}$ remains at low levels. This association between PEFR and $PM_{2.5}$ could be associated with relatively lighter physical build of the female children.

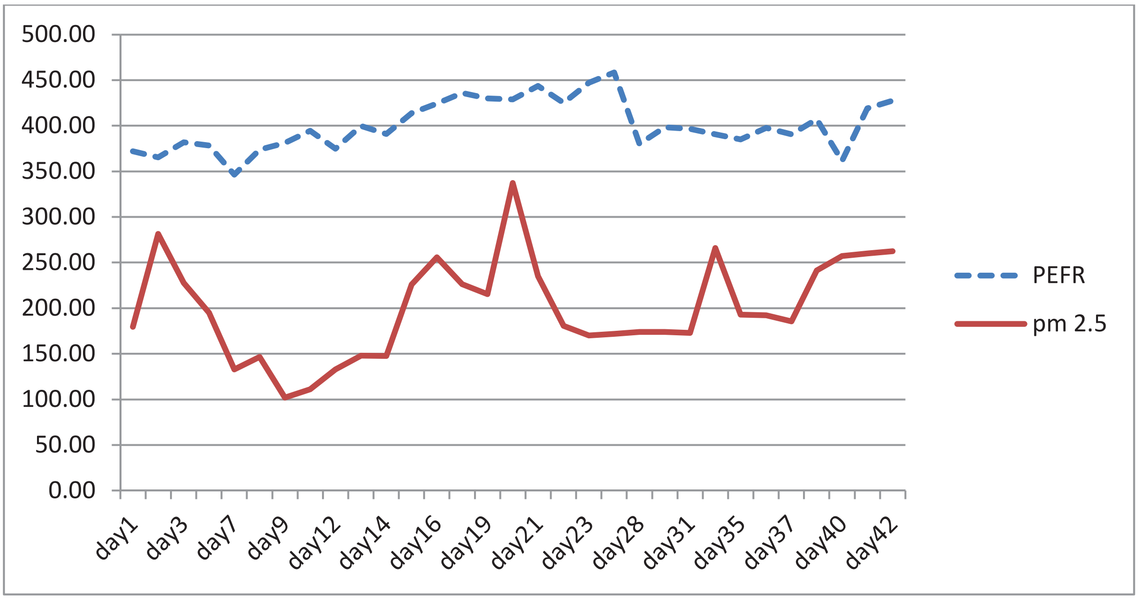

Figure 7: Correlation of PEFR of female children and $PM_{2.5}$ at the urban roadside school. The vertical axis refers to both PEFR in L/min (dotted line) and $PM_{2.5}$ in µg/m^3 (solid line)

The daily PEFR levels of 20 students attending the semi-urban school were plotted with the daily $PM_{2.5}$ concentrations (Figure 8). The $PM_{2.5}$ concentration is generally lower and less variable than in the urban school. The change in PEFR levels matches the change in $PM_{2.5}$ concentration in the later days. Around day 27 and day 32 the PEFR level decreases when the $PM_{2.5}$ concentration is increasing. In the earlier days the PEFR levels do not seem to vary with the small changes in $PM_{2.5}$ concentrations.

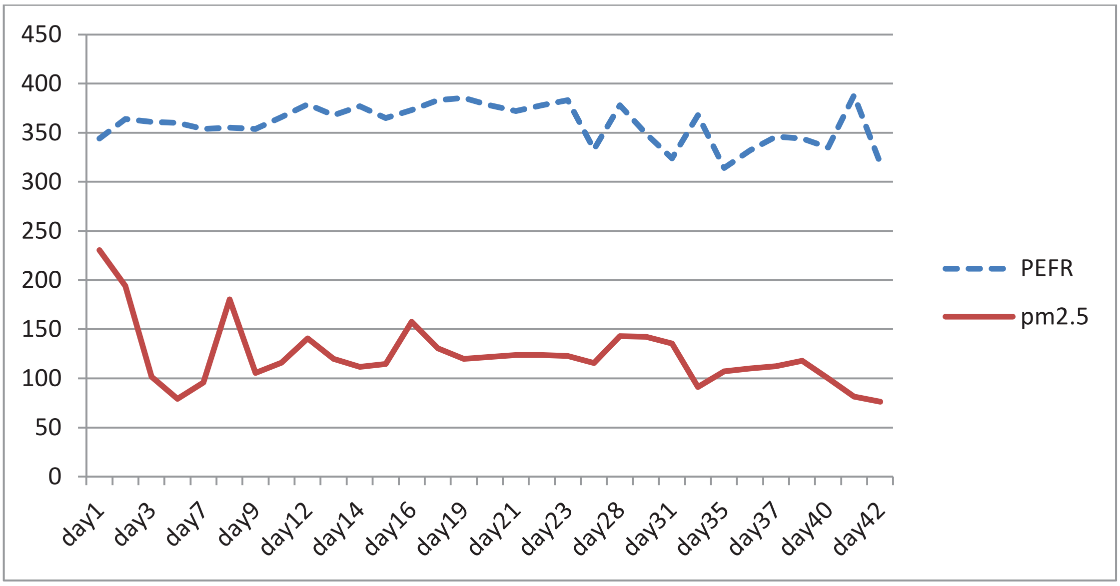

Figure 8: Correlation of $PM_{2.5}$ and PEFR of children attending the semi-urban school. The vertical axis refers to both PEFR in L/min (dotted line) and $PM_{2.5}$ in µg/m^3 (solid line)

The daily PEFR levels of 20 students at the semi-urban school fell with increases in $PM_{2.5}$ concentrations and rose with decreases in $PM_{2.5}$ concentrations for most days in the second half of the monitoring period except for few days. It can be concluded that there may be an association between lung function with the concentration of $PM_{2.5}$. However, the relation could not be quantified statistically due to a small number of observations.

Substantially more children were sampled from the urban roadside school (117 children) than the semi-urban school (20 children). The low numbers sampled at the semi-urban school prevented some statistical analyses and samples could not be pooled due to differences in the lung capacities of the two cohorts of children. It seems that the data for the two variables, $PM_{2.5}$ and PEFR were not linear, preventing regression analysis. The data showed some possible associations for some cohorts in some periods. The data may also suggest a lagged response, with PEFR possibly lagging $PM_{2.5}$ by 2 or 3 days in some periods.

Results in Islamabad

During the study period, the weekly mean concentration of $PM_{2.5}$ in Islamabad was 81 (±30.2) µg/m^3 and it ranged between 25 to 142 µg/m^3. The daily air quality standard for $PM_{2.5}$ in Pakistan is 40 µg/m^3 and it is shown in Figure 9 along with the annual average concentration of $PM_{2.5}$ for five years in Islamabad. The weekly mean concentration of O_3 during the study period was 40 (±28.8) µg/m^3. The weekly mean concentration of SO_2 was 20 (±13.3) µg/m^3, NO_2 was 56 (±18.2) µg/m^3 and NO was 85 (±77.9) µg/m^3. The mean temperature of the atmosphere during the study period was 18.3^{o}C (±5.2). It ranged between 11-33^{o}C. The mean relative humidity during the period was 58.8% (± 8.0), ranging between 35-82 %.

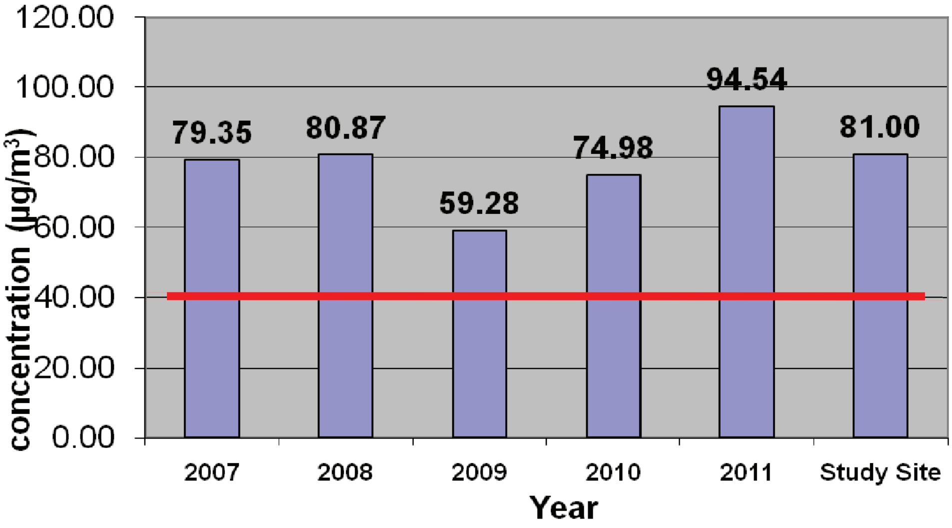

Figure 9: Annual average concentration of PM2.5 for 2007-2011 at the study site in Islamabad. The 24 hour air quality standard is shown by the red bar

The PEFR ranged from 140 L/min to 517 L/min, with a mean of 286 L/min. There was a significant difference in PEFR among both genders ($p<0.001$) being higher in males. There was no significant difference in PEFR among children of different schools. The data of PEFR was analyzed with the demographic characteristics and environmental factors. The rise in PEFR was directly associated with increase in age, weight and height ($p<0.001$).

When possible associations between PEFR and $PM_{2.5}$ were investigated the study found that over the six weeks of monitoring of $PM_{2.5}$, its concentration started to increase in week 2 and kept on increasing until week 3 and then showed a decline (Figure 10). During this period a drop in PEFR was also observed which reverted to normal at week 4. However this association was not statistically significant.

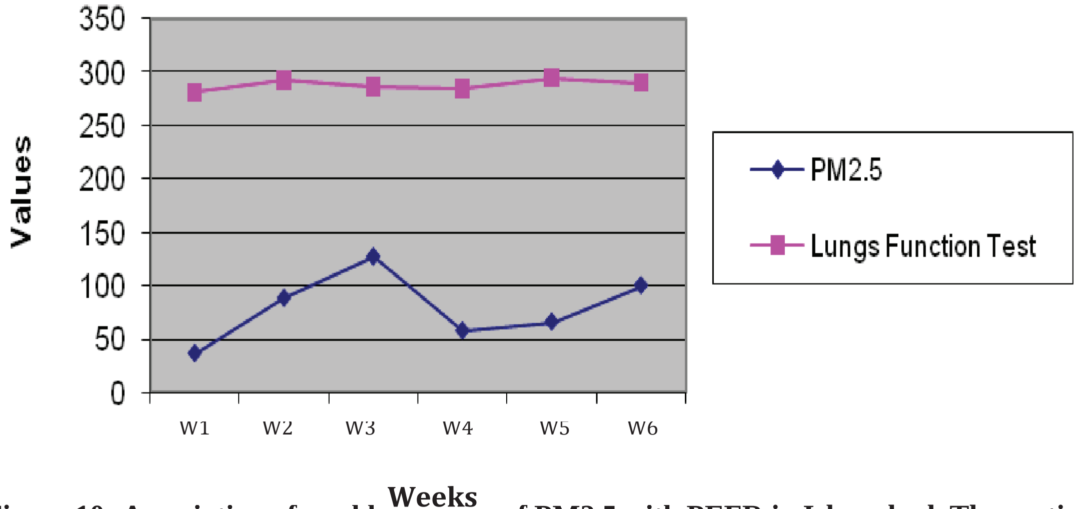

Figure 10: Association of weekly average of PM2.5 with PEFR in Islamabad. The vertical axis refers to both PEFR in L/minute and $PM_{2.5}$ in µg/m^3

3.1.3 Economic cost analysis

The economic burden as well as other impacts of respiratory problems was estimated by analyzing the number of school days missed, work days missed as well as the cost incurred by the respondents in the treatment of their children for respiratory issues (Table 6).

Table 6: Respiratory issues and loss to the children and parents

	Frequency	Percent
Any kind of respiratory problems faced in last year		
No	**564**	**70.4**
Yes	**237**	**29.6**
Total	**801**	**100.0**
Number of school days missed by child		
Not missed school	**35**	**14.8**
Missed 1 to 2 days	**102**	**43.0**
Missed 2 to 4 days	**63**	**26.6**
Missed more than 4 days	**37**	**15.6**
Absence from work by Guardian		
Yes	**99**	**41.8**
No	**138**	**58.2**
Total	**237**	**100.0**

Out of the total children 237 children, nearly 30%, were found to be suffered with one or the other kind of respiratory problems and had to visit the doctor/health facility (Table 6). Due to these respiratory health problems 43 % of the children missed school for 1 to 2 days and 27% of children for 2 to 4 days and nearly 16% missed for more than 4 days. Similarly, 42 % of the child guardians were absent from work due to these respiratory health problems in children and the number of days missed from work were mostly 1 to 2 days.

Out of the 237 children who had to visit the health facility/doctors for their respiratory problems it was found that they spent a minimum of NRs 100 to a maximum of NRs 20000 with mean expenditure of 1966 and median of 1000 (Table 7). Similarly, the median expenditure for travelling was NRs 200 with mean value of NRs 408 and minimum of NRs 50 to a maximum of NRs 3000. Accordingly, total expenditure ranged from NRs 150 to NRs 23000 with median of NRs 1400 and mean of NRs 2375.

Table 7: Expenditure in Nepali Rupees (NRs) for the respiratory illnesses of children

Expenditure (NRs)	Number of children	Mean NRs	Standard Deviation	Minimum NRs	Maximum NRs
Expenditure on medicines and doctor	**237**	**1966**	**2670**	**100**	**20000**
Money spent on travel during the medical visit	**237**	**408.9**	**525.2**	**50**	**3000**
Total money spent for respiratory problems	**237**	**2375.4**	**3063.8**	**150**	**23000**

4. Discussion

The activities of the Malé Declaration have concentrated on enhancing the capacity of key regional stakeholders, including government agencies and health professionals in this case in health impact assessment methods and helping them to access relevant information. The activities provide scientific evidence from South Asian cities to support informed policy decisions on air pollution. This assessment helps to address the need for information on the effects of particles on human health in South Asian cities. It provides locally-gathered evidence to support actions by governments to control particulate emissions. Three health studies were conducted on the health of school children during Phases III and IV of the Malé Declaration in different locations in major South Asian cities. The objectives of the studies were to assess the impacts of particulate air pollution on the respiratory health of school children of selected schools in Dhaka, Bangladesh in Phase III; and the Kathmandu Valley, Nepal; and Islamabad, Pakistan in Phases IV. The studies investigated the relationship between changes in lung function, in this case peak expiratory flow rate (PEFR) in children in response to daily variations in concentrations of $PM_{2.5}$ particulates in air.

These studies were conducted on the health of children as the developing lungs of children are more vulnerable to the adverse effects of air pollution than adult lungs. Children are more susceptible to air pollution than adults because of higher ventilation rates and higher levels of physical activity. In addition, adverse impacts in childhood can continue throughout their adult lives with health, social and economic consequences.

The results of air quality monitoring during the period of the studies in Islamabad and Kathmandu show that ambient concentrations of $PM_{2.5}$ exceed the relevant national air quality standards by substantial margins (Table 8). The mean concentration of $PM_{2.5}$ during the study period in Islamabad was about twice the Pakistan air quality standard. The mean concentration of $PM_{2.5}$ during the study period at the urban school in Kathmandu was more than five times the Nepal air quality standard. At the semi-urban school it was more than three times the standard. At neither school in Kathmandu during the study period was the Nepal air quality standard attained for a day and the $PM_{2.5}$ concentration was rarely less than twice the relevant air quality standard.

Table 8: Concentrations of $PM_{2.5}$ during these studies in Islamabad and Kathmandu

Parameter (in µg/m^3)	**Islamabad**	**Kathmandu Urban school**	**Kathmandu Semi-urban school**
Mean concentration	**81**	**203**	**137**
Maximum concentration	**142**	**337**	**231**
Minimum concentration	**25**	**102**	**76**
Air quality national standard	**40**	**40**	**40**

The $PM_{2.5}$ concentration in this study in Kathmandu at the urban roadside school varied in 24 hour mean concentrations between 102 µg/m^3 and 337 µg/m^3 which exceed the national standard of $PM_{2.5}$ concentration of 40 µg/m^3 every day of the 31 days measured. The mean concentration of $PM_{2.5}$ in Islamabad was 81 µg/m^3 with a range of 25-142 µg/m^3. Measurements frequently exceeded the 24 hour air quality standard in Pakistan of 40 µg/m^3. In the Phase III study conducted in Dhaka, Bangladesh, the 24 hour mean PM_{10} concentration level on the days of data collection ranged from 38 to 385 µg/m^3 with a mean value of 119 (±70) µg/m^3 (Department of the Environment, 2008). The 24 hour mean $PM_{2.5}$ concentration ranged from 18 to 233 µg/m^3 with a mean value of 68 (±48) µg/m^3.

The mean PEFR was higher at the urban roadside school than the semi-urban school in Kathmandu and the difference of 50 L/min is statistically significant with 95% CI (37– 63) and a p value less than 0.05. The average PEFR of the children ranged from 357 to 452 L/min for the urban roadside school whereas it ranged from 314 to 388 L/min for the semi urban school. This difference in the average PEFR between two schools may be due to varying anthropometric measurements. The average height and weight of the students of the semi urban school is significantly lower than the urban school with a mean difference of 5.6 cm in height and 9.56 kg in weight.

Average PEFR levels of all the students of the urban roadside school in Kathmandu were plotted along with the daily average $PM_{2.5}$ concentrations. The $PM_{2.5}$ concentration varied between 100 µg/m^3 and nearly 340 µg/m^3. However, with the changes in $PM_{2.5}$ there is a much smaller fluctuation in the average PEFR of the students. There are few days when the daily PEFR falls with the rise in the $PM_{2.5}$ concentration and there is a rise in PEFR with a fall in $PM_{2.5}$ concentration in a few other days. This suggests that there is an inverse relationship between the daily $PM_{2.5}$ concentrations and PEFR of school children. However on some days PEFR does not appear to change with the daily change in $PM_{2.5}$.

The PEFR of the older age group (13 to 15 years) of children in Kathmandu appeared to vary slightly with the changes in $PM_{2.5}$ concentrations. In the period of day 19 to day 21 the increasing trend of $PM_{2.5}$ is matching with decreasing trend in PEFR concentrations. In the days 28 and 29 the daily PEFR is seen to be increasing when the $PM_{2.5}$ level is maintained in low levels. Otherwise, the older children's PEFR seems to be not affected by daily changes in $PM_{2.5}$ concentrations. This could be because of other factors such as nutritional status of the children including anthropometry that the lung function has not been affected by changes in the $PM_{2.5}$ levels.

The PEFR of children studied in Islamabad showed there was no significant difference in PEFR among children of different schools. When possible associations between PEFR and $PM_{2.5}$ were investigated the study found that over the six weeks of monitoring of $PM_{2.5}$, its concentration started to increase in week 2 and kept on increasing till week 3 and then showed a decline. During this period a drop in PEFR was also observed which reverted to normal at week 4. However this association was not statistically significant. If daily measurements of PEFR and $PM_{2.5}$ had been available the likelihood of a statistically significant association being found would have been considerable higher.

A study to measure the short term effects of air pollution on respiratory morbidity among asthmatic children from the Czech Republic showed that that elevated levels of air pollution were associated with decreased peak expiratory flow rates, increased respiratory symptoms, increased prevalence of school absence and fever, and increased medication use (Zemp et al, 1999).

A study conducted to assess the association between daily changes in respiratory health and PM_{10} in Utah among fifth and sixth grade students showed relatively small but statistically significant

($p<0.01$) negative associations between PEFR and PM_{10} among both symptomatic and asymptomatic children. This association was however, stronger among the symptomatic children. The study concluded that both symptomatic and asymptomatic children may suffer acute health effects of respirable particulate pollution, with symptomatic children suffering the most (Pope et al, 1999). These results are similar to a study conducted on Bangkok children to assess the impact of PM_{10} pollution on child health (Preutthipan et al, 2004).

Children with symptoms of asthma are more susceptible to the effect of PM_{10}, black smoke (BS), SO_2 and NO_2 than children without symptoms (Zee et al, 1999). The study found decrements in evening PEFR had a positive association with concentration of PM_{10}. Another study reported a negative association between PEFR and PM_{10} for both asthmatic and non-asthmatic samples of children but symptomatic children suffers the most (Pope and Dockery, 1992). Similar associations between PEFR and PM_{10} have been reported in many studies (Pope et al, 1999, Romieu et al, 1996 ; Braun-Fahrlander et al, 1992; Schwartz et al, 1994; Timonen and Pekkanen, 1997; Ward and Ayres, 2004).

A study in Holland reported that an increase of 83% in the number of subjects with a reduced PEF response was associated with an increase in the mean PM_{10} concentration of 100 $\mu g/m^3$ (Zee et al, 1999). Morning PEFR decreased among asthmatic children in urban areas of Finland for a 10 $\mu g/m^3$ increase in daily mean PM_{10} concentration (Timonen and Pekkanen, 1997). A study in Germany reported a reduction of suspended particulates by 10-20 $\mu g/m^3$ was associated with a 20% reduction of total bronchial disease prevalence (Heinrich et al, 2000). It can be concluded from these studies that an increase in particulate matter concentration reduces the PEFR, hence increases the respiratory health risks.

A number of studies indicate an adverse effect of particulate air pollution that is greater for $PM_{2.5}$ than PM_{10} especially for PEFR (Ward and Ayres, 2004). When a comparison was made between 12-15 year old children lived in high and low air pollution exposure areas of Indonesia, it was observed that children has a lower PEFR in the area with the higher air pollutant level than those who lived in lower air pollution area (Sawtri et al, 2003).

The results of these studies in Kathmandu and Islamabad show a surprisingly high level of respiratory illnesses not associated with colds or flu in about a third of children. In both cities, nearly 30% of children were reported to have respiratory symptoms such as sneezing, running nose or nasal blockage even when they did not have common cold or flu. Of the students with respiratory symptoms, about 70% of them had such symptoms in the last 12 months and about a quarter of them had symptoms that hampered their studies and activities.

The study in Islamabad showed that 54% children were suffering from some chronic respiratory diseases or allergic disorders including asthma, wheeze, nasal allergy, urticaria and eczema. A study from Karachi reported a prevalence of asthma of 15.8% in school-age children (Hasnain et al, 2007).

Nasal allergy is associated with asthma. In the Islamabad study 38% of children suffered from nasal allergy i.e. presence of sneezing, running nose or nasal blockage without common cold or flu. In Kathmandu 29% of children suffered from nasal allergy. In the Islamabad study 19% children also reported itchy watery eyes. Hay (allergic) fever and eczema were each seen in 17% of children in Islamabad and in 13% and 21% respectively in Kathmandu.

The finding of these studies emphasise the high cost of air pollution to the health of the community and the need to implement cost-effective measures to reduce emissions of health-damaging air pollutants. The studies in Kathmandu and Islamabad showed that nearly 30% of all child participants were found to be suffered with respiratory health issues and had to visit a doctor or other health facility. Due to these respiratory health issues in Kathmandu 43% of the children missed school for one or two days, 42 % of the childrens' guardians missed their work due to these illnesses in children and the number of days missed were mostly one or two days. The median expenditure in Kathmandu for the health facility or doctor was NRs 1000 and for travelling to medical facilities was NRs 200. The total median expenditure was NRs 1400.

A study in Bangladesh reported that the total annual per capita expenditure for respiratory problems experienced by study participants was 5803 Taka and it was significantly higher ($p<0.001$) for asthmatic children (6919 Taka) than for non-asthmatic children (3479 Taka) (Department of the Environment, 2008). An estimate of asthma patients in Bangladesh showed that seven million people are suffering from asthma including four million children of the country (Hassan et al, 2002). Based on that estimate, around 27.67 billion taka (about US$ 395 million) is needed for the treatment of four million children. This expenditure could be substantially reduced with greater control of air pollution emissions.

This study has revealed that $PM_{2.5}$ concentrations in ambient air have a significant adverse economic impact on the families of affected children. It has been estimated that the reduction of PM_{10} concentration by 20% - 80% in Dhaka could allow for avoidance of 1,200 to 3,500 deaths, 80 to 235 million cases of sickness and a saving of US$ 169 to 492 million equivalent to 0.34 – 1.0 % of Gross National Income (World Bank, 2006). Clearly measures to reduce particulate matter emissions by prudent air quality control measures could not only contribute in reducing individual suffering but also contribute towards attaining Millennium Development Goals in health as well as poverty alleviation.

A limitation of this study that is shared by all other such studies is that the ambient pollution concentrations may not adequately reflect exposures of individual subjects. This study has limitations of being done for six weeks only in two selected areas of the study city which may not represent the national situation. It is recommended that long term studies need to be done on national level to establish a reliable baseline.

5. Conclusions

The objective of this study was to determine whether there is an association between daily mean $PM_{2.5}$ concentrations and lung function in children in a chosen city, quantify the relationship and assess the scale and severity of impacts.

Generally the results of these two studies are consistent with other studies and show a surprisingly high level of respiratory illnesses not associated with colds or flu. Many studies have demonstrated increases in respiratory illness, asthma symptoms, medication use, pulmonary function decrements and hospital admissions associated with increases in particulate matter concentrations in air (McGranahan and Murray, 2002). However, few studies have been conducted where particulate matter concentrations are at the highest levels found in many large Asian cities such as Islamabad and Kathmandu, making these studies especially important. The concentrations of $PM_{2.5}$ in the atmosphere measured in this study are far in excess of the WHO air quality guidelines intended to protect human health from the adverse impacts of air pollution.

The finding of these studies emphasise the high cost of air pollution to the health of the community and the need to implement cost-effective measures to reduce emissions of health-damaging air pollutants. In both cities, nearly 30% of children were reported to have respiratory symptoms such as sneezing, running nose or nasal blockage even when they did not have common cold or flu. Of the students with respiratory symptoms, more than 69% of them had such symptoms in last 12 months and 23% of them had symptoms that hampered their studies and activities.

The study in Kathmandu showed that nearly 30% of all child participants were found to be suffered with respiratory health issues and had to visit a doctor or other health facility. Due to these respiratory health issues 43% of the children missed school for 1 to 2 days and 42% of the childrens' guardians missed their work due to these illnesses in children and the number of days missed were mostly 1 to 2 days. The median expenditure on charges by the health facility or doctor was NRs 1000 and costs for travelling to medical facilities were NRs 200. The total median expenditure was NRs 1400.

Even though a strong correlation has not been seen in this study, the high level of $PM_{2.5}$ could have a significant impact on the health status of people especially children, according to international studies. The impact of $PM_{2.5}$ in this study was measured in terms of variation in PEFR levels and it shows an inverse relationship between $PM_{2.5}$ concentrations and PEFR levels in some of the days in Kathmandu. The younger children and female children have been found to be affected more than the older children and male children respectively as seen by the differences in the plots of these groups. This indicates that age and gender could be factor that play an important role in the manifestation of impacts of pollutants in the atmosphere.

This study suggests that the impact of $PM_{2.5}$ in air is more pronounced in the younger age groups and female children. Hence, the intervention needs to be focused to protect the most vulnerable groups from the increasing pollutants. The cross sectional component of this study conducted in the larger group as a baseline study before the impact assessment study hints that the burden of fine particles on the respiratory health could be very substantial and thus requires further investigation.

6. Future Steps

The following future steps could be considered by the Malé Declaration countries:

- Carefully selected technical studies of the health impacts of $PM_{2.5}$ should be established to inform policy, with an emphasis on analysis of social and economic impacts of air pollution on health to enable more thorough national and regional assessments of impacts, policy options, costs and health benefits of key options.

- A regional study should be conducted to quantify and assess the health costs and associated social and economic costs of ambient concentrations of health-damaging $PM_{2.5}$ particles in Malé Declaration countries and reporting to the Governments. The aim is to enable more thorough national assessments of impacts, policy options, costs and health benefits of key options to reduce the burden of disease caused by air pollution. This could be conducted by a team nominated by governments of Malé Declaration countries using national data and working to a common methodology.

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Appendix 1: Illustrations of different activities of the study

Physical examination of the child by Consultant Pediatrician

Collection of preliminary Information of the child before physical examination

Physical examination in progress

Team of Doctors, Investigators and Research Assistants

One of the Teachers involved in data collection

Research assistant guiding the children in the measurement of PEFR

A child taking a PEFR reading

Principal (Father) of St. Xavier's School (Urban Roadside School) receiving a certificate from the study leaders

Students of Santaneshwor Vidya Mandir School (Semi-Urban School) with the study leaders

Presentation of a Certificate of Participation to the Students

Presentation of a Certificate of Participation to the Teachers

Appendix 2: Phase 1 study questionnaire

Title: Assessment of impact of air pollution among the school children

The Departments of ??? are jointly conducting a study of impact of air pollution on school children in selected schools to design measures to protect health. Some information is necessary on the health of your child. Your cooperation in providing this information will help us to protect school children in our city. All the information will be used for research purpose only and will be regarded as confidential. Thank you for your assistance.

ID No. Date:

1. Name of school:
2. Time of interview: Commencement: Ending:
3. Name of child:
4. Parent/Guardian's name:
5. Parent's educational level:
6. Age of the child (in complete years):
7. Date of birth:
8. Gender: Male / Female
9. Religion:
10. Asthma/ Respiratory problem related information.

10.1. Did your child ever experience asthma-like or whistling sound in the chest?
1. Yes 2. No If No go to question no 10.6

10.2. In past 12 months did your child ever experience asthma-like or whistling sound in the chest?

1. Yes 2. No If No go to question no 10.6

10.3. Frequency of asthma-like or whistling sound in the chest in last one year

1. None 2. 1 to 3 times 3. 4 to 12 times 4. >12 times.

10.4. In past 12 months, did asthma-like symptoms or respiratory symptom cause sleep disturbance?

1. Never 2. Once a week. 3. More than once a week.

10.5. In last one year did an asthma-like or whistling sound hamper the child's speech while breathing?

1. Yes 2. No.

10.6. Did your child ever experience asthma or wheeze?

1. Yes 2. No.

10.7. Did your child ever experience asthma or wheeze during exercise or playing in last one year?

1. Yes 2. No.

10.8. Did your child suffer from cold or dry cough at night in the last one year?

1. Yes 2. No.

11.0 The following questions are about problems that occur when your child did not have a cold or flu:

11.1.1. Did your child ever suffer from sneezing, running nose or nasal blockade when he /she did not have a cold or flu?

1. Yes 2. No. If you answered "No" go to question 11.6.

11.1.2. In past 12 months, did your child suffer from sneezing, running nose or nasal blockage when he /she did not have a cold or flu?

1. Yes 2. No. If you answered "No" go to question 11.6.

11.1.3. In the last one year did the child have eye itching or watering along with nasal ailments?

1. Yes 2. No. If you answered "No" go to question 11.6.

11.1.4. In which month did you experience the problem

January	February	March	April	May
June	July	August	September	October
November	December			

11.1.5. Did the nasal problem of your child cause difficulty or hamper his/her study and play in the last year?

1. Yes 2. No.

11.1.6. Did your child ever suffer from hay fever (allergic fever)?

1. Yes 2. No.

12.0 Did your child ever suffer from urticaria that lasted three to six months?

1. Yes 2. No. If No go to question 13.0.

12.1. Was the rash present in other parts of the body like- front of the elbow, back of the knee, back of the ankle, around the neck or beneath the ear or eye?

1. Yes 2. No.

12.2. Did these rashes disappear spontaneously?

1. Yes 2. No.

12.3. Did this rash cause sleep disturbances in last one year?

1. Never 2. Less than once a week 3. More than once a week

13.0 Did your child ever suffer from eczema.

1. Yes 2. No.

14.0 Do any members of your household smoke?

1. Yes 2. No.

14.1 If any member of your household is a smoker, does he/she smoke indoors?

1. Yes 2. No.

Appendix 3: Medical Examination Checklist

ID No____________ **Date________________**

Name of school____

Name____

Age (in complete years) _____________ **Gender: Male /Female**

History of respiratory problem: ____

History of taking prophylactic drug:_____________________________________

General Health: ____

Height (in cm): **Weight (in kg):**

Anemia: **None** **Mild** **Moderate** **Severe.**

Temperature: ___________ **Normal** **Raised.**

Pulse: **/min.**

Heart (List any abnormality detected):____________________________________

Lung (List any abnormality detected):____________________________________

Eye problem : **None** **Redness of eye** **Other_______________**

Skin rash: **Absent** **Present** **Other________________**

Any other Problem____

Comment____

Signature of the Physician

Appendix 4: PEFR Recording Sheet

Date:								Date:					
	Sun	Mon	Tues	Wed	Thur	Fri		Sun	Mon	Tues	Wed	Thurs	Fri
PEFR													
720							720						
700							700						
680							680						
660							660						
640							640						
620							620						
600							600						
580							580						
560							560						
540							540						
520							520						
500							500						
480							480						
460							460						
440							440						
420							420						
400							400						
380							380						
360							360						
340							340						
320							320						
300							300						
280							280						
260							260						
240							240						
220							220						
200							200						
180							180						
160							160						
140							140						
120							120						

Place a tick in the correct box

Malé Declaration 1998-2013: Progress and Opportunities - a synthesis

Lars Nordberg (ICCI) and Kevin Hicks (SEI) with support from Patrick Büker (SEI), Martin Ferm (IVL), Johan Kuylenstierna (SEI), Frank Murray (Murdoch University), Iyngara Mylvakanam (UNEP), Aida Roman (AIT), Karin Sjoberg (IVL), Harry Vallack (SEI)

IG13 Dhaka, Bangladesh
May 20th, 2013

Kevin.hicks@sei-international.org

SEI

Synthesis Report – Writing Process

- First draft written by Secretariat and technical advisors led by Lars Nordberg
- Now require your feedback
  - What is missing?
  - What is incorrect?
  - what could be improved?
- Report will be finalized and widely circulated to policy makers in South Asia and all relevant stakeholders to promote awareness of issues and opportunities.

Overall achievements of the Malé Declaration

- **Awareness** – meetings, internet and newsletters, linking to the youth, even adverts on buses and Malé Declaration song!
- **Training** – capacity and institutional strengthening in all aspects of air pollution policy cycle:

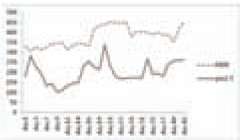
  emissions/deposition ⇨ impacts ⇨ policy
- **Intergovernmental cooperation** - technical know-how and establishment of regional centres, financial mechanism, towards a regional cooperative agreement
- **Relationships** – within and between Malé Declaration countries and internationally

There is a foundation on which to build

Overall achievements of the Malé Declaration

IMPACTS

Malé Declaration Results

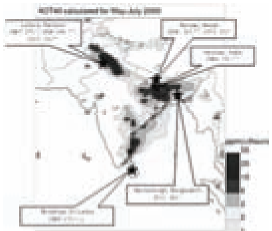


Health

Regional Technical Centre: Bangladesh

High cost of air pollution due to human health impacts and cost of hospital visits and lost school and work days

Malé Declaration Results

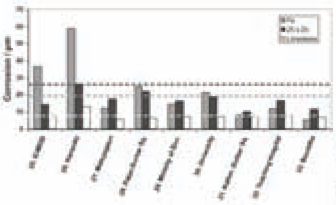


Crops

Regional Technical Centre: Pakistan

Evidence of ground-level ozone impacts during main growing seasons on important South Asian crops

Malé Declaration Results

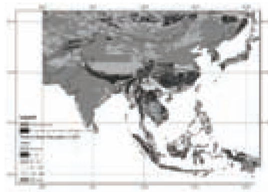


Materials and Cultural Heritage

Regional Technical Centre: India

New dose-response functions had to be developed for carbon steel, zinc, copper and limestone in South Asia

Malé Declaration Results



Acidification and Eutrophication

Regional Technical Centre: Soil Monitoring - Bhutan

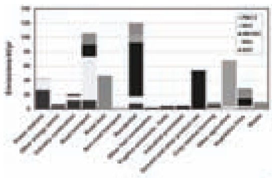
Eutrophication effects of nitrogen pollution are a greater threat to ecosystem health in South Asia than acidification

Overall achievements of the Malé Declaration

Assessment of emission and deposition

Malé Declaration Results

Sri Lanka

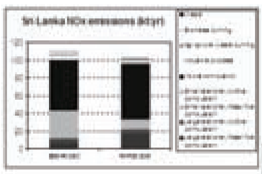


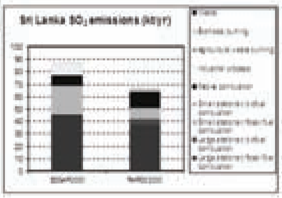
Emissions

Regional Technical Centre: Sri Lanka

National EIs for baseline year 2000 and draft EIs for 2005 are currently being finalised in some countries

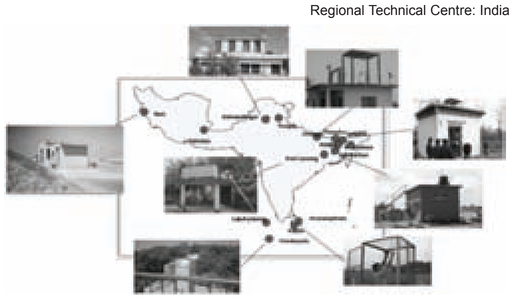
Comparison between Malé Declaration and international emissions data





Malé Declaration Results

Regional Technical Centre: India



The Malé Monitoring Network was established in 2003 with at least one regional monitoring site established in each country

Malé Declaration Monitoring Data

The equipment located at the monitoring sites is as follows:

IVL passive samplers for SO_2, NO_2 and ozone;

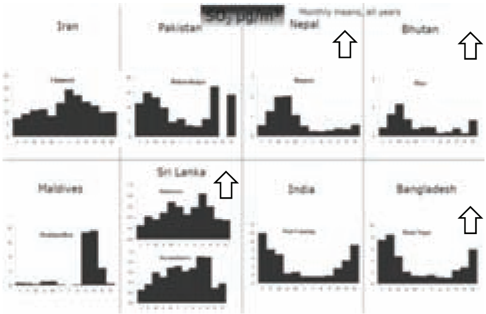
Total Suspended Particles (TSP) and PM_{10} are being measured using high volume samplers (HVS) (regionally sourced);

Two Bulk samplers (funnel and bottle) at each site;

MISU wet-only collector at each site with solar panel;

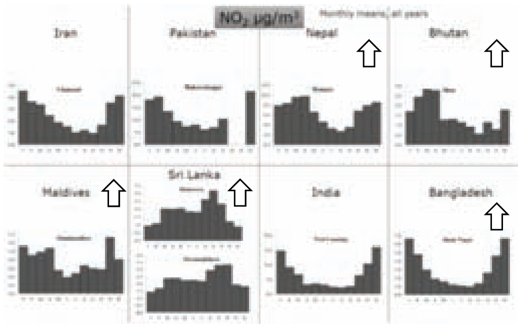
Meteorological measurements.

Malé Declaration Monitoring Data



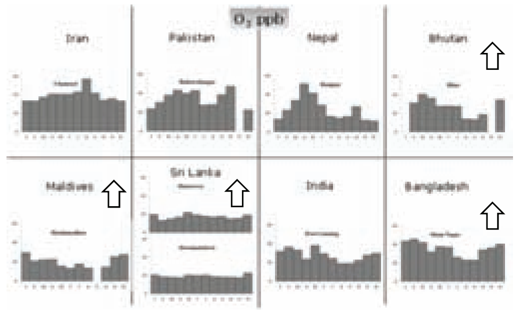
Sulphur dioxide concentrations with IVL Passive Samplers at Malé Declaration regional sites, monthly means 2003-2012

Malé Declaration Monitoring Data



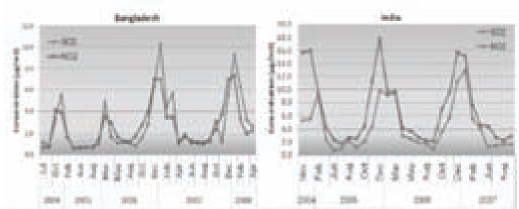
Nitrogen dioxide concentrations with IVL Passive Samplers at Malé Declaration regional sites, monthly means 2003-2012

Malé Declaration Monitoring Data



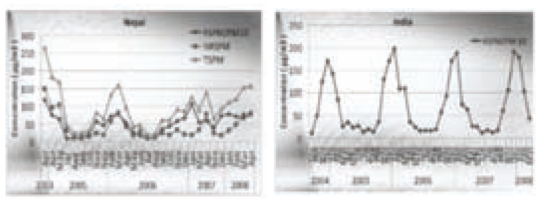
Ozone concentrations with IVL Passive Samplers at Malé Declaration regional sites, monthly means 2006-2012

Malé Declaration Monitoring Data



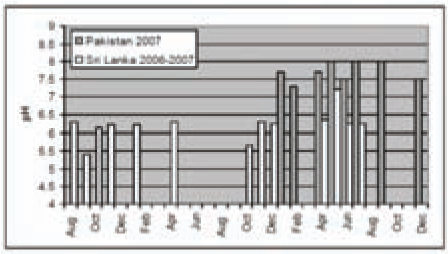
Seasonal variation of SO_2 and NO_2 concentrations measured with the High Volume Sampler (HVS) bubbler system

Malé Declaration Monitoring Data



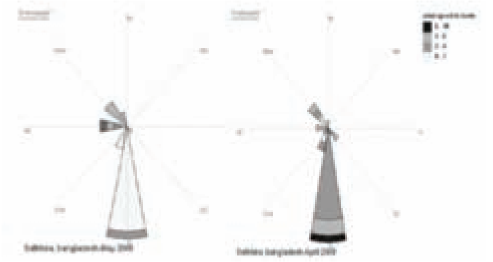
Particulate matter concentrations measured with the High Volume Sampler (HVS)

Malé Declaration Monitoring Data



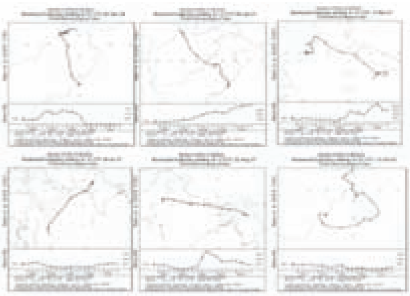
The pH of rainfall collected in the wet-only samplers

Malé Declaration Monitoring Data



Wind rose for the monitoring site in Bangladesh

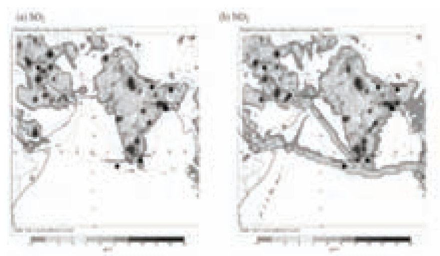
Malé Declaration Trajectory Analysis



Calculated three-dimensional, 5-day backward trajectories arriving at one of Pakistan's Malé monitoring stations during selected days of 2006 and 2007

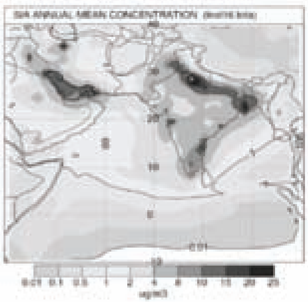
Malé Declaration Modelling Results

Regional Centre Modelling AtmosphericTransport of Air Pollution - Iran



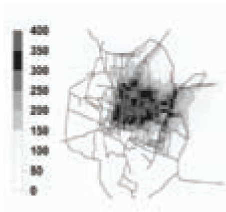
Near surface monthly-mean concentrations of SO_2 and NO_2 in July 2000 across South Asia from the MATCH model using EDGAR emission estimates for 1995.

Malé Declaration Modelling

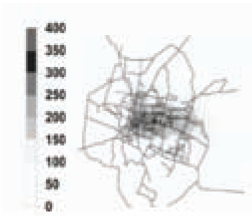


Calculated annual-mean concentration of secondary inorganic aerosols (SIA) – sulphate, nitrate and ammonium (all within the $PM_{2.5}$ size category)

RAPID URBAN ASSESSMENT



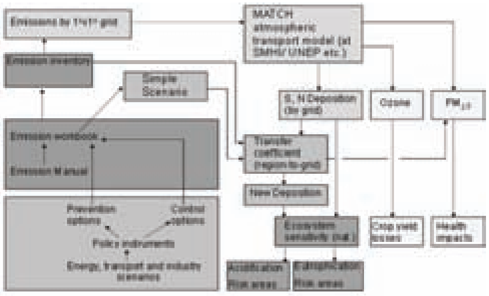
July-September 2007



February-April 2008

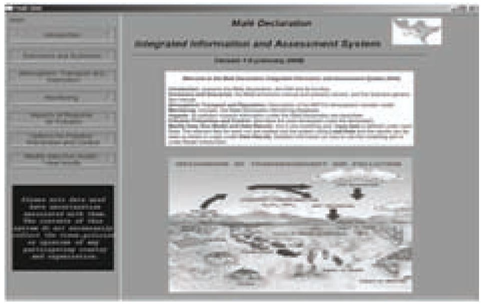
Results make it clear that the most important pollutant in Kathmandu is particulate matter, largely from the transport sector, which is known to have the greatest impact on human health

Integrated Assessment



Schematic outline of the calculations within the Malé Declaration Integrated Information and Assessment System (IIAS)

Malé Declaration Integrated Information and Assessment System (IIAS)

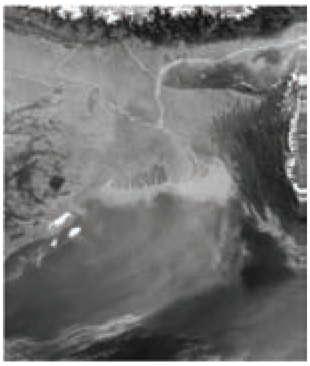


International evidence of the transboundary nature of air pollution

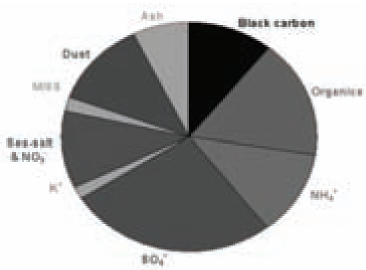
e.g.

- Atmospheric Brown Cloud (ABC)
- Hemispheric Transport of Air Pollution (HTAP), LRTAP
- UNEP Short Lived Climate Pollutant (SLCP) Assessment

Atmospheric Brown Cloud (ABC)

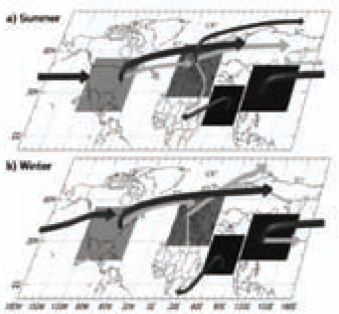


Atmospheric Brown Cloud (ABC) Results



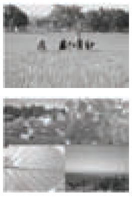
Measured composition of the Atmospheric Brown Cloud over South Asia from the ABC

Hemispheric Transport of Air Pollution (HTAP)

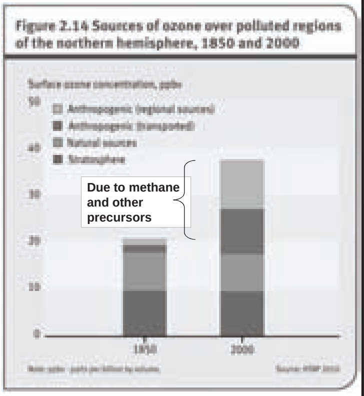


HTAP, 2010

Ground level ozone is increasing



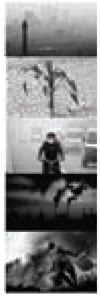
Reducing ground level ozone:
- protects public health
- reduces ozone damage to crops



Source: UNEP GEO-5, HTAP

What are short-lived climate pollutants?

- **Black carbon**
- **Tropospheric ozone**
- **Methane**
- **some Hydrofluorocarbons (HFCs)**



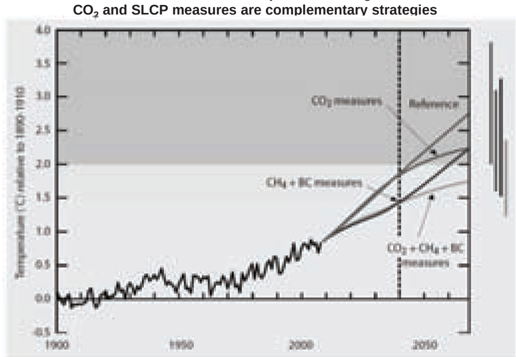
SEI

Lifetimes in the atmosphere

Substance	Lifetime
Carbon dioxide	Decades to centuries and about 20 per cent will persist for many millennia
Ozone	4 – 18 days
Methane	12 years
Black carbon	3-8 days
HFCs	Average of mix: 15 years

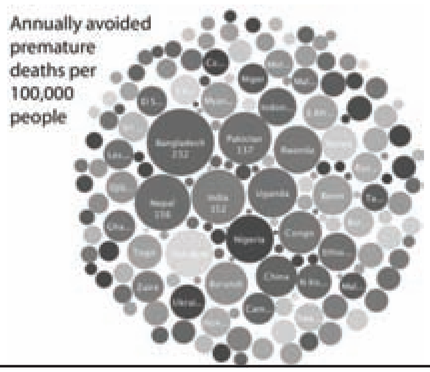
SEI

Result for Global Temperature Change:
CO_2 and SLCP measures are complementary strategies



Source: UNEP/WMO (2011). Integrated Assessment of Black Carbon and Tropospheric Ozone. UNEP, Nairobi

Health Benefits by Country



SEI

Overall achievements of the Malé Declaration

Decision Support Information

Science to Policy

Regional Centre: Pollution Reduction Policies/Strategies – Nepal / Maldives

- Reports and training on good practice for air pollution policy, examining Best Available Techniques (BAT) for the housing, transport and power sectors.
- Study of factors that affect how well policy interventions work in the social and political contexts of the different countries.
- Training on regional cooperation issues focusing on good practices and knowledge on international policies and regulations related to air pollution in other parts of the world.
- Feasibility study of regional cooperative framework.
- Bangladesh National Action Plan for Air Pollution.

Overall achievements of the Malé Declaration

Opportunities and Challenges

Opportunities for Regional Co-operation

- Enough evidence to act - synthesis report showing much evidence produced and capacity established.
- Some Malé Declaration countries are prioritising action on air pollution and SLCPs and good practice in region can be shared – Malé Declaration is prime vehicle for doing this.
- Transboundary nature of air pollution in South Asia - offers incentives for action and co-operation.
- Links to ABC and particularly to black carbon and Himalayas – 30K glaciers in the Himalayas provide extra incentive.
- Ambitious national programmes on emission control contribute to international resolve—and *vice versa*

Opportunities for Regional Co-operation (cont.)

- Address short-term (health and crops) and long-term like climate and sustainability and link to SLCPs
- Monitoring programme important to protect and promote as basis for action – crucial to reviewing success of implementation of measures
- Need to continue work towards a regional treaty on air pollution:

– international agreement involving the different sectors

– characterized by flexibility and differentiated responsibilities and obligations for individual countries according to national priorities and possibilities.

Requirements for Further Progress

Emphasize opportunities based on what the Malé Declaration has already achieved to:

- Achieve stable and long-term funding in the region

- Establish working regional technical centres

- Link to national development planning

- Share good practice and experience across a range of Malé Declaration stakeholders, including policy makers, to facilitate international cooperation for progress on emission reduction.

Thank you for your attention

Malé Declaration

on Control and Prevention of Air Pollution and its Likely Transboundary Effect for South Asia

Report of the Inter – Laboratory Comparison of Precipitation Chemistry Analyses among the NIAs of the Malé Declaration

Third attempt Jul. 2011

May, 2013

This report has been prepared by Dr. Nguyen Thi Kim Oanh, Environmental Engineering Program, School of Environment, Resources and Development, Asian Institute of Technology, Thailand in cooperation with the Malé Secretariat as a part of the phase III implementation of the Malé Declaration on Control and Prevention of Air Pollution and Its Likely Trans-boundary Effects for South Asia (Malé Declaration). The report was based on the analytical results of the artificial rain water samples from the National Implementation Agencies (NIA) of Malé. The contents of the report do not necessarily reflect the views, policies or opinions of any participating country or organization.

National Implementation Agency and National Focal Point

Bangladesh	Bhutan	India	Iran
NFP: Ministry of Environment and Forest	NFP and NIA: National Environnent Commission	NFP: Ministry of Environment and Forests	NFP and NIA: Department of the Environment, Tehran
NIA: Department of Environment Dhaka		NIA: Central Pollution Control Board, New Delhi	
Maldives	**Nepal**	**Pakistan**	**Sri Lanka**
NFP: Ministry of Environment, Energy and Water	NFP: Ministry of Environment Science and Technology	NFP: Ministry of Environment	NFP: Ministry of Environment and Natural Resources
NIA: Department of Meteorology	NIA: International Centre for Integrated Mountain Development(ICIMOD) Kathmandu	NIA: Pakistan Environment Protection Agency, Islamabad	NIA: Central Environmental Authority, Colombo

Secretariat
United Nations Environment Programme (UNEP)
Regional Resource Centre for Asia and the Pacific (RRC.AP)
Outreach Building, AIT, P.O. Box 4
Klongluang, Pathumthani 12120, Thailand
Fax: 66 2 516 2125

Technical Support
Environmental Engineering and Management
School of Environment, Resources and Development
Asian Institute of Technology
Klongluang, Pathumthani 12120, Thailand
Fax: 662 524 5625

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Contents

1. INTRODUCTION

Malé Declaration on Control and Prevention of Air Pollution and Its Likely Trans-boundary Effects for South Asia (Malé Declaration) is an intergovernmental agreement to tackle the issue of transboundary air pollution through regional cooperation in South Asia since 1998. Participating countries are Bangladesh, Bhutan, Iran, India, Maldives, Nepal, Pakistan and Sri Lanka with a National Implementing Agency (NIA) established in each country.

The main objective of the Malé Declaration Programme is to promote the establishment of a scientific base for prevention and control of air pollution in South Asia to encourage and facilitate coordinated interventions of all the stakeholders on transboundary and shared air pollution problems at national and regional levels. One monitoring site was established in each participating country and the monitoring network is being implemented based on the common methodologies and standards. The inter-laboratory comparison is a required quality assurance **(**QA) measure to ensure the harmonization and quality of the data. This inter-laboratory exercises have been practiced by other regional monitoring networks such as Acid Deposition Monitoring Network in East Asia (EANET) for rain water samples or Air Pollution Regional Research Network (AIRPET) for particle composition samples.

This is the third attempt of the inter-laboratory comparison project which involves a round-robin analysis of uniformly prepared artificial rainwater samples by the NIA laboratories of the Malé Declaration project. The overall objective of the inter-laboratory comparison is to recognize the analytical precision and accuracy of the data in each participating NIA laboratory and consequently to provide an opportunity to improve data reliability/quality. The protocol highlighting the methodology of this inter-laboratory comparison has been developed based on Quality Assurance/Quality Control (QA/QC) procedure for Malé Declaration network with reference to the inter-laboratory comparison reports of the EANET project. The sample preparation, distribution and analysis with necessary QA/QC are included in the protocol which was circulated and agreed upon by all NIAs in September 2007, i.e. before the inter-laboratory exercise started.

Artificial rainwater samples contained major ions, were prepared and distributed to NIAs by the reference laboratory at the Asian Institute of Technology (AIT) in July 2011. Seven among eight participating laboratories submitted the analytical data to AIT in time. Obtained data for pH, EC and concentrations of SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+} from these 7 laboratories were compared with the prepared values and statistically treated. List of the participating laboratories, individual analytical data, and various statistical parameters are included in this report.

2. INTER – COMPARISON PROCEDURE

2.1 Participating laboratories

Seven laboratories of the eight countries of the Malé Declaration Programme (one laboratory per NIA) have participated in this inter-laboratory comparison exercise. The name and the contact addresses of the participating laboratories are included in Appendix 1.

2.2 Artificial rainwater samples

Two concentration levels were prepared at the AIT laboratory: the higher concentration sample (No. M31) and the lower concentration sample (No.M32). The ranges of the ten (10) parameters specified in QA/QC of the Malé Declaration including pH, electrical conductivity (EC) and concentrations of ionic species (SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}) are presented in Table 1. The broad ranges of each parameter in the prepared samples (Table 1) were informed to NIAs at the time of the sample distribution. Summary information on the prepared artificial samples is presented in Table 2. These ranges as well as the actual concentration levels for each sample were selected based on the frequency distribution of each parameter obtained from the available data on actual rainwater samples of Malé Declaration Programme that NIA participating laboratories had submitted to the UNEP RRC.AP office.

Table 1 Concentration Ranges in the Artificial Rain Water Samples

Parameter	Range	Parameter	Range
pH	4-6.5	Na^+	1 – 150 µmol/L
EC	0.2-10 mS/m	K^+	1 – 50 µmol/L
SO_4^{2-}	1 – 100 µmol/L	Ca^{2+}	1 – 50 µmol/L
NO_3^-	1 – 100 µmol/L	Mg^{2+}	1 – 50 µmol/L
Cl^-	5 – 150 µmol/L	NH_4^+	1 – 100 µmol/L

2.3 Analytical parameters and methods

Participating laboratories were expected to use the analytical methods specified in the “Technical Document for Wet and Dry Deposition Monitoring for Malé Declaration” and closely followed the “Quality Assurance/Quality Control (QA/QC) Programme for Wet and Dry Deposition Monitoring for Malé Declaration” protocol which is summarized in Table 2.

If NIA uses other methods (than the methods specified by the Malé Protocol) for the routine analysis of rainwater samples and if the practice has already been approved by the UNEP RRC.AP then the NIA should use these methods for the artificial rainwater samples.

Thus, the NIA analyzed the artificial rainwater samples following the routine methods they use to get the data that they report to the Malé network. In addition, the NIA were also encouraged to run and report results by other methods if relevant. It was recommended that NIA do at least 3 runs for each parameter and reported the average concentration value and one standard deviation (Average ± STD).

To ensure the accuracy and precision of the data and for proper assessment of the operation conditions, the persons, who were responsible for analyzing wet deposition samples at the NIA, were also required to analyze these artificial rainwater samples of inter-laboratory comparison. An excel data template was provided to the NIA for the data reporting.

Table 2 Analytical methods specified in the Technical Documents for Wet and Dry Deposition monitoring for Malé Declaration

Parameter	Analytical/Instrument method
pH	Glass electrode
Electrical Conductivity	Conductivity Cell
Chloride	Argentrometric method
Nitrate	Cadmium reduction method-Spectrophotometry
Sulphate	Spectrophotometry
Sodium	Flame photometry
Potassium	Flame photometry
Calcium	Titrimetry (EDTA method)
Magnesium	Titrimetry
Ammonium	Spectrophotometry (Indophenol)*

*- no biocide of *Thymol* is expected in the prepared samples hence the method can be used
Sources: QA/QC program for wet and dry deposition monitoring for Malé Declaration

2.4 Analytical data checking procedure

The analytical results by NIAs were checked and assessed by AIT using the procedures specified in the "Technical Document for Wet and Dry Deposition Monitoring for Malé Declaration" and closely follow the "Quality Assurance/Quality Control (QA/QC) Programme for Wet and Dry Deposition Monitoring for Malé Declaration" protocol. Thus, the criteria for ion balance (R_1) and for agreement between calculated and measured electrical conductivity (R_2) were used.

The allowable ranges of R_1 and R_2, according to the Malé QA/QC protocol, are given in Table 3 and 4, respectively. Detailed methods of the calculation of R_1 and R_2 for the high and low artificial rainwater samples are presented in Appendix 2. It is noted that, however, only 5 NIA laboratories submitted the results of all 10 required analytical parameters thus it was possible to calculate these 2 criteria only for these 5 sets of the results.

Table 3 Allowable ranges for R_1 in different concentration ranges

Ceq + Aeq (μeq/L)	R_1 (%)
<50	±30
50-100	±15
>100	±8

Sources: QA/QC program for wet and dry deposition monitoring for Malé Declaration

Table 4 Allowable ranges for R_2 for different ranges of EC

Λ measured (mS/m)	R_2 (%)
< 0.5	± 20
0.5 – 3	± 13
> 3	± 9

Sources: QA/QC program for wet and dry deposition monitoring for Malé Declaration

2.5 Distributing the artificial samples to NIAs laboratories

The artificial rainwater samples were stored in the 1L polypropylene bottle. Each bottle contains 800 mL of a sample (M31 or M32). Two bottles containing the samples were placed in an ice box with dry ice and sent to the member laboratories through express post (DHL). The samples were departed from AIT on July 13, 2011 to all 8 laboratories. Five among 8 laboratories received the samples within one week others were within two to three weeks. All the Labs reported that samples were delivered in good condition.

It is noted that all the NIAs were requested to analyze the samples within a week after arrival (Protocol for inter-laboratory comparison of precipitation chemistry analyses within the Malé declaration, 2007). Most NIAs analyzed the samples within 2 weeks, except Lab no.4 (Mg^{2+}, Ca^{2+}) and Lab no.6 where samples were analyzed about 2 months after received. Dates of the events including the sample sending and receiving are included in Appendix 3. Based on the follow-up analysis at AIT during the first attempt, alteration of the concentrations in the samples during the storage and shipment period of 2-3 weeks should not be the main cause of large biases.

Table 5 Outline of artificial rainwater samples

Sample name	Amount of sample	Container	Number of samples	Note
No.M31 (high concentration) No.M32 (low concentration)	~ 800 mL/bottle	Poly-propylene bottle, 1000 mL	1 bottle for each level	Known amount of reagents dissolved in deionized water

3. RESULTS

AIT shipped the artificial rainwater samples to all 8 NIA laboratories of the Malé Declaration Programme and received analytical data reports from 7 out of 8 NIA Labs. The received data are summarized in Table 6 and 7. Note that only 5 NIA laboratories analyzed for all 10 parameters specified in the Malé monitoring protocol. All seven NIAs reported pH and EC data. Beside pH and EC, Lab no.2 measured only four cations Na^+, K^+, Ca^{2+} and Mg^{2+} while Lab no.7 did not analyze three cations (e.g. missing data of Na^+, K^+ and NH_4^+). Lab no.2 did not report the data in the specified units for EC. Only one Lab no.6 reported R1 and R2 values.

According to the Malé Inter-laboratory Comparison Protocol the NIAs would analyze each sample 3 times for all parameters and report results in the provided data template. However, not all NIAs followed this requirement. For those NIAs that reported results of all 3 analyses for each parameter in a sample the standard deviation of the data was calculated and presented in Table 6 and 7. For Lab no.2 that did not report the repeated analysis results, only single values are presented.

Table 6 Summary of the analytical results of the high concentration artificial rainwater sample (M31) by NIAs as compared to the prepared levels

Parameter	NIA laboratories								Prepared levels
	Lab no.1	Lab no.2	Lab no.3	Lab no.4	Lab no.5	Lab no.6	Lab no.7	Lab no.8	
pH	5.33±0.4	5.57	5.29±0.01	7.66±0.01	na	5.95±0.06	5.66±0.05	5.067±0.0115	5.63
EC (mS/m)	2.96±0.3	3.21	2,96±0.01	3.50±0.001		3.77±0,07	2.973±0.032	2.9±0	2.88
SO_4^{2-}(μmol/L)	49±1	na	32.78±2.6	50.63±0.21		32.44±1.10	33.83±1.63	44.71±0.08	39.10
NO_3^- (μmol/L)	30±1	na	33.5±0.6	7.70±0.01		30.56±2.21	30.2±1.98	40.01±0.02	38.87
Cl^- (μmol/L)	116±5	na	178.7±8.14	56.04±0.00		89.17±8.13	76.80±0.8	103.59±.03	99.03
Na^+ (μmol/L)	81±1.2	5.49	87.8±1.50	68.11±2.51		131.22±8.22	na	107.25±0.07	71.03
K^+ (μmol/L)	11±0.1	< BL	36.4±0.92	12.82±0.00		30.22±2.99	na	19.07±0.10	8.70
Ca^{2+}(μmol/L)	27±0.5	< BL	31.5±1.5	120±0.25		18.33±2.89	27.24±1.79	30.52±0.52	29.08
Mg^{2+}(μmol/L)	18±0.7	2.03	29.6±0.6	15.23±0.01		8.44±2.93	18.37±1.08	16.67±.06	15.40
NH_4^+(μmol/L)	37±0.7	na	57.4±1.25	44.13±0.18		40±0.00	na	58.07±0.19	47.40

na: data not available (not analyzed)
BL: Blank

Table 7 Summary of the analytical results of the low concentration artificial rainwater sample (M32) by NIAs as compared to the prepared concentrations

Parameter	NIA laboratory								Prepared levels
	Lab no.1	Lab no.2	Lab no.3	Lab no.4	Lab no.5	Lab no.6	Lab no.7	Lab no.8	
pH	5.76±0.4	5.97	5.44±0.02	7.63±0.01	na	6.29±0.19	6.03±0.05	5.17±.01	5.69
EC (mS/m)	0.76±0.3	0.92	0.667±0.002	2.184±0.001		0.31±0.01	0.667±0.015	0.6±0	0.62
SO_4^{2-}(μmol/L)	11±1	na	8.09±0.21	34.14±0.31		3.4±1.9	2.91±0.38	10.29±0.03	9.68
NO_3^- (μmol/L)	7±1	na	2.17±0.13	0.07±0		14.43±3.73	1.95±0.15	4.12±0.09	3.20
Cl^- (μmol/L)	24±5	na	56.42±0	56.04±0		16.43±4.06	8.10±0.13	14.33±0.12	16.05
Na^+ (μmol/L)	12±0.7	0.12	15.94±0.5	4.35±0		46.37±9.13	na	6.23±0,19	5.54
K^+ (μmol/L)	4±0.5	< BL	7±0.15	8.55±1.48		14.68±2.99	na	4.94±0.04	3.20
Ca^{2+}(μmol/L)	3.5±0.5	< BL	16±1.2	40.13±0.34		8.33±2.89	2.85±0.10	5.22±0.13	5.25
Mg^{2+}(μmol/L)	6±0.3	0.49	14.6±0.7	3.89±0.01		3.37±2.92	2.42±0.49	5.27±0.01	5.05
NH_4^+(μmol/L)	7±0.7	na	8.32±0.18	2.7±0.16		13.33±5.77	na	11.73±0.06	9.26

na: data not available(not analyzed)
BL: Blank (<BL can be regarded as not detected)

The statistics were calculated for the obtained data of each parameter such as Average, Minimum (Min.), Maximum (Max.), Standard deviation (S.D.), and Number of data (N) and are presented in Table 8. The relative deviations between the average NIA results for each parameter against the prepared value [$\Delta V/Vp$] are also shown in Table 8. The averages of the submitted data differ from the prepared concentrations, for the low concentration sample (No.M32), within a range of a few percents (~2% for Mg^{2+}) to above 140-156% (Ca^{2+}, K^+, Na^+). For the high concentration sample (No.M31) the relative deviations are relative smaller, ranging from below 5% (for pH, SO_4^{2-}, Cl^-, Mg^{2+}, NH_4^+) to a maximum of 152% (K^+). Note that no outlier treatment was applied for this small data set and all the received data were included in the analysis.

Table 8 Statistics of the NIA analytical results for the artificial rainwater samples

Parameter	Average (Va)	S.D	N	Min	Max	Prepared (Vp)	$\Delta V/Vp$ (%)
Sample No.M31 (high concentration)							
pH	5.79	0.87	7	5.07	7.66	5.79	2.84
EC (mS/m)	3.18	0.33	7	2.90	3.77	3.18	10.47
SO_4^{2-}(μmol/L)	40.6	8.5	6	32.4	50.6	40.60	3.7
NO_3^- (μmol/L)	28.7	10.9	6	7.7	40.0	28.70	-26.3
Cl^- (μmol/L)	103.4	42.4	6	56.0	178.7	103.40	4.4
Na^+ (μmol/L)	80.1	42.7	6	5.5	131.2	80.10	12.8
K^+ (μmol/L)	21.9	11.1	6	11.0	36.4	21.90	151.6
Ca^{2+}(μmol/L)	42.4	38.3	7	18.3	120.0	42.40	45.9
Mg^{2+}(μmol/L)	15.5	8.6	7	2.0	29.6	15.50	0.5
NH_4^+(μmol/L)	47.3	9.8	5	37.0	58.1	47.30	-0.2
Sample No.M32 (low concentration)							
pH	6.04	0.79	7	5.17	7.63	6.04	6.18
EC (mS/m)	0.87	0.61	7	0.31	2.18	0.87	40.74
SO_4^{2-}(μmol/L)	11.6	11.5	6	2.9	34.1	11.60	20.2
NO_3^- (μmol/L)	5.0	5.2	6	0.1	14.4	5.00	54.7
Cl^- (μmol/L)	29.2	21.5	6	8.1	56.4	29.20	82.1
Na^+ (μmol/L)	14.2	16.7	6	0.1	46.4	14.20	155.6
K^+ (μmol/L)	7.8	4.2	6	4.0	14.7	7.80	144.4
Ca^{2+}(μmol/L)	12.7	14.3	7	2.9	40.1	12.70	141.3
Mg^{2+}(μmol/L)	5.1	4.5	7	0.5	14.6	5.10	2.0
NH_4^+(μmol/L)	8.6	4.2	5	2.7	13.3	8.60	-7.0

Note: ΔV = Average (Va) – Prepared (Vp)

The data obtained from NIAs were evaluated against the Data Quality Objectives (DQOs) of the QA/QC for Malé Declaration Monitoring program, namely for every parameter the measured value should be within ±15% of deviation from the prepared value. The bias (a measure of accuracy) of the data was calculated for analytical results of each parameter of the artificial rainwater samples as below:

$$\text{Bias (\%)} = 100 \times (\text{Analytical value} - \text{Prepared value})/(\text{Prepared value})$$

Flag "E" was put to the data that exceed DQOs by a factor of 2, i.e between ±15% and ±30%.
Flag "X" was put to the data that exceed DQOs more than a factor of 2, i.e. beyond ±30%.

The results were evaluated from three aspects:

i) Sample-wise comparison to gain the concentration dependence assessment: separate analysis for sample No.M31 (higher concentrations) and No.M32 (lower concentrations) and compare the results
ii) Parameter-wise comparison to assess the data quality for individual parameters, and
iii) Comparison of circumstances of analysis in each participating laboratory.

Evaluation for each sample is presented in "3.1 Sample-wise comparison", evaluation for each parameter is presented in "3.2 Parameter-wise comparison" and evaluation of the data against the circumstances in the analytical laboratories such as analytical methods used, number and experiences of the personnel, and other analytical conditions are presented in "3.3 Circumstances of sample analysis".

3.1 Sample-wise comparison

Sample No.M31 (higher concentrations)

Table 9 presents the evaluation of NIA results for sample No.M31 (higher concentrations), which shows 17 non-reported data points accounting for 21% of total commitment data (10 parameters/NIA x 8 NIA = 80 data points). The non-reported data points were assigned as 999. There were 18 analytical data points out of reported 63 exceeded the DQOs by a factor of ≤2 and were flagged by "E". There were 17 analytical data points out of 63 exceeded the DQOs by more than a factor of 2 and were flagged by "X". The total flagged data account for 56% of reported analytical data for this sample, in which flagged "E" and "X" accounted for 29% and 27%, respectively. Two (2) measured data points that were below blank levels were also flagged (Figure 1).

Table 9 Numbers of flagged data for the Sample No.M31 (higher concentrations)

	pH	EC	SO_4^{2-}	NO_3^-	Cl^-	Na^+	K^+	Ca^{2+}	Mg^{2+}	NH_4^+	**Total**
Total available data points	7	7	6	6	6	6	6	7	7	5	**63**
999 (non-reported data), points	1	1	2	2	2	2	2	1	1	3	**17**
999 (non-reported data), %	13	13	25	25	25	25	25	13	13	38	**21**
Flag data (against the number reported data points)											
Flag E	0	1	4	3	2	1	1	0	2	4	**18**
Flag X	1	1	0	1	2	3	4	2	3	0	**17**
Below BL							1	1			**2**
Total flag data (E+X), points	1	2	4	4	4	4	5	2	5	4	**35**
Flagged data (E+X), %	14	29	67	67	67	67	83	29	71	80	**56**
Data within the DQOs (against the number of reported data points)											
Data within DQOs, points	6	5	2	2	2	2	0	4	2	1	**28**
Data within DQOs, %	86	71	33	33	33	33	0	57	29	20	**41**

Total available data: 63 (including the below blank data)
BL: blank
E: value exceeds the DQO (±15%) by a factor of ≤2
X: value exceed the DQO (±15%) more than a factor of 2

Table 10 Analytical results of sample No.M31 (higher concentrations)

	pH	EC (mS/m)	SO_4^{2-} (μmol/L)	NO_3^- (μmol/L)	Cl^- (μmol/L)	Na^+ (μmol/L)	K^+ (μmol/L)	Ca^{2+} (μmol/L)	Mg^{2+} (μmol/L)	NH_4^+ (μmol/L)	R1	R2
Lab no.1	5.33	2.96	49 E	30 E	116 E	81	11 E	27	18 E	37 E		
Lab no.2	5.57	3.21	na	na	na	5.49 X	<BL	<BL	2.03 X	na	-	-
Lab no.3	5.29	2.96	32.78 E	33.5	178.7 X	87.8 E	36.4 X	31.5	29.6 X	57.4 E		
Lab no.4	7.66 X	3.5 E	50.63 E	7.7 X	56.04 X	68.11	12.82 X	120 X	15.23	44.13	I	
Lab no.5	na											
Lab no.6	5.95	3.77 X	32.44 E	30.56 E	89.17	131.22 X	30.22 X	18.33 X	8.44 X	40 E	I	C
Lab no.7	5.66	2.97	33.83	30.2 E	76.8 E	na	na	27.24	18.37 E	na	-	-
Lab no.8	5.07	2.9	44.71	40.01	103.59	107.25 X	19.07 X	30.52	16.67	58.07 E	I	

E: value exceeds the DQO (±15%) by a factor of ≤ 2
X: value exceed the DQO (±15%) more than a factor of 2
na: not available (not analyzed)
I: poor ion balance agreement
C: poor electrical conductivity agreement
(-) not enough data to calculate R_1 and R_2

Among 10 measured parameters, pH data had the least flagged data points, i.e. 14%. Most of the others were flagged E or X (29 to 80%). All data points for K^+ were flagged including those flags for data points below BL. The evaluation against the criteria for ion balance (R_1) and electrical conductivity (R_2) was possible only for the data from 5 laboratories (Lab no.1, Lab no.3, Lab no.4, Lab no 6 and Lab no.8) which reported the full composition data sets with 10 parameters. Lab no.6 has both poor "electrical conductivity agreement" and "ion balance". Only Lab no.1 and Lab no.3 have both R_1 and R_2 within the recommended ranges though many data points of these laboratories were flagged. Thus, due to overall low data quality, meeting the R_1 and R_2 criteria would not guarantee for the good analytical data due to the possible compensation effects of the errors.

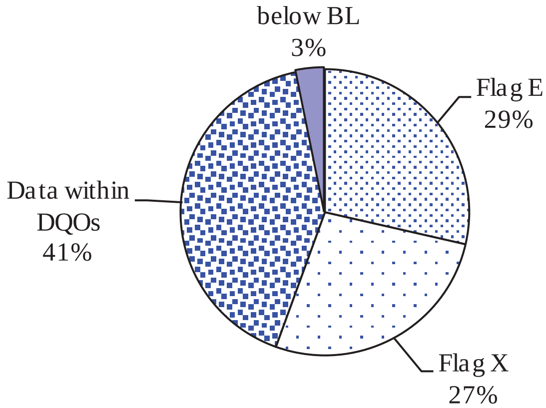


Fig.1 Percentage of data meeting DQOs and flagged data for Sample No.M31 (higher concentrations)

Sample M32 (lower concentrations)

Table 11 presents the evaluation of NIA results for sample No.M32 (lower concentrations), which shows 17 non-reported data points accounting for 21% of total 80 committed data points. These non-reported data points were assigned to as 999. There were 8 analytical data points out of 63 exceeded the DQOs by a factor of ≤ 2 and were flagged "E", 36 analytical data points exceeded the DQOs by more than a factor of 2 and were flagged "X". Two (2) data points reported below blank were also flagged. Total flagged data account for 70% of analytical data points for this sample, in which E and X flag accounted for 13% and 57%, respectively (Figure 2).

As presented in Tables 12, measured pH had less flagged data points (14%). Above 68% of analytical results of every ion were flagged and 100% of NO_3^- and K^+ (including the flags for the below blank data points) results were flagged. The evaluation against the criteria for ion balance (R_1) and electrical conductivity (R_2) was possible only for the data from 5 laboratories (Lab no.1, Lab no.3, Lab no.4, Lab no.6 and Lab no.8). Most of NIAs had poor agreement for both electrical conductivity and ion balance except for Lab no.1 and Lab no.8 which had the R1 within the DQOs although most of its reported data were flagged. Similarly to the discussion for sample M31 presented above, meeting the R_1 and R_2 criteria would not guarantee for the good analytical data.

Table 11 Numbers of flagged data for the Sample No.M32 (lower concentrations)

	pH	EC	SO_4^{2-}	NO_3^-	Cl^-	Na^+	K^+	Ca^{2+}	Mg^{2+}	NH_4^+	**Total**
Total available data points	7	7	6	6	6	6	6	7	7	5	**63**
999 (non-reported data), points	1	1	2	2	2	2	2	1	1	3	**17**
999 (non-reported data), %	13	13	25	25	25	25	25	13	13	38	**21**
Flag data (against the number reported data points)											
Flag E	0	1	1	1	0	1	1	0	1	2	**8**
Flag X	1	3	3	5	4	4	4	5	5	2	**36**
Below BL							1	1			**2**
Total flag data (E+X), points	1	4	4	6	4	5	5	5	5	4	**44**
Flagged data (E+X), %	14	57	67	100	67	83	83	71	71	80	**70**
Data within the DQOs (against the number of reported data points)											
Data within DQOs, points	6	3	2	0	2	1	0	1	2	1	**17**
Data within DQOs, %	86	43	33	0	39	17	0	14	29	20	**27**

Total available data: 63 (including the below blank data)
BL: blank
E: value exceeds the DQO (±15%) by a factor of ≤2
X: value exceed the DQO (±15%) more than a factor of 2

Table 12 Analytical results of sample No.M32 (lower concentrations)

	pH	EC (mS/m)	SO_4^{2-} (μmol/L)	NO_3^- (μmol/L)	Cl^- (μmol/L)	Na^+ (μmol/L)	K^+ (μmol/L)	Ca^{2+} (μmol/L)	Mg^{2+} (μmol/L)	NH_4^+ (μmol/L)	R1	R2
Lab no.1	5.8	0.8 E	11.0	7.0 X	24.0 X	12.0 X	4.0 E	3.5 X	6.0 X	7.0 E		
Lab no.2	6.0	0.9 X	na	na	na	0.1 X	< BL	< BL	0.5 X	na	-	-
Lab no.3	5.4	0.7	8.1 E	2.2 X	56.4 X	15.9 X	7.0 X	16.0 X	14.6 X	8.3	I	
Lab no.4	7.6 X	2.2 X	34.1 X	0.1 X	56.0 X	4.4 E	8.6 X	40.1 X	3.9 E	2.7 X	I	C
Lab no.5	na											
Lab no.6	6.3	0.3 X	3.4 X	14.4 X	16.4	46.4 X	14.7 X	8.3 X	3.4 X	13.3 X	I	C
Lab no.7	6.0	0.7	2.9 X	2.0 X	8.1 X	na	na	2.9 X	2.4 X	na	-	-
Lab no.8	5.2	0.6	10.3	4.1 E	14.3	6.2	4.9 X	5.2	5.3	11.7 E		

E: value exceeds the DQO (±15%) by a factor of ≤2
X: value exceed the DQO (±15%) more than a factor of 2
I: poor ion balance agreement
C: poor electrical conductivity agreement
(-) not enough data to calculate R_1 and R_2

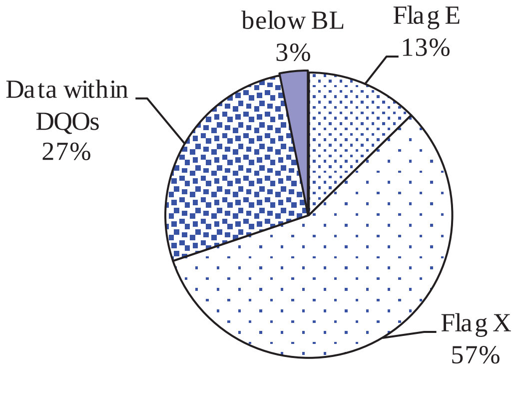


Fig.2 Percentage of data meeting DQOs and flagged data for Sample No.M32 (lower concentrations)

Summary remarks

There is a larger number of non-reported data in the third attempt as compared to second attempt (18-19 vs. 11) but lower than the first attempt (24 missing data points per sample). Overall, only pH, EC and Mg^{2+} were analyzed by all 7 NIA laboratories which submitted the results. The complete sets data of required 10 parameters, specified in the Malé declaration monitoring protocol, were submitted only by 5 NIA laboratories (Lab no.1, Lab no.3, Lab no.4, Lab no.6 and Lab no.8) which were used for the evaluation against the criteria R_1 and R_2. Only one data set satisfied both R_1 and R_2 criteria for both samples (Lab no.1, M31 and M32). Lab no. 3 had both R_1 and R_2 criteria satisfied for sample M31 and also quite closely meet the criteria for sample M32. However, many data points reported by these laboratories were flagged. Thus, because of the overall low data quality, meeting the R_1 and R_2 criteria would not guarantee for the good analytical results due to the possible compensation errors. However, if these criteria are not satisfied then the overall data quality is questionable. Thus, checking these criteria would help the NIAs to quickly assess the overall data quality. Nevertheless, only 1 NIAs (lab no. 6) submitted R_1 and R_2 calculation results though these values are required in the protocol for all laboratories.

Overall, the percentages of flagged data points are high for both samples. The total data points satisfying the DQOs for sample M31 (higher concentrations) account for 41% which is higher than that (27%) for sample M32. Total number of flagged data by “E” as well as flagged data by “X” for sample M32 was higher than that for sample No.M31 (56 and 70%, respectively). It indicates the difficulty of the analysis of the lower concentration sample. One lab reported a value “below blank” (regarded as below the detection limit) for K^+ and Ca^{2+} in both samples which suggests the need for improvement the analysis method, specifically the preparation of the laboratory blanks used in this laboratory.

3.2 *Parameter-wise evaluation*

The results are analyzed and discussed for each analytical parameter separately as presented below.

1) pH

Most of the participating laboratories reported pH results. There is no consistency in reporting the equipment names thus it is assumed that the glass electrode was used as recommended by the Malé monitoring protocol (Table 13). The pH measurement was carried out at the temperature close to the recommended condition (~25^{o}C) except for Lab no.2 which measured pH at 20.9^{o}C and Lab no.6 at 17-18^{o}C. Among all the parameters, pH data set has the smallest flagged data points. The relative deviation of the average submitted pH data as compared to the prepared was 3% for sample M31 and 6% for sample M32 (Table 8). Most of the data satisfied the DQOs of the Malé declaration QA/QC program (Fig.3). There was "X" flagged data points for pH by the Lab no.4. The different (lower measurement temperatures) by the Lab no.2 (at 20.9^{o}C) and no.6 (at 17-18^{o}C), as compared to the recommended, did not seem to affect on the final results which, however, this may also be caused by compensating errors. Lab no.4 reported pH value of 7.6 for both high and low concentration samples which are abnormally high (for acid rain samples, pH should be below 6.5). It is expected that this type of error should be noticed and double-checked, and the samples should be re-analyzed by NIA before sending the data for this inter-laboratory comparison exercise.

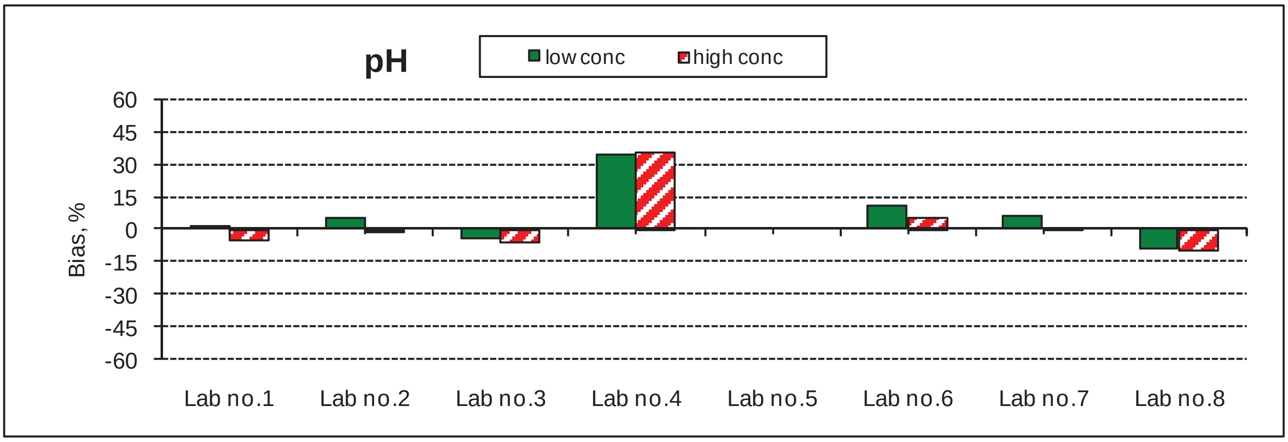


Fig.3 Distribution of pH data normalized by prepared value

Table 13 Analytical methods and flagged data of pH

Analytical methods	
pH meters (glass electrode)	7/8
Non-reported data	1/8

Flagged data	E	X	Flagged %
Sample No.M31	0	1	14
Sample No.M32	0	1	14

2) EC

All participating laboratories used conductivity meters to measure EC. There is inconsistency in reporting the equipment names. It is assumed that the conductivity cell was used as recommended by the Malé monitoring protocol (Table 14). The relative deviations of the average reported data and the prepared value were 41% and 10% for sample M32 and M31, respectively (Table 8). As presented in Fig.4, there were one "E" (Lab no.6) and one "X" (Lab no. 4) flagged data points for the EC values for the higher concentration sample (M31). For lower concentration sample (M32), there was one data flagged "E" (Lab no.1) and 3 data points flagged "X" (Lab no2, Lab no.4 and Lab no.6). Most of laboratories carried out the EC measurement at the temperatures close to the recommended condition (~25^{o}C) except for Lab no.2 which measured EC at 21^{o}C. This may effect on the measured data for the lower concentration sample.

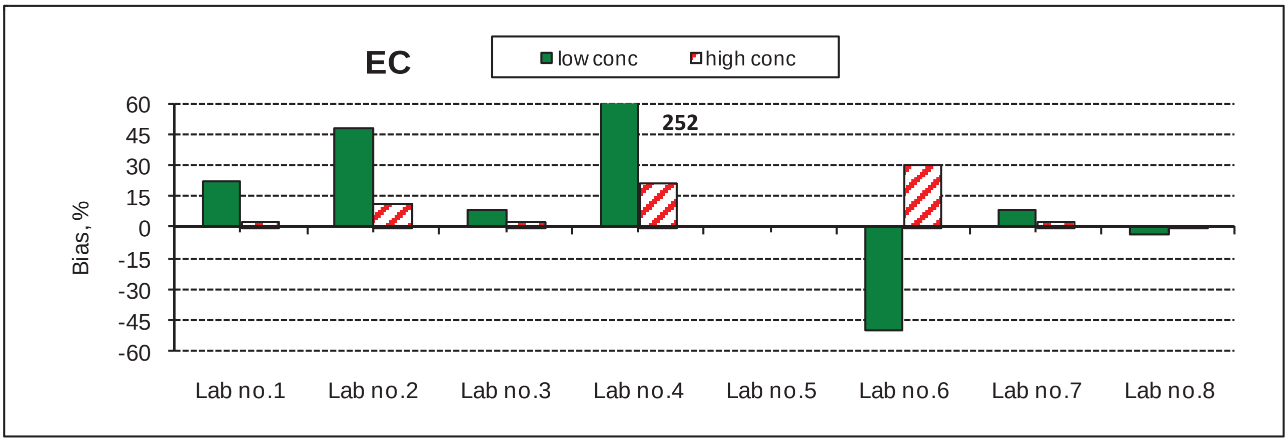


Fig.4 Distribution of EC data normalized by prepared value (off-scale values are indicated, %)

Table 14 Analytical methods and flagged data of EC

Analytical methods	
Conductivity Cell	7/8
Non-reported data	1/8

Flagged data	E	X	Flagged %
Sample No.M31	1	1	29
Sample No.M32	1	3	57

3) SO_4^{2-}

Six countries submitted SO_4^{2-} analytical data, five of them used spectrophotometry, one laboratory (Lab no.8) employed an ion chromatograph (IC) for the determination (Table 15).

There was no "X" flagged data but four flagged "E" for the higher concentration sample (M31, Fig.5) while it was 3 and 1, respectively, for the lower concentration sample (M32). A concentration below blank for both concentration samples by Lab no.2 was reported. However, the detection limit of the equipment and method (for $BaSO_4$ precipitation) were not reported. Two data points were within the DQOs for higher concentration sample (Lab no.7 and Lab no.8) and two data points for the lower concentration sample (Lab. no 1 and Lab no. 8). Though five laboratories used the spectrophotometry but the biases were different. Lab no.8, which used the ion chromatography, produced no flagged results for both samples M31 and M32. The largest bias was for Lab no. 2 results for the lower concentration sample (2.5 times higher than the prepared).

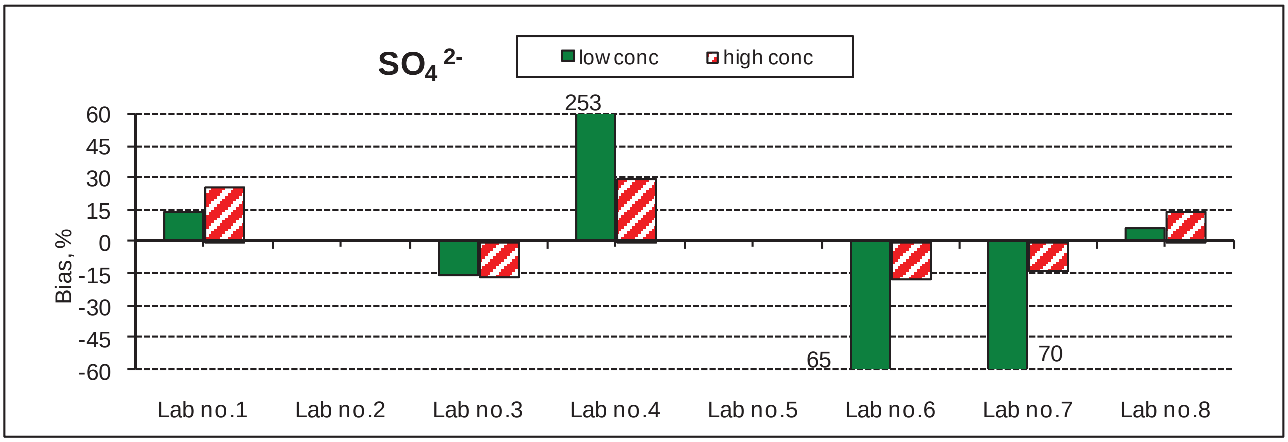


Fig.5 Distribution of SO_4^{2-} data normalized by prepared value (off-scale values are indicated, %)

Table 15 Analytical methods and flagged data of SO_4^{2-}

Analytical methods	
Spectrophotometry	5/8
Ion Chromatography	1/8
Non-reported data	2/8

Flagged data	E	X	Flagged %
Sample No.M31	4	0	57
Sample No.M32	1	3	57

4) NO_3^-

Six countries submitted NO_3^- analytical data. Lab no.8 laboratory employed an IC whereas others used spectrophotometers for the determination of NO_3^- (Table 16).

Most data submitted by the six NIAs were flagged “E” or “X” for both high and low concentration samples. Only 2 data points were within the DQOs for Lab no.3 and Lab no.8 for M32 (Fig.6). The data produced by Lab no.8 using IC also appear to be less biased for the lower concentration sample (M32).

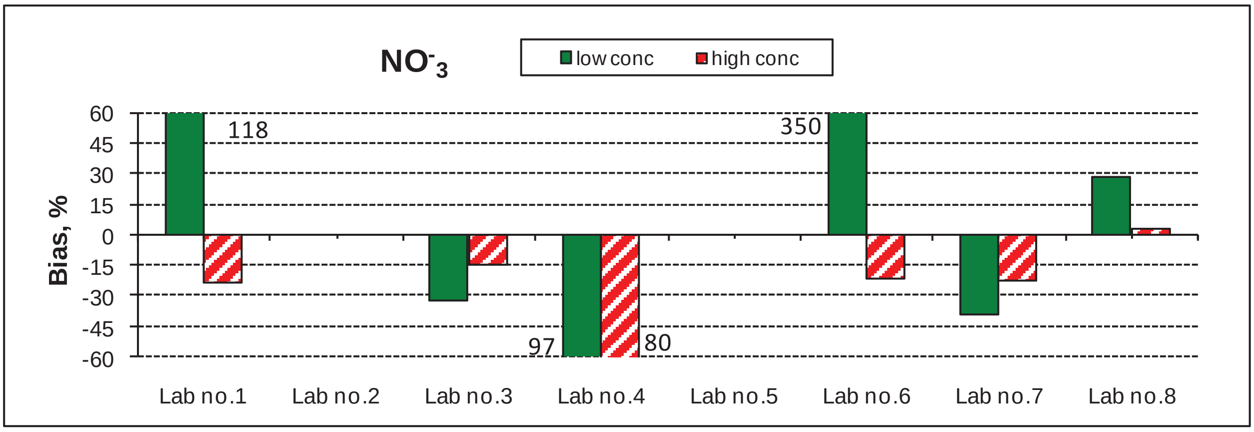


Fig.6 Distribution of NO_3^- data normalized by prepared value (off-scale values are indicated)

Table 16 Analytical methods and flagged data of NO_3^-

Analytical methods	
Spectrophotometry	5/8
Ion Chromatography	1/8
Non-reported data	2/8

Flagged data	E	X	Flagged %
Sample No.M31	3	1	67
Sample No.M32	1	5	100

5) Cl^-

Among six NIAs submitted Cl^- analytical data, only Lab no.8 employed an IC while others used the recommended Argentrometric method by the Male’ protocol for the Cl^- determination (Table 17). Results for M31 and M32 reported by Lab no.6 and Lab no.8 were within DQOs (Fig.7). There were 2 data points flagged “E” and 2 flagged “X” for the higher concentration sample, while 4 data points flagged “X” flagged for the lower concentration sample. The bias for Cl^- was the largest by Lab no.3 and Lab no.4, around 2.5 times higher than the prepared concentration biases for the lower concentration sample (M32).

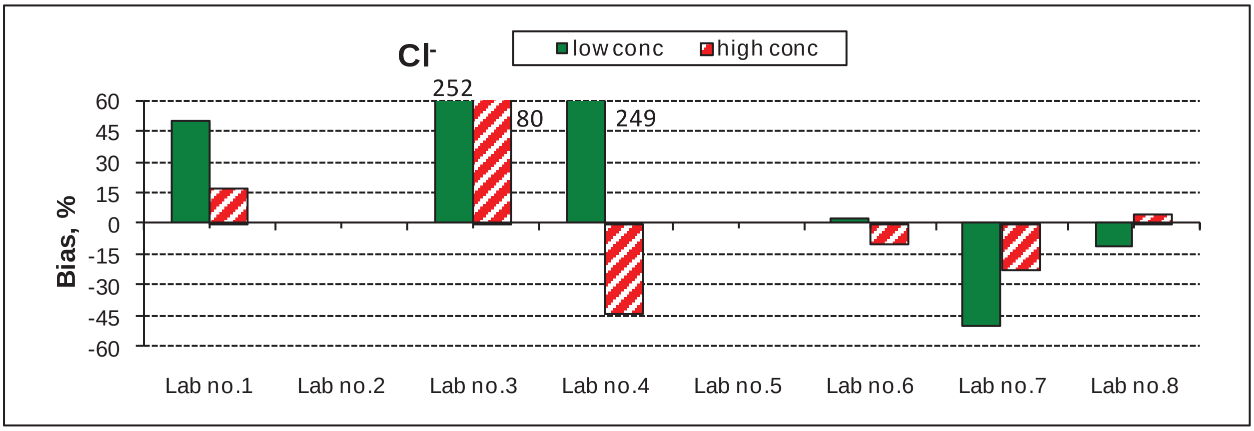


Fig.7 Distribution of Cl^- data normalized by prepared value (off-scale values are indicated, %)

Table 17 Analytical methods and flagged data of Cl^-

Analytical methods	
Argentrometric - Titrimetry	5/8
Ion Chromatography	1/8
Non-reported data	2/8

Flagged data	E	X	Flagged %
Sample No.M31	2	2	67
Sample No.M32	0	4	67

6) Na^+

Among six laboratories submitted Na^+ analytical results (Lab no.5 and 7 did not report the data). Lab no.1, 2 and 6 used Atomic Absorption Spectrophotometer (AAS), Lab no. 3 and 4 used the flame emission spectrometry while Lab no. 8 used IC (Table 18). Two reported data points by Lab no. 1 and 4 were within DQOs; one by Lab no.3 was flagged “E” and three by Lab no. 2, 6 and 8 were flagged “X” for the higher concentration sample (Fig.8). For the lower concentration sample, only one data by Lab no.8 was within DQOs, the other 5 data points were flagged “E” or “X”.

The bias for Cl^- was the most significant among all analyzed parameters and the largest biases were for results of Lab no.6, around 7 times higher than the prepared level in the lower concentration sample.

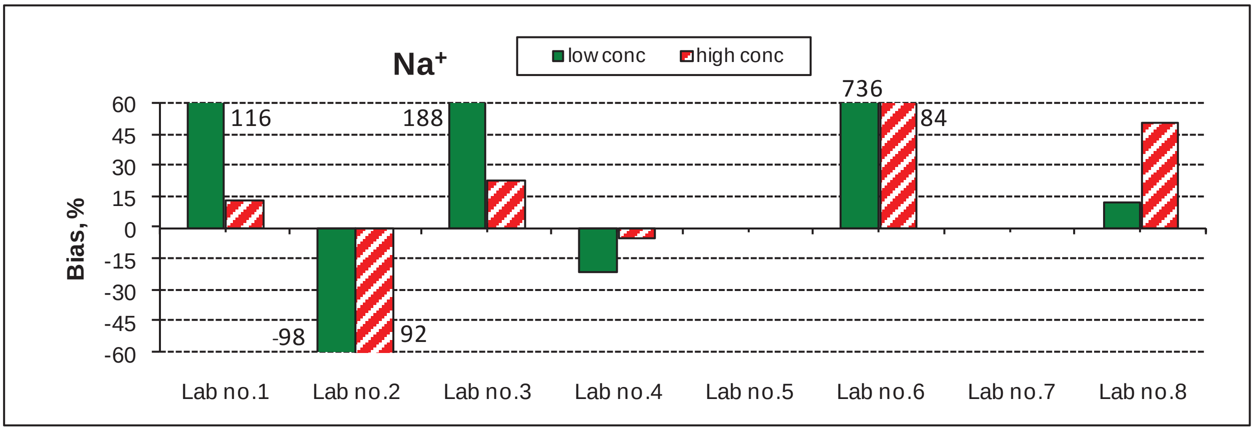


Fig.8 Distribution of Na^+ data normalized by prepared value (off-scale values are indicated)

Table 18 Analytical methods and flagged data of Na^+

Analytical methods	
Atomic absorption spectrophotometry	3/8
Flame emission spectrometry	2/8
Ion Chromatography	1/8
Non-reported data	2/8

Flagged data	E	X	Flagged %
Sample No.M31	1	3	67
Sample No.M32	1	4	83

7) K^+

The number of NIA laboratories, the analytical methods and number of reported results for K^+ were similar as for the Na^+ analysis (Table 19). All of data points were flagged for both higher (M31) and lower (M32) concentration samples which did not depend on analytical instruments used (Fig.9). One result by Lab no. 2 was negative value and was considered as below blank concentration.

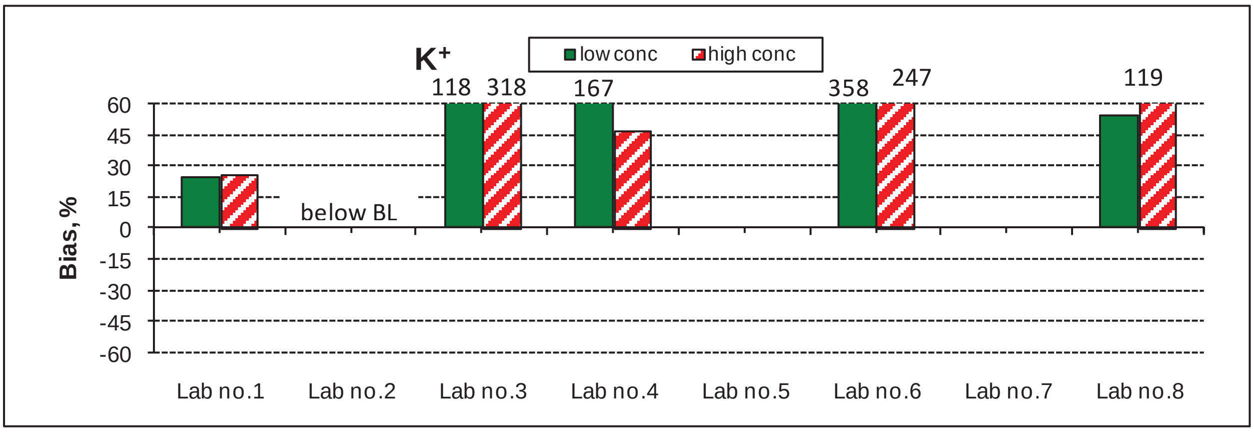


Fig.9 Distribution of K^+ data normalized by prepared value (off-scale values are indicated, %)

Table 19 Analytical methods and flagged data of K^+

Analytical methods	
Atomic absorption spectrophotometry	3/8
Flame emission spectrometry	2/8
Ion Chromatography	1/8
Non-reported data	2/8

Flagged data	E	X	< blank	Flagged %
Sample No.M31	1	4	1	100
Sample No.M32	1	4	1	100

**% flag includes below blank (negative) data points*

8) Ca^{2+}

Seven laboratories submitted the analytical data for Ca^{2+}. Three laboratories (Lab no.3, 4 and 6) used the titrimetry method, two laboratories (Lab no.1 and 2) used AAS, Lab no. 7 used spectrophotometry and Lab no.8 used IC (Table 20).

Lab no. 1, 3, 7 and 8 used different analysis methods but obtained results were within DQOs for the higher concentration sample. Lab no. 4 and 6 used the same analysis method as Lab no. 3 but reported data flagged "X". Result for Lab no. 2, which used the same analysis method as Lab no. 1, was negative (below blank). Only data points by Lab no.8, where IC was used, were within DQOs, other data were flagged "X" for the lower concentration sample.

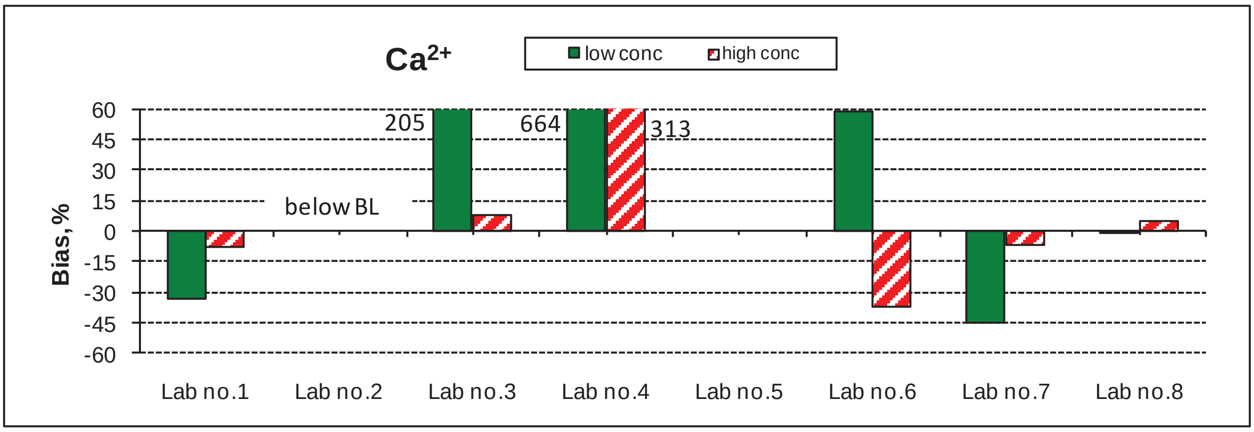


Fig.10 Distribution of Ca^{2+} data normalized by prepared value (off-scale values are indicated, %)

Table 20 Analytical methods and flagged data of Ca^{2+}

Analytical method	
Titrimetry	3/8
Atomic Absorption Spectrophotometry	2/8
Spectrophotometry	1/8
Ion Chromatography	1/8
Non-reported data	1/8

Flagged data	E	X	< blank	Flagged %
Sample No.M31	0	2	1	43
Sample No.M32	0	5	1	86

**% flag includes below data*

9) Mg^{2+}

The number of NIA laboratories, the analytical methods and number of reported results for Mg^{2+} were similar as for Ca^{2+} analysis (Table 21).

Six among seven data points for the lower concentration sample (M32) were flagged “X”, only data by the Lab no.8 was within DQOs. For the higher concentration sample, three data points for sample M31 were flagged “X”, two were flagged “E”, the results from lab no.4 and 8 was within DQOs (Fig.11). Again, the laboratories, which applied the same analytical method, produced different biases. Similar to the Ca^{2+} analysis, the laboratory used IC method was the one that showed the lowest bias of all.

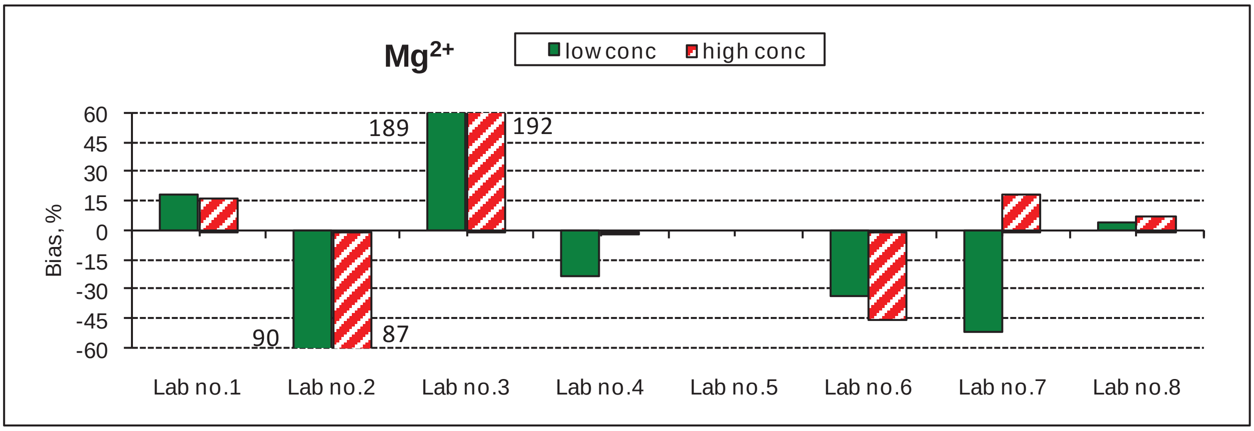


Fig.11 Distribution of Mg^{2+} data normalized by prepared value (off-scale values are indicated)

Table 21 Analytical methods and flagged data of Mg^{2+}

Analytical method	
Titrimetry	3/8
Atomic Absorption Spectrophotometry	2/8
Spectrophotometry	1/8
Ion Chromatography	1/8
Non-reported data	1/8

Flagged data	E	X	Flagged %
Sample No.M31	2	3	71
Sample No.M32	1	5	86

10) NH_4^+

Five NIAs submitted the analytical results. Lab no.1, 3 and 4 used spectrophotometry method as recommended by the Malé declaration. Lab no.6 applied the Nessler method, Lab no.8 used the IC (Table 22). Only one data for the higher concentration sample (M31) and one data for the lower concentration sample (M32) was within DQOs. The other four data points for the higher concentration sample were flagged "E" while for the lower concentration sample there was two flagged "E" and two flagged "X" (Fig.12).

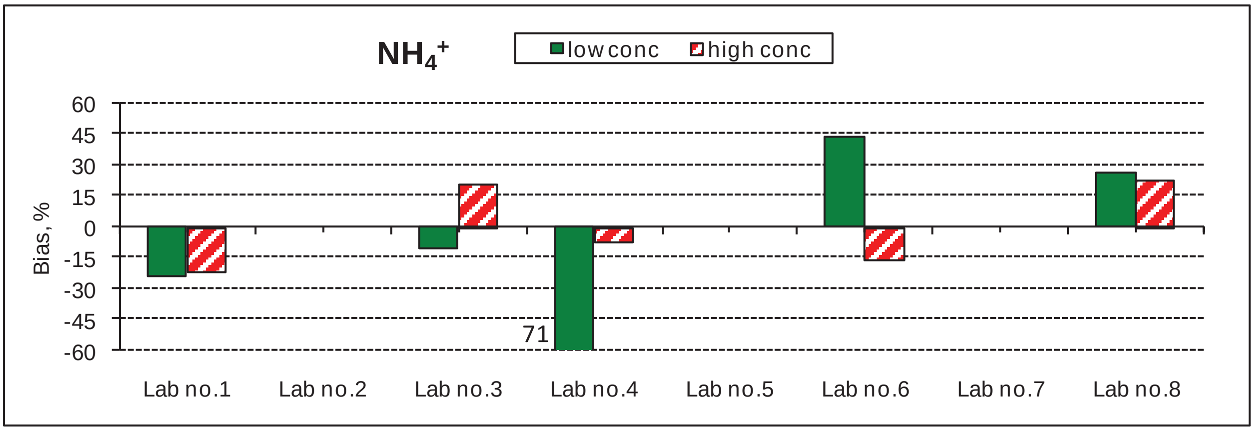


Fig.12 Distribution of NH_4^+ data normalized by prepared value (off-scale values are indicated, %)

Table 22 Analytical methods and flagged data of NH_4^+

Analytical method	
Spectrophotometry	3/8
Titration (Distillation)	1/8
Ion Chromatography	1/8
Non-reported data	3/8

Flagged data	E	X	Flagged %
Sample No.M31	4	0	80
Sample No.M32	2	2	80

Summary remarks

Among the analytical parameters, pH and EC results appeared to be more accurate with lower bias by most of NIAs. Results by some NIAs were higher while others were lower than the prepared values. The submitted analytical results for all specified anions and cations are in general highly biased. K^+ has 100% data points flagged for both samples while NO_3^- has 100% flagged data for lower concentration sample.

Other ions have large portions (above 65%) of the flagged results for both samples M31 and M32. It appeared that the methods that involve intensive sample treatment would result in more biases (ions) while simple measurements for pH and EC produced better results.

The bias for Na^+, K^+ and Mg^{2+} were generally the highest. The relative deviation between the average submitted data and the prepared value of each parameter (%) is presented in Figure 13 which shows high positive biases for Cl^-, Na^+, K^+, Ca^{2+} for the lower concentration sample (M32). For the higher concentration sample less number of biased parameters but still show positive biases for K^+ though in general the biases are lower than for M32. This again indicates the lower accuracy in analyzing low levels of constituents in the sample. Further improvement is still required in the sample analysis in the network. Strict implementation of the Malé Declaration QA/QC program in each NIA laboratory is expected to improve the accuracy of the analysis.

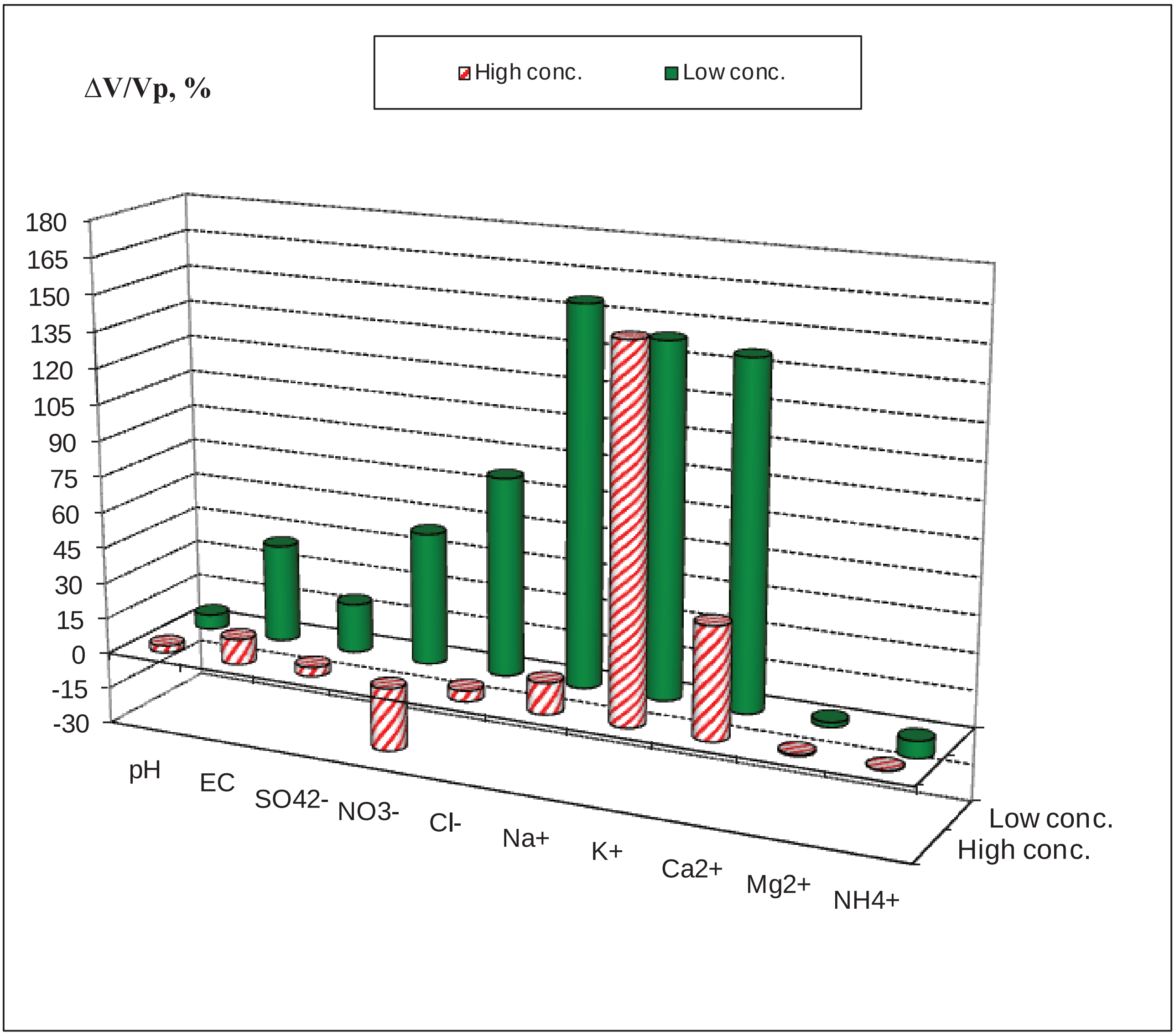


Fig.13 Relative deviation between average submitted data and prepared value
[ΔV = Average (Va) – Prepared (Vp)]

31

Other remarks:

- An excel data template was provided to the NIA for the data reporting but not all NIAs followed
- Lab no.2 reported data not following the standard unit as required on the Male Manual for EC
- Lab no. 4 analyzed Ca^{2+} and Mg^{2+} in September, i.e. almost two months after receiving the samples.
- Lab no. 6 reported wrong receiving date of the samples, i.e. September instead of July (confirmed by the DHL track chain) and submitted highly fluctuating triple measurements of several ions (SO_4^{2-}, Ca^{2+}, Mg^{2+} and NH_4^+ for the low concentration sample, and Mg^{2+} for the high concentration sample.
- Some NIAs reported detection limits which are higher than the concentrations prepared for the lower concentration sample
- Only one NIA reported R1 and R2 values

3.3 Circumstance of Sample Analysis

1) Measurement methods used

Not all NIAs used the recommended methods by the Malé Declaration Monitoring Protocol. A summary of the methods used for each parameter is presented in Table 23. It is noted that some NIAs did not report the specific name of the methods following the Malé protocol. Thus, the name of the same methods may be reported differently and also not precisely. For example, some NIAs simply reported the spectrophotometer without mentioning other information such as reaction agents used, etc.

Table 23 Recommended methods and methods used by NIAs

Para.	Recommended method	Bangladesh	Maldives	Bhutan	India	Iran	Nepal	Pakistan	Sri-Lanka
pH	Glass electrode	Electrode	NA	Multi para test kit	WTW	Glass electrode	pH meter	Glass electrode	Electrode
EC	Conductivity Cell	Electrode	NA	Multi para test kit	WTW	conductivity cell	conductivity cell	Conductivity cell	Electrode
SO_4^{2-}	Spectrophotometry	Spectrophotometry	NA	NA	Elico	Spectrophotometry	Spectrophotometry	Spectrophotometry	IC
NO_3^-	Cadmium reduction method-Spectrophotometry	Spectrophotometry	NA	NA	Elico	Spectrophotometry	Spectrophotometry	Spectrophotometry	IC
Cl^-	Argentrometric method	Argentrometric	NA	NA	Titration	Argentrometric	Titrimetry	Argentrometric	IC
Na^+	Flame photometry	AAS	NA	AAS	Flame photometry	Flame photometer	AAS	NA	IC
K^+	Flame photometry	AAS	NA	AAS	Flame photometry	Flame photometer	AAS	NA	IC
Ca^{2+}	Titrimetry (EDTA method)	AAS	NA	AAS	Titrimetry	Titrimetry	Titrimetry	Spectrophotometry	IC
Mg^{2+}	Titrimetry	AAS	NA	AAS	By difference	Titrimetry	Titrimetry	Spectrophotometry	IC
NH_4^+	Spectrophotometry (Indophenol)	same	NA	NA	Elico	Spectrophotometry	distillation	na	IC

na: data not available (not analyzed)
IC: Ion Chromatograph
AAS: Atomic Absorption Spectrophotometry
AES: Flame Atomic Emission Spectrometry
same: applied the same method as recommended method

2) Number of staff in charge of measurement and year of experience

The numbers of staff in charge of measurement and year of experience on rainwater samples are shown in Table 24. Given the overall low accuracy of the data, there is no strong association between the data quality and the number of years of experience or number of staff involved in the sample analysis.

Table 24. Staff in charge of measurement and year of experience

Country	Total staff	Year of experience	pH	EC	SO_4^{2-}	NO_3^-	Cl^-	Na^+	K^+	Ca^{2+}	Mg^{2+}	NH_4^+
Bangladesh	2	5 year										
Bhutan	2	7 years			NA	NA	NA		high BL	high BL		NA
India	3	more than 11 years										
Iran	2	more than 8 years										
Maldives			NA		NA	NA	NA	NA	NA	NA	NA	NA
Nepal	1	7 years										
Pakistan	1	more than 11 years						NA	NA			NA
Sri-Lanka	2	more than 8 years										

Dotted mesh: flagged (E or X) in sample No.M31 or sample No.M32.
Darked mesh: flagged (E or X) data of both sample No.M31 and No.M32
NA: No data (not analyzed)

34

3) Water temperature at measurement (pH and EC)

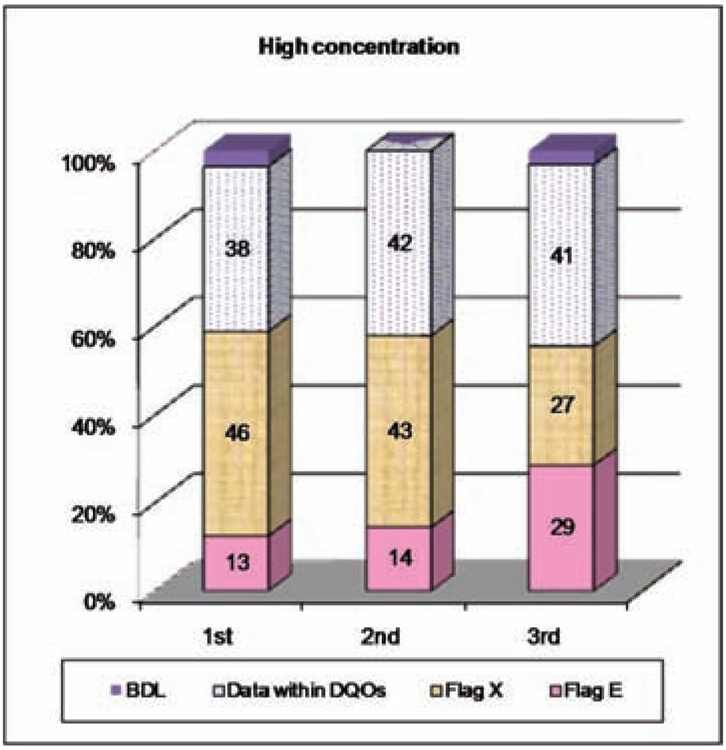
Most of the NIA laboratories measured pH and EC at the recommended temperature (25^0C). However, Lab no.2 and 6 measured these two parameters at temperature lower than 25^0C (Table 14). However, this did not seem to significantly affect the measurement results.

Table 14 Water temperature at measurement for pH and EC (^{o}C)

Country	pH		EC	
	No. M31	No. M32	No. M31	No. M32
Bangladesh	24.8	24.8	24.8	24.8
Bhutan	20.9	20.9	20.9	20.9
India	25.0	25.0	25.0	25.0
Iran	25.0	25.0	25.0	25.0
Maldives	NA	NA	NA	NA
Nepal	17-18	17-18	25.0	25.0
Pakistan	25 - 26	25 - 26	25 - 26	25 - 26
Sri-Lanka	27.0	27.0	27.0	27.0

Blue (dark) background: difference of more than 2^oC of the recommended value (25^oC)

4. Comparison between the first and the second attempts



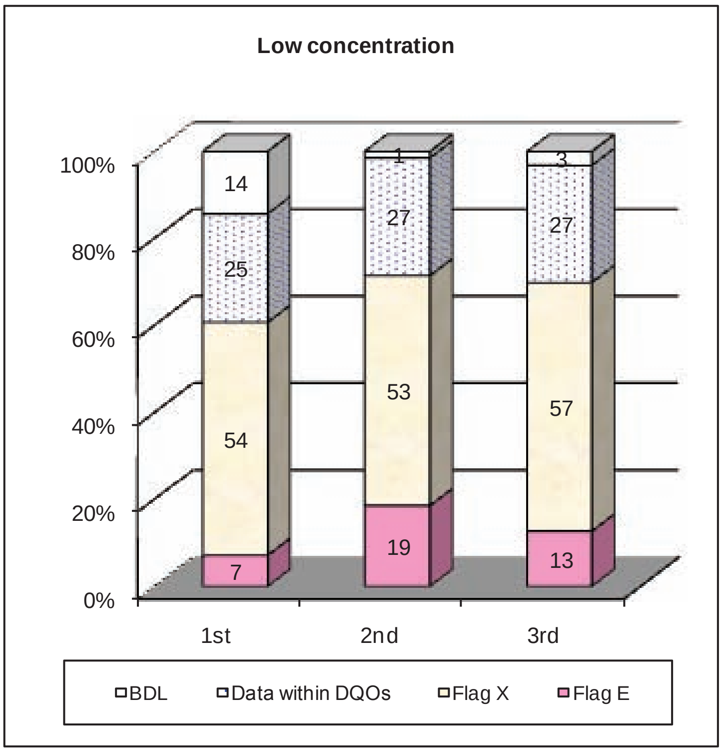


Fig. 14 Comparison of 1st, 2nd and 3rd attempts

The data quality still remains the major issue. The percentage of the data within the DQOs is more or less still the same as previous attempts. The flagged "E" data points in the third attempt increased while those with flags "X" (lower quality) reduced for the higher concentration sample (Figure 14). The 3rd attempt also shows certain improvement in term of the number of NIA laboratories submitted the analytical results: one NIA that did not report any analytical results and 7 NIAs submitted most of the requirement parameters. Most NIA laboratories submitted triple or duplicate measurements (except for Lab no. 2).

Note that, the concentration levels prepared in the higher concentration samples were similar for three attempts while those in the lower concentration sample in the 2nd and 3rd attempt were increased 2 to 5 times. This may be the reason for the substantial reduction of the below detection limit data points in these later attempts.

5. Implementation for improvement of measurement accuracy and precisions

The analytical results submitted by NIAs show strong bias from the prepared values for most of the parameters, especially for the low concentrations in sample M32. Various factors may lead to the low accuracy of the data. It is observed that not all NIAs follow the Malé QA/QC Monitoring Protocol strictly in term of the equipment and methods. If NIAs have more advanced equipment (IC) in place it would be easier to do the repeated analyses hence to check the precision of the data themselves. In general, the methods require intensive sample treatment provide lower accuracy. The parameters that can be measured directly such as pH and EC produced much better accuracy than the ions. The intensive treatment of samples may introduce errors from various dosing and glassware contamination as well as the purity of the chemicals used for the sample treatment. In this case, the NIAs have to observe the standard operating procedures (SOP) of the analytical methods and the QA/QC elements required by the Malé monitoring protocol.

The following fundamental recommendations matters should be taken into account in measurement, analysis, and data control processes.

Fundamental factors to improve data quality

- Properly clean the apparatus/glassware
- Use the materials and reagents of required purity with as low as possible blank values of target analytical substances.
- Measurement and analysis should be conducted by persons who are well trained and are committed to produce high quality data. In house-expertise within each NIA laboratory should be developed for this purpose. If NIAs have the samples analyzed by other institutions, the data control and data quality check should be in place and should be done by in-house experts of the NIAs.
- SOPs must be prepared for the management of apparatus, reagents, and procedure of operation. The SOPs have to be followed strictly.
- A log book should be kept for the sampling and analysis in each NIA laboratory
- Details on measurement and analysis of samples are presented below.

1) Deionized water

Use only water with conductivity less than 0.15mS/m for dilution of samples and cleaning the glassware for measurements and analyses. It was reported by one NIA that the water used was not pure enough (high EC) while other NIAs did not mention about the EC of the waster used. This is a simple check that may help much to improve data quality.

2) Use certified materials and certified samples (SRM) to standardize the used methods

- NIA laboratories should use the standard reference materials to evaluate their measurement methods. These are samples with known concentrations to NIAs and they can compare the measurement results with the certified values. Thus, repeated analyses can be made and the NIA measurement procedures can be calibrated samples until the results are within the ranges of the certified values.
- The certified/standard reference materials (certified solutions and certified materials) should be used periodically in each NIA laboratory as a QC element for their routine analysis. The Malé Declaration Programmes can consider to purchase the SRM and distribute to NIAs at least once per year.

3) Pretreatment of samples, storage and analysis time

- Conductivity and pH should be measured as soon as possible after sample receiving at the temperature recommended by Malé QA/QC monitoring protocol of 25^{o}C. Temperature of the measurements should be recorded. In this inter-laboratory exercise 2 NIAs did not follow this requirement (deviation of more than 2^{o}C).
- Other parameters should be analyzed within a week of sample receiving. The samples should be capped and stored properly in refrigerators all the time before analysis. Care should be taken to avoid the cross-contamination during sample transport and storage.
- It is noted in this exercise that the parameters that were analyzed by methods requiring intensive sample treatment had the analytical results with strong biases. SOPs need to be followed closely in this case. Hands-on trainings for the staff can be offered within each NIA by more experiences staff or by Malé Declaration Programme.
- Repeated analyses should be made to ensure the data quality (precision). In this inter-laboratory exercise, 3 analyses are required for each parameter. However, not all NIAs submitted the results.

- A log book should be kept to record the timing (arrival in the laboratory, analysis etc.) and the conditions of the samples, personnel involved, conditions of the equipment etc.

4) Calibration of analytical instruments

- Each analytical instrument must be calibrated when it is used. The appropriate adjustments should be made. For sophisticated equipments, the calibration curves must be checked regularly by a standard solution.
- Standard solutions and reference solutions must be prepared from different stock solutions to ensure the independence (to eliminate the same systematic error in these solutions)
- New calibration and standard curves should be prepared if a new reagent bottle is used.
- Calibration should be done regularly, after 20-30 measurements, event though the same reagent bottles are still used.
- The calibration curves have to be checked before each analysis by injecting a standard solution (with known concentration)

5) Data quality checking and control by NIA laboratory

- When samples seem to be obviously contaminated, these data should be marked and treated as unrecorded data. A log book record may be very useful for this track.
- In house experts should check for abnormal data points in the data series. A simple time series plot may help to detect the abnormality. Appropriate reasons should be specified to explain the situation.
- Incorrect data can corrupt the overall research results. Careful checks are needed to avoid producing data of inadequate quality. When abnormal or unrecorded data appear, the process should be carefully reviewed to prevent the occurrence of the same problem in the future.
- The standard deviation of the repeated analyses should be as small as possible to ensure the data precision. Highly precise data ensure that there are no random errors. The random errors can be caused by human mistakes, ambient conditions (including contamination) as well as the unstable instrument sensitivity. The random errors cause the results of repeated analyses or re-measurements to be significantly different. If the standard deviation of the repeated analyses is small and the analytical methods are made following the SOP then the data quality is ensured.
- Calculating the criteria for ion balance (R_1) and for agreement between calculated and measured electronic conductivity (R_2) following the Male Protocol. Once these criteria are not met then the measurement data quality should be reexamined. It is note that, however, meeting these criteria is the necessary condition but not the enough condition.

Overall comment: "It's better to have no data than to have wrong data. Wrong data will give wrong information hence may be quite expensive if the actions are taken in the wrong direction".

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5. Report of the Malé Declaration Inter – laboratory comparison of precipitation chemistry analyses among the NIAs, Round robin analysis survey, 2nd Attempt, 2009
6. Reports of the EANET Inter – laboratory comparison Project 2003 (Round robin analysis survey, 6th Attempt) 2004.
7. Reports of the EANET Inter – laboratory comparison Project 2003 (Round robin analysis survey, 7th Attempt) 2005.
8. Reports of the EANET Inter – laboratory comparison Project 2003 (Round robin analysis survey, 8th Attempt) 2006.
9. Asian regional research network for improving air quality in developing countries (AIRPET), http://www.serd.ait.ac.th/airpet

APPENDIX 1: Participating laboratories

Countries/Laboratories

1. Bangladesh

Khulna Divisional Laboratory, Department of Environment, Govt. of the People's Republic of Bangladesh

2. Bhutan

National Environment Commission (NEC), Royal Government of Bhutan

3. Iran

Environmental Research Center, Air Pollution Research Office, Station directorate environment

4. India

Central Pollution Control Board, Ministry of Environment & Forests, Government of India

5. Maldives

Maldives Climate Observatory, Department of Meteorology

6. Nepal

Central Soil & Plant Analysis Laboratory, Institute of agriculture and Animal Science, Chitwan

7. Pakistan

Pakistan Environmental Protection Agency

8. Sri Lanka

Central Environmental Authority

Appendix 2: Calculation of R1 and R2 for artificial rain water sample

(1) Calculation of ion balance (R_1)

- Total anion (**A**eq) of equivalent concentration (μeq/L) is calculated by summing the concentration of all anions (C: μmol/L).

  Aeq (μeq/L) = $\Sigma\ n \cdot C_{Ai}$ (μmol/L) = $2C(SO_4^{2-}) + C(NO_3^-) + C(Cl^-)$

  Where, n is electric charge and C_{Ai} = concentration (μmol/L) of anion 'i'.

- Total cation (**C**eq) equivalent concentration (μeq/L) is calculated by summing the concentration of all cations (C: μmol/L).

  Ceq (μeq/L) = $\Sigma\ n \cdot C_{Ci}$ (μmol/L) = $10^{(6\text{-}pH)} + C(NH_4^+) + C(Na^+) + C(K^+) + 2C(Ca^{2+}) + 2C(Mg^{2+})$

  Where, *n* is electric charge and C_{Ai} = concentration (μmol/L) of cation 'i'.

- Calculation of ion balance (R_1)

  R_1 (%) = 100 x (**C**eq **-** **A**eq)/(**C**eq + **A**eq)

(2) Calculation of R_2 *(calculated vs. measured EC)*

- Total electric conductivity (Λ calc) is calculated as follows:

  Λ calc (mS/m) = {349.7 x $10^{(6\text{-}pH)}$ + 80.0 x $2C(SO_4^{2-})$ + 71.5 x $C(NO_3^-)$ + 76.3 x $C(Cl^-)$ + 73.5 x $C(NH_4^+)$ + 50.1 x $C(Na^+)$ + 73.5 x $C(K^+)$ + 59.8 x $2C(Ca^{2+})$ + 53.3 x $2C(Mg^{2+})$}/ 10,000

  Where, C denotes the molar concentrations (μmol/L) of ions given in the parenthesis at 25°C. The constant value is ionic equivalent conductance at 25°C for each ion.

- The agreement (ratio of R_2) between calculated (Λ calc) and measured (Λ meas) electric conductivity should be calculated as follows:

  R_2 = 100 x (Λ calc – Λ meas)/(Λ calc + Λ meas)

Appendix 3: Dates of Events

Date of sending samples 13-Jul-11

Country	Date of receiving sample	Date of measurement									
		pH	EC	SO4	NO3	Cl	Na	K	Ca	Mg	NH4
Bangladesh	27-Jul-11	29 Jul to 4 Aug 2011									
Bhutan	15-Jul-11	15 to 19 Jul 2011									
India	1-Aug-11	1 to 3 Aug 2011									
Iran	23-Jul-11	24-28 Jul 11							11-Sep-11		28-Jul-11
Maldives	17-Jul-11	na									
Nepal	18-Jul-11	17 to 19 Sep 11									
Pakistan	20-Jul-11	22 to 29 Jul 11									
Sri-Lanka	20-Jul-11	20 to 23 July 11									

na: sample not analyzed

Malé Declaration/IG13/6/2

MALÉ DECLARATION ON CONTROL AND PREVENTION OF AIR POLLUTION AND ITS LIKELY TRANSBOUNDARY EFFECTS FOR SOUTH ASIA

Compendium of Good Practices on Prevention and Control of Air Pollution

Malé Declaration Secretariat

Regional Resource Centre for Asia and the Pacific (RR.CAP)

May 2013

The first report was compiled by Prof. Ram M. Shrestha, School Environment, Resources and Development, Asian Institute of Technology, Thailand in collaboration with Malé Secretariat as part of the phase III implementation of the Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia. It was reviewed by the ninth Session of the Intergovernmental meeting from Malé Declaration. This report has been updated by the Centre for Environment Education in collaboration with Male' Secretariat as part of the phase IV implementation of the Male' Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia. The contents of the report do not necessarily reflect the views, policies or opinions of any participating country and organization

National Focal Points (NFP) and National Implementation Agencies (NIA)

Bangladesh	**Bhutan**	**India**	**Iran**
NFP: Ministry of Environment and Forest	NFP and NIA: National Environnent Commission	NFP: Ministry of Environment and Forests	NFP and NIA: Departr of the Environment, Te
NIA: Department of Environment Dhaka		NIA: Central Pollution Control Board, New Delhi	
Maldives	**Nepal**	**Pakistan**	**Sri Lanka**
NFP: Ministry of Environment, Energy and Water	NFP: Ministry of Environment Science and Technology	NFP: Ministry of Environment	NFP: Ministry of Environment and Natu Resources
NIA: Department of Meteorology	NIA: International Centre for Integrated Mountain Development(ICIMOD) Kathmandu	NIA: Pakistan Environment Protection Agency, Islamabad	NIA: Central Environmental Author Colombo

Coordinating Agencies

Regional Resource Centre Asia and the Pacific Programme(RRC.AP)- UNEP Collaborating Centre, Bangkok, Thailand

South Asia Co- operative Environment Colombo (SACEP), Sri Lanka

Stockholm Environment Institute (SEI) Stockholm, Sweden

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Distributed by

The Secretariat, Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia, Regional Resource Centre for Asia and the Pacific (RRC.AP)-UNEP Collaborating Centre Outreach Building, Asian Institute of Technology
P.O. Box 4, Klong Luang, Pathumthani 12120 Thailand

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List of Abbreviations

ABC	:	Atmospheric Brown Cloud
ADB	:	Asian Development Bank
ALS	:	Area Licensing Scheme
BAT	:	Best Available Technology
CAAA	:	Clean Air Act Amendment
CAC	:	Command and Control
CH_4	:	Methane
CLRTAP	:	Convention on Long Range Transboundary Air Pollutants
CNG	:	Compressed Natural Gas
CO_2	:	Carbon dioxide
COE	:	Certificate of Entitlement
CSE	:	Center for Science and Environment
ERC	:	Emission Reduction Credit
ERC	:	Emission Reduction Credit
ERP	:	Electronic road pricing
EU	:	European Union
EV	:	Electric Vehicle
FY	:	Fiscal Year
GBP	:	Great Britain Pound
GEO	:	Global Energy Outlook
GHG	:	Greenhouse Gas
IEA	:	International Energy Agency
IPCC	:	Intergovernmental Panel on Climate Change
IPPC	:	Integrated Pollution Prevention and Control
NAAQS	:	National Ambient Air Quality Standard
NEC	:	National Emission Ceiling
NEQS	:	National Environmental Quality Standard
NH_3	:	Ammonia
NMVOC	:	Non-methane Volatile Organic Compound
NOx	:	Nitrogen Oxides
NSPS	:	New Source Performance Standard
OECD	:	Organisation for Economic Co-operation
OMV	:	Open Market Value
PARF	:	Preferential Additional Registration Fee
PEPA	:	Pakistan Environmental Protection Agency
PSI	:	Pollutant Sub Index
RPS	:	Renewable Portfolio Standard
RZ	:	Restricted Zone
SCR	:	Selective Catalytic Reduction
SEK	:	Swedish Kroner
SEPA	:	Singapore Environmental Protection Agency

List of Abbreviations (Contd.)

SEPA	:	State of Environmental Protection Agency- China
SEPA	:	Swedish Environmental Protection Agency
SIP	:	State Implementation Plan
SO_2	:	Sulfur dioxide
SPM	:	Suspended Particulate Matter
TAP	:	Transboundary Air Pollution
TCZ	:	Two Control Zone
TGC	:	Tradable Green Certificate
TOMA	:	Tropospheric Ozone Management Area
UNDP	:	United Nations Development Programme
UNECE	:	United Nation Economic Commission for Europe
UNEP	:	United Nations Environment Programme
UNESCAP	:	United Nations Economic and Social Commission for Asia and the Pacific
USEPA	:	United States Environmental Protection Agency
VOC	:	Volatile Organic Compound
VQS	:	Vehicle Quota Scheme
WHO	:	World Health Organization

Chapter I

Introduction

The South Asian region is the home of over a billion people, which accounts for over 22 per cent of the global population. With increasing dependence on fossil fuels, countries in the region are faced with the growing problems of local and transboundary air pollution in recent years. According to Carmichael et al. (2002), sulphur emissions in Southeast and South Asia (particularly India) would continue to increase rapidly and regional air pollution problems would intensify. Similarly, NOx emission in South Asia is also likely to grow more rapidly in future to a large extent due to rapid growth in oil and gas based road transport sector. Many urban areas in the region are also facing increased levels of air pollution and poor air quality. With growing urbanization and motorization, it is likely that urban air quality in South Asia would worsen in future in the absence of appropriate strategies and mechanisms to manage the air quality.

In 1998, the Environment Ministers of South Asia adopted the Declaration for Prevention of Transboundary Air Pollution (also known as the Malé Declaration). Following the Male' Declaration, a number of activities have been carried out already in three phases for the implementation of the Malé Declaration. The Phase IV implementation (2009-2012) is to focus on assisting the member countries of the Malé Declaration in the reduction of air pollutants. Assisting the member countries enhances their regional cooperation, monitoring, and impact assessment; strengthen the initiatives started in the first three phases and to initiate new ones is continued.

1.2 Objective

One of the specific objectives of Phase IV for the implementation of the Malé Declaration is to assist member countries strengthen the initiatives started in the first three phases and increase regional cooperation for air pollution control and prevention. The first draft of the compendium of good practices in preventing and controlling air pollution that have been adopted in different countries in the world and to identify potential strategies to implement and upscale the good practices in South Asia is now updated and would be useful to the countries in the sub-region. The objective of this report is to discuss key issues related to air pollution in South Asia and present some promising good practices on the control of air pollution, which could help the policy makers in the formulation of effective policies and measures to control and prevent the emissions of transboundary air pollutants.

1.3 Scope

The report discusses the key issues related to emissions of air pollutants in South Asia and compiles good practices on control and prevention of emission of key transboundary air pollutants.

1.4 Organization of the report

This report is organized as follows: Major issues related to air pollution in South Asia are discussed in Chapter II. The chapter includes a discussion of energy consumption, energy-mix and their implications for pollutant emissions in different sectors. The chapter also discusses the existing regulatory frameworks in South Asian countries for managing air quality. Chapter III first discusses major international agreements/protocols and national acts, which are followed by a discussion of different approaches for control and prevention of air pollution including practical examples of their adoption in different countries. In Chapter IV, selected cases of the good practices to reduce air pollution and thus to improve the air quality in different countries are presented. The final chapter presents summary and concluding remarks.

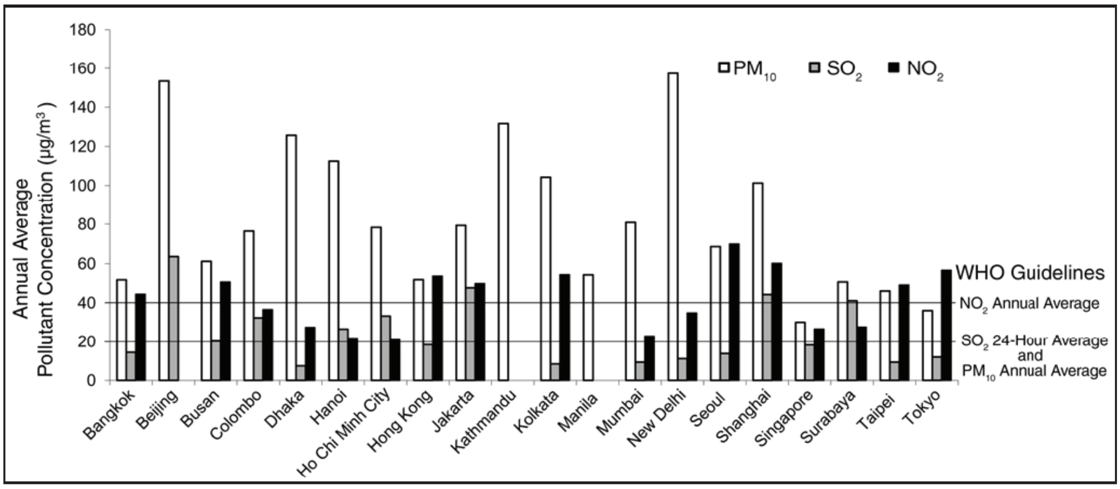
Chapter II

Status and major issues of Transboundary Air Pollution in South Asia

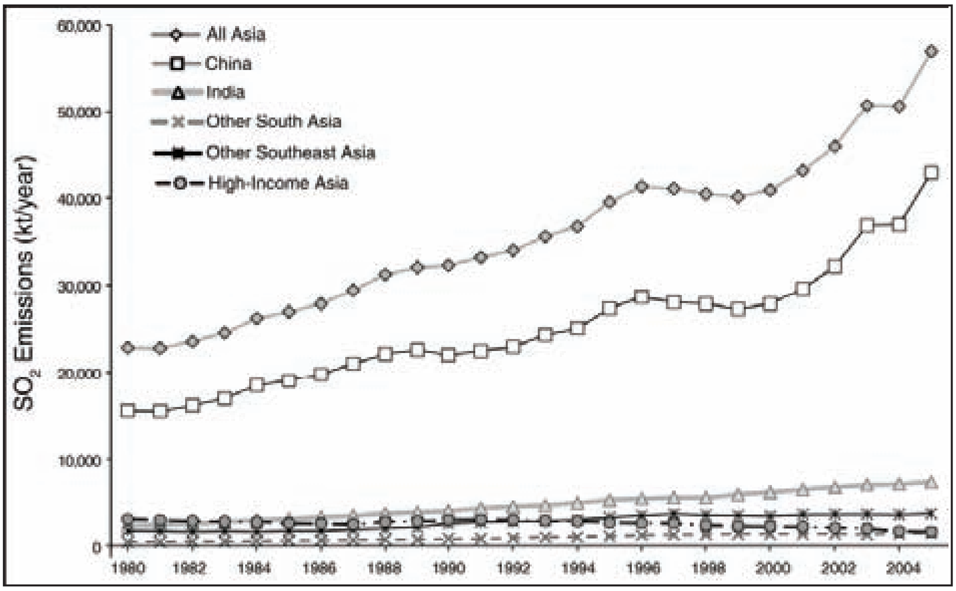
2.1 Introduction

Air pollution is a major issue in many parts of Asia and has prompted actions to improve air quality. Even with the increasing fossil fuel consumption, there is an improvement in air quality across the Asian region. Yet, concentration of all major pollutants in Asian cities is higher than current WHO health-based air quality guidelines.

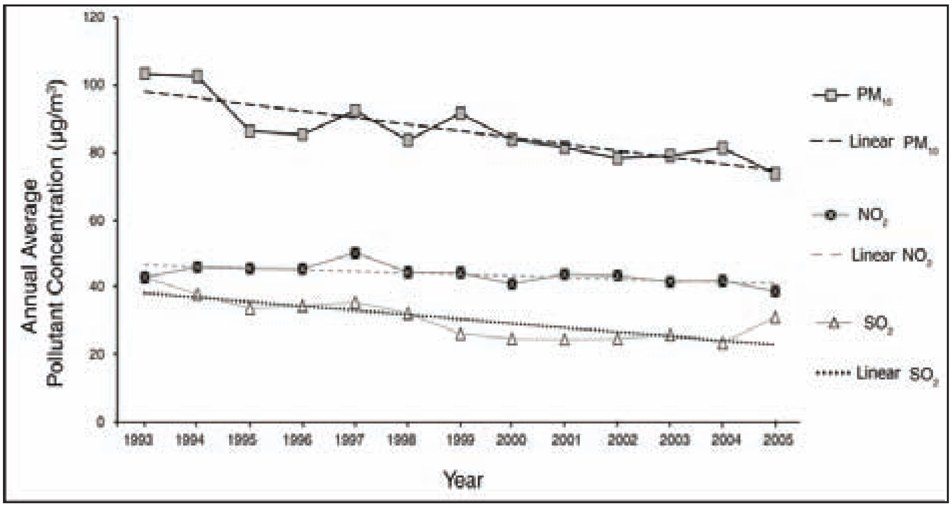
Average PM10, SO2, and NO2 concentrations in selected Asian cities[1]



Air quality in Asia reflects complex and evolving relations between increased energy consumption for transport and power generation and measures being taken to improve air quality. Overall, the air quality is improving throughout urban Asia based on the estimates of pollution emissions and measurement of ambient concentrations.



SO2 emissions in Asia, 1980–2005[1]. Data are given in kilotons per year.



Annual averages of PM_{10}, So_2 and No_2 aggregated among selected Asian cities[11]

emission would increase by about 30 per cent during the same period for a number of reasons (e.g., two-control zone policy in China, de-emphasis of coal use, fuel switching and spread of environmental awareness from East Asia to Southeast Asia and ultimately to Indian subcontinent). A study by Charmichael et al. (2002) reveals that sulfphur deposition increased in most of Asia during 1975-2000 and that the largest increases have occurred in Southeast Asia and South Asia. The study also states that the area of high sulphur deposition (i.e., above 0.5g of sulphur per m^2 per annum) has expanded in South Asia during 1975-2000.

According to Aardenne et al. (1999), NOx emission is estimated to grow by a factor of 3.5 in Asia during 1990-2020. During the period, NOx emission from South Asia is estimated to increase 5.5 fold.

South Asian economies have wide variations in terms of energy mix. The major types of fuel being used are coal, oil and biomass. Increasing use of the fossil fuels is the source of rising emissions of the transboundary pollutants in the region. The power, industry and transport sectors are mostly responsible for air pollution in the region. In this chapter, major issues of air pollution in South Asia are discussed.

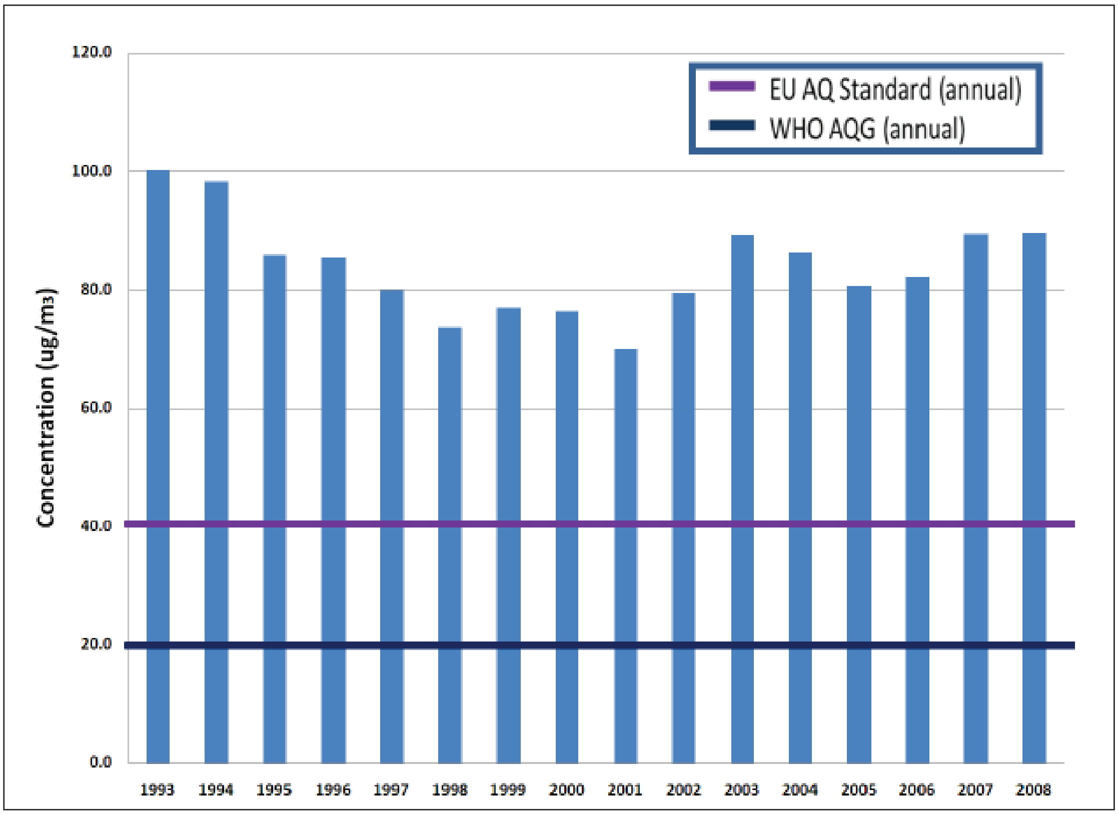
2.2 Status of major transboundary air pollutants emission in South Asia

Particulate matter trend

Clean Air Initiative -Asia has undertaken a long term assessment on status and trend of air quality in Asia for the period 1993 to 2008. This analysis indicates that improvements in air quality have been achieved, but levels of PM10 and SO2 continue to exceed World Health Organization (WHO) air quality guidelines (AQG). There is not enough air quality data to assess PM2.5 and Ozone. The ambient air quality standards of most countries lag behind WHO AQG and US EPA (Environmental Protection Agency) NAAQS. Most Asian countries have already adopted NAAQS, with some countries regularly reviewing and updating their standards to take into account current conditions of the country and recent scientific information. Nonetheless, there are a number of Asian countries still without NAAQS. [1]

[1] : Outdoor Air Pollution and Health in the Developing Countries of Asia: A Comprehensive Review by HEI International Scientific Oversight Committee, http://ehs.sph.berkeley.edu/krsmith/publications/2011/heiasiareview.pdf

[1] : Air quality in Asia: status and trends, 2010 edition.
http://cleanairinitiative.org/portal/sites/default/files/documents/AQ_in_Asia.pdf



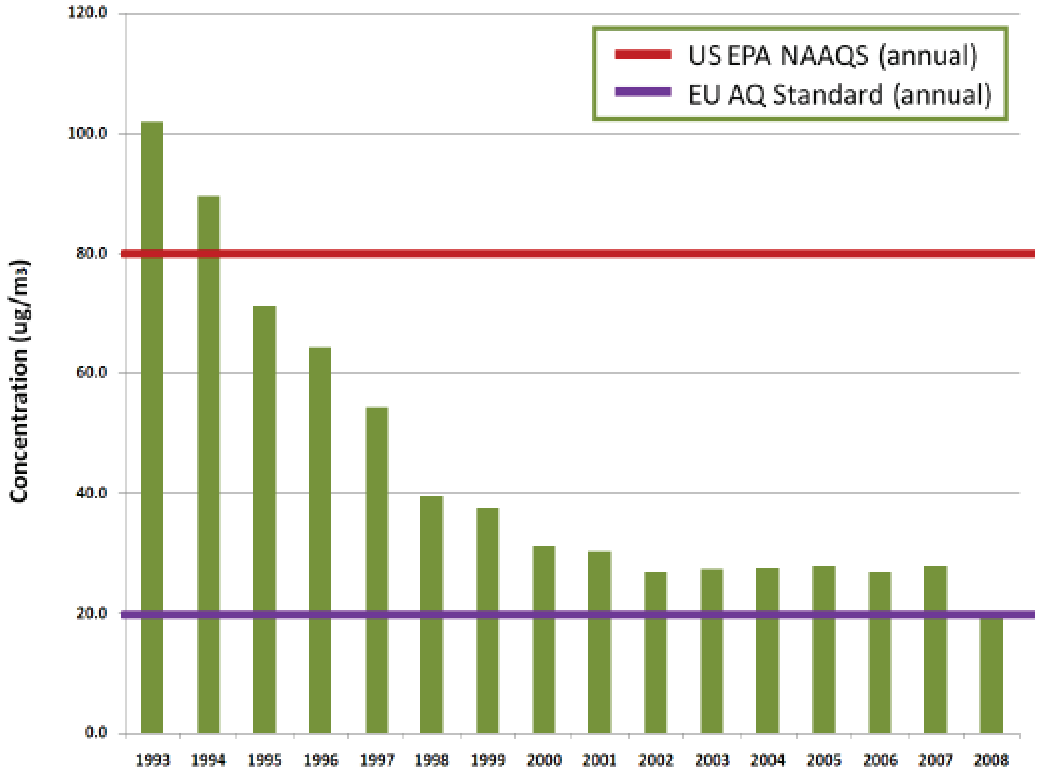
Trend of average of annual PM10 concentrations in selected Asian cities (source: CAI-Asia, 2010)

The above figure is indicating increase in PM10 in most Asian countries. Only 2 cities complied with WHO air quality guidelines of 20 $\mu g/m^3$. 58 per cent of cities are not complying with even the WHO interim target of 70 $\mu g/m^3$ for PM10. The average of annual average PM10 concentration is 89.5 µg/m3 which is about 4.5 times higher than WHO AQG.

Although PM2.5 is not a part of most regulatory ambient air quality monitoring networks in Asia, a study by HEI points out that annual average PM2.5 concentrations are generally above 25 microgramme per cubic metre (micro-gm/cu.m) and as high as 150 microgm/ cu.m, with PM2.5:PM10 ratios ranging from roughly 0.4 to 0.7 in urban areas of rapidly developing countries in Asia

SO_2 trends

Annual trends in air quality (1993–2005) across major Asian cities suggest a significant downward trend in annual average SO2 concentrations in urban areas in contrast to the increase in overall country-level emissions, with the exception of an average increase in SO2 concentration during 2005. These SO2 reductions occurred inspite of increasing fuel consumption. Regulations requiring the use of low-sulphur fuels and relocation of major coal-fired power plants and industrial facilities to outside of cities were responsible for these decreases. Average of annual SO2 concentrations of 213 Asian cities for 2008 is 18.7 µg/m3. About 40 per cent of the cities had annual average SO2 levels equal or lower than 10µg/m3. However, 24 per cent of the cities' annual average SO2 concentrations do not meet even the 24-hr WHO AQG.



Average of Annual Average Annual Ambient AQ in Selected Asian Cities (1993-2008), CAI-ASIA 2010

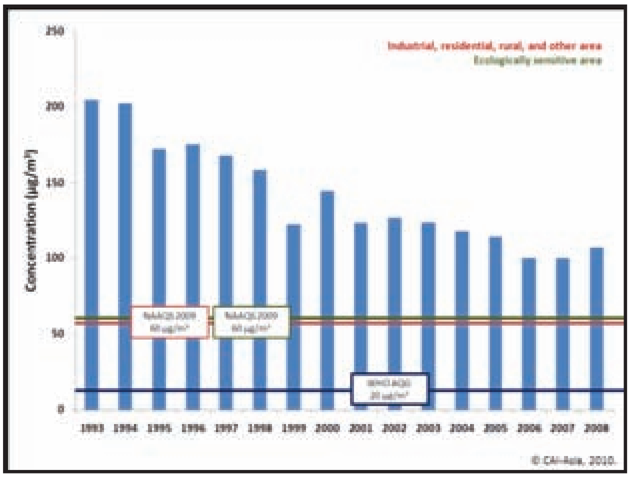
NO_2 trend

According to the study revealed by Clean Air Initiative Asia office, the average of annual NO2 concentrations for 234 Asian cities is 30.7 µg/m^3 which is within the WHO AQG (40 µg/m3). For the past two decades, the average of annual NO_2 levels in Asia is within air quality standards of WHO, EU and USEPA. The WHO limits for SO2 and NO2 are 50 µg/m^3 and 40 µg/m^3, respectively, with only Beijing exceeding the SO2 limit and 9 cities (Bangkok, Busan, Hong Kong, Jakarta, Kolkata, Seoul, Shanghai, Taipei, and Tokyo) of 20 major cities exceeding the NO_2 limit.

Table 2.1: Emissions of key transboundary air pollutants in South Asian countries in 2000

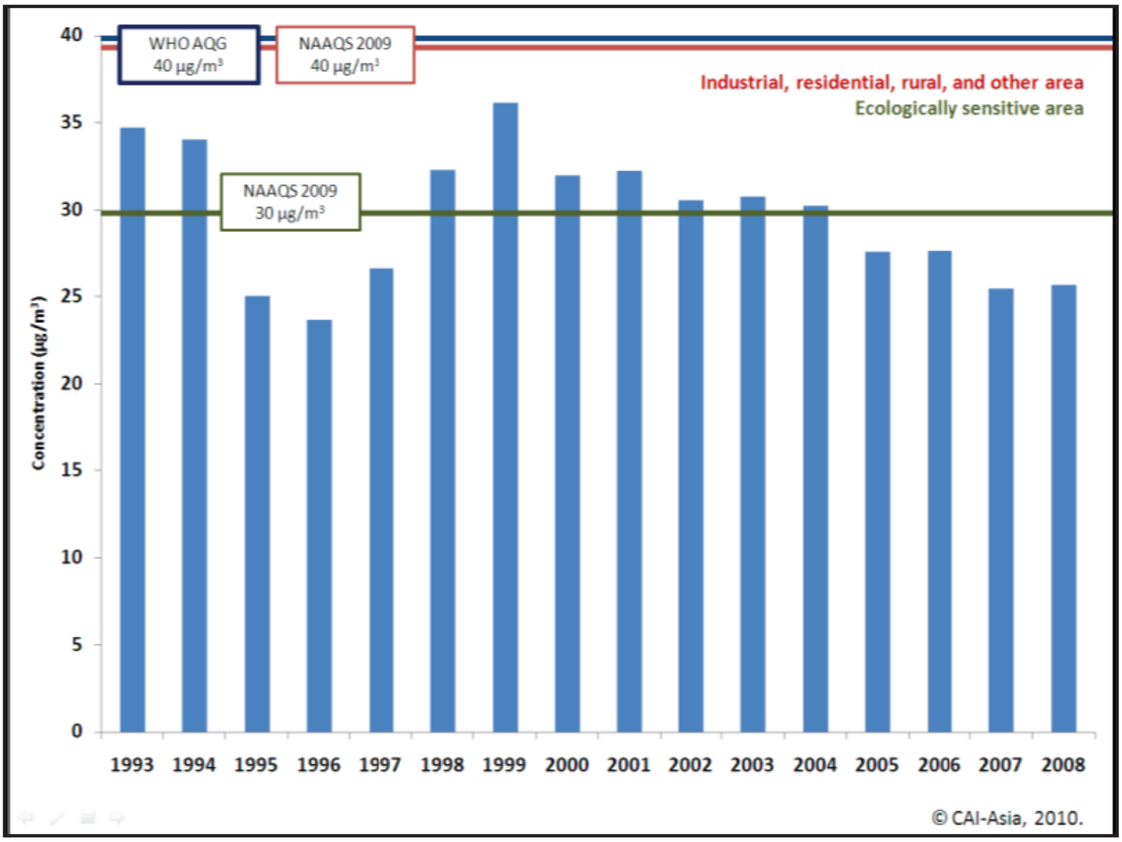
Countries/ Region	Total SO_2 emission (kt/year)	Total NOx emission (kt/year)	Total NMVOC emission (kt/year)	Total NH_3 emission (kt/year)
Bangladesh	106	169	483	
Bhutan	5	8	21	
India	6140	4730	8638	
Nepal	26	41	206	
Pakistan	1095	640	1135	
Sri Lanka	97	120	196	
Total of Six countries	7469	5708	10679	
Asia	42778	27316	40238	

In India, the average of annual PM10 levels of residential monitoring stations in most cities (89.5 µg/m3) exceeded the annual PM10 National Ambient Air Quality Standards (NAAQS) (60 µg/m3) as per the data of 2008. None of the cities were compliant with annual PM10 World Health Organization (WHO) air quality guideline (AQG) (20 µg/m3). NO2 levels at 81 per cent of the monitoring stations in industrial areas and 70 per cent of the monitoring stations in residential areas were found to be lower than the annual NAAQS and the WHO AQG (40µg/m3)



Average of annual PM10 Concentrations in 137 Indian Cities 2008

Average of Annual Average of NO2 Concentrations in 133 Indian Cities 2008

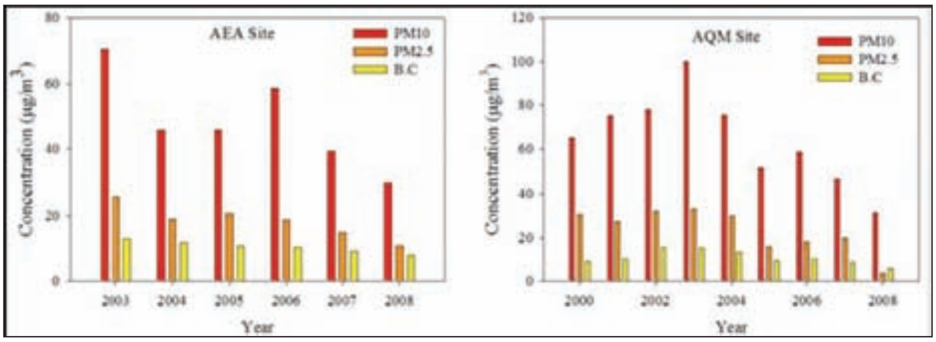


In Sri Lanka, the annual average of ambient PM10 level in Colombo over the year has remained within the range of 70-80 µg/m^3, which is still higher than WHO's latest guidelines of 20 µg/m^3 for PM10. SO2 and NO2 levels in Colombo during the period 1997 to 2000 were high as compared to 2003 levels.[2]

The chemical composition data of fine air particulate matter (PM2.5) was collected from Colombo (AQM) and Orugodawatta (AEA site). According to this project of Central Environmental Authority,

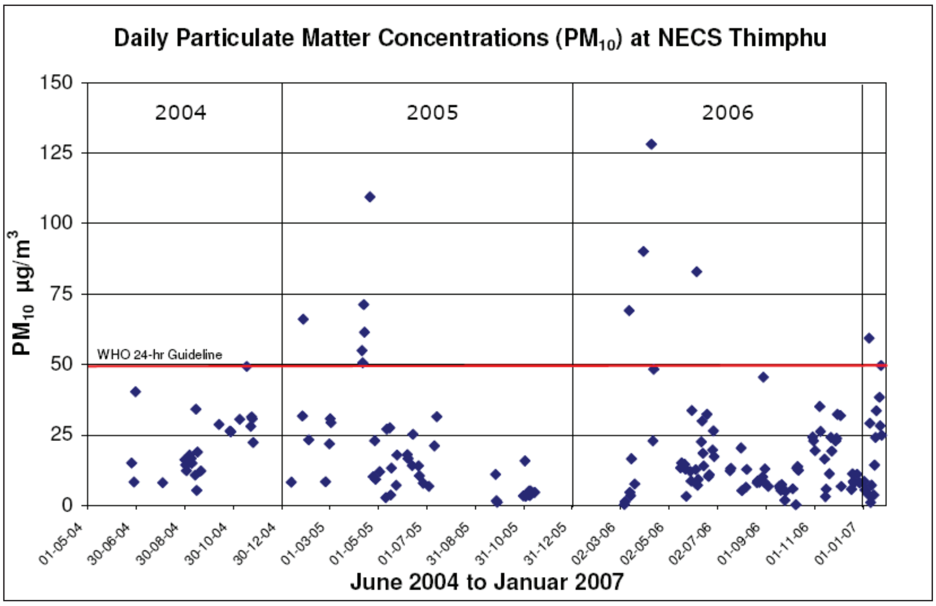
[2] : Male Declaration, overview of progress in Sri Lanka
http://www.rrcap.unep.org/male/uploadedfiles/srilanka1-4.pdf

Sri Lanka, the annual averages for PM10, PM2.5, and black carbon (BC) at the AQM station during 2000 – 2005 ranged from 50 to 100, 16 to 32, and 8 to 15 µg/m3, respectively as given in the figure below.



Annual mean concentrations of PM10, PM2.5, and BC at the two sampling sites[3]

In the case of Bhutan, the daily PM10 concentrations in Thimpu for the period of 2004-2007, varies from 50-125 µg/m3. The 50 µg/m3 line corresponds to the WHO guideline for 24- hour average PM10 concentration.[4]



The NO2 and SO2 concentrations are in the range of 11 to 17 µg/m3 and 0.7 to 2.4 µg/m3 respectively. SO2 concentrations were very low and far under the WHO annual guideline level of 20 µg/m3.

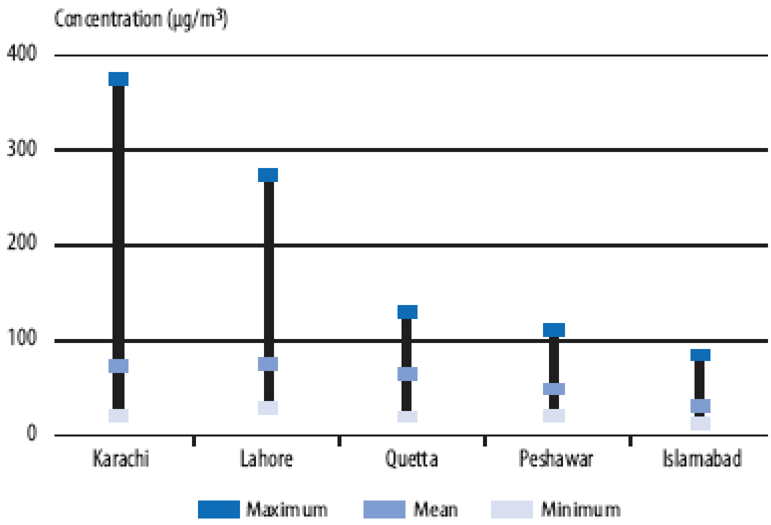
In Pakistan, Nitrous Oxides are emerging air pollutants with the highest concentrations recorded in Karachi, followed by Lahore, Quetta, Peshawar, and Islamabad according to Figure ---------. It reaches up to 350 µg/m3.[5]

[3] : Characterization and source apportionment of particulate pollution in Colombo, Sri Lanka by M.C. Shirani Seneviratne, et all, http://www.atmospolres.com/articles/Volume2/issue2/APR-11-026.pdf

[4] : Strategy for Air Quality Assessment and Management in Bhutan, www.nec.gov.bt/publications/**Air**%20**Quality**%20Mgt%20**Strategy**.pdf

[5] : Country synthesis report on urban air quality management for Pakistan, discussion draft, 2006 by ADB and CAI-ASIA, cleanairinitiative.org/portal/system/files/documents/**pakistan**_0.pdf

Ambient Levels of Nitrogen Dioxide in Different Cities in Pakistan

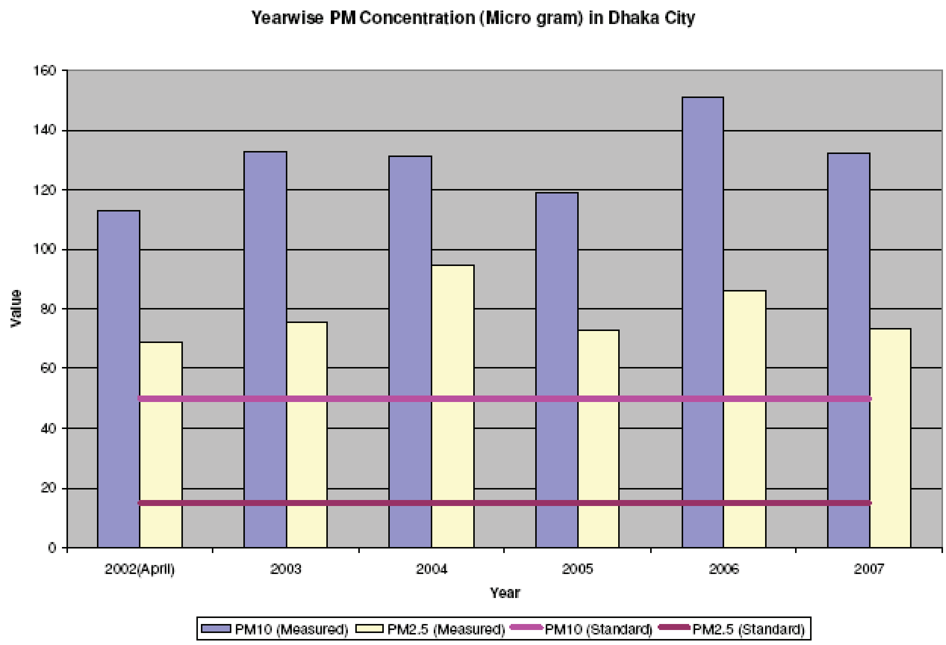


Source: Lodhi (2006).

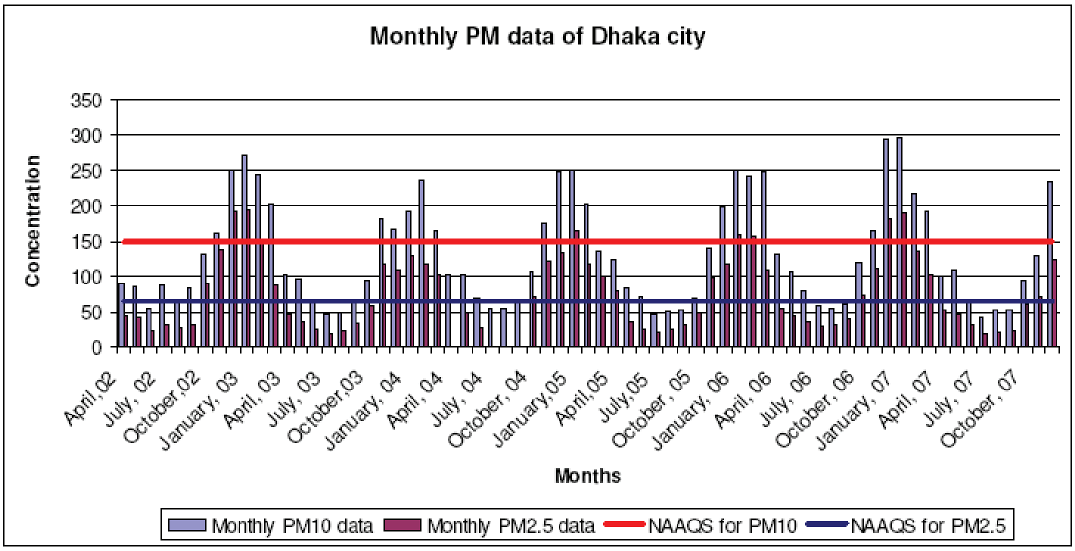
Nitrogen Dioxide Concentrations in Pakistan's Main Cities

The figure below indicates average national levels of PM10 in major cities of Bangladesh, since 1993. It clearly shows that SO_2 and NOx levels are increasing. It is important to note that in 2007, the average of both NOx and SO2 remained below Bangladesh national ambient air quality standards and World Health Organization (WHO) guideline values, but that PM10 and PM2.5 levels continue to exceed both Bangladesh national ambient air quality standard and WHO guideline values and the maximum value reaches up to 150 microgram for PM10.

[1] : Country synthesis report on urban air quality management for Pakistan, discussion draft, 2006 by ADB and CAI-ASIA, cleanairinitiative.org/portal/system/files/documents/**pakistan**_0.pdf

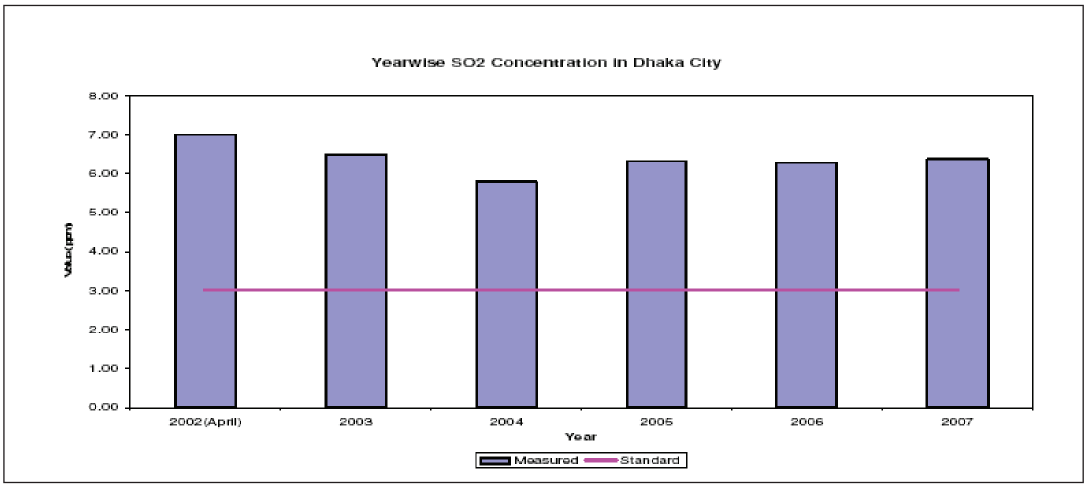


Trends in PM10 and PM2.5 levels in Dhaka between 2002 and 2007[6]

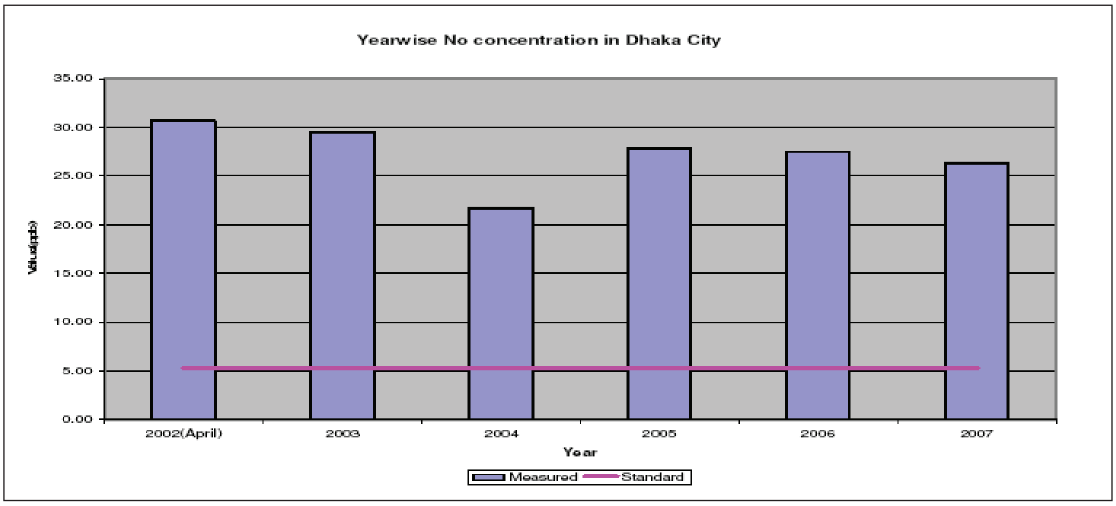


Monthly PM10 and PM2.5 concentration of Dhaka city from 2002 to 2007[7]

[6] : Clean Air in Bangladesh: Summary of progress on improving air quality, November 2008
***cleanair**initiative.org/portal/system/files/.../**bangladesh**_0.pdf*



Trends in SO2 levels in Dhaka between 2002 and 2007[7]



Trends in NOx levels in cities in Bangladesh (national average) between 2002 and 2007[7]

According to Garg et al. (2001 and 2006), SO_2 emission at the all India level increased from 2.4 Tg in 1985 to 4.8 Tg in 2005[7], i.e., at a compound annual growth rate (CAGR) of about 3.5 per cent during 1985-2005. In terms of emission by fuel type, coal contributed to 64 per cent of total SO_2 emissions in India in 1990, while petroleum products and biomass accounted for 29 per cent and 4.5 per cent of the emission respectively and non-energy consumption contributed to 2.5 per cent of the emission. The share of natural gas use in SO_2 emissions was negligible.

Recent information on sectoral contributions to total SO_2 emission is lacking for most countries. Studies on India by Garg et al. (2001, 2006) show that the power sector has the largest share in total SO_2 emissions of India. The share increased from 46 per cent to 56 per cent during 1995-2005. The industry sector is the second largest SO_2 emitter and its share has decreased from 36 per cent to 32 per cent during the same period. The share of the transport sector has decreased from 7.8 per cent to 2.5 per cent. Furthermore, the share of biomass consumption had decreased from 6 per cent to 4.3 per cent during the period. A study by Shrestha et al. (1998) on SO_2 emissions in Asia based on 1990 data (assuming no further control is carried out under existing laws and regulations) shows that the largest source of sulphur emission in South Asia was the power sector followed by the industrial and residential sectors. The transport sector had the smallest contribution in the emission of sulfur (Figure 2.1). In the case of Pakistan, the industry sector had the large contribution owing to the coal and oil

[7] 1 Tg = 10^{12} g.

use. In Nepal and Bhutan, the residential sector had the highest share in sulphur emission largely due to the consumption of traditional fuelwood using conventional biomass stoves.

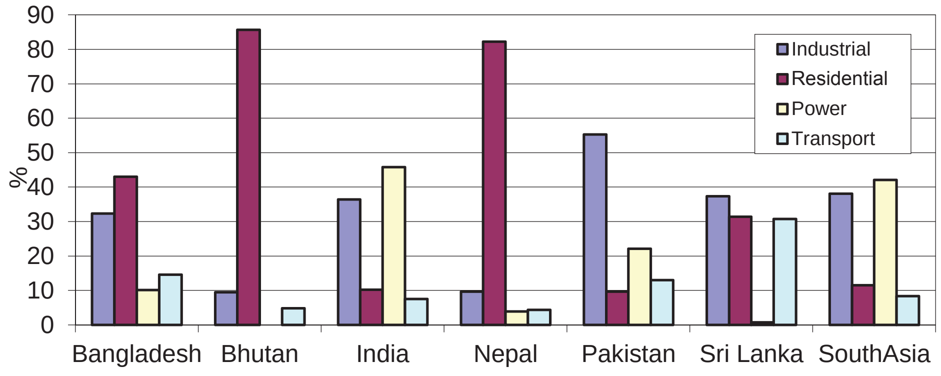


Figure 2.1: Share of SO_2 emission in South Asia (based on data 1990s data) (Shrestha et al., 1998)

Note: Residential sector accounts combined emission from residential, commercial and agricultural sector. Data on Maldives are not available. However, the major source of sulphur emission in Maldives is the power sector, which is fully based on petroleum products

According to Garg et al. (2006), NOx emission in India was 5.02 Tg in 2005 and was growing at the CAGR of 4.4 per cent during 1985-2005. The transport sector is the largest source of NOx emission in India followed by the power sector. The share of the transport sector had increased from 31 per cent to 38 per cent during 1985-2005, while the share of the power sector had increased from 17 per cent to 30 per cent during the period. On the contrary, the share of industrial sector had decreased from 21 per cent to 17 per cent during the same period. Aardenne et al. (1999) estimates that the NOx emission in the South Asian region would grow significantly by 2020 (Figure 2.2). The study estimates that the NOx emission in India would grow by a
factor of 5 in 2020 as compared to the 1990 level and that the transport sector would be the largest contributor (more than 50 per cent) to total NOx emission in India by 2020 (Figure 2.3). The study also estimated NOx emission in selected megacities of Asian countries and highlighted that the transport sector would be the largest contributor to NOx emissions (Table 2.2).

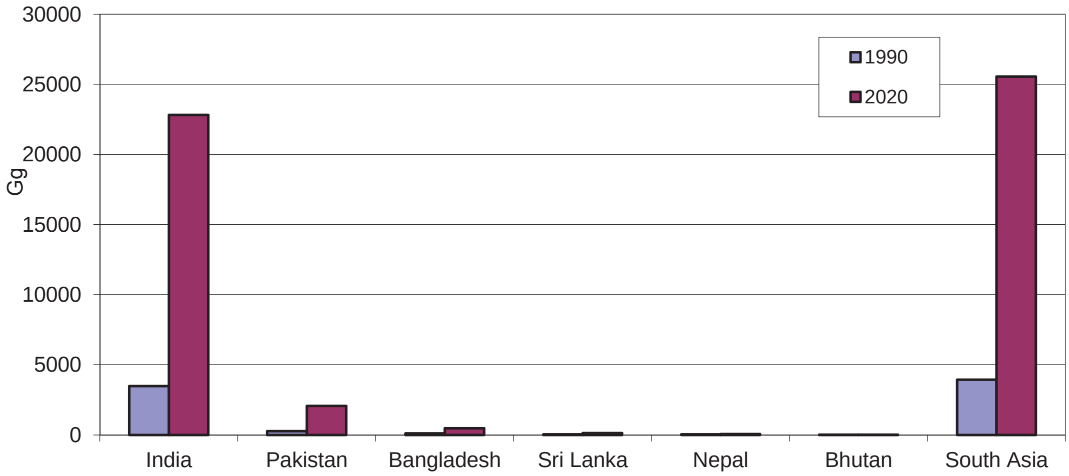


Figure 2.2: NOx emission in South Asian countries in 1990 and 2020 (Aardenne et al., 1999)

Table 2.2: Sectoral shares (%) in NO_x emission in selected Asian Mega cities in 1990 and 2020

	Bangkok		Delhi		Jakarta		Manila		Seoul		Beijing		Shanghai	
Sector	1990	2020	1990	2020	1990	2020	1990	2020	1990	2020	1990	2020	1990	2020
Conversion	1	1	0	0	12	12	0	0	0	0	3	2	2	1
Industry	7	6	2	1	3	1	13	4	11	18	46	23	38	18
Domestic	2	1	2	0	9	3	1	0	11	3	8	5	3	1
Transport	80	89	61	80	77	84	65	66	67	45	12	46	7	29
Power	10	4	2	5	0	0	21	29	9	24	3	5	7	8
Large point source	0	0	33	14	0	0	0	0	0	11	27	19	42	44
Total NO_2 (Gg)	192	1382	55	648	63	301	48	221	295	1749	184	772	280	1053

Source: Aardenne et al., 1999

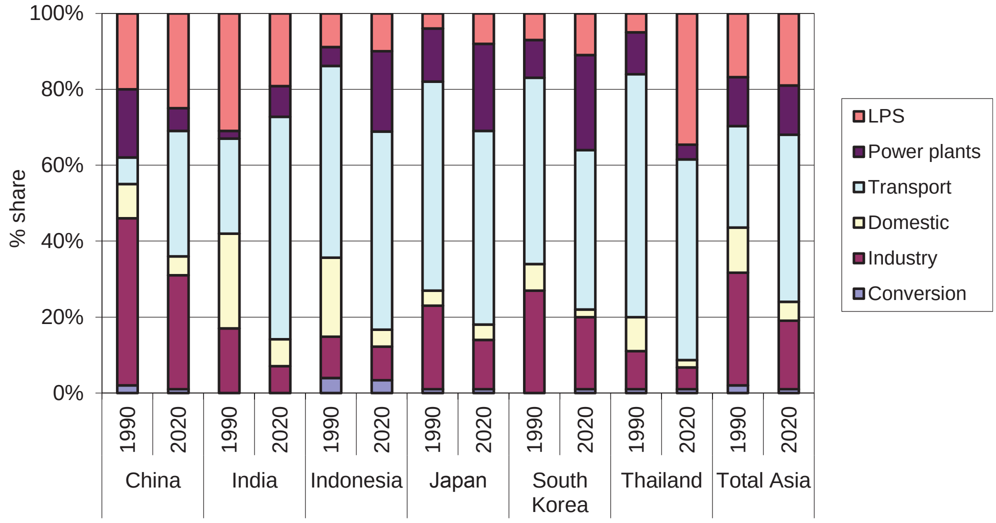


Figure 2.3: Sectoral shares in NOx emission in selected countries
in Asia in 1990 and 2020 (Aardenne et al., 1999)

Country specific emissions of VOCs are mostly lacking in South Asia. Streets et al. (2003) has estimated total emission of NMVOCs in the South Asian countries (excluding Maldives) to be 13,664 Gg in 2000, of which India accounted for nearly 80 per cent. A study by Varshney et al. (1999) has studied anthropogenic emissions of VOC by different sources in India. The study estimates that the burning of biomass is the major contributor to NMVOC emissions (Table 2.3). Rice (paddy) fields and livestock together are estimated to emit more than half of the total VOCs emission in the region (Varshney et al., 1999).

Table 2.3: Sources of VOCs in India

Sources	Total VOCs (tons)	Share (%)
Fuelwood and agricultural straw burning	4,706,813	21.94%
Petroleum industry: production and refining	1,007,878	4.70%
Fuel consumption for power generation	161,354	0.75%
Natural gas: production and distribution	518,040	2.41%
Transportation	975,515	4.55%
Manufacturing	1,343,886	6.26%
Coal mining (CH_4)	531,200	2.48%
Rice paddy fields (CH_4)	4,223,417	19.69%
Others (livestock) (CH_4)	7,984,622	37.22%
Total	21,452,725	100.00%

Source: Varshney et al., 1999.

2.3 Issues related to air pollution in South Asia

In this section, issues related to air pollution in South Asia are discussed. These include: (1) Growing thermal power generation and the role of coal, (2) low efficiency in power generation, (3) inefficient coal preparation/cleaning mechanism, (4) lack of emission control mechanism in power plants, (5) lack of regulations on industrial pollution and enforcement of existing regulations, (6) urbanization and growth of personal transport vehicles, (7) high dependence on biomass fuel burning in rural areas, (8) lack of information on emission source apportionment, (9) lack of effective regulatory and economic policies to improve air quality and (10) lack of comprehensive and regular monitoring of air pollution. Each of these is discussed next.

2.3.1 Growing thermal power generation and the role of coal

In South Asia as a whole, coal accounts for 72 per cent (147,368 ktoe) of total energy used in power generation. Nearly 99 per cent of the coal use for power generation in the region (i.e., 147,287 ktoe) took place in India in 2004, while the rest was used for power generation in Pakistan (IEA, 2006c). Coal based electricity generation accounted for 80 per cent of total electricity generation in India in 2004 (Figure 2.4).

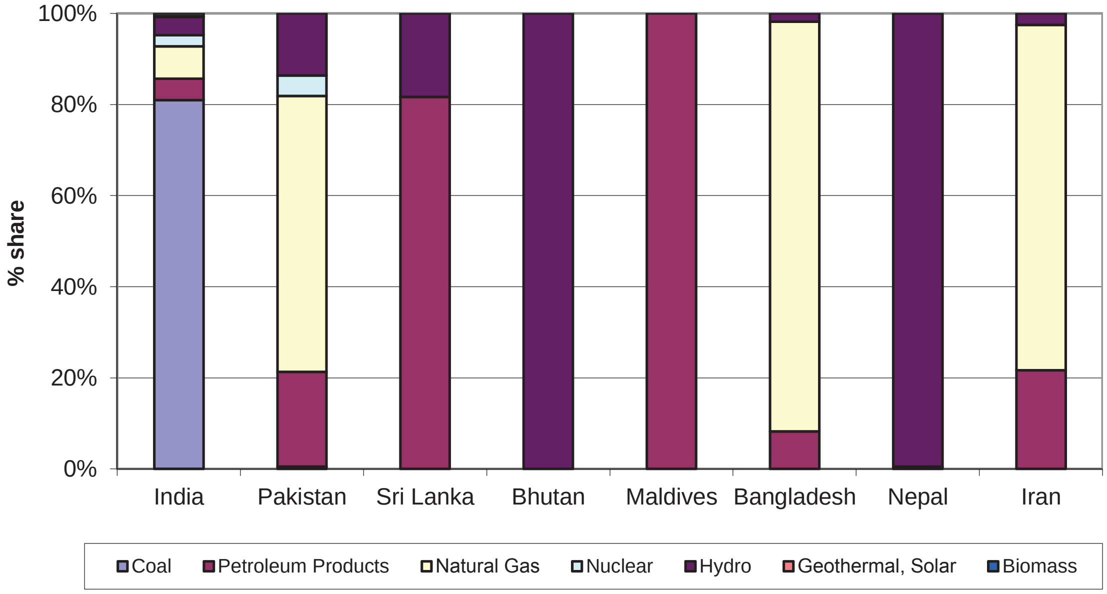


Figure 2.4: Fuel mix in the power sector

Sources: IEA (2004a) except for Bhutan and Maldives, DOEMTI/TERI (2005) for Bhutan; estimates for Maldives are based on information provided in UNEP/RRCAP (2002).

According to Garg et al. (2006), the total SO_2 emission of India reached to 4.8 Tg in 2005, while Streets et al. (2003) estimated the emission to be 5.54 Tg in year 2000.

Though there are variations in the estimated values, these studies show that coal use in the power sector is mainly responsible for the high share of SO_2 emission in India.

With the high growth of economy in India, IEA (2006b) makes a projection that coal demand in the country would increase from 441 million tonnes in 2004 to 1,020 million tonnes by 2030 in the IEA's Reference Scenario. However, GOI (2006) has estimated the coal requirement of the country in 2031/32 to range from a low value of 1,580 Mt to a high value of 2,555 Mt under various scenarios. The consumption of coal in India had increased from 140 Mt in 1984 to over 400 Mt in 2004 with a growth rate of 5.4 per cent (GOI, 2006). In this context, if coal import is to be avoided in future, India has to increase its domestic coal production in order to meet its growing coal demand (GOI, 2006).

In Pakistan, coal has historically played a rather minor role in power generation. However, the recent discovery of large stock of low ash, low sulphur lignite will probably increase its use in future. Thermal power stations are mainly based on natural gas (besides some generation using furnace oil and diesel) (WAPDA, 2007) and accounted for over 80 per cent of total electricity generation in Year 2004 (Figure 2.1). In Sri Lanka power supply is predominantly hydro-based, however, it is now gearing towards thermal electricity generation. Thermal power generation share has increased from below 1 per cent in 1990s (Siyambalapitiya et al, 1993) to around 30 per cent recently. There are several diesel-fired power plants with installed capacity of 405 MW in Sri Lanka. The country has a plan to build its first coal-fired power plant which will be equipped with particulate, SO_2 and NOx emissions control systems. By 2010, the installed capacity of thermal power plants in Sri Lanka would reach 2,200 MW (UNEP RRCAP, 2007). Overall, with the increasing power generation based on fossil fuels (like coal and diesel), SO_2 emission from the power sector is likely to grow in South Asia in future.

Besides power generation, coal is also used as a source of energy in the industrial sector in South Asia (IEA, 2006c). In some countries like Iran and India, coal is also used in residential and commercial sectors but their shares are relatively lower than in the industrial sector. On the other hand, the transport sector has the largest share in the

consumption of petroleum products followed by industrial and residential sectors (IEA, 2006c)

2.3.2 Low efficiency in power generation

There is a wide variation in efficiency of electricity generation in Asia. In South Asia as a whole, coal plays a major role in power generation mainly because of the dominant share of coal in the power sector of India. The overall efficiency of coal fired power generation in India was 29.6 per cent in year 2004 (IEA, 2007), which is significantly lower than the corresponding figure in the OECD countries as a whole (41.9 per cent) (Figure 2.5). It is also lower than the average efficiency of coal fired power plants in Asia. The efficiency of coal-fired electric power plants on an average in Asia as a whole (excluding China) was 32.5 per cent in 2004, while the corresponding values for China and Thailand were 30 per cent and 40.3 per cent respectively. If the efficiency of coal fired power generation in India was improved to the level of the OECD, the coal requirement and SO_2 emission would be reduced by 29.4 per cent. Similarly, if the efficiency of coal fired power generation in India was improved to the level of Thailand, the coal requirement and SO_2 emission would be reduced by 26.5 per cent.

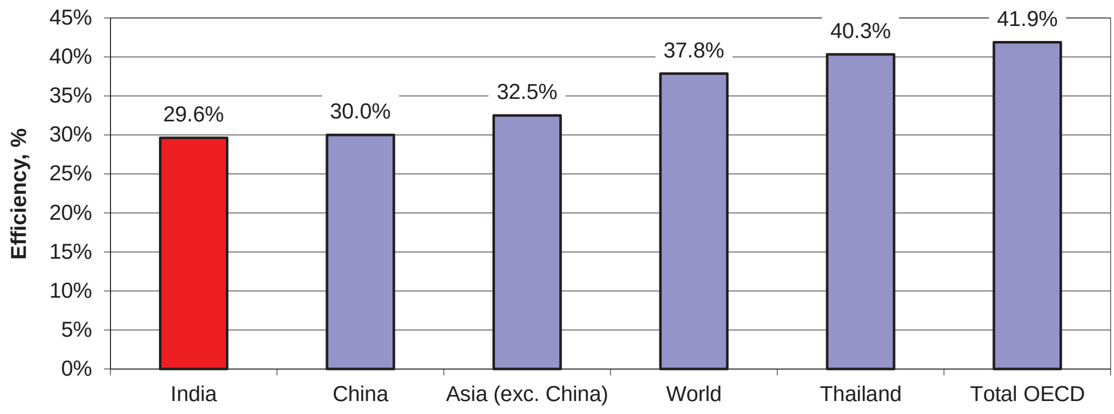


Figure 2.5: Efficiency of coal fired power generation in selected countries in year 2004 (Sources: IEA, 2006c)

2.3.3 Inefficient coal preparation/cleaning mechanism

Coal production in India has been largely based on open-cast mining (WCI, 2006; GOI, 2006). Inefficient exploitation of in-place coal reserves and lack of control on mining practices are some of the factors that have led to deterioration in the quality of domestic thermal coal over the years (GOI, 2006). Although the sulphur content of Indian coal is low, it has high ash content, which can result in higher emissions of suspended particulate matters (SPM) (GOI, 2006). Further, the domestic coal in India has low calorific value – i.e., 4000 kcal/kg (on an average) as compared to 6000 kcal/kg of the imported coal. Furthermore, the average calorific value of coal used in India's power plants is reported to be about 3,500 kcal/kg (GOI, 2006). Presently untreated coal with ash content typically in the range 40-45 per cent is used in the power sector in India (DTI, 2000). The Ministry of Environment and Forests (MOEF) of India has introduced a regulation prohibiting the use of unwashed coal containing more than 34 per cent ash if this has to be transported to a distance longer than 1000 km. As the power stations are often located at longer distances from the major coal fields, this regulation might give a push for clean coal preparation technologies. However, the effectiveness of the regulation would depend upon the level of its enforcement. The increased dependence of the power sector on lower quality coal has been associated with increased emissions of particulate matters, toxic elements, fly ash, oxides of nitrogen, sulphur and carbon from power plants (UNEP, 2001).

2.3.4 Lack of emission control mechanism in power plants

At present, most of the coal use for power generation in the South Asia region takes place in India. Existing coal-fired power generation in India is mainly based on conventional sub-critical pulverized combustion technologies with low efficiency of conversion. The country is moving towards greater use of clean coal technologies and has plans for addition of 20 GWe of supercritical coal fired thermal units (WCI, 2006). However, the Indian coal has high ash content and results in high emission of suspended particulate matter (SPM). Since the sulphur content of the Indian coal is reported to be low (GOI, 2006), controlling particulate matters through the use of electrostatic precipitators on existing and new generating units has been given a priority. Thus there are standards on maximum emission limit for particulate matters and for minimum stack height for thermal power stations in India (CPCB, 2007a).

Bangladesh started its first coal based power generation plant with an installed capacity of 250 MW in January 2006. Some coal mining projects are being planned in the country (EIA, 2007a). However, there is no emphasis on technology except that there is a standard for stack height of the power plant (DOE/BMEP, 2003).

There are no coal fired plants in Bhutan and Nepal at present nor is there any plan for having such plants in the future in these countries. Nepal is using some oil for captive power generation. With the increasing electricity demand during dry seasons in peak hours and shortage of generation capacity in the national grid, the usage of such power plants has been increasing (Nepal Electricity Authority, 2007).

2.3.5 Lack of regulations on industrial pollution and enforcement of existing regulations

Industry sector is one of the major sources of transboundary air pollutants. Streets et al. (2003) states that the industrial sector is the second largest contributor to national SO_2 emissions after the power sector in South Asia. Emission estimates by disaggregated industry types are not available for most countries in South Asia. According to Garg et al. (2006), iron and steel industry accounted for nearly one fifth of the total industry sector SO_2 emission in India in 2005 (Figure 2.6). Together iron and steel, cement and fertilizer industries accounted for nearly half of the industrial SO_2 emission in that country. In Bangladesh, the major SO_2 emitting industries are identified as textiles, non-ferrous metal, sugar and refineries, vegetable oil, iron and steel and tobacco (BBS, 2005). Similarly, textiles, sugar, refineries, cement and vegetable oil are reported as the major particulate emitting industries.

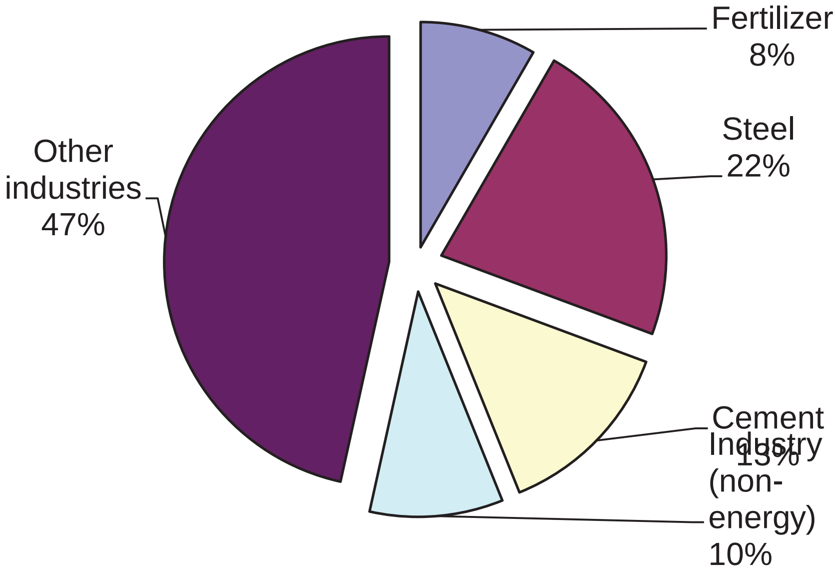


Figure 2.6: Shares in total industry sector SO_2 emission in India by type of industry in 2005 (Source: Garg et al., 2006)

While not much information on NOx emissions at the sectoral level are available for most South Asian countries, Garg et al. (2006) report that the industrial sector is the third largest contributor of NOx emission in India after the transport and power sectors (Industry sector accounted for 17 per cent of total NOx emission in India in year 2005). Given the importance of the industry sector in emissions of pollutants, it is clear that significant regulatory mechanisms and/or economic policies are warranted to deal with the emissions from the sector.

In 2000, Pakistan imposed a pollution levy on industrial effluents (including discharges to the water and air). The pollution levy was set initially at Pakistani Rs. 50 per unit of pollution load and was to be increased proportionately in the following years till it reaches Rs.100 per unit pollution load (PEPA, 2000). The country also has a provision to provide tax incentives to the industries for importing pollution abatement equipments. However, this policy is yet to be implemented effectively.

Bhutan has introduced the “Environmental Discharge Standards for Industrial Pollution” effective from year 2000. These standards are mandatory for new industries. Also an environment fund has been created in that country to support the existing industries to upgrade and meet the new standard.

Although some initiatives have been undertaken by some countries in the region to introduce standards to regulate emissions in the industrial sector, they are not comprehensive and seem to be highly inadequate for an effective management of air quality. Further, there are indications that the enforcement of existing standards is weak in most countries.

2.3.6 Urbanization and growth of personal transport vehicles

South Asian countries are undergoing rapid urbanization. As a result, the countries have witnessed high growth of energy consumption in transport, residential, industrial and commercial sectors in the cities and the resultant emissions of air pollutants(Guttikunda et al., 2003). Air quality in the cities (Dhaka, New Delhi, Calcutta, Mumbai, Chennai, Lahore and Karachi) under the study in South Asia has been deteriorating over the years (Guttikunda et al., 2003). Presently, air pollutants originating from the urban areas are recognized as the increasing sources of regional level pollution as well as greenhouse gases. Guttikunda et al., (2003) estimated that sulphur emission from urban centers in Asia would triple during 2000-2020 if current sulphur emission is unabated. Due to urbanization and motorization, concentration levels of suspended particulate matter (SPM) in particular are very high and exceeded WHO guidelines (Hayashi et al., 2004 and Siddiqi, 2007). One of the major causes of transport-related environmental problems in Asia is the severe traffic congestion resulting from growing vehicle stocks and lack of appropriate public transport infrastructure (Hayashi et al., 2004). This could be seen from the tremendous growth of passenger car ownerships in countries like India (Figure 2.7). For example, the total personal vehicle registration in Delhi, India increased by 105 per cent during 1996-2006; cars alone increased by 157 per cent and diesel cars increased by 425 per cent during the same period (CSE, 2006).

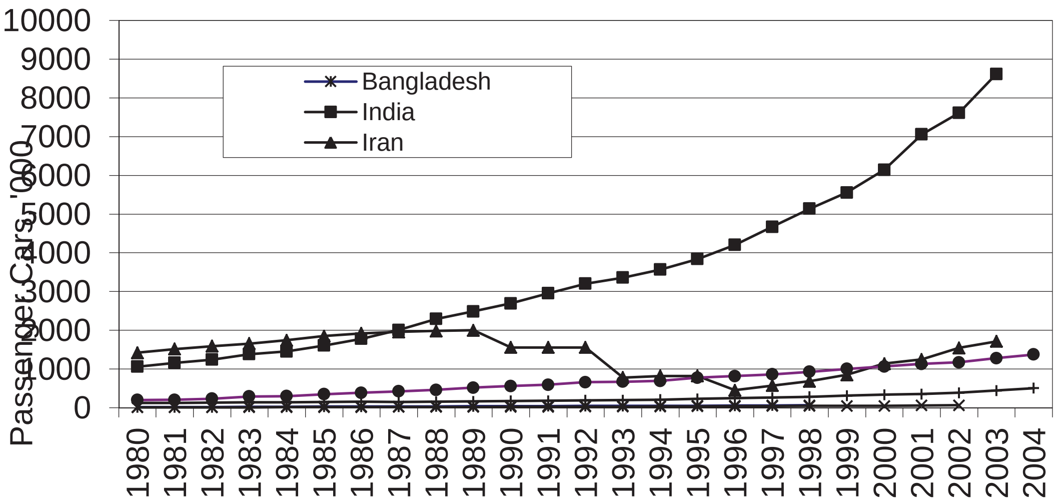


Figure 2.7: Stock of Passenger cars in South Asian Countries
Source: UNEP, 2007.

A 2006 study by the Centre for Science and Environment (CSE) in India has warned that the level of air pollution has started to increase (CSE, 2006). It states that the rising pollution level in Delhi is due to the rapid growth in cars, especially diesel cars, in the city. It is reported that particulate levels are still very high and NO_x levels are steadily rising (Figure 2.8).

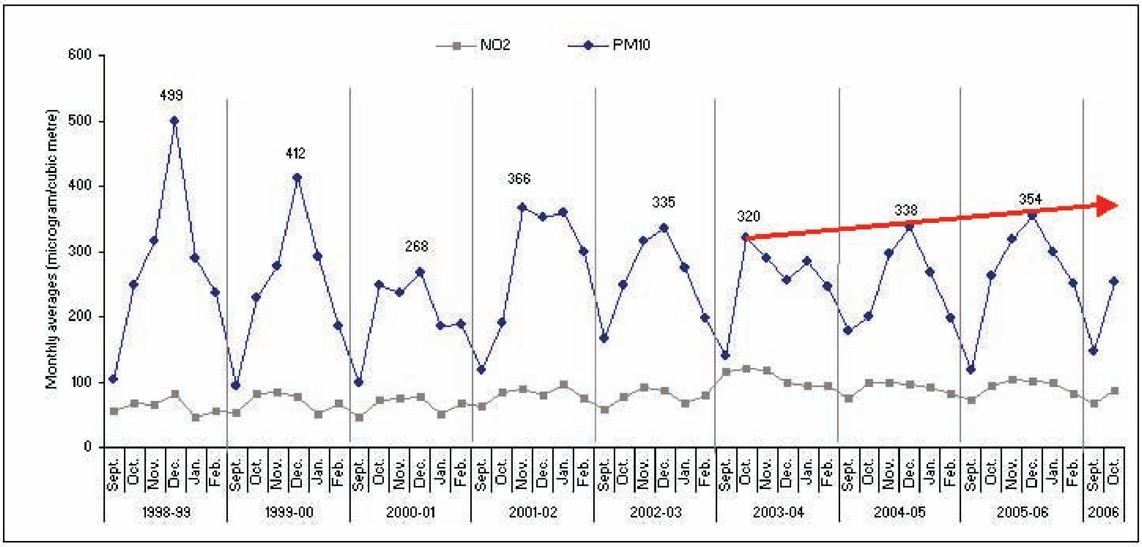


Figure 2.8: Trend of NOx and PM in Delhi
Source: CSE, 2006

In Delhi, diesel cars represented nearly 20 per cent of new car registrations in 2006, up from 4 per cent in 1999. While population of gasoline cars in the city increased at 8.5 per cent, annually, diesel cars maintained a growth rate of 16.6 per cent during 1999-2006. According to the estimates of CSE, 118,631 diesel cars on the city's roads is equivalent to adding particulate emissions from nearly 30,000 diesel buses (CSE, 2006). It further warns that the diesel personal cars are threatening to nullify the impact of the compressed natural gas (CNG) program.

Transport policies that consider environmental concerns at the national level are lacking in most countries. There is also lack of well defined policies to promote private participation in public transport in the region (Siddiqi, 2007). With the growth of population, economy and urbanization, travel demand has seen a rapid increase in the region. Countries in the region also suffer from an inefficient and inadequate public transport system, which result in a large switch to the use of personal motorized vehicles.

The stocks of low occupancy personal vehicles like 2-wheelers and cars are steadily increasing in South Asian cities and are contributing to increasing traffic congestions and air pollution. For example, in the past 30 years, total population of Delhi more than tripled, whereas the number of vehicles increased almost fifteen-fold (Bose et al., 2001).

In Thimphu, Bhutan, two-wheelers are estimated to have a share of 45 per cent in total vehicle population, while cars and jeeps accounted for 35 per cent and buses account for 2 per cent. Traffic volume had increased by more than 100 per cent during 1997-2003. It is projected that by 2020, the number of vehicles in Bhutan would rise to 100,000, with more than 45,000 in Thimphu alone (NECS, 2006). In Nepal, there was a three fold increase in vehicle population during 1989-2004 with the total vehicle stock being 472,795 in FY2004. Two wheelers account for the largest share in total vehicle population (i.e., 43 per cent in 1989 and 63 per cent in 2004). In Pakistan the number of vehicles increased from 0.8 million to 4 million during 1984-2004 showing an overall increase of more than 400 per cent (PEPA, 2005). Road transport vehicles are the major contributors of particulate matter emissions. The concentration levels of particulate matters greatly exceed the national and World Health Organization standards, and vehicular transport is by far the largest source of air pollution in several cities in the region; for example, in the Kathmandu Valley, vehicular emissions are reported to be responsible for 38 per cent of the total PM_{10} emission in the Valley (ICIMOD, 2007). A World Bank study on the Kathmandu Valley states that particulate matters (PM_{10}) from vehicle exhaust increased to 471 per cent during 1993-2001 (ADB, 2006a). The foregoing discussion shows that the vehicle stock in South Asia is growing rapidly and would thus increase the pollution load further in the cities.

2.3.7 High dependence on biomass fuel burning in rural areas

Biomass (including agricultural waste and dung) has been the major source of energy for most of the rural households in South Asia. The share of biomass in total primary energy is high in most countries of the region. In some countries, like Nepal, biomass is the predominant source of energy accounting for about 80 per cent of the total primary energy supply. Mostly, biomass is used for residential cooking. Traditional firewood cooking stoves are mostly being used for the purpose. Biomass is also used in the industrial sector in several countries including India, Pakistan and Iran (IEA, 2006c).
Table 2.4 shows that the burning of crop residues is relatively high in South Asia (when compared to the total residues burning in Asia as a whole. The data in the table indicate that the use of biomass burning, especially crop residues, could be one of the major sources of VOCs in rural regions of South Asian countries.

Table 2.4: Biomass burned in South Asian countries

Countries in South Asia	Biomass Burned (Tg) Savanna/ Grassland	Forest	Crop Residue
Bangladesh	0	9	11
Bhutan	0	1	0
India	9	37	84
Nepal	0	5	2
Pakistan	3	1	10
Sri Lanka	0	4	0
Asia Total	147	330	250

Source: Streets et al., 2003.

2.3.8 Lack of information on emission source apportionment

There is lack of information and scientific studies on source apportionment of air pollutants in both urban and rural areas in South Asian countries. Sound scientific studies and database on the sources of emission and the manner they contribute to air quality are required in order to formulate/design effective air pollution control regulations, policies and strategies.

2.3.9 Lack of effective regulatory and economic policies to improve air quality

Most countries in South Asia have developed some ambient air quality standards (see Table 2.5)[8]. In order to attain the air quality standards, one would need effective instruments (for example., emission standards, technology standards, fuel quality standards or economic instruments like emission charge or permits). While Euro-I standard is being implemented in all countries for cars and heavy diesel trucks, India has implemented Euro-III in its 11 metropolitan cities and Euro II in the rest of the country[9]. Several countries have also adopted standards on quality of diesel in terms of allowable limit on sulphur content (which vary from 0.05 to 1 per cent across countries of the region) (see Table 2.6).
While some regulatory frameworks and standards are in place in some countries, they are either inadequate or suffer from poor enforcement in most countries in the region. The approach of economic instruments (i.e., using emission charge or permits) is yet to be adopted by countries in the region except Pakistan, which started levying emission charges to the industries after amending the National Environmental Quality Standards (NEQS) in 2000 (PEPA, 2001). The policy of emission charge in Pakistan requires the industries to monitor and report the emissions regularly as per the standard to the authority. Emissions exceeding the NEQS would be charged. Interestingly, the charge is collected by Chambers of Commerce and Industry. The outcome of the policy is yet to be evaluated.

[8] Bhutan follows the USEPA and WHO guidelines in the absence of its own standards for ambient air quality. The country has developed its own Industrial Emission Standards in 2004 (CAI, 2006 and NECS, 2006).

[9] The rest of the country would implement Euro III by 2010 (See Society of Indian Automobile Manufacturers Website: http://www.siamindia.com/scripts/technicalregulations.aspx).

Table 2.5: Ambient Air Quality Standards of the South Asian countries in comparison to EU, USEPA and WHO, μg/m^3

Type	Averaging Time	EU guidelines	USEPA guidelines	WHO guidelines	Iran*	Sri Lanka/ Colombo	Bangladesh / Dhaka	Nepal/ Ktm	India/ Delhi/ Kolkata/ Mumbai
Carbon Monoxide	15 mins	-	-	100,000		-		100,000	-
	30 mins	-	-	60,000		-		-	-
	1 hour	-	40,000	30,000	40000	30,000		-	4,000
	8 hours	10,000	10,000	10,000	10000	10,000	2,000	10,000	2,000
	24 hours	-	-		-			-	-
Lead	1 hour	-	-	-				-	-
	24 hours	-	-	-		2		-	1.0
	1 month	-	-	-		-		-	-
	3 months	-	1.5	-		-		-	-
	1 year	0.5	-	0.5		0.5		0.5	0.75
Nitrogen dioxide	1 hour	200	-	200		250		-	-
	8 hours	-	-	-		-	80	-	-
	24 hours	-	-	-		100		80	80
	1 year	40	100	40	100			40	60
Ozone	1 hour	-	240	-	280	200		-	-
	8 hours	120	160	120		-		-	-
	1 year	-		-		-		-	-
Sulphur Dioxide	10 minutes	-	-	500		-		-	-
	1 hour	350	-	-	210	200		-	-
	8 hours	-	-	-		120	80	-	-
	24 hours	125	370	125	-	80		70	80
	1 year	20	78.5	50	-	-		50	60
TSP	1 hour	-	-	-		500		-	-
	3 hours	-	-	-		450		-	-
	8 hours	-	-	-		350	200	-	-
	24 hours	-	-	-	260	300		230	200
	1 year	-	-	-		100		-	140
PM_{10}	1 hour	-	-		-	-		-	
	24 hours	50	150	-	-	-		120	100
	1 year	40	50	-	-	-		-	60
$PM_{2.5}$	24 hours	-	65	-	-	-		-	
	1 year	-	15	-	-	-		-	

Source: CAI–Asia, 2007,
* Data for Iran is extracted from Aziz (2006).

Table 2.6: Sulphur content in diesel

Type	Bhutan	Maldives	Pakistan	Iran	Sri Lanka	Bangladesh	Nepal	India
Sulfur content in diesel	0.25%	0.5%	1.0%*	0.05%#	0.8%	0.5%	0.25%	0.25%

Source: Extracted from state of environment of the countries
* PEPA, 2005, # Hastaie, 2000

2.3.10 Lack of comprehensive and regular monitoring of air pollution

Inadequate air quality monitoring and lack of data have been a major hindrance in South Asian countries for assessing air quality and for formulating efficient policies and regulations for air quality management. The problems associated with the monitoring mainly include insufficient monitoring stations to have an adequate geographical coverage, lack of monitoring of all major pollutants and lack of regular monitoring. In India, particulate matters, SO_2 and NOx are monitored regularly (MoEF, 2006). In most other countries, it is only the particulate matters that are monitored regularly in few places.

Chapter III

International agreements and approaches for control and prevention of transboundary air pollution

3.1 Introduction

In the environmental economics and management literature, the approaches for environmental management are categorized as follows: i) command and control approaches, ii) market based approaches iii) property rights based approach and iv) approaches based on voluntary action. In the case of transboundary air pollutants (TAPs), often collective actions by countries involved would be necessary in order to effectively deal with the transboundary air pollution problem. That means, countries involved in the transboundary pollution will have to commit themselves through an agreement to achieve necessary reductions in emission of pollutants by stipulated time frame. Thus, the first step towards the control of TAPs is to secure such an agreement among the countries involved in TAP emissions in a region. Once the target level of emission reduction by each country is agreed, the next step for a country concerned is to formulate appropriate measures/strategies/policies to attain the committed emission reduction targets.

This chapter first discusses various important international treaties and agreements to prevent/control emissions of TAPs. Some of the treaties and agreements are designed to deal with a single pollutant, while others deal with multiple pollutants. The chapter then discusses different types of approaches and measures (including those based on command and control, market or economic instruments, and voluntary actions) adopted by various countries to attain their emission reduction targets.

3.2 Major treaties, protocols and acts

International/regional treaties on transboundary air pollution lead to formulation of protocols to reduce specific transboundary pollutants over specific time period. These protocols are ratified by member countries/states. Some major treaties and protocols are discussed next. There are four major sub-regions or political groupings in Asia:

Central Asia, South Asia, the ASEAN grouping and the East Asia. Sub-regional agreements have been formulated at the subregion level. Regional Environment Action Plan for Central Asia, Malé Declaration on Control and Prevention of Air Pollution and Its' Likely transboundary Effects for South Asia (Malé Declaration), the ASEAN haze action plan, and East Asian Network on Acid Deposition are the sub-regional level intergovernmental initiatives in Asia.

3.2.1 Male Declaration

The Seventh meeting of the Governing Council of SACEP, held in April 1998 in Malé, the Republic of Maldives, adopted the declaration naming it the "Malé Declaration on Control and Prevention of Air Pollution and its likely Transboundary Effects for South Asia ". The Malé Declaration stated the need for countries to carry forward, or initiate, studies and programmes on air pollution in each country of South Asia. In addition to the Declaration, the countries also nominated National Implementing Agencies (NIAs) for its implementation.

At the regional level, the implementation is being facilitated by United Nations Environment Programme (UNEP) in collaboration with South Asia Cooperative Environment Programme (SACEP) and Stockholm Environment Institute (SEI) with the financial support from Sida, the Swedish International Development Agency.

There are four stages of implementation from 1999 to 2012:

Phase I - Agreement and Awareness (1999 – 2000)

Phase II - Capacity Building (2001 – 2004)

Phase III - Tackling Air Pollution Problems (2005 -2008)
Phase IV – Ongoing (2010-2012)

Phase IV focuses on sustainable financing mechanism and selection of regional centres on air quality and impact assessment studies. It also continues to conduct the impact assessment activities on crop, health and corrosion and regular monitoring.

Objective of phase IV

- Strengthen Regional Cooperation and move towards developing a regional agreement strengthen the air pollution monitoring network and conduct regular monitoring of high quality
- Enhance the capacity of NIAs to undertake mission inventory and scenario development, atmospheric transfer of pollutants and Integrated Assessment Modeling
- Enhance the impact assessment capacity of the national institutions and assess the impacts of air pollution in the participating countries
- Assist the member countries of the Malé Declaration with the development of air pollution reduction policies and development of a regional framework
- Raise awareness for action on air pollution issues through targeted dissemination.

A common methodology, trained technical staff, strengthened monitoring stations, established scientific and stakeholder networks are evidence for the contribution towards long-term objectives. These achievements are the first step toward building the scientific base to support the intergovernmental cooperation. Continuation of this initiative through building the capacity at the national level is vital to obtain long-term trends on trans-boundary air pollution.
Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan and Sri Lanka are members of this initiative.

http://www.umad.de/infos/cleanair13/pdf/288.pdf

3.2.2 Acid Deposition Monitoring Network in Asia

Sulphur and nitric acids are recognized as major causes of atmospheric acidification. Sulphur dioxide and nitrogen oxides emitted from the burning of coal and oil react in the atmosphere to form sulphfuric acid and nitric acid that are deposited on the earth.. In some major cities in East Asia, the annual deposition of sulfphate amounts to more than 100 kg/ha. Sulphfuric acid is also transported together with sulphur dioxide and sulfphate as well as other acids to surrounding areas and may affect natural ecosystems through acidification of soil and water as well as damage to buildings and cultural heritage through corrosion of metals, concrete and stone.

The Acid Deposition Monitoring Network in East Asia (EANET) is an intergovernmental regional network established for promoting cooperation among countries in East Asia to address the problem of acid deposition.

Objectives of EANET are:

- To create a common understanding of the state of the acid deposition problems in East Asia.
- To provide useful inputs for decision making at local, national and regional levels aimed at preventing or reducing adverse impacts on the environment caused by acid deposition.
- To contribute to cooperation on the issues related to acid deposition among the participating countries.

Cambodia, China, Indonesia, Japan, Lao P.D.R, Malaysia, Mongolia, Myanmar, Philippines, Republic of Korea, Russia, Thailand, Vietnam are member countries of EANET.

Some of EANET's activities include acid deposition monitoring, promotion of quality assurance and quality control, technical support and capacity building and research and studies on acid deposition monitoring.

Achievements: Currently there are 51 acid deposition monitoring sites in the EANET network (20 remote, 12 rural and 19 urban). Out of these, 12 sites conduct wet deposition monitoring, 39 conduct air concentration monitoring. Data and information for ecological impact studies are currently collected from 14 inland aquatic monitoring sites and 16 soil and forest vegetation monitoring sites. All the sites follow a standardized set of methodologies for site selection, sampling and chemical analyses to ensure technical conformity within the network. The Network Center has established a central data collection system for compiling, storing and managing the data from the EANET monitoring sites. The technical capabilities and skills of those involved in managing acid deposition in the participating countries were significantly enhanced through a number of EANET activities. Technical missions were dispatched annually to all participating countries to assist in monitoring performance, laboratory operations, data management and other procedures.

The Japan International Cooperation Agency (JICA), in cooperation with EANET, conducts the JICA Training Course on EANET held in Japan and the Third Country Training Program on acid deposition and other air pollution issues held in Thailand annually.

Numerous EANET publications (technical manuals, monitoring guidelines, data publications, QA/QC programs, training materials etc.) have been disseminated to EANET countries and will continue to be produced for use by countries to further enhance capabilities of personnel in monitoring, assessment and management of acid deposition.

A number of scientific research projects on acid deposition and its effects were conducted by EANET in collaboration with scientists from the participating countries. The projects were conducted in countries with diverse natural environments and climatic conditions in the East Asian region to obtain a better understanding of the processes involved.

Since 2005 EANET has implemented a research fellowship program to encourage young scientists from the region to carry out air pollution research activities at the Network Center in Japan. Two researchers participate in this activity annually.

EANET has also succeeded in promoting cooperation with other regional initiatives, in particular the Convention on Long Range Transboundary Air Pollution (CLRTAP), and established strong links with international organizations such as the World Meteorological Organization (WMO) and World Health Organization (WHO). Experts from these initiatives have been regularly invited to attend EANET meetings and many have contributed their expertise in enhancing the network.

3.2.3 ASEAN HAZE Action Plan

Southeast Asian countries like Brunei Darussalam, Indonesia, and Singapore were badly affected by smoke haze caused by land and forest fires during nineties. The severity and extent of the smoke haze pollution was unprecedented, affecting millions of people across the region.

ASEAN Environment Ministers had in June 1995 agreed on an ASEAN Co-operation Plan on Transboundary Pollution focusing on broad policies and strategies to deal with. The plan is called Regional Haze Action Plan, which sets out co- operative measures needed amongst ASEAN member countries to address the problem of smoke haze in the region arising from land and forest fires.

Objectives

The primary objectives of this Plan are:

a. to prevent land and forest fires through better management policies and enforcement;
b. to establish operational mechanisms to monitor land and forest fires; and
c. to strengthen regional land and forest fire-fighting capability and other mitigating measures.

ASEAN countries recognised the need to strengthen national policies and strategies to prevent and mitigate land and forest fires and signed the Agreement on Transboundary Haze Pollution (2002). As of June 2007, eight countries have ratified The elements of National Plans are policies strategies, guidelines and support services to curb activities leading to forest fires and market development for economic recovery and utilization of biomass (e.g. briquette) and appropriate methods for the disposal of agricultural waste.

3.2.1 Convention on Long-Range Transboundary Air Pollution (CLRTAP)

The Convention on Long Range Transboundary Air Pollution (CLRTAP) is the initiative taken to address major environmental problems in United Nation Economic Commission for Europe (UNECE) region (with special focus on Eastern Europe, the Caucasus and Central Asia and South-East Europe). The Convention was adopted in 1979 in Geneva and entered into force in 1983. Up to now it has 51 parties (members) and it has been extended by eight protocols that identify specific measures to be taken by parties to the Convention to cut their emissions of air pollutants (UNECE, 2007a). The following are the protocols:

i) The 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Entered into force in 2005)
ii) The 1998 Protocol on Persistent Organic Pollutants (POPs) (Entered into force in 2003)
iii) The 1998 Protocol on Heavy Metals (Entered into force in 2003)
iv) The 1994 Protocol on Further Reduction of Sulfur Emissions (Entered into force in 1998)
v) The 1991 Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes (Entered into force in 1997).
vi) The 1988 Protocol concerning the Control of Nitrogen Oxides or their Transboundary Fluxes (Entered into force in 1991)
vii) The 1985 Protocol on the Reduction of Sulfur Emissions or their Transboundary Fluxes by at least 30 % (Entered into force in 1987)
viii) The 1984 Protocol on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) (Entered into force in 1988)

The Convention was the first international legally binding instrument to deal with problems of air pollution on a broad regional basis in Europe. Besides laying down the general principles of international cooperation for air pollution abatement, the Convention also set up an institutional framework bringing together research and policy to combat transboundary air pollutions in the region. The approach of the protocols adopted by the convention is either on the basis of stabilization of ambient level of emission in critical level[10], or on the effect based on critical load concept[11]. The protocols on SO_2, NOx, VOCs and NH_3 are discussed next.

[10] "Critical levels" means the concentration of pollutants in the atmosphere above which direct adverse effects on receptors, such as human beings, plants, ecosystems or materials, may occur, according to available knowledge.
[11] “Critical load" means a quantitative estimate of the exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to available knowledge.

3.2.1.1 Protocols on SO_2 emission reduction

Helsinki Protocol
Signed in Helsinki in 1985, this protocol required to reduce sulphur emissions by at least 30 per cent between 1980 and 1993 (UNECE, 2007b). This was the first sulphur protocol under the Convention on Long-Range Transboundary Air Pollution (CLRTAP). The protocol was able to have an average reduction of 46 per cent among the signatories[12]. Many western European signatories had achieved higher reduction than that. The reduction of sulfur emissions resulted in the reduction of ambient sulfur dioxide concentration by 40-60 per cent in most places in the Western Europe.

The Oslo Protocol
This protocol was the second protocol on the reduction of sulfur emission, which was signed in 1994 in Oslo and came into force in 1998. It required further reductions on sulfur emission and stipulated most western European countries to reduce their sulfur emissions by 70 to 80 per cent by the year 2000, while eastern European nations have reduction targets of typically between 40 to 50 per cent (from the 1980 levels) (UNECE, 2007c).

The protocol was based on the effects-based approach using the critical load concept, best available technologies, energy savings and application of economic instruments. An effects-based approach aims at gradually attaining critical loads, sets long-term targets for reductions in sulfur emissions as it has been recognized that critical loads will not be reached in one single step (UNECE, 2007c). Further, the protocol had explicitly mentioned about the possible use of best available technologies and economic instruments for meeting the sulfur emission obligation by the signatories.

3.2.1.3 Protocols on VOCs emission reduction

The Geneva Protocol
It was the first protocol adopted by the CLRTAP to control emissions of volatile organic compounds (VOCs), the second major air pollutant responsible for the formation of the ground level ozone. It was signed in Geneva in 1991 and came into force in 1997. It stipulates three ways of choosing emission reduction targets (UNECE, 2007e). They were targeted to achieve emission reduction by 1999 with flexibility to choose base year in between 1984-1990 as per the data availability. These options are:

i) 30 per cent reduction in emissions of volatile organic compounds (VOCs) by 1999 using a base year lying between 1984 and 1990 (to be chosen by each country). The base year chosen varied across the countries. Austria, Belgium, Estonia, Finland, France, Germany, Netherlands, Portugal, Spain, Sweden and the United Kingdom used 1988 as the base year, while it was 1985 in the case of Denmark, 1984 in the case of Liechtenstein, Switzerland and the United States, and 1990 in the case of Czech Republic, Italy, Luxembourg, Monaco and Slovakia.
ii) The same amount of reduction as in (i) as aforementioned within the Tropospheric Ozone Management Area (TOMA)[13]. The party can choose any base year emission level corresponding to a year during 1984-1990. However, it has to ensure that by 1999 total national emissions do not exceed the 1988 emission levels. (TOMAs in Norway chose base year as 1989 and Canada chose base year as 1988).
iii) If the total VOC emission in 1988 is lower than 500,000 tonnes, and 20 kg/inhabitant and 5 tonnes/km^2, the parties are to ensure stabilization at that emission level by year 1999. (This has been chosen by Bulgaria, Greece, and Hungary) (UNECE, 2007e).

[12] members who had ratified the protocol.
[13] The Protocol designates TOMA 1 as the Lower Fraser Valley in the province of British Columbia and the Windsor-Quebec Corridor in the provinces of Ontario and Quebec in Canada; and TOMA 2 as the Norwegian mainland as well as the exclusive economic zone south of 62°N latitude in the region of the Economic Commission for Europe (ECE)

3.2.1.4 Protocols dealing with multi-pollutants

The Gothenburg Protocol (A multi-pollutant and multi-effects protocol)
The protocol is a natural continuation of the earlier protocols under the CLRTAP. The protocol is unique in that it focuses on abatement of three effects namely acidification, eutrophication, and ground-level ozone and targets emission reductions of four pollutants, namely sulfur dioxide (SO_2), nitrogen oxides (NOx), volatile organic compounds (VOCs), and ammonia (NH_3). The protocol was adopted by the Convention on Long-Range Transboundary Air Pollution in its seventeenth session in 1999 in Gothenburg (Sweden). The protocol is also called as 'Multi-pollutant and multi-effects protocol' (UNECE, 2007f). The protocol sets binding emission ceilings on emissions of the four air pollutants to be achieved by 2010. It also prescribed the application of emission and fuel standards (UNECE, 2007f).

3.2.2 European Commission National Emission Ceilings Directive (2001/81/EC)

This is a directive issued by the European Commission for limiting the emission of SO_2, NOx, NH_3 and VOCs. The directive enforces the Gothenburg Protocol with more stringent national ceilings than that of the protocol (European Parliament and the Council of the European Union, 2001). The directive came into force on 27 November 2001. With accession of new member states in the European Union, the directive was amended in 2003 and issued to the member states. The directive has issued national ceilings to these member states for the four pollutants and requires member states not to exceed the national ceilings of the four pollutants latest by 2010 (European Parliament and the Council of the European Union, 2003). The directive has issued interim environmental objectives, which aims to reduce the acidification and ground level ozone formulation effect of these pollutants by three different ways, which utilize either the control of all pollutants or achieve a level of ground level ozone not exceeding the ozone level of health based standard or vegetation standard. The EC-Directives issued in 2003 are discussed next.

- Acidification: In the areas, where critical loads are exceeded, emission of all pollutants is to be reduced by at least 50 % compared to that of year 1990.
- Ground-level ozone (health): The ground-level ozone load above the critical level for human health[14] is to be reduced by two-thirds in all grid cells[15] compared to that of year 1990. In addition, the ground-level ozone load is not to exceed an absolute limit of 2,9 ppm.h in any area;
- Ground-level ozone (vegetation): The ground-level ozone load above the critical level for crops and semi-natural vegetation[16] is to be reduced by one-third in all grid cells compared to that of 1990. In addition, the ground-level ozone load is not to exceed an absolute limit of 10 ppm.h, expressed as an exeedence of the critical level of 3 ppm.h in any area.

For compliance of the EC Directive (2001/81/EC), the member states are allowed to decide on the measures to adopt for compliance. For example, in Denmark, the government has set an annual sectoral SO_2 emission limit for power plants with a capacity of 25 MW or larger. There is a consortium of two power companies, which decides how to allocate the SO_2 emission limit (or cap) among their individual power plants (OECD, 1998). There is flexibility for utilities to exceed the limit by 10% in any one year, as long as the cumulative emission limit over four years is reached.

[14] It means the sum of the difference between hourly concentrations of ground-level ozone greater than 120 µg/m^3 (=60 ppb) and 120 µg/m^3 accumulated throughout the year (termed as AOT60) is zero.
[15] It is a 150 km x 150 km square, which is the resolution used when mapping critical loads on a European scale, and also when monitoring emissions and depositions of air pollutants under the Cooperative Programme for Monitoring and Evaluation of the long-range Transmission of Air Pollutants in Europe (EMEP)
[16] It means the sum of the difference between hourly concentrations of ground-level ozone greater than 80 µg/m^3 (= 40 ppb) and 80 µg/m^3 during daylight hours accumulated from May to July each year (termed as AOT40) is 3 ppm.h;

3.2.3 The US Clean Air Act Amendment 1990

In the United States, the approach to limit emission of transboundary air pollutants is primarily based on Title IV of the 1990 Clean Air Act Amendment (CAAA). Studies in the US during the late 1980s suggested that SO_2 was the largest contributor to acid rain and that the electricity sector accounted for two-thirds of the SO_2 emissions. Therefore, the US approach had a major focus on SO_2 emissions reduction from the electricity sector, while the reduction of NO_x was also targeted but it was programmed with different approach than SO_2 reduction. The US adopted a nationwide program to address the reduction of these pollutants and the program was called as ‘Acid Rain Program’. The program has used economic instruments like sulfur emission allowance and emission trading to control sulfur emission and has stipulated rate based emission standards for NOx emission.

In fact, the US effort on limiting SO_2 can be traced back to 1970 when for the first time the US, through amendments on the Clean Air Act as a federal legislation, established a national standard for maximum ambient concentration of SO_2. However, the primary concern then was not acid rain; rather it was the damage to human health (Ellerman et al., 2000).

The US approach has addressed the impacts of acid rain formation by addressing emissions on a regional basis, i.e., controlling emission reductions from bordering or “upwind” states. Each state was required to prepare state implementation plan (SIP) specifying actions to be taken for compliance. It also imposed a standard for new plants called as New Source Performance Standard (NSPS), according to which new plants could not exceed 1.2 lb of SO_2 emission per million Btu of fuel burned. However, many states would not be able to comply with the standard by the deadlines specified in the Act. In 1977, the US congress again amended the Act with extended deadline until 1982, and required the Environmental Protection Agency (EPA) to designate the areas failing to meet the initial deadline as ‘non-attainment’ areas and these areas were subject to tight regulatory controls. Two alternative rate based emission standards were imposed for coal-fired plants built after 1978. Such standards link the maximum allowable emission rate with the percentage of sulfur removal attained. The power plants were required to operate either at SO_2 emission rate below 1.2 lb per million Btu with 90 per cent removal of potential SO_2 emission or at SO_2 emission rate below 0.6 lb per million Btu with 70 per cent removal of potential SO_2 emission (Ellerman et al., 2000).

3.3 Approaches for controlling and preventing transboundary air pollution
There are different types of approaches and measures to control and prevent TAPs. The approaches may be based on command and control, market or economic instruments, or voluntary actions.

3.3.1 Command and control approaches

It is a traditional approach of control, in which a standard is set on the polluting activity. The standard can be of different types: e.g., technology based standard, emission standard, fuel quality standard. A technology based standard stipulates the use of specific type of technology or equipment (e.g. catalytic converter, SOx scrubber mechanism etc.). An emission standard sets the level of permissible emission per unit of output or input: e.g. kg of SO_2/kWh or NO_x/kWh). A fuel quality standard sets an allowable limit for the pollutant content in the fuel. Different type of emission standards in practice are discussed next.

SO_2 emission standard in the US and Europe
The United States imposed an emission standard for new plants as 1.2 lb of SO_2 per million Btu of fuel burned in 1970s. Later, two alternative emission standards were imposed for new coal-fired plants built after 1978. The plants could:

a) either operate at SO_2 emission rate less than 1.2 lb per million Btu with 90 per cent SO_2 removal of potential SO_2 emission; or
b) operate at SO_2 emission rate less than 0.6 per million Btu with 70 per cent SO_2 removal of potential SO_2 emission.

Later these emission rates were extended to existing coal-fired power plants (through Title IV of Clean Air Act 1990). This kind of standard based on sulphur removal rate required all new as well as existing coal fired plants to use flue gas desulfurization system (scrubbers) whether they burn high or low sulfur coal. However, high cost of operation was reported for the power plants using coal with low sulphur content as compared to the plants using high sulphur coal (Ellerman et al., 2000).

In Europe, the Integrated Pollution Prevention and Control (IPPC) Directive of the EU required each member states to issue emission permits or technical measures based on the best available technology (BAT) (European Parliament and the Council of the European Union, 2008).

While the practice of technology based standards with fuel taxes is also available, according to Peszko and Lenain (2001), when all firms comply with the BAT requirement, the differences in marginal abatement costs among them may become negligible, which leaves little room to apply economic instruments on top of BAT standards to achieve additional emissions reduction.

3.3.2 Market based instruments

Market based instruments (MBIs) (also called economic instruments) can include direct instruments, e.g., emission charge (based on the level of emission), and emission permits (with or without emission trading) as well as indirect instruments such as environmental tax (e.g., sulfur tax based on sulfur content of the fuel), fuel tax (e.g., gasoline tax) and energy tax (i.e., tax per unit of heat content) and subsidy on cleaner fuel or efficient technologies. These market based instruments are discussed in the following sections.

3.3.2.1 Emission charge

An emission charge per unit of pollutant emission, based on the polluters' pay principle and levied on the level of pollutant emitted, requires the regulator to monitor emissions. However, fixing a charge has been mostly a debated issue as this has direct implication on the emission abatement cost for a firm as the firm may reduce emission to the point where its marginal abatement cost is equal to the charge or tax rate (Stavins, 2003). Theoretically, an economically efficient emission tax rate should be equal to the marginal benefits of cleanup at the efficient level of cleanup (Stavins, 2003, Tietenberg, 2003). In some cases, these taxes are used in conjunction with fines or non-compliance fees in order to comply with the maximum permitted emission level (so called "emission ceiling"). These fees are intended to provide incentive to reduce pollution to the permitted levels and therefore play a compliance function (Speck et al., 2000).

Emission taxes on volatile organic compounds (VOCs) emissions from aircraft engines
In 1997 in Switzerland, for the first time, an aircraft engine emission charge was introduced in Zurich Airport to control aviation related pollution (Knaus et al., 1997). It is reported that 20-30 per cent of the NOx emission and up to 90 per cent of the VOC emission during an entire flight would occur during the landing and take-off cycle (LTO). The aircraft engine emission charge is expressed as a percentage of the regular landing fee and is added to the landing fee as such. Based on a number of considerations such as clean air incentives, available technologies, existing and forecast aircraft fleet mix, five classes were defined each for turbofan and turboshaft engines, giving a range of engine emission factors for each class. Class 5 (which currently includes 48 per cent of all scheduled and chartered planes) is free of charge. Airline operators with planes in Class 4 (17 per cent of all planes) pay 5 per cent of the regular landing fee; while those with planes in Class 3 (30 per cent), Class 2 and Class 1 pay 10, 20 and 40 per cent of the landing fee respectively (Knaus et al., 1997). It should be noted that the charge doubles from one class to the next, which indicates the intended economic incentive for promoting and accelerating the introduction and use of best available engine technology in order to stabilize airport emissions without having to set limits on operations. Apart from the size

of aircraft engines, the aircraft emission charge is based on NOx and VOC emissions in the LTO (Landing and Take-Off) cycle (Knaus et al., 1997).

The charge was intended primarily to provide an incentive to encourage operators to use lowest emissions aircraft and to accelerate the use of best available technology (BAT). These charges are revenue neutral and do not affect consumer demand (IPCC, 1998). They do, however, provide an incentive to airlines to purchase and operate aircraft with lower engine emissions. Revenues are used to finance emission reduction measures at the airport (Carlsson, 1999). Similar emissions-related charge scheme was applied at 10 Swedish airports in 1998 and in France in 2003. UK has introduced emission charges at two of its airports in 2004 and Germany is going to introduce it in 2008 (Fleuti, 2007; ECAC, 2005).

SO_2 and NO_x charges in European countries
In Poland, Czech Republic, Estonia, Latvia, Lithuania, and Slovakia, SO_2 and NOx charges were introduced in conjunction with a permit system (SIEI, 2000). A base charge rate is applied to all pollution within the permitted level and a penalty rate is added for pollution above that level (the so-called non-compliance fee). Large point source polluters (combustion plants, heavy industry) are subject to these charges. The charges are intended to raise revenues and encourage cost-effective abatement below the permitted level. The fines, non-compliance fees, are intended to provide incentive to reduce pollution to permitted levels and play a compliance function. Such revenues are largely earmarked for expenditure through national and regional/local environmental funds (SIEI, 2000; Speck et al., 2000).

Denmark, Sweden, Italy and France also have emission tax on SO_2 and NOx emission. However, the taxes vary from country to country. Emission taxes for SO_2 emission in Denmark, France, Italy and Sweden were Euro 2,700 per ton of Sulphur[17], 27.4 per ton of SO2, 53.2 per ton of SO_2 and 3,470 per ton of Sulphur respectively (Speck et al., 2000). Emission taxes for NOx in France, Italy and Sweden were Euro 22.9, 105, 4630 per ton of NOx respectively (Speck et al., 2000). Norway has also introduced taxes on NOx emission since January 2007.

Emission taxes as a pollution damage levy in Japan
In Japan, emission tax was charged to polluting firms in order to collect revenue to compensate the victims of designated diseases (NCEE, 2004). It was implemented under a framework of the Pollution-Related Health Damage Compensation and Prevention Law, which was established in 1973. Under the framework, areas having a certain level of pollution were designated as Class I and people living in the area for certain period of time and suffering with designated diseases were defined as air pollution victims. Eighty per cent of the revenue was obtained by collecting pollution levies from polluting firms based on their emissions of sulfur oxides (SOx) and the remaining 20 per cent was collected from vehicle tax charged to polluting motor vehicles (Azora Foundation, 2005). Significant reduction in emissions was reportedly achieved. However, it was not clear how much reduction was due to the tax (NCEE, 2004).

Refund based tax system for NOx and sulphur tax in Sweden
An innovative approach called "Refund Based Tax System" has been in practice in Sweden (SIEI, 2000; Roseveare, 2001; NCEE, 2004). The approach is not intended to raise revenue. It is designed to provide an incentive to the participants to reduce emissions. The system imposes tax on the emitting sources based on their emission and then redistributes the revenue so collected to the sources in proportion to their energy production.

A charge of 40 SEK/kg NOx ($ 4.4/kg) has been imposed in Sweden since 1992. The charge is applied to large heat and power plants, which produce more than 25 GWh/yr (Roseveare, 2001). Before 1996/97, it was applied only to the large plants producing more than 50 GWh/yr (IISD, 1994). While the tax is collected on the basis of emissions, it is rebated (redistributed) to them in proportion

[17] 1 ton Sulphur is equivalent to the 64/32 ton of SO_2.

of energy production. This means, the total tax thus collected is divided by total energy production (certain amount is deducted for administration charge) and redistributed in proportion to their rate of energy production. That is, the plants, which produce more energy with less emission, would benefit more from this system. At the beginning of every year, large plants report their NOx emission and energy production for the previous year to the Swedish Environmental Protection Agency (SEPA). On the basis of these reports, SEPA calculates the total taxes and refund rate per unit of energy generated (MWh). SEPA has mentioned that the target has been achieved with significantly reduced emission per unit of produced energy in Sweden (Roseveare, 2001).

Since 1991, Sweden also has imposed the sulphur tax of 30 SEK/kg S ($ 3.3/kg S), which is applicable to fuel oils and coal having more than 0.1 per cent sulphur. It is reported that a remarkable reduction (i.e., below the allowable limit) in the sulphur content of oil products was achieved due to the sulphur tax (Hammer and Lofgren, 2001).

3.3.2.3 Fuel and environmental taxes

Fuel and environmental taxes are indirect instruments that are based on the users pay principle, where the user of a polluting fuel pay a fee, which is either per unit use of the fuel or per unit output of the polluter's activity consuming the fuel (e.g., per unit electricity generation based on coal) (Blackman & Harrington, 2000). Historically, fuel taxes are the most used market mechanism internationally. These taxes are applied as an indirect tax charged on the polluting fuel so as to increase the prices of these fuel and the products or services using the polluting fuel. On the other hand, environmental taxes are either charged to the goods used as an input in polluting activity or products associated with pollution or content of polluting substance contained in the inputs. Other forms of indirect taxes are annual vehicle tax/registration tax, sales tax, scrappage tax, parking fees, city tolls, road pricing, congestion pricing etc. These affect the environmental quality in two ways: first, they can affect polluting behavior and the choice of inputs by the firms. Second, they can influence the demand for polluting products (NCEE, 2004).

3.3.2.4 Fuel and environmental taxes in practice

In countries like Finland, Mexico and Australia fuel taxes are levied in the form of excise duty[18]. In Germany, eco-tax is levied along with excise duties. The eco-tax is similar to the environmental tax, which is intended to achieve an environmental effect. These taxes are intended to influence the consumption of scarce resources by changing the price that users have to pay. In Germany, eco-tax was introduced in 1999 as a part of its Environmental Tax Reform. It was designed to make energy and resource consumption more expensive, while lowering the cost of labour (Diefenbacher et al., 2006). The taxes raised the price of electricity by 2 Pfennigs[19]/kWh, price of mineral oil by 6 Pfennig/liter, price of heating oil by 4 Pfennig/litre and gas price by 0.32 Pfennig/litre. Labour costs were cut by reducing pension contributions. By the end of 2002, tax collected had a significant contribution in lowering the pension contributions. In addition, some of the eco-tax revenue, up to €150 million a year, was used to promote renewable energy (Diefenbacher et al., 2006). The level of eco-tax on fuel varies with sulphur content (IEA, 2002). In other European countries like in Finland, Belgium, Denmark, France, Norway, Portugal, Sweden, Switzerland and United Kingdom, differential fuel tax rates are applied according to the sulphur content of fuel with higher tax applied for fuels having higher sulfur content (SIEI, 2000). But it is unclear whether these taxes, as in the case of eco-tax in Germany, are utilized for an environmental objective other than revenue generation. In Finland, there are special tax (environmental damage tax) systems as oil pollution fee on oil imports besides excise tax, (IEA, 2007) (Table 3.1).

[18] Excise duty is a form of tax applied on goods produced and sold within a particular region, country or state.
[19] 2 Pfennigs is roughly equivalent to one Euro cent.

Table 3.1: Fuel taxes in Finland

Fuel Type	Tax Type	Date	Tax Rate	Remark
Light Fuel Oil	Excise Tax	2003 onward	19.30 Euro/kl	
	Oil Pollution fee (imports)	1990 onward	032 Euro/kl	
Automotive Diesel Oil	Excise Tax	2003 onward	0.295 Euro/kl	(sulfur content > 0.005%)
	Excise Tax	2004 onward	0.295 Euro/kl	sulfur content 0.001 - 0.005%
	Excise Tax	2004 onward	0.268 Euro/kl	sulfur content 0.001 - 0.005%
	Oil pollution fee (imports)	1990 onward	0.00032 Euro/kl	
Gasoline	Excise Tax	2003 onward	0.618 Euro/kl	Premium leaded
			0.539 Euro/kl	Premium unleaded
	Oil Pollution Fee (imports)	1990 onward	0.00029 Euro/kl	

Source: IEA, 2007

3.3.2.5 Emission reduction credit and emission trading system

In Emission Reduction Credit (ERC) system, firms are issued an emission permit or allowance, which is based on the target, set either on the basis of the ambient air standard in the region or based on the necessity of reducing emissions from a reference level. If a source or firm reduces emission below the level required, the extra reduction is credited to the source. The credits so earned can be used by the same firm or another firm to comply with the emission allowance. As the cost of pollutant abatement may be different for different firms, some firms may opt for buying the credits from other firms if the former's cost of abatement is higher than that of the latter. This mechanism is called as emission trading (ET). The emission trading mechanism can result in a lower total cost of emission abatement by all the firms taken together than that under the Command and Control (CAC) approach.

3.3.2.6 Emission reduction credit and emission trading in practice

SO_2 allowances trading in the United States

In the case of suphfur emission allowances trading mechanism in the US under its Acid Rain Program, emission permits are issued to the polluting sources. The emission permits have been based on the reduction requirement with reference to a baseline emission projection. In the trading program, some proportion of the surplus allowance is also auctioned to the public (USEPA, 2007a). Agencies lobbying for environment protection and other public ventures concerned on environmental conservation have been buying the credits (surplus allowances) in the auction. These credits could be retired physically[20] so that the emission is permanently reduced. In this case, it is observed that the cost to the society of emission reduction has been lowered (Tietenberg, 2003; Stavins, 2003).

SO_2 emission trading in Slovakia

In 2002, Slovakia started issuing the SO_2 emission permits (quotas) based on the combination of historical emissions, future plans and programmes of power plants on an annual basis (EEA, 2005). It is applied to power plants with capacity above 50 MW, which represented about 90 per cent of emissions in 1998. The country's Ministry of Environment decides an overall envelope of allowances on an annual basis. This overall allowance is then divided into district-wise allowances and a district may transfer the unused quota to other districts under certain circumstances. However, few such trades have been noted (EEA, 2005).

[20] Buyer of the credit terminates the allowances so that that allowance is neither traded nor transferred in the following year.

NOx emission trading in the Netherlands

Some countries in Europe (Netherlands and Slovakia) have adopted emission trading. In Netherlands, emission trading is used as a flexible policy tool with which the government regulates the electricity generation sector for NOx emission as a part of national policy to comply with the EU National Emission Ceilings (NEC) Directive (VROM, 2007). According to this directive, the Netherlands was obliged to reduce its overall NOx emissions from 490 kilotons in 1995 to 260 kilotons in 2010. An annually decreasing cap on emission (through permits) is issued as per the obligatory participant's commitment to monitor the emission adhering to the monitoring protocol[21]. The participant then needs to monitor, report and verify the emissions every year. These emissions are registered against emission permits. If the emissions registered are lower than the allowance, credits are issued accordingly by the Dutch Emission Authority (DEA, 2007). All participants are allocated an annually declining performance standard rate (PSR)[22] (which declines from NOx emission of 68 g/GJ in 2005 to 40 g/GJ in 2010) (IEA, 2004). The participants can borrow or bank a proportion of the credits (limited to 10 per cent of the 2004 NOx allocation for each source, 7 per cent of the corresponding figure in 2005 and 5 per cent of the corresponding annual allocation for subsequent years). As the emission is based on the energy input, the major disadvantage with this scheme is that it does not encourage firms to reduce their emissions by increasing their energy efficiency, as lowering their input would also lower their baseline emissions.

3.3.2.7 Innovative mechanisms in emission trading

There are four separate innovative mechanisms, which are being practiced in emission trading in the US (originally they were developed for SO_2 emission trading in the US) (Stavins, 2003; Tietenberg, 2003). The mechanisms are as follows:

a) Offset Mechanism
   It was used as a mechanism where new or expanded sources can be installed in non-attainment areas provided they acquire sufficient emission reduction credits from either existing sources. Thus, the emission by new sources can be offset by using the emission reduction credits earned by the existing sources. It is also in practice in Netherlands for ammonia (Roseveare, 2001)
b) Bubble Mechanism
   In this policy mechanism, the existing source in non-attainment areas can either adopt control technology or acquire the technology that emits at higher rates, provided, the sum of emission reduction credits plus actual reductions must equal the assigned reduction considering emission from the system as an emission from imaginary bubble. The mechanism is also in practice for NOx and SO_2 emission in Netherlands and SO_2 emission in United Kingdom (Roseveare, 2001).
c) Netting Mechanism
   It is a policy that allows sources undergoing modification or expansion to escape the burden of new source review requirements so long as any net increase in plant-wide emission is insignificant.
d) Banking Mechanism
   It allows the firms to store emission reduction credits for use in the bubble, offset or netting mechanism. In the United States and Netherlands, certain proportion of total surplus allowances is allowed for banking (Tietenberg, 2003; Roseveare, 2001).

3.3.3 Approaches based on voluntary action

It is an approach in which individuals or individual firms engage in pollution-control activities in the absence of any formal, legal obligation to do so (Field et al, 2002). Generally, two types of voluntary actions are in practice. One is moral persuasion and the other is informal community pressure. In

[21] Issued by Netherlands Emission Authority
[22] It is the standard rate at which NOx emission is allowed per unit of electricity generation.

addition to the command and control approach, in Poland, there is a practice of publishing the names of top 80 worst national polluters. This has informally influenced firms to comply with the standard in the country (Peszko and Lenain, 2001). Another example of voluntary action is the willingness on the part of some electricity users to buy green electricity (electricity from renewable energy technologies) at a premium price. This concept of Green Pricing, exists in Europe and the US.

3.3.4 Fuel Switching and cleaner fuel use

One of the widely used strategies for controlling air pollution is switching to the use of cleaner fuels. For example, use of low sulphur fuel has been widely adopted in several developed countries in Europe and North America. Switching to the use of cleaner fuel vehicles (like CNG and electric vehicles) are also examples of such strategies. These are discussed next.

3.3.4.1 Fuel Switching and cleaner fuel use in practice

Switching to Compressed Natural Gas Vehicles
In India and Pakistan, public passenger transport system has made a switch from diesel/petrol to compressed natural gas (CNG). Delhi, the capital city of India, has converted its fleet of public passenger vehicles to CNG with success following the intervention of the Supreme Court of India (DPCC, 2001), and is now followed across many cities in India.---need more data

Electric Vehicles
In Nepal, electric vehicles (EVs) in the form of Electric Trolley Buses were introduced in Kathmandu in 1975 with the support of the Chinese government. In early 1996, a group of private investors started a company with 7 EVs. Currently, there are over 600 electric three wheelers (called "Safa Tempos") plying on the streets of the Kathmandu valley and five EV manufacturers in the country. EVs in Nepal have almost no emission as electricity in the country is produced almost solely from hydro resources (CAI-Nepal, 2007). In cases where electricity is produced using fossil fuels, electric vehicles will not be a solution to reduce a transboundary air pollution. More examples ----------

3.3.5 Congestion charge and transport management

Congestion charge is applied to the vehicles using a designated region based on the degree of congestion. While entering these designated zones, the vehicles have to pay additional charge or tax and the level of the charge depends upon the time of day, vehicle type etc. Such a system has been put into practice successfully in Singapore, Stockholm, Dubai and London. Though the main purpose of the congestion charge is to reduce traffic congestion in and around the charging zone rather than to obtain environmental benefit, it is widely believed that they have helped improve air quality in these cities. Similarly limiting the vehicular operation by issuing license permits and banning the vehicles from operating in designated days of a week are some of the approaches used primarily for traffic management in practice, which also have potential to reduce air pollutant emissions. Some of the schemes in practice are as follows:

3.3.5.1 Congestion charge and transport management in practice

Congestion Charge in London
In London, congestion charge was introduced in 2003. The major focus of the charge was to reduce traffic congestion in the designated charging zone. Vehicles entering, or parked on the streets, in central London on weekdays during the day (7.00 to 18.30 hrs) are subject to a daily charge of GBP 5, which can be paid electronically. The charging zone covers 22 km^2 in the heart of the capital. Certain vehicles, for example motorcycles, buses (having 9 or more seats), emergency vehicles like ambulances, fire engines, police vehicles and alternatively fuelled vehicles are exempted from the charge, while some users, for example, residents in the zone and the disabled, benefit with discounts (TFL, 2007).

Congestion Charge in Singapore
In Singapore, the government introduced differentiated congestion taxes to the vehicles. Initially it introduced Area Licensing Scheme (ALS) which was a road tax charged to users on pay-as-you-use principle and it required each vehicle to have a license to enter certain restricted zones (RZ) during peak hours in the morning (7:30 AM – 9:30 AM). The system was later replaced by electronic road pricing (ERP), later converted into Area Road Electronic road pricing (ERP). The ERP charge varies each half-hour of a day and varies in the range of S$ 0.5 to S$ 9 depending upon the time of the day (e.g. peak vs. non-peak hours) and the type of vehicles (LTA, 2007a).

License Permits in Singapore
The License Permit policy is aimed at reducing the congestion related pollution from vehicles in designated time. A user is required to acquire a permit in order to run his/her vehicle. Vehicle Permits are used for regulating the vehicular operation.

In Singapore, a vehicle quota scheme (VQS) was introduced in 1990. Under the scheme, the government issues certain number of quota for new users as well as quota for renewing for the existing users for limiting the vehicles on road. The quota was called as Certificate of Entitlement (COE), which was required to operate the vehicles on road. The government issues the quota through a bidding process. All COEs are offered at the lowest offered price subject to it would exhaust the total available quota of COEs when arranged from highest to lowest priced bidders. The bidding process was conducted twice a month (LTA, 2007a).

License Permits in Chile
In Santiago, Chile, the government imposed an auctioning system for access right licenses for buses and taxis to enter certain congested areas. Under this system, in order to participate in the auction, the vehicles need to comply with a uniform emissions standard. The system is claimed to have significant improvement in vehicular emissions due to traffic congestion (Stavins, 2003).

Banning of vehicles from running in designated days in Mexico
In Mexico city, the city administration imposed a regulation in 1990 that banned running of cars on specific days, which was determined by the last digit of the license plate of cars. The regulation was called *Hoy No Circula* (known in English as "One Day without a Car"), It consisted of prohibiting the circulation of 20 per cent of vehicles from Monday to Friday depending on the last digit of their license plates (Answer, 2008). Vehicles with certain ending numbers[23] on their license plates are not allowed to circulate on certain days in an attempt to cut down on pollution and traffic congestion. Initially the program had a good result in curbing air pollution in the city. However, later, it was reported to be controversial since it had resulted in many better-off households buying extra cars reducing the program's benefits; also, newer vehicles are exempt from complying with the program. This policy is considered as a failed attempt to anticipate behavior reactions in longer run (Tietenberg, 2003).any updates on policy?

Banning of vehicles from running in designated days in China
The Mexican practice has been followed in China recently (Philly News, 2007). Cars with even-numbered license plates are ordered off roads on Fridays and Sundays, and vehicles with odd-numbered plates are banned on Saturdays and Mondays. Emergency vehicles, taxis, buses and other public-service vehicles are exempted from this requirement. The government officials claim that air quality after imposing this requirement is in good condition (air index below 100 according to State Environmental Protection Agency of China). But other additional measures to supplement the programme may be required based on the lesson learnt from the experience of Mexico City. In Mexico City during the initial phase, such programme was a success, but after few years, it proved to be a mistake in that it led to an over investment in vehicles (Tietenberg, 2003).

[23] Corresponding digits for Monday is 5 or 6, 7 or 8 for Tuesday, 3 or 4 for Wednesday, 1 or 2 for Thursday and 9 or 0 for Friday (http://www.answers.com/topic/hoy-no-circula).

3.3.6 Co-benefits of greenhouse gas emission reduction policies and technologies

Several measures to abate greenhouse gas (GHG) emissions could reduce air pollutants and vice versa. Many of the driving forces underlying air pollution and climate change are identical: economic growth, consumption and production processes, and demography. Air pollutants and greenhouse gases are often simultaneously emitted from the same sources. Any measure that modifies the activity level of a source also influences emissions of both local/regional air pollutants and greenhouse gases simultaneously. And the benefits in terms of reduction of local/regional pollutants resulting from a GHG emission reduction measure are attributed as co-benefits of the GHG mitigation measure. In this sense, promotion of renewable energy by using a Renewable Portfolio Standard (RPS) and implementing GHG reduction technologies are some of the practices, which not only help reduce GHG emissions but also reduce local/regional pollutant emissions. The policy of RPS and some GHG reduction technologies are discussed next.

3.3.6.1 Renewable Portfolio Standard policy

Electricity from renewable energy sources is being promoted in several European countries through a wide array of instruments (feed-in tariffs, tradable green certificates (TGCs), bidding/tendering schemes, investment subsidies, fiscal/financial and green pricing schemes) (Rio, P., 2004). Similarly, in many countries, firms are required to have certain proportion of electricity generation mix from renewable energy resources popularly known as maintaining Renewable Portfolio Standard (RPS). Electricity generation from wind resources has been increasing. While the policy is aimed at reducing CO_2 emission from electricity generation sector, it has co-benefits in terms of reduced fossil fuel consumption. In cases, where coal use is reduced as a result of such policy, there can also be a reduction in sulphur emissions.

3.3.6.2 GHG emission reduction technologies

GHG emissions reduction technologies could reduce air pollutants in addition to emission reduction of GHG pollutants. Energy conservation, fuel substitution, change in production level etc. with the implementation of technical emission control measures have effects on several pollutant emissions. Thus, measures aimed at the reduction of one pollutant may lead to reductions of other pollutants, e.g. efficiency improvement of coal fired power plants would not only reduce coal use and GHG emission but they also simultaneously reduce sulphur emissions. It is, however, also possible for some pollutants to increase with the implementation of controlling measures, e.g., use of SO_2 scrubber reduce SO_2 emission but it may increase fuel consumption and GHG emission.

There are a number of emission control technologies that reduce both air pollutants and greenhouse gases. For instance, some of the measures in the agricultural sector that reduce NH_3 emissions (e.g. dietary changes, improved storage of manure) also lead to lower Nitrogen Oxides emissions. Under certain conditions, new engine technologies that improve fuel efficiency and reduce CO_2 emissions, could reduce NOx emissions at the same time. Selective catalytic reduction (SCR) on gas boilers reduces not only NOx, but also N_2O, CO and CH_4. The three-way catalysts on cars reduce emissions of NOx, CO and CH_4. Regular inspection and maintenance programmes on oil and gas production and distribution facilities would reduce losses of CH_4 and other VOCs (EEA, 2004).

Some technologies in controlling air pollutants might increase the emission of other pollutants. Desulphurization techniques involving $CaCO_3$ increase CO_2 emissions, and catalysts that are used to reduce NOx, VOC and CO emissions from vehicles tend to cause higher N_2O and NH_3 emissions. In general, emission control measures, which increase energy consumption (e.g. scrubber mechanism reducing SO_2 or NOx from flue gases) would also increase some greenhouse gases emissions.

Chapter IV

Good practices on prevention and control of transboundary air pollution

4.1 Introduction

According to the United Nations Development Programme (UNDP), good practices are defined as "Planning and/or operational practices that have proven successful in particular circumstances. These are used to demonstrate what works and what does not and to accumulate and apply knowledge about how and why they work in different situations and contexts" (ADB, 2006b). Thus the good practices are those practices that have succeeded in achieving the target and these may be transferable in part, or as a whole, to other regions/countries (ADB, 2006c). Transfer of good practices to other countries/regions requires consideration adaptation or modification as the success of a particular practice depends the country/region specific factors and conditions which varies widely among different countries/regions. Some good practices may not be transferable at all and often it is difficult to know impacts of some good practices over time (ADB, 2006c). However, important lessons can be learnt from the study of the good practices as to their applicability and potential for their up-scaling in a different country/regional context.

In Chapter III, several approaches for preventing and controlling transboundary air pollution have been discussed giving brief references to the actual examples of their applications. In this chapter, more detailed descriptions of the successful practices under different approaches are presented. The good practices presented in this chapter are: the clean air score card initiatives in Bangkok, Thailand, Philippines, Manila and Indonesia, stationary source emission standards in Sri Lanka, Environmentally sustainable transport in Nepal, use of a tool- GAIN to combat air pollution and climate change in China and India, Atmospheric Brown Cloud problem in Asia, Bus Rapid Transit system in Asia, national environmentally sustainable transport strategy for Philippines and effective use of Sustainable Mobility Network for sustainable transport in India.

4.2 Case Examples of Good Practices

1. Clean Air Scorecard for Bangkok, Thailand; Jakarta, Indonesia; and Manila, Philippines

Country/Region	:	Asia
Area coverage	:	Asia
Sectoral Category	:	Energy
Type of approach	:	Policy/Economic Instrument
Implemented by:		Clean Air Initiative (CAI-Asia)

The aim of Clean Air Scorecard was identifying strengths and gaps in the management of air pollution levels, management of air quality and climate change, and policies and measures to reduce air pollution and greenhouse gas emissions.

Description and activities

The indices of the scorecard are Air Pollution and Health Index which assesses air pollution levels of a city against World Health Organization (WHO) guideline values and interim targets (i.e., a "good" air day in this index is in relation to WHO guidelines rather than the city's ambient air quality standards, which are generally less stringent). Pollutants included are carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter with a diameter less than 10 microns (PM10), particulate matter with a diameter less than 2.5 microns (PM2.5), and sulphur dioxide. A city is required to have, at a minimum, monitoring data for PM10.

Clean Air Management Capacity Index assesses a city's capacity to (i) determine sources of emissions and their contribution through an emission inventory; (ii) assess the status of air quality (includes monitoring, modeling, data analysis, and reporting); (iii) estimate impacts on health, environment, and the economy; and (iv) reduce air pollution and greenhouse gas emissions through an institutional and policy framework as well as financing.

Clean Air Policies and Actions Index helps to assess the existing laws and policies with its enforcement at national and local levels and simultaneous actions to address air pollutants and greenhouse gas emissions from mobile, stationary, area, and trans-boundary sources.

Each of the three indices consists of relevant questions with points. Higher scores indicate better air quality levels, management capacity, and policies and measures. The three indices contribute a possible 33.3 points each to a possible total clean air score of 100. Cities are then categorized based on their overall scores. The results show that Bangkok is far ahead of Jakarta and Manila in managing its air quality and greenhouse gas emissions, for all three indices. Both Jakarta and Manila need to invest to ensure that a basic management system is in place, supported by appropriate and enforceable policies and measures.

The Clean Air Scorecard is an Excel-based tool composed of questions that represent sub-indices and indicators relevant to the three indices .The results of the index are not a reflection of the levels of exposure of residents, as these take into account primarily the annual average concentrations of pollutants. This index then also does not represent the exceedance for short-term exposures to pollutants.
www.adb.org/documents/books/km-air-quality/km-air-quality.pdf

2. Stationary Source Emission Standards in Sri Lanka

Country/Region	:	Sri Lanka/ Asia
Area coverage	:	Sri Lanka
Sectoral Category	:	Energy
Type of approach	:	Policy/Economic Instrument
Year of Introduction	:	Since 2010
Implemented by:		Sri Lanka Energy Managers Association

Description
In Sri Lanka, Industrial activity is growing at a relatively rapid pace and increasing air pollution proportionately. The main stationary emission sources in Sri Lanka are power plants and industries. Various industrial activities (e.g., combustion for energy conversion, incineration, and evaporation) emit different pollutants. Sri Lanka's main challenge in managing emissions from stationary sources is the lack of legally enforceable emission standards. Unlike several countries in the region, Sri Lanka does not have a Clean Air Act. In early 2010, the Ministry of Environment and Natural Resources expressed interest in drafting an act.

Central Environmental Authority of Sri Lanka has been given work of reviewing current emission and developing sound, locally acceptable standards for stationary sources to the Sri Lanka Energy Managers Association in April 2010.

Impact
The Sri Lanka Energy Managers Association study described several existing nitrogen oxide, sulphur dioxide, and particulate emission control technologies for power plants and industries. The typical emission reduction efficiency (for e.g., flue gas desulphurization can reduce sulphur oxide by 70%–90%) for each technological solution was included (for e.g., flue gas desulphurization results in solid waste that cannot be reused). This assures regulators that existing technologies are available to meet the proposed standards.

Clean Air Sri Lanka, with the CAI–Asia Center, undertook a policy case study to review the 2010 proposed standards for Sri Lanka.

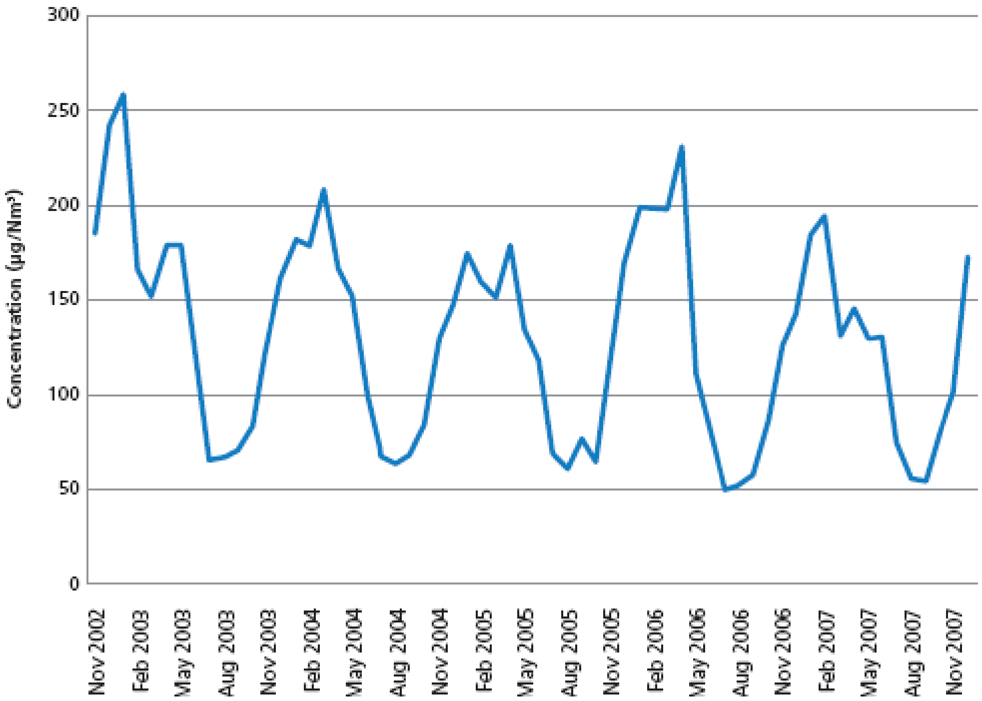
The need for stationary source emission standards to be part of an integrated framework for air quality management. Some of the issues raised by stakeholders are (i) a clean air act to be drafted to provide this framework, (ii) emission inventory to identify the major sources of air pollution, and (iii) air quality modeling to ensure that the stationary source emission standards contribute to attaining the ambient air quality standards.
www.adb.org/documents/books/km-air-quality/km-air-quality.pdf

3. Environmentally Sustainable Transport for Kathmandu, Nepal

Country/Region : Nepal/South Asia
Area coverage : Kathmandu valley
Sectoral Category : Transport
Type of approach : Policy/Economic Instrument
Implemented by: Clean Air Initiative (CAI- Asia)

The CAI– Asia Center supported the development of an environmentally sustainable transport strategy for the Philippines and Indonesia with ADB and the Swedish International Development Cooperation Agency (SIDA), and this experience provided a good opportunity to help prepare for the development of another strategy and action plan through the Clean Air Network Nepal, a country network of CAI–Asia.

Figure 55 PM_{10} Concentration in Kathmandu Valley, 2002–2007



μg/Nm³ = microgram per Normal cubic meter, PM_{10} = particulate matter with a diameter of 10 microns more or less.
Source: Generated with data provided by Government of Nepal, Ministry of Environment, Science and Technology.

Description
One study showed that the excess mortality due to Kathmandu's air quality situation is 900 per million people. It also estimated that a 50 µg/m3 reduction on PM10 levels would contribute to avoiding 1,600 deaths every year. Figure shows the levels of air pollution from 2002 to 2007 with high levels of PM10 during the months of December and January. This business-as-usual scenario for most transport systems is unacceptable, unviable, and unaffordable for the future of our planet.

At the Fifth Environmentally Sustainable Transport Forum (BOAS) in the year???, the Government of Nepal requested assistance from the United Nations Center for Regional Development (UNCRD), to develop a national environmentally sustainable transport strategy and action plan to guide its transport and related policies and projects.

Issues identified include:

- inappropriate taxation policies for electric vehicles and lack of awareness about their use and promotion,
- the share of renewable energy (hydropower in the case of Kathmandu) in the transport system,
- heavy dependence of transport sector on fossil fuels, absence of oil reserves, alarming increase in the number of private vehicles, congestion of road network, inadequate public transport system, weak enforcement of exiting policies,
- lack of integration of land use planning with transport planning,
- weak vehicle parking system etc.

To guide an environmentally sustainable transport strategy and action plan for Nepal and Kathmandu, a vision for environmentally sustainable transport was drafted:

www.adb.org/documents/books/km-air-quality/km-air-quality.pdf

4. GAIN- A tool to combat air pollution and climate change simultaneously

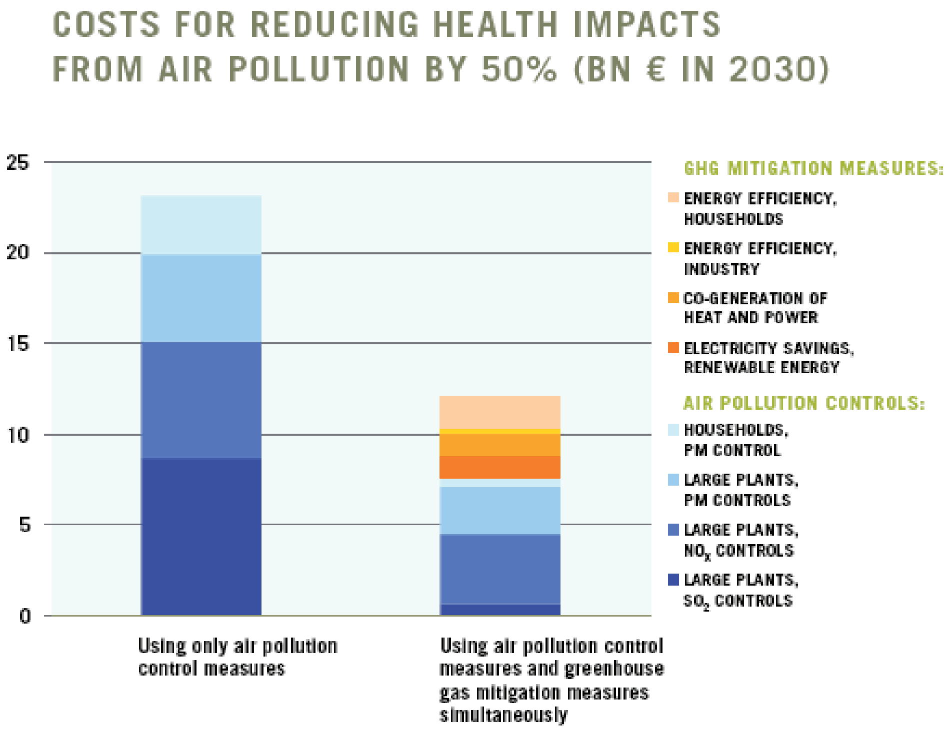
Country/Region : South Asia
Area coverage : India, China
Sectoral Category : Scientific tool
Type of approach : Policy/Economic Instrument
Implemented by :

Description
An international team of researchers have developed a scientific tool to guide policy makers through the complex process of air pollutant controls and greenhouse gas mitigation in China and India. Known as GAINS (Greenhouse Gas and Air Pollution Interactions and Synergies), this state-of-the-art interdisciplinary model builds on a scientific tool that has already helped European governments slash air pollution across the continent without compromising economic development. The GAIN works on following four strategies:

- Current economic growth will counteract ongoing efforts to improve air quality problems unless pollution control laws are significantly upgraded.
- Advanced emission control technologies are available to maintain acceptable levels of air quality despite the pressure from growing economic activities.
- A cost-effective strategy can reduce costs for air pollution control by up to 50 per cent compared to conventional approaches.
- A smart mix of measures that includes actions to reduce energy consumption can further cut air pollution control costs, and achieve lower greenhouse gas emissions.

Impact
The GAINS optimization tool allows a systematic search for those measures that ensure that total emission control costs are minimized. For Asia, an integral element of such an air pollution control strategy will be measures to eliminate indoor pollution from the combustion of solid fuels. Statistical figures from China suggest that air pollution lowers life expectancy and these health impacts could be reduced by 43% by 2030 by using available technology to improve ambient air quality.

GAINS demonstrates that the additional controls of climate-friendly measures, for e.g., energy efficiency improvements, co-generation of heat and power, fuel substitution, integrated coal gasification combined cycle (IGCC) plants, etc., are more than compensated for by savings in air pollution control equipment. GAINS also shows by selecting a smart mix of measures to simultaneously cut air pollution and greenhouse gas emissions, China can almost halve air pollution control costs as well as lower greenhouse gas emissions by 9 per cent (see figure).



http://gains.iiasa.ac.at/gains/download/gainsbrochure_web.pdf
http://gains.iiasa.ac.at/images/stories/reports/Asia/IR-GAINS-India.pdf

5 Bangkok's strategy to tackle air pollution

Country/Region	:	Thailand/ Bangkok
Area coverage	:	Bangkok
Sectoral Category	:	Transport
Type of approach	:	Policy/Economic Instrument

Description
Bangkok, the capital of Thailand, has experienced serious air pollution problems over the past several decades as a consequence of population increase, city development and a growing number of motor vehicles on its roads. Recently, in ----, the Thai government adopted measures to help the growing city manage its air quality, putting Bangkok on the path to cleaner air and better quality of life for its residents. Transport is the greatest source of air pollutants in Bangkok. Street-level concentrations of air pollutants along the city's major roads can reach hazardous levels, owing to increased numbers of high emission motor vehicles coupled with long distances traveled and extreme traffic congestion.

The number of motor vehicles registered in Bangkok soared from 600,000 in 1980 to 4,163,000 at the end of 1999 – a seven-fold increase. Between 1999 and 2007, vehicle registrations continued to rise. By the end of 2007, there were 5,614,294 vehicles choking Bangkok's inadequate street and roadway networks. Results of ambient air quality monitoring indicate that the air pollutants of concern in Bangkok are particulate matter (PM), ozone (O3), carbon monoxide (CO), sulphur dioxide (SO2), and nitrogen dioxide (NO2). The ambient air quality in the city and in general background and roadside areas is shown in Figure 1. This illustrates that PM (PM10 and total suspended particles) is the pollutant of greatest concern, and the pollution near roads is more serious than elsewhere in the city.

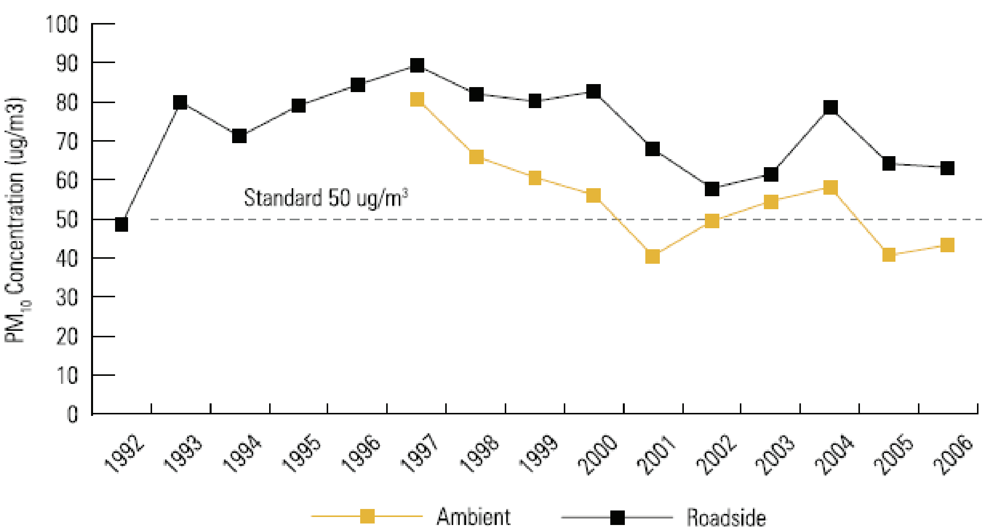
Activities

The government's ultimate goal is to bring emissions and ambient air quality in line with the National Air Quality Standards or better. Elimination of lead from gasoline was such example.

Since the 1990s, the government has facilitated ongoing collaboration among the municipality of Bangkok, various sectors impacting air pollution, and the public, resulting in the adoption of air pollution control strategies for transport-related sources, such as improving fuel quality; enforcing emission standards for new and in-use vehicles; implementing an inspection and maintenance program; reducing vehicle kilometers traveled; and performing roadside inspection, traffic management and gasoline vapor recovery.

Air pollution control strategies for stationary sources have also evolved, including requiring environmental impact assessments, enforcing emission standards and fuel oil standards, and implementing monitoring requirements.To provide transport alternatives and decrease the number of vehicles on the roads, Bangkok developed a new public transport system, featuring a subway line and an above-ground Skytrain, in 2004. The mass-rapid-transit system has helped improve air quality somewhat, but the limited area covered by the system does little to alleviate traffic and curb the city's overall pollution. Bangkok is now working to expand the distance reachable by Skytrain, which will help ensure good air quality even while the population increases. Thailand has succeeded in mitigating air pollution in Bangkok, and disseminating and sharing its experiences in air pollution control with other countries in Asia.

ANNUAL AVERAGE OF PM10 IN BANGKOK DURING 1992 - 2005



Sources: Thailand Department of Land Transport, 2008, with contributions from Pollution Control Department of Thailand and Clean Air Initiative for Asian Cities Centre.

http://www.unhabitat.org/downloads/docs/presskitsowc2008/Bankok%20strategy.pdf

6. Atmospheric Brown Clouds

Country/Region	:	Asia
Area coverage	:	Asia
Sectoral Category	:	Energy
Type of approach	:	Policy/Economic Instrument
Participants	:	countries
Implemented by:		United Nations Environment Programme (UNEP)

Description
Atmospheric brown clouds (ABCs) are regional scale plumes of air pollution that consist of tiny particles of soot, sulphates, nitrates, fly ash and many other pollutants.

As per IPCC report, ABCs are the same as the aerosols. Soot results from the incomplete combustion of fuels and consists of nano- to a few micro-metre (millionth of a metre) size particles. Black carbon and many organic acids are the main constituents of soot. The brownish colour of ABCs is due to the absorption and scattering of solar radiation by anthropogenic black carbon, fly ash, soil dust particles, and nitrogen dioxide gas. Average aerosol concentrations are in the range 100 - 300 cm-3, whereas in polluted continental regions the concentrations are in the range 1000 - 10 000 cm-3.

ABCs start as indoor and outdoor air pollution consisting of particles (referred to as primary aerosols) and pollutant gases, such as nitrogen oxides (NOx), carbon monoxide (CO), sulphur dioxide (SO2), ammonia (NH3), and hundreds of organic gases and acids. These pollutants are emitted from anthropogenic sources, such as fossil fuel combustion, biofuel cooking and biomass burning. Gases, such as NOx, CO and many volatile organic compounds (VOCs), are referred to as ozone precursors since they lead to the production of ozone which is both a pollutant and a strong greenhouse gas. Aerosols that are formed from gases through chemical changes (oxidation) in the air are referred to as secondary aerosols.

ABC-induced atmospheric solar heating and surface dimming are large over Asia in general and over India and China, in particular. Bangkok, Beijing, Cairo, Dhaka, Karachi, Kolkata, Lagos, Mumbai, New Delhi, Seoul, Shanghai, Shenzhen and Tehran are identified as ABC hotspots in Asia. The annual mean solar heating of the troposphere increased by 15 per cent or more over China and India. Heating increase in the lower atmosphere (surface to 3 km), where ABCs are located, is as much as 20 - 50 per cent (6 - 20 W m-2) over China and India.
http://www.rrcap.unep.org/abc/userfiles/file/ABC_Report_Summary_FinalJAN10.pdf

Project Atmospheric Brown Cloud (ABC): Based on the findings of the Indian Ocean Experiment (INDOEX) research on ABC, UNEP has facilitated an international scientific team to look into observation, science and impacts of ABC on regional climate, water budget, agriculture and human health. The aim of Project Atmospheric Brown Cloud (ABC) is to better understand the science and its impacts in order to provide a scientific basis for informed decision making. Establishment of monitoring stations, assessment of potential impacts of ABC on various sectors and awareness are major components of project.

Over a dozen ABC observatories have been implemented and first impact assessment report was published in 2008. Phase II of project comprising activities like long term monitoring of ABC, expansion of other regional hotspots and dissemination of findings etc. has begun.
http://www.rrcap.unep.org/abc/

7. Bus Rapid Transit Systems in Asia

Country/Region	:	India
Area coverage	:	Ahmedabad/India
Sectoral Category	:	Transport
Type of approach	:	Policy/Economic Instrument
Pollutant Type	:	NO_x, CO2, PM
Year of Introduction	:	Since 2009
Participants	:	Government organizations and urban local bodies
Implemented by:		Municipal Corporations/local bodies

Description

The deterioration in the public transport mode and limited financial sources for public transport forced policy makers to look for another option to improve public transport. This resulted in several cities experimenting with BRT systems as more economical alternative for efficient public transport, and has now evolved into a broader urban transport solution.

BRT systems are considered as a viable alternative to traditional public transport. It provides the quality of light rail systems with the flexibility of buses at a fraction of the cost. Instead of a train or metrorail, BRT systems use buses to ply a dedicated lane that runs at the centre of the road. At specific locations, passengers can embark or disembark at conveniently located stations, which often feature ticket booths, turnstiles, and automatic doors. BRT stations are designed in such a way that they can be easily accessed from surrounding areas, and if combined with pedestrian paths, cycle tracks and access to other transport modes, they provide good intermodal connectivity. Currently, there are over 80 BRT systems in development in Asia.

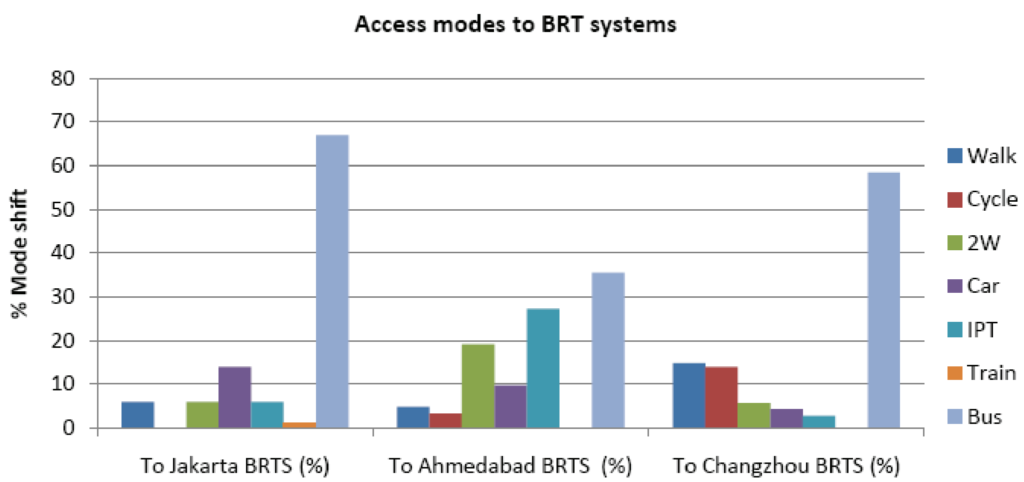
Impacts

Experience from various projects has shown that BRT systems are:

- Cheaper and faster to build (1-10 million USD/km, executed in 1-3 years)
- Profitable for bus owners
- Able to carry up to 45,000 passengers per hour per direction
- Inexpensive for commuters compared to other motorized transport modes
- Able to provide mobility at 20-35 km/hr
- Easily integrated into existing land use, and can help transform existing land use to provide co-benefits
- Provide environmental benefits – for example literature shows that the reduction in CO2 /km for a two lane BRT system can vary from 900 tons to 5000 tons/year

Literature review suggests co-benefits (CO2 reductions, PM-NOx reductions, accident savings, fuel savings etc.) from BRT systems result primarily from:

- Improved public transport vehicles
- Modal shift from private automobiles
- Compact development
- Operational efficiency improvement



Several cities in India have adopted the Bus Rapid Transit System to tackle problems of increasing mobility and higher density in traffic. It is part of the initiatives undertaken under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM), to encourage reforms and fast track planned development in 63 cities. The central improvements on constructing a BRTS are to existing infrastructure, vehicles and scheduling. Infrastructural changes are minimal, since buses travel on roads. Vehicles used in BRTS are larger and have a greater capacity of passengers. BRTS are thus also known as the High Capacity Bus System (HCBS). Besides being safe, flexible and economical, BRTSs contribute to increased use of public transportation and saving of greenhouse gas emissions.

Example Ahmedabad: The BRTS was developed by the Gujarat Infrastructure Development Board (GIDB), who entrusted the system design task to CEPT University, Ahmedabad. A part of the first corridor connecting was opened to public on October 14, 2009. The system has a length of 155 km with 55 bus stations. The city of Ahmedabad was announced as a winner of the 2010 Sustainable Transport Award for the successful implementation of India's first full Bus Rapid Transit (BRT) System. It carries about 90,000 passengers daily with deployment of 45 diesel buses (30 AC buses out of 45, 12 meter long, 900mm floor height), with commercial speeds greater than 24 Kms per hour. A review of the two months progress of the Ahmedabad BRTS project, in terms of various parameters, indicates that the system is running successfully.

Average passengers per day, average collection per day, average passenger per bus per day, average collection per bus per day have increased considerably during two months period. During the period, average rating giving to BRTS by users is 8.61 out of 10.

The project was awarded by the Ministy of Urban Development as the Best Mass Transit Project under JNNURM in the year 2008-2009. other awards………

http://www.niua.org/projects/tpt/AHMEDABAD%20BRTS.pdf
http://www.ahmedabadbrts.com/images/09.Environmental%20Impact%20Assessment.pdf

8. National Environmentally Sustainable Transport Ttrategy- Philippines

Country/Region : Asia
Area coverage : Philipines
Sectoral Category : Transport
Type of approach : Policy
Year of Introduction : 2011
Implemented by:

Description and activities

The National Environmentally Sustainable Transport (EST) Strategy for the Philippines was formally launched last 20 May 2011. It includes specific targets, multi-sector commitments and recommends measures for the promotion of EST in Philippines.

The overall goal of the EST strategy is reduction of the annual growth rate of energy consumption and associated greenhouse gas and air pollutant emissions from the urban transport sector and sustainable urban mobility enhancement. Activities highlighted in EST are related to public health, road-side air quality monitoring and assessment, traffic noise management, vehicle emission control, cleaner fuels, public transport planning, road safety maintenance, land use planning social equity and gender perspectives etc.

The national EST strategy is consistent with the Bangkok Declaration 2020 that sets sustainable transport goals for Asian countries from 2011 – 2020 and complements the twelve thematic areas identified by the Aichi Statement of 2005 which establishes the forum for promoting EST in Asia.
http://www.uncrd.or.jp/env/est/docs/110520_est_philippines_highlights.pdf

9. SUM NET India

Country/Region	:	India
Area coverage	:	India
Sectoral Category	:	Transport
Type of approach	:	Policy
Year of Introduction	:	2009
Participants	:	NGOs, Individuals
Implemented by:		

The Sustainable Urban Mobility Network India seeks to promote the sustainable transportation agenda at the national, state and city levels, and highlight gaps in policies and implementation; it consists of civil society organizations in the transportation sector as well as allied road user groups and others affected by unsustainable transportation models.

SUM Net India seeks to
1. Promote non-motorized transportation and public transport
2. Promote participation of user groups especially from the urban poor and providers of para-transit services, and citizens in general and democratic governance in the creation and management of transportation infrastructure
3. Facilitate discussions and sharing of experiences / reflections related to the principles of sustainable urban mobility, so as to advance the general thinking about it

Principles:
- Make cities walkable for everyone
- Promote cycle networks
- Promote public transport
- Support intermediate public transport including cycle rickshaws
- Create transportation systems around the needs of various road user groups, especially recognizing the link of transportation systems and informal sector livelihoods
- Encourage rethinking and debate on expensive systems such as Metro Rail and mono rail and to explore cheaper more environmentally efficient and locally relevant options.
- Discourage private vehicles using traffic demand management measures, including through parking policies and congestion charging
- Create democratically accountable transport management systems
- Promote thinking and debate on the idea of ‘car-free’ cities

Activities:
An initial and ongoing activity is the preparation of a directory of organizations engaging in urban transportation issues, with a view to share strategies of work and to promote mutual support
http://www.sumnet.in/en/

4.2 NOx charges as feebate in Sweden

Country/Region	:	Sweden/Europe
Area coverage	:	Sweden
Sectoral Category	:	Energy
Type of approach	:	Policy/Economic Instrument
Pollutant Type	:	NO_x
Year of Introduction	:	Since 1990
Participants	:	Electricity generating utilities
Implemented by	:	Swedish Environmental Protection Agency (SEPA)

Description
In 1990, the Swedish parliament endorsed NOx emission charge applicable to large combustion plants. It was implemented since 1992. The NOx charge is a feebate economic instrument that applies to every real emission of NOx from these plants based on measurements. However, the charge is redistributed among the plants in the proportion of energy production by these plants. So, the NOx charge is not taken as tax (IISD, 1994). In this system, a plant that produces more energy per unit of emission benefits more. The Swedish NOx charge is an example of how an economic instrument can be used to reduce pollution without distorting an industry's competitiveness while meeting the objective of reducing the emission at the least cost.

The charge is SEK 40 (US $4.80 at the August 1993 exchange rate) per kilogram of NOx emitted, and the revenue from the charges paid by liable operations is redistributed among the plants in proportion to their energy production. While the tax is collected on the basis of emissions, it is rebated (redistributed) to the firms (i.e., liable operations) in the same proportion as their energy production. This means that the total tax thus collected is divided by total energy production and redistributed in proportion to their energy production. So, the redistribution of tax collected among the participants based on their rate of energy production implies that the plants that produce more energy with less emission will benefit more from this system.

Since 1992, large combustion plants are subject to the charge scheme. 'Large' plants are defined as the installations having a capacity of 10 MW or more and an annual energy production exceeding 50 GWh. In 1996 and 1997, the coverage was expanded to include all installations producing more than 25 GWh of useful energy per year. In 2001, around 400 units were covered by the charge (Roseveare, 2001). It was administered by the Swedish Environmental Protection Agency (SEPA). The administration cost of the system (not more than 0.5% of the revenue generated from the tax) was deducted from the pay-out (IISD, 1994).

Smaller combustion plants are not liable because of the higher relative cost of continuously measuring the emissions (IISD, 1994). Most of the liable combustion plants are involved in energy production, that is, plants producing heat and power. Besides, industrial firms like the pulp and paper-, chemical- and metal industries that have combustion plants for energy production and waste incineration plants producing energy are similarly liable to the charge.

The unique feature of the system is the refund system, which was necessary in order to achieve a fair system. The competition between small (non-liable) and large (liable) combustion plants would have been distorted if the charge was not refunded to the liable plants (IISD, 1994). The fact that the charge is refunded and thereby only has an environmental purpose has facilitated its acceptance. A positive side effect is that the less polluting plants are favored economically and thus given a competitive advantage. The refund system has contributed to a considerable success of the charge scheme. Though the combustion plants are given an economic incentive to reduce their emissions, they are not forced to do so by regulation. It is up to the individual plants to decide ways to reduce the NOx emission. Companies can choose whether to reduce their NOx emissions or pay the charge. With the flexibility on choosing the technology type, the number of NOx emission reduction technologies after implementation of such system is observed to have significantly increased.

Major Activities
The utilities (or liable operations) are not forced to adopt any specific technology for NOx reduction. They are left on their own to choose the most cost effective NOx reduction technology.

Impact on Air Pollution
Significant improvement in the reduction of NOx emission was noted after the implementation of the NOx charge scheme (IISD, 1994):

- Total NOx emission in 1992 was 35% lower than that in 1990. By 1993, NOx emission was 44% below the 1990 level.

- The number of combustion plants with NOx-reduction technologies increased by a factor of about 16 between 1982 and 1994. A sharp increase is noted after the introduction of the charge scheme, and further installations are planned (IISD, 1994).
- SEPA has noted that NOx emissions decreased much more rapidly than expected. The target for 1995 of a 35% reduction from 1990 levels was already achieved in 1993.
- The average cost to reduce NOx is SEK 10/kg ($1.2/kg). The charge of 40 SEK/kg-NOx has provided a substantial economic inducement to reduce emissions.

4.3 Two Control Zone (TCZ) Plan and Program to control Sulphur pollution

Country/Region	:	China/South East Asia
Area coverage	:	64 major cities and 12 provinces
Sectoral Category	:	Energy
Type of approach	:	Policy/Planning/Technology/Fuel Substitution
Pollutant Type	:	SO_X and $PM_{2.5}$ (Sulfate) (Acid rain)
Year of Introduction	:	2000-2005
Participants	:	SEPA-China, CRAES, EPB (Hebei and Hunan Province and Shijiazhuang and Greater Changsa region), CGRER, University of Iowa, boiler manufacturing industries.
Implemented by	:	State Environmental Protection Agency - China

Description

In 1998 China adopted a national legislation "Tenth Five-Year Plan for Prevention and Control of Acid Rain and Sulphur Dioxide Pollution in the Two Control Zones" to limit ambient Sulphur Dioxide (SO_2) concentration and to curtail the increasing occurrences of acid rain in the country. The major backbone of this policy and plan was to reduce the sulphur concentration in the country by understanding its local as well as transboundary effect (World Bank, 2003).

China is the world's the largest coal producer (43 per cent) and nearly half (45 per cent) of China's coal in 2004 was used in the industrial sector (EIA, 2007b). The use of coal has been the major source of air pollution in the country and is the major cause of acidic precipitation as well as Particulate Matters (PM) related pollution (World Bank, 2003). The combustion sources include small domestic stoves as well as large industrial plants and power plants. The major sources of SO_2 emissions are facilities burning fossil fuels, including coal- fired power plants and boilers, ore smelters, and oil refineries. Smaller stationary combustion sources, such as space heating, also contribute to the problem, especially in urban areas during the winter. Most of the major cities in China are heavily polluted by SO_2 and PM emissions (Yi et al., 2007). In 2006, acid rain affected about 32.6 per cent (occurrence[24] of acid rain over 5 per cent) and 15.4 per cent (occurrence of acid rain over 25 per cent) of the total land in China (SEPA, 2006).

The "Two Control Zone (TCZ)" Plan, as the name suggests, classified two control zones, of which the Sulphur Pollution Control Zone (SPCZ) covered 64 major cities, where the ambient sulphur concentration was high and the other was Acid Rain Control Zone (ARCZ), which encompassed 12 provinces of southern and eastern China, which were affected by acid rain. These two zones covered 1.09 million km^2 of area and were responsible for two-third of sulphur emission of the country (World Bank, 2003). Closing of mines producing high-sulphur coal, limiting the sulphur content of coal in use and emission control in power plants and large industries were the measures taken to control the sulphur pollution. Most major cities in China were required to comply with the SO_2 pollution requirement and SO_2 emission charges were applied. Sulphur emissions and acid rain reduction plans

[24] Frequency of incidence of acid rain.

for large areas of the south and the east area of the country were the major thrust areas of the TCZ plan. The legislation covers wide-ranging sulphur control measures usually observed in Europe and North America. Probably, such a policy has been put into practice for the first time in developing countries (World Bank, 2003).

Major Activities

- Gradual phasing out of mining of coal containing 3 per cent or more sulphur
- Prohibition of construction of coal fired power stations (except coal fired co-generation plants with primary purpose of supplying heat for household use) inside large and medium-sized cities and surrounding suburbs.
- Mandatory use of coal with sulphur content not exceeding 1 per cent in new and renovated old coal fired power stations
- Requirement to adapt SO_2 reduction measures including installation of flue gas desulphurization by the existing coal fired power plants using coal more than 1 per cent sulphur content.
- Implementation of suphur emission charges by major sulphur emitters.

Impact on Air Pollution

SEPA (2002, 2004 and 2005) have reported significant reduction in SO_2 emission during 1998-2005.

In the Sulphur Dioxide Pollution Control Zone, the major achievement was 12.3 per cent point increase in cities meeting Grade II[25] and 16.5 per cent point decrease in the cities not meeting Grade III standard in terms of SO_2 annual average concentration. The cities meeting Grade III increased by 4.2 per cent point (Table 4.1).

In the Acid Rain Control Zone, the major achievement was the 11.2 per cent point decrease in the cities not meeting Grade III in terms of SO_2 annual average concentration and 3.3 per cent point increase in the cities witnessing annual SO_2 average concentration meeting Grade II quality standard. The cities reaching Grade III was increased by 7.9 per cent point.

Table 4.1: Percentage of cities in Two Control Zones meeting SO_2 Grades

SO_2 Grading	SO_2 Control Zones (64 major cities)					Acid Rain Control Zones (12 provinces)				
	1998	2000	2002	2004	2005	1998	2000	2002	2004	2005
Cities reaching Grade II, %($SO_2 \leq 0.06$ mg/m^3)	32.8	47.7	40.6	40.6	45.1	70.6	81.2	79.5	73	73.9
Cities reaching Grade III, %(0.06 mg/m$^3 \leq SO_2 < 0.1$ mg/m^3)	29.7	24.6	31.3	29.7	33.9	13.7	6.3	13.7	20	21.6
Cities worse than Grade III, %($SO_2 > 0.1$ mg/m^3)	37.5	27.7	28.1	29.7	21	15.7	12.5	6.8	7	4.5

Source: SEPA (2002, 2004 and 2005)

4.4 The Acid Rain Program in US

Country/Region	:	United States of America/North America
Area of coverage	:	United States of America
Sectoral Category	:	Energy
Type of Approach	:	Policy
Pollutant Type	:	SO_x and NO_x

[25] The grades are defined as follows. Grade I: This grade is set as the standard in natural conservation, resort, or tourist areas, and in those with historic monuments (SO2 <0.02mg/m^3); Grade II: This grade is set as the standard in areas that are urban residential, commercial/residential, cultural, or rural (0.02 mg/m^3 < SO_2 < .06 mg/m^3); and Grade III. This grade is set as a standard in interim administrative measure for environmental management in industrial districts and traffic centers (0.06 mg/m^3 < SO_2 < 0.1 mg/m^3) (SEPA, 2004 and 2005).

Year of Introduction	:	Since 1990
Participants	:	Utilities, coal and gas companies, emissions control equipment vendors, labor, academia, public utility commissions, state pollution control agencies, and environmental groups.
Implemented by	:	United States Environmental Protection Agency (USEPA)

Description

The main purpose of Acid Rain Program in the US was to reduce the adverse effects of acid deposition by reducing its key precursor pollutants SO_2 and NO_x. The programme is a market based approach to control the SO_2 and NO_x emissions and was created by the US Government in 1990 through the Title IV of Clean Air Act Amendment 1990. However, controlling SO_2 emissions through the Clean Air Act Amendments (CAAA) could be traced back in 1970s; for the first time, the CAAA in 1970 had established national maximum standards for ambient concentrations of SO_2, CO, NO_2, particulates, ozone and lead. While the CCAA of 1970 are largely based on the command and control approach, CAAA in 1990 has introduced market based, cap and trade approach and has also targeted NOx reduction.

SO_2 Reduction

Title IV of the Clean Air Act has set a goal of reducing annual SO_2 emissions by 10 million tonnes below 1980 levels by 2010. To achieve these reductions, the law required a two-phase tightening of the restrictions placed on fossil fuel-fired power plants.

Phase I began in 1995 and affected 263 units at 110 mostly coal-burning electric utility plants. Additional 182 units joined Phase I of the programme as substitution or compensating units[26] in 1997, bringing the total of Phase I affected units to 445. Phase II, which began in the year 2000, tightened the annual emissions limits imposed on these large, high emitting plants and also set restrictions on smaller, cleaner coal, oil, and gas fired plants fired by, encompassing over 2,000 units in all. The programme affects existing utility units with an output capacity of greater than 25 megawatts and all new utility units.

The programme is an innovative cap and trade approach, in which a permanent cap is allocated on the total amount of SO_2 emission that may be generated by a utility, based on its historic fuel consumption and its specific emission rates, prior to the start of the program (USEPA, 2007a). Currently, one allowance provides a regulated unit a limited authorization to emit one ton of SO_2. The total allowances allocated for each year equal the SO_2 emission cap.

SO_2 Allowance Trading Mechanism

Reductions in SO_2 emissions are facilitated through a market-based system for capping and trading—the centrepiece of US EPA's Acid Rain Program (USEPA, 2007a). Through the market-based allowance trading system, utilities regulated under the Acid Rain Program decide the most cost-effective way to use available resources to comply with the requirements of the Clean Air Act. Utilities can reduce emissions by employing energy conservation measures, increasing reliance on renewable energy, reducing usage, employing pollution control technologies, switching to lower sulfur fuel, or developing other alternate strategies.

[26] During Phase I of the of the Acid Rain Program, a unit not originally affected until Phase II may elect to enter the program early as a substitution unit or a compensating unit to help fulfill the compliance obligations for one of the 263 units initially targeted by Phase I. A unit brought into Phase I as a substitution unit can assist one of these 263 units in meeting its emissions reductions obligations. Utilities may make cost-effective emissions reductions at the substitution unit instead of at the initially targeted unit, achieving the same overall emissions reductions that would have occurred without the participation of the substitution unit (USEPA, 1998).

Units that reduce their emissions below the amount allowed (according to the allowances they hold) may trade the surplus allowances with other units in their system, sell them to other utilities in the open market or through EPA auctions, or bank them to cover emissions in future years (USEPA, 2007a).

The USEPA holds an annual auction of SO_2 allowances (Chicago Board of Trade used to administer it till 2005) in which anyone including the utilities can participate. The USEPA set aside 2.8% of annual sulfur emission from each utility for Auction Allowance Reserve (USEPA, 2007b). The allowances are awarded to the highest bidder. Typically environmental groups[27] bids acquire the allowances for different purpose including 'retiring' them so that they cannot be used to legitimize emissions, thus lowering the emission limit permanently (Tietenberg, 2003).

Conservation and Renewable Energy Incentives

The Acid Rain Program has a provision to promote renewable energy and energy conservation initiatives. A reserve of 300,000 SO_2 allowances is provided as the Conservation and Renewable Energy Reserve (CRER). Utilities could apply for these allowances if they have employed efficiency or renewable energy measures to produce early emission reductions before their generating became subject to the Acid Rain Program (USEPA, 2007a).

NOx Reduction

The Clean Air Act Amendment 1990 had also set a target to reduce 2 million tons of NOx emission below the 1980 level by year 2000. The program focuses on one set of sources that emit NOx --coal-fired electric utility boilers. As with the SO_2 emission reduction requirements, the NOx program was implemented in two phases, beginning in 1996 and 2000. The NOx program is similar in principle to SO_2 emission reduction program, but it does not "cap" NOx emissions as the SO_2 program does, nor does it utilize an allowance trading system.

Emission limitations for the NOx boilers provide flexibility to for the electric utilities by focusing on the emission rate to be achieved (expressed in pounds of NOx per million Btu of heat input, See Table 3.5). In general, two options for compliance of the emission limitations are provided:

- Compliance with an individual emission rate for a boiler.
- Averaging of emission rates over two or more units to meet an overall emission rate limitation.

If a utility properly installs and maintains the appropriate control equipment designed to meet the emission limitation established in the regulations, but is still unable to meet the limitation, the NOx program allows the utility to apply for an alternative emission limitation (AEL) that corresponds to the level that the utility demonstrates is achievable.

Phase I of the NOx program began on January 1, 1996 and was applied to two types of boilers (which were already targeted for Phase I SO_2 reductions): a) dry-bottom wall-fired boilers and b) tangentially fired boilers (Table 4.2). Dry-bottom wall-fired boilers had to meet a limitation of 0.50 pounds of NOx per million Btu averaged over the year, and tangentially fired boilers had to achieve a limitation of 0.45 pounds of NOx per million Btu, again, averaged over the year. Approximately, 170 boilers needed to comply with these NOx performance standards during Phase I.

Phase II of the NOx program began in 2000. It

- set lower emission limits for Group 1 boilers first subject to an acid rain emissions limitation in Phase II, and

[27] In a bid in 2007, Washington College Student Environmental Alliance bid 1 allowance at $1,120, AEM 250 Cornell University bid 1 allowance at $490, and similarly Clean Air Conservancy Charitable Trust bid 3 allowances for $1,800. (http://www.epa.gov/airmarkets/trading/2007/07summary.html downloaded on 5 July 2007)

- established initial NOx emission limitations for Group 2 boilers, which include boilers applying cell-burner technology, cyclone boilers, wet bottom boilers, and other types of coal-fired boilers (Table 4.2).

Table 4.2: NOx Emission Limit by Boiler Type

Coal-Fired Boiler Type	Title IV Standard Emission Limits (lb/mmBtu)	Number of Units
Phase I Group 1 Tangentially Fired	0.45	132
Phase I Group 1 Dry Bottom, Wall-fired	0.50	113
Phase II Group 1 Tangentially Fired	0.40	301
Phase II Group 1 Dry Bottom, Wall-fired	0.46	295
Cell Burners	0.68	37
Cyclones >155 MW	0.86	54
Wet Bottom >65 MW	0.84	24
Vertically Fired	0.80	26
Total	**n/a**	**982**

Source: USEPA (2007a), USEPA (2005) and USEPA (2004)

The Acid Rain Program is flexible in allowing a utility to select its own methods of emission control for SO_2 and NO_x emission reduction compliance. The program encourages early reductions of the emissions so that the utilities can bank unused allowances in one year and can carry them forward to the next year. These allowances are transferable among the affected utilities such that utilities can trade the surplus allowances to other utilities. This is a *Win Win* situation as it not only reduces the cost to utilities but also reduces the cost of reducing pollution to the society (Tietenberg, 2003).

Special features of this program are:

a) It has a fixed upper limit on total annual sulfur emissions from the utilities;
b) It allows anyone to lower the limit by acquiring the allowances; and
c) It facilitates real time emission monitoring and real time online allowance trading mechanism.
d) It has a mechanism of penalty for non-compliance and it is adjusted with inflation rate.

The program has an online real time emission monitoring mechanism, in which each utility must continuously measure and record its emissions of SO_2, NO_x, and CO_2, as well as volumetric flow and opacity. A continuous emission monitoring (CEM) system is used for this purpose (USEPA, 2007c). This has been taken as an important feedback to boost the confidence among the stakeholders by the realization of emission reductions in real time.

The program has a real time online allowances trading mechanism, which facilitates utilities to trade the sulfur allowances in real time so that the utilities' sulfur emissions do not exceed their allowances at the end of the year and the allowance transfer can be recorded to meet the compliance.

The program has set a penalty of $2,000/ton sulfur in 1990, which is adjusted annually as per the inflation rate. The 2005 penalty level was set at $3,042 per excess ton of SO_2.

Major Activities
With the implementation of the Acid Rain Program, utilities have adapted one or more options that include blending low-sulfur coal, installing SO_2 and NO_x controls such as scrubbers and low-NOx burners, or purchasing allowances from the market or using banked allowances in order to meet the emission reduction requirements. Furthermore, there was also an increased use of efficient advanced combined cycle generation units using natural gas as the fuel source.

Impact on Air Pollution Scene
The program had made the following achievements by the end of Year 2005 (USEPA, 2007a):

SO_2 emission was reduced by more than 5.5 million tons from the 1990 level and by more than 7 million tons from the 1980 level; these figures were about 35% and 41% of the total power sector emissions in 1990 and 1980 respectively (USEPA, 2005).

Similarly, the program was able to reduce NO_x emissions by 3 million tons from the 1990 level. The NOx emissions in 2005 were less than half the level anticipated in the absence of the Acid Rain program (USEPA, 2005).

The program led to the initiation of the following other emission reduction policy programs in 2005:

- Clean Air Interstate Rule (CAIR) to address transport of fine particles and ozone in eastern United States,
- the Clean Air Visibility Rule (CAVR) to improve visibility in national parks and wilderness areas, and
- the Clean Air Mercury Rule (CAMR) to reduce mercury emission from power plants.

4.5 Urban Transportation Planning and Travel Demand Management in Singapore

Country/Region	:	Singapore/South East Asia
Area of coverage	:	Singapore City
Sectoral category	:	Energy/Transportation
Type of approach	:	Policy
Pollutant Type	:	SO_x, NO_x and particulate matter
Year of introduction	:	Since 1960s
Participants	:	Government agencies, vehicle operators and public
Implemented by	:	Government of Singapore, Land Transport Authority

Description
A major source of air pollution in most of the countries is the vehicular emissions. As such, reduction of vehicular emission has been a major issue. Exhaust emissions from vehicles are controlled in many countries utilizing technological options. However, the control of air pollution using the traditional command and control policies that curtail travel demand has been a difficult task, though it has been tried in several countries (Dhakal, 2003). The transport policies of Singapore provide good examples of the government authority being able to limit the air pollution by limiting private vehicle growth with a series of demand management measures (Chin, 1996), while sustaining rapid economic growth for over four decades (Willoughby, 2001). Though the initial purpose of the transport demand management measures was the reduction of the growing traffic congestion thereby reducing the travel time and not reduction of environmental pollution but the secondary effect of the policies has been higher vehicular average speed, controlled private vehicular ownership, promotion of public passenger vehicles resulting ultimately in reduced fuel consumption and lower vehicular emissions. For example, the 24-hr average air quality of Singapore is found to be within the acceptable limit of the USEPA Annual Mean Ambient Air Quality Standard for the pollutants SO_2, NO_x, Carbon Monoxide, Ozone and PM_{10} measured (National Environmental Agency, 2007).

Since its independence in 1967, the approaches taken by Singapore for transportation management were a mix of command-and-control policies initially and market-based-instruments later on. The policies were effective in managing the traffic congestion and also the related environmental problems. A series of the policies was introduced in order to curb the travel demand in the past. Also there were quick enforcements of the revised policies after sensing the undesired impact of policy, which has resulted better later. It is argued that the policy was largely focused on limiting the vehicle ownership rather than maximum utilization of the transport infrastructure and pointed out the disadvantage of the policy instrument as it could lead to under-utilization of the road infrastructure because of the high tax rate (Willoughby, 2001). However, in 1998 and in subsequent years, the reform of the tax structure along with introduction of more flexible schemes (like off peak car scheme, park and ride schemes, increasing the number of bidding process to twice a month and short duration of bidding process) marked the shift in policy from that targeted to limiting the vehicle ownership limiting to the one focused on higher usage of road infrastructure.

Major Activities

The evolution of road transport management policy instruments and activities implemented in Singapore since its independence are listed chronologically as follows:

1967 : Singapore city separated from Malaysia and became independent city-state

1968 : Ministry of Communications established; Imposed 30% import duty on Cars

1970 : Bus service reform begins with an effort to consolidate ten small bus companies into three bus companies to serve different geographical sectors.

1972 : Import duty and Additional Registration Fees (ARF) was increased

1973 : The 3 bus services were merged to Singapore bus service (SBS)

1974 : Bus lanes were introduced (left-most lanes on major roads were designated for exclusive use by buses during peak hours); ARF was raised to 55%;

1975 : Area Licensing Scheme (ALS) initiated in peak hours during week days only; Manual implementation of ALS was conducted,
ARF raised to 100% of the cost of vehicle, Preferential ARF (called as PARF) was started

1975 : ARF raised to 125%; Park and Ride Scheme was introduced

1977 : Double Decker buses were operated

1980 : ARF raised to 150%

1983 : Another bus service operator (now SMRT) came into operation

1987 : MRT was started; Public Transport Council was setup as regulatory body for bus route, tariff approvals and other bus services.

1989 : ALS extended to other areas; Transit Link Setup integrating, all bus and train services forming single comprehensive road network

1990 : Implementation of Vehicle Quota System;
Compulsion to have Certificate of Entitlements (COEs) to run vehicles on the road;
Closed bidding for limited Certificate of Entitlements (COEs) which was valid for 10 years
Weekend Car Scheme (WEC) was introduced
Single card system implemented for public transport network

1992 : COEs was made valid for 5 years instead of 10 years in the past
Graduated PARF was introduced ranging from 80% to 130% of Open Market Value of vehicles (OMV)

1994 : ALS was implemented for whole day and also for part day
Off peak Car scheme was introduced and replaced WEC Scheme
Vehicle Parking Certificate (VPC) Scheme for heavy vehicles was implemented

1995 : Institutional Reformation with the merger of 4 utilities to a single utility named as Land Transport Authority (LTA)

Road Pricing System (RPS) on expressway
Euro I emission standard was applied to vehicles
1996 : LTA brought White Paper with the purpose to build World Class Transport System
1998 : Electronic road pricing (ERP) was started;
Vehicle tax structure reformed
Complete phase out of leaded petrol
1999 : ERP was extended to highways
Sulfur content of diesel was reduced to 0.05% by weight
2000 : Classic Car Scheme was introduced
Chassis Dynamometer Smoke Test (CDST) was enforced for defaulters
2001 : Euro II – Emission Standard applied, all vehicles was equipped with catalytic converters
Green Vehicle Rebate Scheme was introduced; Low emission vehicles: CNG, Electric and Hybrid Vehicles were given rebate on registration fees and special tax incentives
2002 : Open Bidding System fully replaced the Closed Bidding System of the Certificate of Entitlement (COE).
2004 : Two tier ARFs (110% for new vehicles and 130% for old vehicles)
2005 Sulfur content of diesel was reduced to 0.005%
2006 : Euro IV – Emission Standard was applied to diesel vehicles

Major policies for road transport management implemented in Singapore are:
a) Additional registration fee (ARF)
b) Area license scheme (ALS)
c) Vehicle quota scheme (VQS)
d) Electronic road pricing (ERP)
e) Flexible schemes (Off-Peak Car Scheme)

a) Additional registration fee (ARF)
ARF is a tax on new vehicle registrations charged in addition to the registration fees. This was originally introduced by the colonial government in the late 1950s as a revenue-raising measure. In 1975, its value was increased to 100% of the Open Market Value of a vehicle (OMV). With the fear that higher ARF might discourage the renewal of the existing vehicles, a preferential additional registration fee (PARF) was introduced as an alternative, to counter the effect. It offered reduced rates when an old vehicle of the same size-class was taken off the road at the same time as the new vehicle was acquired. In 1990 the standard ARF rate reached up to 175% of OMV (Koh, 2003). ARF/PARF proceeds were the largest single source of government revenue from the road transport sector in the 1980s. In addition to the registration fee of S$ 140, two tier system ARF is in place (LTA, 2007a):

a) Vehicles registered before 2004 March has 130% of OMV
b) Vehicles registered after 2004 March has 110% of OMV

The PARF has the following structure (LTA, 2007a):

Table 4.3: Preferential Additional Registration Fee (PARF) Structure

Age of Vehicle at De-registration	**Graduated PARF Rebate (For cars registered with COEs[28] obtained before May 2002 tender exercise)**	**PARF Rebate (For cars registered with COE obtained from May 2002 tender exercise and onwards)**
Not exceeding 5 years	130% of OMV	75% of ARF paid
Above 5 years but not exceeding 6 years	120% of OMV	70% of ARF paid
Above 6 years but not exceeding 7 years	110% of OMV	65% of ARF paid
Above 7 years but not exceeding 8 years	100% of OMV	60% of ARF paid
Above 8 years but not exceeding 9 years	90% of OMV	55% of ARF paid
Above 9 years but not exceeding 10 years	80% of OMV	50% of ARF paid

Source: LTA, 2007a

b) Area license scheme (ALS)

It is a license required for a vehicle to enter a designated area. ALS was introduced for the first time in 1975. It involves a road tax charged to users on pay-as-you-use principle and required a license for each vehicle to enter certain restricted zones (RZ) of the city during peak hours in the morning (7:30 AM – 9:30 AM). The license was mandatory to be displayed and an observer was stationed in the entry posts (22 entry posts) to observe the license and record the vehicle number of the defaulters. As a result of the combined effect of ALS and simultaneous sharp increases in downtown parking charge (which was approximately double the cost of commuting to work by car (Willoughby, 2001)), the car traffic volume in the peak morning hours fell beyond expectation, while the traffic volume was found to have increased during the period before and after the restricted hours. In 1989, the requirement for area licenses was extended to vehicles entering the RZ during afternoon peak hours. The exemptions for car pools[29] and goods vehicles[30] were also eliminated. In 1994, ALS was extended to vehicles entering the RZ any time from 7.30 am to 7.00 pm on all week-days. Later in 1998, to overcome the difficulty in observing and recognizing the different types of license issued according to vehicle type, and in order to make the system efficient, the system was replaced by electronic road pricing (ERP).

c) Vehicle quota scheme (VQS)

Under the vehicle quota scheme, all prospective purchasers of new vehicles are required to own a Certificate of Entitlement (COE) to operate the vehicles on road. The VQS was implemented in 1 May 1990. The COEs are issued by the government equivalent to the vehicle quota issued quarterly. The COE was valid for 10 years and one needs to buy the COE in closed bidding in an auction conducted quarterly initially (twice a month in later years). All COEs are offered at the lowest offered price subject to it would exhaust the total available quota of COEs when arranged from highest to lowest priced bidders (LTA, 2007a). This lowest price offered is called the Quota Premium (QP) (Table 4.4). In the initial auctions, the Quota Premium was modest but later in 1994 it increased steadily and reached above S$ 27,000 for medium sized cars and above US$ 45,000 for larger cars

[28] Certificate of Entitlements
[29] Car pooling is the shared use of a car by the driver and one or more passengers.
[30] Vehicles that carry goods.

(Willoughby, 2001). Prevailing quota premium (PQP)[31] was also introduced so that vehicle owners could renew the COE for the next period. The PQP was based on the monthly average of the QP for 3-months. In 2002, open bidding process replaced with the closed bidding process. In 2007, the bidding process was conducted twice a month (LTA, 2007b).

Table 4.4: Result of 2nd Bidding Process conducted on 18 July 2007

Category		Quota Issued	Quota Premium (S$)	Prevailing Quota Premium (S$)
A	Car (1600cc & below) &Taxi	2,208	16,000	15,957
B	Car (Above 1600 cc)	1,133	17,602	18,413
C	Goods Vehicle & Bus	492	3,889	6,582
D	Motorcycle	480	1,052	1,190
E	Open	1,105	17,410	

Source: LTA, 2007b

d) Electronic road pricing (ERP)

ERP is an electronic tax system, which replaced ALS in 1998. The ERP was in effect during 7.30 a.m. to 7.00 p.m. in all areas, which had been covered by ALS; it was also extended to few other expressways. The ERP scheme is similar to ALS but its enforcement is automatic and electronic equipments like sensors, cameras with short-range radio communication system are utilized to sense vehicle entries. Vehicles are equipped with an electronic In-vehicle Unit (IU), in which a general-purpose smart card (cash card) with positive cash balance is inserted. The toll applicable at the time when the vehicle passes under a gantry is automatically deducted without the driver having to slow down. Also the system is well setup to recognize a vehicle category. Charges are different for motorcycles, cars, good vehicles, taxies and buses. Half of the approximately US$125 million total cost of the ERP scheme was incurred in the fitting of IUs, provided free to the vehicles on first come first serve basis during the initial period of its implementation. Total cost per vehicle for the scheme was less than US$190 in the then existing fleet (Willoughby, 2001). Since February 2003, graduated ERP was implemented in order to avoid vehicles speeding up or slowing down to avoid paying higher ERP charges during few minutes before and after the restricted hours. The ERP varies every half-hour of a day and varies by type of vehicle and by time of day (e.g. peak and off-peak) (LTA, 2007b).

e) Flexible Schemes (Off-Peak Car Scheme)

The Off-Peak Car (OPC) Scheme was introduced on 1 October 1994 and replaced the Weekend Car Scheme. Under the Weekend Car Scheme, special permits were issued to cars allowing them to run during weekends only. Under OPC, permits are issued to cars allowing them to run during off peak hours only. The scheme is intended to increase off-peak car usage. OPC offers the new and existing car owners an option to save on car registration and road taxes so that car usage can be reduced. In 2007, an upfront rebate of S$17,000 was provided to be offset against COE Quota Premium and Additional Registration Fee (ARF) (LTA, 2007c). The rebate was used to offset against the COE premium payable first. If there was any surplus (unused) rebate after that, it was used to offset against the ARF payable. Also a flat discount of S$ 800 on annual road tax was provided, subject to a minimum road tax payment of $50 per year. Normal car was also allowed to be converted to Off-Peak Car after paying an additional fee of S$ 100 (LTA, 2007c).

[31] PQP is the amount required to extend or renew the COE for a vehicle already in use. Unlike buying a new vehicle, one does not need to bid for COE when buying a used vehicle; instead, all you need to do is to pay the PQP and the COE will be extended or renewed. The COE may be renewed for a period of either 5 or 10 years. COEs which have been renewed for a period of 5 years are not eligible for another renewal and will have to be de-registered after they expire. Otherwise, there is no limit to the number of times for renewal.

In addition to the above policy instruments for demand management, the following were the other measures and approaches undertaken (Chin, 1996):

i. construction and improvement in land communications;
ii. reorganization, investments and improvements to public transport;
iii. traffic management schemes;
iv. integrated transport and land use planning.

Impact on Air Pollution

The average speed of the vehicles was found maintained at about 62-65 km/hour in expressways and about 24 – 27km/hour in Arterial roads (Table 4.5).

Table 4.5: Average speed during peak hours* (km/hour)[32]

	Expressways	Arterial Roads
2002/03	65.2	25.1
2003/04	64.2	24.4
2004/05	62.7	26.1
2005/06	63.0	27.2

Note: * Average of AM Peak (8am - 9am) and PM Peak (6pm - 7pm)

Source: LTA, 2007a

The air quality of Singapore has been meeting the USEPA standards except for the levels of PM10 in 1994 and 1997 (Fig 4.1 and Fig 4.2) when Singapore was affected by transboundary smoke haze. The rest of the air pollutants (sulfur dioxide, carbon monoxide, ozone and nitrogen oxides) are well within the standards prescribed by WHO and USEPA.

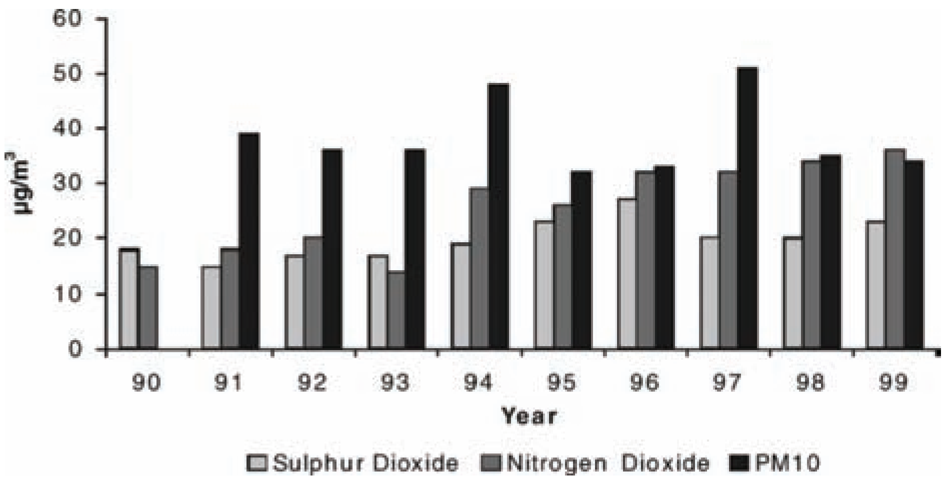


Figure 4.1: Annual average levels of sulfur dioxide, nitrogen oxide and PM_{10} in Singapore (Quaha et al., 2003)

[32] Downloaded on 26 July 2007

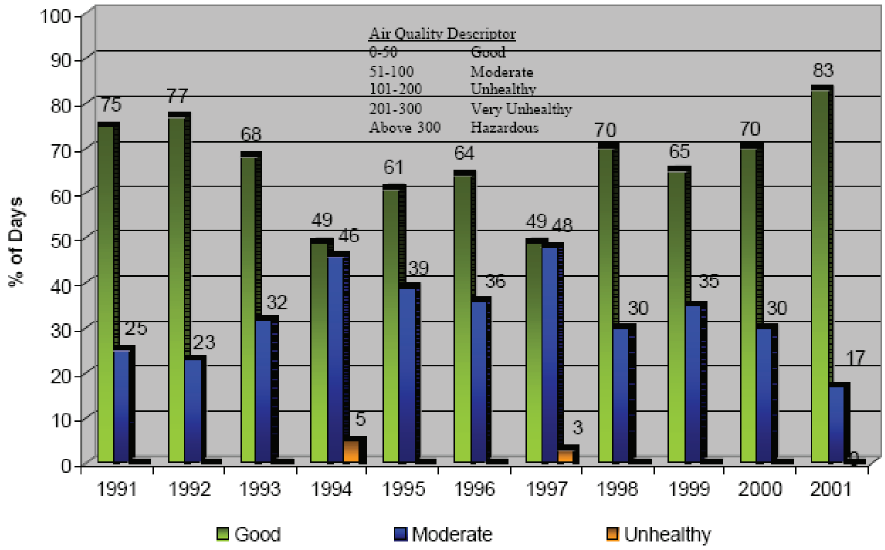


Figure 4.2: Annual average Pollutant Sub Index (PSI) in Singapore (Yong, 2002)

Table 4.6 presents the air quality data in Singapore as an illustration. It shows that air quality to be good all over Singapore.

Table 4.6: 24-hr PSI[33] at 4pm, 25 July 2007[34]

Region	24-hr Sub-Index at 4pm, 25 July 2007					PSI*	Air Quality Descriptor	Responsible Pollutant
	Sulfur Dioxide	PM10	Ozone	Carbon Monoxide	Nitrogen Dioxide+			
North	8	31	7	7	-	31	Good	PM_{10}
South	11	27	3	6	-	27	Good	PM_{10}
East	7	25	3	7	-	25	Good	PM_{10}
West	13	27	11	8	-	27	Good	PM_{10}
Central	4	27	2	8	-	27	Good	PM_{10}
Overall Singapore*	13	31	11	8	-	31	Good	PM_{10}

Source: National Environmental Agency, 2007

Note:

A sub-index value of 1 to 50 of a pollutant indicates that the level of the air pollutant for the day is in the good range and within the USEPA annual mean ambient air quality standard. A sub-index of 51 to 100 indicates the level of the air pollutant is in the moderate range, but still within the USEPA 24-h ambient air quality standard.

+Sub-index for Nitrogen Dioxide is reported only when the one-hour Nitrogen Dioxide concentration exceeds 1130μg/m3).

*Based on the highest indices in accordance with the USEPA guidelines for PSI reporting.

4.6 Compressed Natural Gas Conversion of Public Passenger Vehicles in Delhi

Country/Region	:	India/South Asia
Area of coverage	:	Delhi
Sectoral category	:	Energy/Transport
Type of approach	:	Policy/Technology

[33] PSI is Pollutant Sub Index based on highest indices in accordance with USEPA guidance

[34] Downloaded on 26 July 2007 (http://app.nea.gov.sg/psi/psi2mthv1.asp)

Pollutant Type : SO_2 and NOx
Year of introduction : 1998 onward
Participants : Supreme Court, Delhi Government, Environmental Pollution (Prevention and Control) Authority, Gas Utilities, Automobile Industries, Transport Operators and Civil Society
Implemented by : Delhi Government

Description

The transport sector is the major polluter in Delhi (DPCC, 2003). In response to a writ petition filed in 1985, the Supreme Court of India issued in 1998 directives to the Delhi Government to convert entire public transport system (comprising of auto rickshaws, taxies and buses) to use compressed natural gas (CNG) by March 31, 2001 . This was a historic decision in which the judiciary body had to intervene for the implementation of counter measures in transport sector to improve air quality in the city (Bell et al., 2003).

> The Supreme Court had also issued an order in March 2001 that all operators of the Public Transport System (comprising buses, taxis and auto rickshaws) to show proof of commitment for switching over to CNG. The proof of commitment had to be in the form of conversion/booking to CNG kits or booking of new CNG vehicles. On the basis of the proof, all operators were issued special permits (by 15th April, 2001) with a limited period validity till 30th September 2001, which were further extended till 31st January 2002 in pursuance of directions of the Supreme Court. On the expiry of the stipulated period, the Supreme Court imposed a daily fine for not converting to CNG. Fines amounting to about Indian Rupees 0.24 billion were collected through such daily fines. Sales tax exemption, interest subsidy on loan was provided for conversion to CNG.

Measures to reduce vehicular pollution include the use of improved fuel quality (like low sulfur diesel), retrofitting the exhaust tail end pipe with catalytic converters, switching to cleaner fuel or traffic management. However, the complete conversion of the public transport to CNG in Delhi was a unique example, through which a significant reduction in air pollution was achieved within few years in the city, which was otherwise considered as the one of the world’s 10 most polluted cities (Mumbai Newsline, 1998). While the role played by other sectors can not be undermined, the ruling of Supreme Court of India played the major role. Moreover, the court was active in issuing a series of directives to the implementing agencies and in many occasions, it even criticized them for their slow responses with excuses of not having the necessary infrastructures available (UNEP, 2006). On July 28, 1998, the Supreme Court had ruled that the total passenger bus fleet of Delhi be increased from the then figure of about 6,000 to 10,000 by April 1, 2001 and that the entire city bus fleet be converted to CNG with an objective to expand the city's public transport system as well as to control air pollution. This was based on the recommendations of Environment Protection Control Authority (EPCA), also known as Bhure Lal Committee (BLC), set up by the Ministry of Environment & Forests.

Delhi had the largest fleet of CNG buses in the world in 2005. There were 2,394 buses, over 27,000 autos and 14,000 other vehicles running on CNG by 2005. More than 146 fueling stations (till March 2006) have been established (IGL, 2006b).

Major Activities
The major activities conducted could be traced back to early 1990s. Major activities that led to the implementation of the historic court decision into reality include the following (Bell et al., 2003):

1991:
The Supreme Court (SC) makes its first order to the Gas Authority of India, Ltd. (GAIL), the gas distribution arm of the Delhi government, to switch over to a clean fuel. It orders that at least five stations providing CNG should be set up, and that a minimum of 5 Delhi Transport Corporation (DTC) buses should be converted to CNG.

1995:
The SC ordered and agreed to a schedule to convert government cars to CNG or retrofitting of catalytic converters.

1996:
The SC ruled that 720 Delhi government vehicles must either be fitted with a catalytic converter or be converted to CNG and gave a deadline for doing so. The SC ordered the Ministry of Surface Transport (MoST) and Ministry of Environment and Finance (MoEF) to ensure that the conversions take place on time.

1998:
The SC gave directives for switching over of the entire public transport system (comprising of autos, taxies and buses) to the compressed natural gas (CNG/clean fuel mode) as per schedule specified by the court. The Court had also directed to establish 80 CNG dispensing stations in Delhi by March 2000. India's first CNG bus was launched in Delhi. The bus was run by DTC[35] on a trial basis.

1999:
A committee was formed to devise the implementation plan of SC directives. CNG was made available at 9 dispensing stations in the capital.The Motor Vehicles Act was amended to include CNG.That all 7,500 DTC buses plying in the capital would be converted to CNG by March 31, 2001 – was announced. Further, twenty five hundred new CNG buses were to be added. Diesel with 0.25% sulfur content was introduced.

2000:
First emission standard for CNG-vehicles was introduced. 12 CNG stations were operating in Delhi. Bharat Stage II standard equivalent to Euro II standard was issued. Significant reduction in pollution at traffic intersections and in industrial areas was reported. Ministry of Science and Technology provided certification of standards for converted CNG vehicles. Inadequacy of CNG filling stations and shortage of kits hampered meeting of the implementation plan deadlines. Out of total converted 10 CNG buses, 7 were only running on trial basis. About 1,800 buses (almost all of the buses), 17,000 rickshaws, and 1,200 taxis -- which were all over 8 years old-- go off the road. Commuters panic and some were left stranded.The SC directed the central government to supply petrol and diesel with 0.05% sulfur content and 1% benzene content from June 2001. The SC directed the Ministry of Petroleum and Natural Gas to supply petrol with 0.05% sulfur content with 1% benzene content.

2001:
The SC refuses to extend the March 31, 2001 CNG conversion deadline. Private bus operators request financial assistance from the government for the conversion. SC sought more precise definition of “clean fuel”. The other fuels, particularly low (500 ppm) and ultra low (10 ppm) sulfur diesel, should be considered in addition to CNG as “clean fuel” for vehicles.The Court granted a temporary extension for the CNG conversion of buses until the end of September 2001 for groups that showed conformity of commitment

[35] state owned transport company

2002:
The SC directed that no retro-fitted or converted CNG bus be allowed to ply without certificate of conformity that the buses met the safety standard after CNG conversion. New CNG buses would not come under this order.

2003:
All 8,000 buses in Delhi were reported to operate on CNG. Nearly all auto-rickshaws in the city had converted to CNG.Delhi won the US Department of Energy's first 'Clean Cities International Partner of the Year' award for ''bold efforts to curb air pollution and support alternative fuel initiatives''.

2006:
Delhi had 10,761 buses (owned by DTC and private), 63,962 three wheelers, 5,229 taxis & 5,258 Vans running on CNG (India Times, 2006). 19,351 private cars in Delhi had also converted to CNG (IGL, 2006a).

Impact on Air Pollution
Improvement in air quality of Delhi in recent years is widely acknowledged. The Central Pollution Control Board of India is continuously monitoring the ambient air quality of the major cities of the country. The air quality measurements of Delhi from 1998 to 2005 show that the average concentration of SO_2 is drastically reduced to the safe limit. Further, the concentration of NOx meets the criteria of the annual average national standard value (Table 4.7). However, the suspended particulate matter in the city is far above than the national ambient air standard. These can be seen from Table 4.7.

Table 4.7: Ambient Air Quality of Delhi from 1998 - 2005

Area	**SO_2**						
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Sarojini Nagar[a]	15.7	19.6	15.9	13.8	11.8	9	7
Town hall	12.2	17.4	14.3	13.3	11.5	11.5	11
Mayapuri Industrial Area[b]	17.8	20.2	17.7	13	16.7	11.4	12

	NOx						
Area	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Sarojini Nagar[a]	28	24.8	24.6	22.5	27.3	31.8	53
Town hall	44	54.5	64	70.1	53.3	58.9	60
Mayapuri Industrial Area[b]	28.7	25	26	22.5	36.3	32.6	56

	Suspended Particulate Matter (SPM)						
Area	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Sarojini Nagar[a]	384	337	225	324	378	281	356
Town hall	465	505	590	561	534	478	508
Mayapuri Industrial Area[b]	371	345	282	291	415	343	484

b - Data from 1998-2003 is from Shahadra
All units are in yearly average $\mu g/m^3$.

<u>Annual Average National Ambient Air Quality Standard:</u>
SO_2/NO_x – 80 $\mu g/m^3$ for industrial and 60 $\mu g/m^3$ for residential.
SPM – 360 $\mu g/m^3$ for industrial and 140 $\mu g/m^3$ for residential.

Source: CPCB, 2007b and 2007c

4.7 Environmental Measures and NOx Tax System in Norway

Country/Region : Norway/Europe
Area of coverage : Norway
Sectoral category : Energy/Transport
Type of approach : Policy/Technology
Pollutant Type : NOx
Year of introduction : January 2007 onward
Participants : Manufacturing Industries, Transport comprising of ships, fishing vessels, air traffic and railways
Implemented by : Norwegian Government, Norwegian Pollution Control Authority

Description
In 2006, the Norwegian Parliament endorsed a tax policy on emission of NOx to be applicable from January 1, 2007. The tax amounts to NOK 15 per kg NOx (US $ 2.5/kg) emitted from ships, fishing vessels, air traffic and diesel railways, and also engines, boilers and turbines in the manufacturing industries. The large units in these categories are applicable for the tax system. Large units are defined as units with capacity higher than 10 MW for boilers and 750 kW for propulsion engines. In addition, NOx tax is also imposed on flaring offshore and on oil and gas installations on shore. The tax covers approximately 55 % of the total Norwegian NOx emissions (NPCA, 2008).

Table 4.8: Emission ceiling 2010 according to the Gothenburg Protocol and status 1990 and 2006 (in tonnes)

Component	Emissions 1990	Emissions 2006	Emission ceiling 2010	Necessary reduction 2006-2010
Nitrogen oxides (NO_X)	212 524	194 506	156 000	39 000 tonnes (20 %)
NMVOC	294 875	196 345	195 000	1 000 tonnes (1 %)
Ammonia (NH_3)	20 375	22 610	23 000	Emission ceiling reached at the moment

Source: NPCA, 2007

The tax is geographically delimited in accordance with the Gothenburg Protocol. This implies that emissions from foreign sea and air transport not are covered, for instance. As per the Gothenburg Protocol, Norway is required to meet its NOx emission target of 156,000 tonnes in 2010 (Table 4.8) and the tax system is expected to help in meeting this obligation (NPCA, 2008).

Major Activities

Environmental Regulation
Under the Pollution Control Act, the regulation relating to the pollution control was introduced in 1981 (NPCA, 2007). The scope of the regulation covers emission of particulate matters (PM2.5 and PM10), nitrogen dioxide and nitrogen oxides, Sulfur dioxide, lead, benzene, carbon monoxide, arsenic, cadmium, nickel, benzo(a)pyrene (as a marker for polycyclic aromatic hydrocarbons) and mercury. The regulation considers only the locally-created contributions in determining whether a source contributes substantially to exceeding individual limit values (Table 4.9). Emission from road traffic is seen as a whole, regardless of who owns the roads. Similarly, contiguous port area with different owners is treated as once emission source. Furthermore, emissions from small heating plants as a whole are taken as one source.

The limit values for the concentration of outdoor air pollution for different averaging periods and the deadlines to meet these targets are given in Table 4.9.

Municipalities are authorized to draw necessary assessments of possible measures in consultation with parties involved. Municipalities are also authorized to ensure the owners of smaller heating plans to comply with the regulation. Also they are given authority to order/issue directives to plant owners to comply with the regulation even when such plants do not contribute significantly to the concentration of the pollutant.

Table 4.9: Maximum Allowable Limit on Concentration of pollutants in outdoor air and the date by which the limit value is to be met

	Averaging period	**Limit value**	**Margin of tolerance**	**Date by which limit value is to be met**
Sulfur dioxide				
1. Hourly limit value for the protection of human health	1 hour	350 µg/m^3	The limit value must not be exceeded more than 24 times a calendar year	1 January 2005
2. Daily limit value for the protection of human health	1 day (fixed)	125 µg/m^3	The limit value must not be exceeded more than 3 times a calendar year	1 January 2005
3. Limit value for the protection of ecosystems	Calendar year and winter (1/10–31/3)	20 µg/m^3		4 October 2002
Nitrogen dioxide and oxides of nitrogen				
1. Hourly limit value for the protection of human health	1 hour	200 µg/m^3 NO_2	The limit value must not be exceeded more than 18 times a calendar year	1 January 2010
2. Annual limit value for the protection of human health	Calendar year	40 µg/m^3 NO_2		1 January 2010
3. Annual limit value for the protection of vegetation	Calendar year	30 µg/m^3 NOx		4 October 2002
Particulate matter PM_{10}				
1. Daily limit value for the protection of human health	1 day (fixed)	50 µg/m^3 PM10	The limit value must not be exceeded more than 35 times per year	1 January 2005
2. Annual limit value for the protection of human health	Calendar year	40 µg/m^3 PM10		1 January 2005

Source: NPCA, 2007

The air quality is being measured and/or calculated according to health-based (Table 4.10) and vegetation-based evaluation thresholds (Table 4.11):

Table 4.10 Assessment threshold for health protection

Pollution component	Upper assessment threshold	Lower assessment threshold
Sulfur dioxide	75 µg/ m^3 (day value) which must not be exceeded more than 3 times a calendar year	50 µg/ m^3 (day value) which must not be exceeded more than 3 times a calendar year
Nitrogen dioxide	140 µg/ m^3 (hourly mean) which must not be exceeded more than 18 times a calendar year 32 µg/ m^3 (annual mean)	100 µg/ m^3 (hourly mean) which must not be exceeded more than 18 times a calendar year 26 µg/ m^3 (annual mean)
Particulate matter (PM10)	30 µg/ m^3 (daily mean) which must not be exceeded more than 7 times a calendar year 14 µg/ m^3 (annual mean)	20 µg/ m^3 (daily mean) which must not be exceeded more than 7 times a calendar year 10 µg/ m^3 (annual mean)
Lead	0.35 µg/m^3 (annual mean)	0.25 µg/ m^3 (annual mean)
Benzene	3.5 µg/m^3 (annual mean)	2.0 µg/m^3 (annual mean)
Carbon monoxide	7 µg/m^3 (8-hourly mean)	5 µg/m^3 (8-hourly mean)

Source: NPCA, 2007

Table 4.11: Assessment threshold for the protection of vegetation

Pollution component	Upper assessment threshold	Lower assessment threshold
Sulfur dioxide	12 µg/m^3 (winter mean)	8 µg/m^3 (winter mean)
Oxides of nitrogen	24 µg/m^3 (annual mean)	19.5 µg/m^3 (annual mean)

Source: NPCA, 2007

NOx Tax System

The tax base is applicable to propulsion machinery with a cumulative installed engine rating of over 750 kW or motors, boilers and turbines with a total installed capacity of more than 10 MW. If the installed propulsion power rating exceeds 750 kW, NO_X emissions from other auxiliary machinery are also subject to tax in addition to the tax on the propulsion machinery (NMD, 2007). The tax is calculated based on 3 principles: a) according to actual emission; or b) according to a fixed source specific emission factor; or c) based on the maximum rotations per minute (rpm) template if ‘a’ and ‘b’ are non-existent. Application of (a) requires actual emission documented measurements carried out by competent party approved by the Norwegian Maritime Directorate (a pre-defined NOx Tax Calculations Table or 'rate card') while (b) requires a source specific emission factor documentation in accordance with guidelines given by the Norwegian Maritime Directorate, submitted and approved by the Norwegian Maritime Directorate (a source-specific Manual Onboard Measurement) and (c) requires documentations based on rotation speed recorded or main engine manufacturer’s certificates (continuous onboard monitoring).

The tax system is applicable to Norwegian registered vessels in 'near waters' - defined as sea areas within 250 nautical miles from Norway's coast. It is also applicable to emissions from all domestic and foreign vessels operating within Norwegian territorial waters, i.e. within 12 nautical miles of the coast. However, vessels sailing direct routes between Norwegian and foreign harbors, and vessels in transit through Norwegian territory (innocent passage) are exempted from the tax.

The policy has a provision to refund the tax based on the difference between emissions before and after the installation[36] of cleansing equipments, measuring equipments. In the absence of such information, the policy also has a provision to fix source specific emissions factors by competent authority[37] In such a case, the tax is calculated on the basis of source emission factors relevant to fuel consumption (DOCE, 2007)

Impact on Air Pollution
In 2007, Norwegian NOx emissions were reduced by 8.7% as compared to 1990. In 2007, the total NOx emission was about 190,000 tonnes. This was 0.6% lower than the NOx emission in 2006 (NPCA, 2008). Emissions from the road transport, sea transport and fishing decreased, whereas the emissions from liquefied natural gas (LNG) plant and industries increased. The decrease in emissions from the road transport was mainly due to the requirements of exhaust gas purification, increasing share of petrol run cars with catalytic converters.

4.8 Solar Water Heater System (SHWS) Development and Promotion Policies

Country/Region	:	Several countries
Area of coverage	:	Several countries
Sectoral category	:	Energy
Type of approach	:	Policy/Technology
Pollutant Type	:	SO_2, NOx, particulate matter
Year of introduction	:	1960s onward
Participants	:	Manufacturers, suppliers, industries, households

Description
It was estimated that around 10 million solar water heating systems (SWHs) were already installed in developing countries by 2001 (Refocus, 2005). Countries in Asia like China, India and Nepal are using solar energy significantly for water heating purpose. China's SWHs cumulative installations were over 60 million m^2 by the end of 2004, more than 70% of the total world market (Refocus, 2005). SWHs have provided hot water supply for more than 35 million families competing with water heating technology options fueled by electricity and natural gas. In India, over 500,000 m^2 solar collector area was already installed by 2000 (Refocus, 2004). Solar water heater (SWH) for domestic water heating purpose is one of the most successfully used water heating systems in Nepal (Bajracharya et. al, 2003). Over 308,000 m^2 of collector area was already installed in the country by 2004 (OGARTA and Himal Energy, 2004). Every year, over 2000 SWHs are installed in Nepal (Shrestha et. al, 2002). There are approximately 60,929 households using SWHs (approximately 16% of the total households) in the country, of which more than 80% live inside the Kathmandu Valley (OGARTA and Himal Energy, 2004). This shows that one SWH is installed in every 5 households inside the Kathmandu Valley.

Major Activities
Direct grants, subsidies are the most prevalent schemes, whereas tax incentives while importing SWHs and their components are other indirect schemes used for promoting SWHs the most countries using SWHs. Accelerated depreciation schemes for commercial and public applications are also other schemes used in few of the countries. In India deployment of a further one million SWHs is aimed for domestic use by 2012 (Refocus, 2004).

[36] There is restriction of such provision. Applicant has to agree to install cleansing or fixing source specific emission factor before 1 July 2007. In the case of measuring equipment installation, the applicant has to agree on the installation before 31 December 2007.
[37] It is an authority to determine the specific emission factors. (e.g., Norwegian Pollution Control Authority for land based activities; Civil Aviation Authority for aircraft; Norwegian Maritime Director for ships/vessels)

New constructions of government-owned housing in Namibia are not allowed to install water heaters other than SWHs (Refocus, 2004). In Mexico, rather than giving direct financial incentives, the policy is targeted towards creating an enabling environment with roundtable talks between the sellers and potential users and developing a virtual marketplace.

In Florida (USA), under the ‘Solar Weatherization Program’, low income households were given free SWHs to replace electrical water heaters so as to lower the share of the energy cost in their budget. The average cost of the SWH was around 1500 Euro. Each SWH saves on average 130 Euro of electricity bill per year. The programme is operated by local program agencies and other non-profit agencies in cooperation with local volunteer groups (Refocus, 2004).

Australia has policies to promote the use of SWH to reduce the electrical load under the Renewable Portfolio Standard, under which, all SWHs replacing electrical water heaters are allowed to have green certificates. These certificates are marketable. Electricity suppliers are obliged to purchase a certain share of electricity from renewable energy sources and they can buy these green certificates to meet their obligation. Typically, a SWH will receive between 10 and 35 certificates with an electricity equivalent of 1 MWh over its lifetime. The market value of one certificate is reported to be between 18 and 20 Euro. About one fourth of the issued green certificates in 2001 in Australia were from SWHs (Refocus, 2004).

SWHs in Barbados are supported through different mechanisms. The Fiscal Incentive Act of 1974, which made provisions for import preferences and tax holidays, 30% consumption tax on electric water heaters are some of the mechanisms that helped to make SWH competitive (Refocus, 2004).

In Nepal, the development of solar thermal conversion devices started in the early 1960’s. After several improvements, an experimental SWH was installed in a school in 1975, which was the first unit installed for public use. With its market growth, a number of local manufacturers are involved into the commercial business. There are already more than 200 local manufacturers in such business (REDP/UNDP/AEPC, 2002). More manufacturers get into the business during the winter season (approx 4 months) when the sale of SWHs is high (OGARTA and Himal Energy, 2004).

Impact on Air Pollution

In the Indian northern state of Himachal Pradesh, every rural household uses 720 kg of firewood for heating water every winter and solar water heaters have been used in small villages to replace the demand for wood (Refocus, 2004). In Gujrat, daily consumption of firewood for water heating purpose in domestic use has been decreased by the use of SWHs. Each household previously used 5-7 kg of firewood per day for water heating. By replacing it with solar water heaters, households save the corresponding amount of firewood reducing carbon dioxide emissions (SPRERI, 2002). Solar energy is renewable and zero emission device, thus there is a strong possibility of earning carbon credits when it replaces fossil fuels generated electricity. It is estimated that the use of SWHs would save nearly 200 million kWh of electricity each year in Nepal (OGARTA and Himal Energy, 2004). SWHs could also reduce the consumption of fossil fuels like diesel and kerosene used in industrial boilers. In Nepal, it was estimated that the use of SWHs would reduce approximately 9,974 tCO_2 every year and significant amount of other pollutants would also be reduced (ASTED, 2006).

In China, solar-powered water heaters provided 7.2 million tons of coal equivalent (tce) of heat (calculated at 120 kgce per year/m^2 collector) in 2004, providing approximately 12% of China's renewable energy. The application of SWH in China is estimated to reduce around 12 million tons of CO_2 emission and associated other regional pollutants emissions in 2004 (Refocus, 2005).

The island of Barbados has over 35,000 solar water heaters installed and this is equivalent to about one in every three households (Refocus, 2004). Solar water heaters are also widely used in the hotel industry and each unit saves about 4,000kWh per year, which results in a cumulative electricity saving of 140 million kWh (i.e., equivalent of 227,000 barrels of oil) if use of diesel is considered to generate electricity in place of solar. A substantial quantity of emissions, such as carbon dioxide, Sulfur dioxide and the oxides of nitrogen are avoided with the use of SWHs (Refocus, 2004).

4.9 Vertical Shaft Brick Kiln Technology Promotion in Asia

Country/Region	:	South and South East Asia
Area of coverage	:	South and South East Asia
Sectoral category	:	Energy
Type of approach	:	Policy/Technology
Pollutant Type	:	SO_2, particulate matter
Year of introduction	:	1990s onward
Participants	:	Brick manufacturing industries, The Energy Resources Institute (TERI), SKAT, Swiss Agency for Development Cooperation (SDC), Center for Pollution Control Board (CPCB) of India and Ministry of Environment, Science and Technology of Nepal

Description

Vertical Shaft Brick Kiln (VSBK) technology is an energy efficient brick manufacturing technology originally developed in China. The design of the VSBK resembles to an intermittent updraft kiln with a unique method of continuous firing clay bricks (VSBK Nepal, 2007). The first version of VSBK originated from traditional updraft intermittent kilns in China during the 1960s. During the 1970s, this kiln became popular in several provinces of China and it was reported that there were more than 50,000 installations in China. Attempts to encourage the use of the VSBK technology outside of China started in early 1990s. The VSBK technology was promoted to several Asian countries such as India, Nepal, Afghanistan, Pakistan, Vietnam and Bangladesh (APEIS, 2003a).

Major Activities

India

In India, the brick manufacturing is very labor-intensive, since bricks are usually hand-molded and sundried before firing in the kiln (APEIS, 2003a). The firing of the bricks is the mostly done in either Bulls' Trench Kilns (BTKs) or in clamps. BTKs are generally the choice of medium and large projects and account for about 70 % of the total production in the country, while clamps are often used in operations with smaller production capacities. Coal and biomass are used for firing the bricks in the kilns. Estimated coal consumption in the brick sector of the country is about 24 million tonnes per year (APEIS, 2003a). With such a large consumption of coal, the brick industry is the cause of significant air pollution in terms of suspended particulate matter (SPM).

The emission standard enforced by the Government of India in April 1996 limited stack emission to 1,000 mg/Nm^3 of emissions for small capacity kilns and 750 mg/Nm^3 for medium and larger kilns. The use of moving chimney BTKs were banned after June 2002. The various state pollution control boards are now enforcing the ban on this technology. While kilns with the higher production levels had the option to switch to fixed chimney type BTKs, small and medium capacity brick makers are required other options to meet the enforced standards on SPM emissions (APEIS, 2003a). The government regulations have therefore been a vital instrument that provided a framework for the adoption and dissemination of VSBK technology for small and medium brick makers in India.

With the support from Swiss Agency for Development and Cooperation (SDC), in the action research phase (1996-2000), VSBKs are introduced and demonstrated. Major activities carried out under the research phase included providing training, developing technology options to suit different regions of the country and conducting awareness seminars, and study tours. There were no government-supported demonstrations/ subsidies for the adoption of VSBK technology. In India there were 45

VSBK installations by 2004 and it was reported that the installations are over 100 by 2007 (SDC, 2008).

Vietnam
In Vietnam, the VSBK technology was introduced under UNDP Project funded by the Small Grant Programme of the Global Environment Fund. The adoption of the new VSBK was growing rapidly all over the Vietnam. Approximately, around 200 VSBKs were already constructed in Vietnam by 2004 (Kim et. al, 2004). It is reported that over 300 VSBKs are constructed in Vietnam (SDC, 2008). Raising awareness among the local authorities on the possibility of air pollution reduction while retaining the livelihood of the brick-makers was one of the major achievements of the project. The project also made an effort to involve local policymakers from the beginning of the project. The national government had placed deadlines for the phase-out of the traditional brick kilns, which provided a push to find efficient technologies such as VSBKs to meet the needs of the very large number of small scale brick producers throughout the country. However, some VSBKs failed because of monetary losses incurred by them. This was due to the dissemination of wrong information about VSBKs and managerial problems.

Nepal
In Nepal, joint efforts between the government and local entrepreneurs have boosted the development of VSBK technology. A strong lobby from local community resulted banning of BTK citing heavy air pollution in the nearby vicinity (Heierli and Maithel, 2008). For the first time VSBK was introduced in Nepal in 1992 as a demonstration project. SDC, through its VSBK Program executed by Skat consulting (Swiss Resources Centre and Consultancies for Development), has been providing technical support to interested entrepreneurs to install VSBK. Currently, over 10 VSBKs are in operation in the Kathmandu Valley (SDC, 2008). Establishment of VSBK Entrepreneurs Forum was one of the major achievements of the program. In the Second VSBK Entrepreneurs Workshop, the forum was established in order to address various issues related to VSBK technology. This forum had established a good network among all VSBK entrepreneurs (VSBK Nepal, 2007).

In Pakistan and Bangladesh, some pilot projects are ongoing in VSBK technology transfer.

Impact on Air Pollution

VSBK technology is environmentally friendly. SPM emissions from VSBKs are very low compared to the environmental requirements (80 to 250 mg/Nm^3 as against about 750 mg/Nm^3 for medium and large capacity BTKs and 1,000 mg/Nm^3 for small capacity BTKs). Apart from the obvious stack emissions, other fugitive emissions are also significantly lower.

For clamp type kilns, the comparison with VSBK is even more dramatic. These kilns generally do not have a stack for the dispersion of flue gases, which are usually let out into the surroundings. On a global level, the energy savings resulting from VSBK (20 to 50 %) would help considerably in reducing CO_2 emissions if the technology were adopted on a wide scale.

4.10 Alternative Fuel Vehicle Promotion in Kathmandu Valley[38]

Country/Region	:	Nepal/South-Asia
Area of coverage	:	Kathmandu Valley
Sectoral category	:	Energy
Type of approach	:	Policy/Technology
Pollutant type	:	SO_2, NOx, particulate matter
Year of introduction	:	1995-2000

[38] The material in this section draws heavily on RAPIDC (2008).

Participants : Donor supported (USAID/US-AEP) demonstration project, private investment, and government-provided facilitation and benefits

Description
Motor vehicles have been identified as the major source of air pollution in the Kathmandu Valley. A sudden surge of diesel-operated three-wheelers was observed during 1989-92. These vehicles emit a thick black smoke and were noisy. With the growing problem of air pollution and due to public outcry, the government put a ban on further registration of these vehicles in 1992 (APEIS, 2003b). Despite growing public awareness over air quality and pressure from NGOs and other civic groups, a ban on these vehicles from operating on the streets could not be enforced in the early days due to a number of local economic and political difficulties. Policy makers failed to create any incentive mechanism to motivate the owners to abandon their three-wheelers. In 1995, the prohibition of the use these vehicles on the street was put into effect. Then the combined effort of the government, the private sector and civil society (mainly NGOs and advocacy groups) produced synergy effects to promote and expand the use of battery-operated electric three-wheelers on a commercial basis in the valley, to fill the vacuum created by the restriction on diesel three-wheelers. These vehicles were promoted as zero-emission vehicle since over 90% of the electricity produced in Nepal is hydropower (Nepal Electricity Authority, 2006). Currently over 600 electric vehicles (popularly named as '*Safa*[39]' tempo) are running inside the Kathmandu Valley.

Major Activities

The key activities behind the successful introduction of electric vehicles in the Kathmandu Valley are given below:

Major institutional efforts
As a major institutional effort to improve environment, the government of Nepal set emission standards in 1994 and formed the Ministry of Environment in 1995. It passed the Environmental Protection Act 2056 in 1997. The ministry attempted in late 1998 to start the phase out of non-complying vehicles within two years and in early 1999 formulated a phase-out program in association with the Department of Transport Management and local municipalities, and in consultation with the private sector and NGO groups. Unfortunately, these efforts did not succeed.
Public pressure and creating awareness on the environment
The non-governmental sectors like the tourism, industry, cine-artists associations, local clubs, NGOs and civil society fueled the anti-diesel three-wheeler movement which peaked in 1995 (Dhakal, 2004). The movement led to street protests and road blockades against three-wheelers. Finally, the government provided an incentive for the owners to replace their diesel three-wheelers, in the form of a 75 % customs holiday on the import of 12- to 14-seater public transportation vehicles (Dhakal, 2004). Consequently, diesel three-wheelers were banned from operating in the valley, starting in July 1999.

Demonstration of technological and economic feasibility of electric three-wheelers
Initially, Global Resource Institute conducted a pilot project for the demonstration of the technological feasibility of an electric vehicle, which was converted from a diesel three-wheeler. By 1995, a total of eight electric three-wheelers had been designed and pilot-tested on one of the major routes in the valley for six months (Dhakal, 2004). This demonstration project, apart from designing vehicles, also created awareness of the new vehicles and encouraged their acceptance by the government, private sector and the public.

Emergence of a new industry

[39] '*Safa*' in Nepali language means clean.

The demonstration project showed that the battery-operated three-wheelers were technologically and economically feasible in the valley. As a result, the private sector was attracted to invest in this industry. Since then, the private sector has been the main impetus for the growth of the electric vehicles in Kathmandu. There were 600 *safa tempos* operating in Kathmandu, servicing 100,000 people daily in 17 routes and employ over 70 women drivers by 2004 (ADB, 2006a and Dhakal, 2004). There were also 37 charging stations. These *safa tempos* were assembled in Kathmandu using body and chassis parts from India and electronic parts and batteries from the other countries (e.g., United States). These vehicles can carry an average load of 12 persons and one set of batteries. The government has been providing tax incentives on vehicle parts importation and there were no fees for annual registration of electric vehicles (ADB, 2006a). The EV industry in the valley principally consists of three major groups: vehicle manufacturers, vehicle owners and charging station operators. Currently, there are about five major manufacturers, 38 battery-charging centers, and about 450 owners. Each charging centre owns about 5 to 10 vehicles, and individuals own the rest.

The demand for electric vehicles is likely to grow as an alternative to fossil-fuel based vehicles (Tiwari, 2007). The private sector has been interested in manufacturing four- wheeled electric vehicle with an alternating current drive system. Recently, five electric cars (REVA) were imported from India into the country through private organizations. Hulas Motors, the only automobile manufacturer in Nepal, came out with its first five to ten passenger electric van in 2007. Other local electric vehicle manufacturers are also working on four wheel and alternating current drive-based electric vehicles (Tiwari, 2007).

Role of private sector association

The Electric Vehicle Association of Nepal is an umbrella organization of the electric vehicle (EV) industry. It integrates the charging station operators' association, the manufacturers' association and the owners' association, and also represents the EV industry when dealing with the government, the media and the public.

Donors' Interest

The support of foreign donors in promoting electric three-wheelers is also one of the important factors behind the growth of EVs in the valley. Two donors, the US Agency for International Development (USAID) and Danish International Development Agency (DANIDA), played instrumental roles: The USAID supported the demonstration programs and DANIDA provided support at the later stages. Since donors are influential in many of the governmental policies, such donor involvement helped to create a favourable response from Nepal's policy makers (Dhakal, 2004).

Lower electricity tariff and tax benefit

The state-owned Nepal Electricity Authority provided electricity at low tariff (NRs 2.95-4.70/kWh for transport as compared to NRs 4 - 6.55/kWh for industries) for electricity use for battery charging in electric vehicles in 2006 (Nepal Electricity Authority, 2006). Since most of the electricity in Nepal is generated from run-of-the-river hydro power plants, the charging of batteries could use the surplus and unutilised energy during off-peak periods (i.e., night-time charging) at reduced tariffs. Indeed, electric vehicles provided a new market for the electric utility. The EV sector also enjoys benefits offered to manufacturing industries that deal with energy efficiency, energy conservation and pollution abatement as announced by the Industrial Enterprises Act 2049 (Article 15e). Under this, they are entitled up to a 50% discount from taxable income for a period of seven years.

Impact on Air Pollution Scene

Although air quality data are not available, banning of the diesel-three-wheelers had improved the visibility in the region. Vehicular smoke was reduced to some extent and pollution during hours of traffic congestion was reduced.

4.11 The OTC NOx Budget Program, the NOx SIP Call and NOx Trading Program in the Eastern States of the U.S.[40]

Country/Region	:	United States (US)
Area of coverage	:	22 states in US
Sectoral category	:	Energy
Type of approach	:	Policy/Emission Trading
Pollutant type	:	NOx
Year of introduction	:	1999
Participants	:	Electric power plants, large industrial boilers and turbines, Ozone Transport Commission (OTC)

Description and Major Activities

The OTC NOx Budget Program

It is a program implemented in the Northeast and Mid-Atlantic region of the United States to meet the air quality standard for ground-level ozone under the Clean Air Act Amendments of 1990. The Ozone Transport Commission (OTC) was established for this purpose. Under this program, a regional cap (budget) on NOx emissions was set for emissions from electric power generating facilities, large industrial boilers and turbines during the "ozone season" (from May 1st through September 30th) beginning in 1999. The ozone season covers the summer months, during which the formation of ozone was found to be of greatest concern. To meet the cap, the sources were required to reduce emissions significantly below the 1990 baseline levels, and could use emissions trading to achieve the most cost-effective reductions possible.

Each state within the OTC was allowed to design and implement its own trading program consistent with the state conditions and needs. However, all participating states have agreed to adopt guidelines for applicability, duration of the control period, targeted NOx emissions monitoring and record-keeping, and electronic reporting. States have the authority to establish individual enforcement procedures and penalties. Accurate monitoring of all emissions and timely reporting ensured that a ton of NOx emitted from one budget[41] source is equal to a ton from any other source. This has maintained the integrity of the budget and the states have accurate and comprehensive compliance information. Transparency was maintained keeping all emissions and allowance data from the budget sources publicly available on the EPA Web site (USEPA, 2007d). States work with the federal Environmental Protection Agency (EPA), which reviewed and approved the State Implementation Plans (SIPs) as well as developed and operated allowance and emissions tracking systems.

EPA´s NOx SIP Call

EPA issued a regulation in 1998 to reduce the regional transport of ground level ozone since the OTC NOx Budget Program did not bring the region (the Northeast and Mid-Atlantic) into compliance, due to the transboundary flow of NOx across state boundaries. The regulation was commonly known as State Implementation Plans (NOx SIP Call). SIP was issued to

- reduce seasonal NOx emissions in 22 states and the District of Columbia by 2003 and
- to create a Federal NOx Budget Trading Program.

In the 2003 ozone season the NOx SIP Call superseded the OTC NOx Budget Program. The NOx SIP Call did not mandate which sources must reduce emissions; rather, it required states to meet an overall emissions budget and gave them flexibility to develop control strategies to meet the budget. All affected states chose to meet their NOx SIP Call requirements by participating in the NOx Budget Trading Program.

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[40] The material in this section draws heavily on RAPIDC (2008).

[41] Budget means the participating source with an assigned emission limit in the NOx Budget program.

The NOx Budget Trading Program

Under the SIP Call, EPA developed NOx trading program known as the OTC NOx Budget Trading Program. Under this program, budget sources were allocated allowances by their state government. Each allowance would permit a source to emit 1 ton of NOx during the control period.

As in US Acid Rain Program, these allowances could be bought, sold, or banked. Any person was allowed to acquire allowances and participate in the trading system. In 2006, more than 2,500 units were involved under the NOx Budget Trading Program (NBP). These include electricity generating units with output capacity of 15 MW or more. These also includes large industrial units with fossil fuel fired boilers or indirect heat exchangers having maximum rated heat input capacity of 250 million British thermal units per hour or more (USEPA, 2007e).

States were given broad discretion as to how they could allocate allowances from their trading budget to affected sources.

Impacts

Changes in NOx

In 2006, under the NOx Budget Program, the budget sources emitted 491,483 tons, which means a reduction of NOx by more than 38,000 tons, or 7 % from the emission in 2005 and 74 % from 1990 emissions (USEPA, 2007e). However, there were also contributions of other programs under the Clean Air Act such as the Acid Rain NOx Reduction Program and other state, local, and federal programs on NOx reduction. The significant decrease in NOx emissions after 2000 largely reflects reductions achieved by the OTC Budget Trading program, and the NOx Budget Program. Over 99.7% of the total affected sources had achieved compliance with the NOx Budget Trading Program in 2006 (USEPA, 2007e).

Changes in ground-level ozone

Like NOx emissions, ozone concentrations in urban and rural areas had decreased during 2004-2006 (after implementation of the NOx Budget program) in comparison to that during the period 2000-2002 (i.e., before implementation of NOx Budget Program). The average reduction in ozone concentrations in states participating NOx Budget Program was estimated as 5% (USEPA, 2007e).

Chapter V

Summary and concluding remarks

With the increasing dependence on fossil fuels and heavy use of biomass, the countries in South Asia are increasingly facing the problem of air pollution. Three sectors, i.e., power, industry and transport are reported to be mainly responsible for air pollution in the region. The power sector is reported to be the largest emitter of SO_2, while transport sector, biomass burning and agriculture (crop residues and live stocks) are considered to be the largest contributors to NO_x, NMVOC and CH_4 emissions respectively in the region (Garg et al., 2001 and 2006; Shrestha et al, 1998; Varshney et al., 1999).

The use of coal is increasing in the region (especially in India) to meet the growing demand for electricity. As a result, SO_2 emission is also expected to rise in the region in the future. In addition, the problem of SO_2 emission is getting aggravated by the deteriorating quality of coal, inefficient coal preparation and coal cleaning mechanisms in the region. Low efficiency of the thermal power generation (especially from coal fired power plants) is another factor resulting in higher SO_2 emission and offer potential for significant coal and SO_2 reduction from the region. Lack of regulations/mechanisms to control emissions other than particulate matters from the power plants, lack of regulations on Industrial pollution and enforcement of existing regulations are some of the key issues that need to be addressed in the region for prevention and control of transboundary air pollution.

The South Asia region is also facing the problem of worsening air quality in urban areas largely due to growing emissions from the urban transport sector. On the other hand, the rural areas in the region are facing the indoor air pollution problems related to biomass burning due to their high dependence on such fuels.

Most countries in the region lack regular monitoring of air pollution as well as information on emission source apportionment, which are prerequisites for formulation of effective air quality management strategies. Furthermore, most countries lack effective regulatory and economic policy instruments in order to improve the air quality.

The Declaration for Prevention of Transboundary Air Pollution ("The Male' Declaration") adopted by the Environment Ministers of South Asian Countries in 1998 is a milestone in the process of fostering regional cooperation towards the control and prevention of transboundary air pollution (TAP) in the South Asia region. However, the region is yet to adopt specific regional treaties/agreements/protocols that set quantitative targets for reduction of transboundary pollutant emissions at the national levels. International treaties and agreements provide the legal and political basis for formulating national level strategies and policies to control transboundary air pollution.

This report has reviewed various existing international treaties and agreements that address the problem of TAP in other regions of the world, especially Europe and North America. Worth mentioning in this context are the Convention on Long Range Transboundary Air Pollution (CLRTAP), the European Commission National Emission Ceilings Directive (2001/81/EC) and the mechanism set by Title IV of Clean Air Act 1990 Amendment in the US. The CLRTAP addresses the major TAP problems in the United Nations Economic Commission for Europe (UNECE) region (with special focus on Eastern Europe, the Caucasus and Central Asia and South-East Europe). It adopted 8 protocols targeting emission reduction of major transboundary air pollutants. Likewise, the US has taken an initiative to control transboundary air pollution under Title IV of Clean Air Act 1990 Amendment. The Act requires the states in the US to achieve stipulated SO_2 and NOx emission reductions within a specified time horizon.

As a prerequisite to setting national emission reduction targets in any regional level agreements/treaties for control of transboundary air pollution, it is important to have reliable information on emissions and their effects/impacts as well as the costs of abatement measures. This requires installation of comprehensive monitoring system.

Once the targets for reduction of national emissions are agreed upon, next important task is to formulate and introduce most appropriate approaches to control emissions of pollutants. Keeping this in view, the present report has also discussed the approaches used by different countries to control air pollution so that appropriate lessons could be learned for controlling TAP in the region.

The major approaches used for environmental management in general and air quality management particular can be categorized as: (i) command and control approaches including emission standards, fuel quality standards and technology standards, (ii) market based or economic approaches which include emission tax (with or without refund), emission permits and emission trading and (iii) approaches based on voluntary actions. In addition, property right based approaches are also mentioned in the environmental economics literature.. Further, the present report has presented in greater detail several examples of good practices existing in different countries in the world for the control of transboundary air pollution, which the policy makers of the South Asian countries could benefit from.

Examples of the application of command and control approach include the requirement of the Integrated Pollution Prevention and Control (IPPC) Directive of the European Union for each of its member states to adopt best available technology (BAT); in that sense the directive sets technology based standards. In the case of the US, an emission standard is imposed on new power plants in terms of SO_2 emission per unit of heat content of fuel burned.

Economic or market based approaches for environmental management employ either an emission tax (or emission charge) or emission permits (which could be tradable) as the instruments. The economic instruments are designed to influence the polluters' behavior (and thus the level of their pollutant emissions) through economic means. There are several examples of the use of emission charges in practice. A tax on NO_x emission is in use in several countries (e.g., France, Italy, Norway, Sweden and Switzerland). Similarly, a tax on SO_2 emission has been introduced in a number of countries (e.g., Denmark France, Norway, Sweden and Switzerland). In Switzerland, there is a tax on volatile organic compounds (VOCs) from the emission of aviation engines. In Japan, emission tax was charged as a pollution levy to polluting firms in order to collect revenue to compensate the victims of designated diseases.

Historically, fuel taxes are the most used market mechanism. In general, it is levied in the form of excise duty. In Finland, a special tax (Environmental Damage Tax) system and oil pollution fee for the imported oil are in effect besides an excise tax. Differentiated fuel tax rates based, on the amount of sulfur content of fuel, are also applied in European countries. In Germany eco-tax is levied along with the excise duty. The eco-tax was in the form of an environmental tax designed to make energy and resource consumption more expensive.

A refund based tax system is followed in Sweden, which is not intended to raise revenue but to provide an incentive to the participants for emission reduction. The system imposes tax on the emitting sources based on their SO_2/NOx emission. However, in the case of NOx, the tax is refunded to the participants based on the level of electricity produced so that the tax system benefits the participants generating more energy output with less NOx emission.

The system of allowing emission reduction credits (ERC) and emission trading is in practice in the United States and also in some European countries. In this system, firms are issued an emission permit (allocated to their emission sources) and if the sources reduce emission below the permitted level, the firms are given a credit for such reductions. These credits could be used by the same firm or through trade by another firm to meet the latter's emission reduction target. This system usually lowers the cost of abatement as compared to the Command and Control (CAC) approach. In the US, in its sulfur emission allowance mechanism under the Acid Rain Program, some portion of the surplus allowances is auctioned to the public. Agencies lobbying for environment protection are allowed to buy the credits (allowances) in the auction. These credits are also allowed to retire physically so that the emission is permanently reduced on the following year. Innovative approaches in emission trading include the mechanisms of Offset, Bubble, Netting and Banking which are in practice in the US.

Approaches for voluntary action to reduce emissions include publication of top worst polluters (e.g., in Poland) and green electricity pricing that are in practice in some countries in Europe and US.

Congestion charges have been applied successfully in Singapore, Hong Kong and London on the vehicles entering the designated regions based on the degree of congestion. Though the major focus of this practice is to reduce traffic congestion rather than environmental benefits, it is believed to have also contributed to the improvement of air quality in the cities. Similarly, the license quota system that requires permits to run the new or existing vehicles in Singapore and Chile are some of the successfully adopted mechanisms to control vehicular emission. Banning of vehicles from running in designated days of a week was also introduced in Mexico. However, the scheme does not seem to have the desired effect and is reported to be economically inefficient.

Apart from the economic approaches, other emission control measures adopted in different countries include switching to the cleaner energy sources/fuels e.g., hydrogen fuel cell, compressed natural gas (CNG) and electricity. The switch of public passenger transport vehicles in India and Pakistan from Diesel/gasoline to compressed natural gas (CNG) is such an example in the South Asia region of such approach. Use of low sulfur fuel has been widely adapted in the USA and European countries. In Nepal, electric vehicles have been introduced in public passenger transport system. In developing countries like India, China and Nepal, solar water heaters are extensively used for water heating purpose. Similarly, in several countries in Asia: India, Nepal, Bangladesh, Pakistan, Vietnam, China, energy efficient technology for brick making like Vertical Shaft Brick Kiln (VSBK) has been implemented as an alternative to traditional brick kilns.

In many cases emissions of pollutants like CO_2, SO_2 and NOx are closely linked with the level of fossil fuel combustion. Thus, any measure that modifies the level of fossil fuel combustion (e.g. energy conservation by increasing energy efficiency, fuel substitution, change in production level, etc.) would also influence emissions of air pollutants and greenhouse gases simultaneously. Several countries in Europe, Asia and North America are promoting electricity generation from renewable energy sources under the policy of renewable portfolio standards (RPS). They have utilized the mechanisms like feed-in tariffs, tradable green certificates (TGCs), bidding/tendering schemes, investment subsidies, fiscal/financial and green pricing schemes for the purpose. While the policy is aimed primarily at reducing CO_2 emission from electricity generation from thermal power plants, it also can yield co-benefits in the form of reduced SO_2 and/or NOx emissions.

It should be noted that the success of any emission control approach adopted would, to a large extent, depend on the effective monitoring of emissions and enforcement of the policies introduced to control/prevent the emissions.

Upscaling of these good practices requires several pre-requisites. Among them are: i) political will, iii) an institution framework with good technical and human resources to carry out the measures; appropriate rules and regulation that help to carry out such measures; and iii) Awareness and networking among the stakeholders. Demographic characteristics such as population, geography and economy are some factors which need to be considered during the process of upscaling. A reliable information system on emissions and their effects/impacts and the costs of abatement measures are some of the important requirements for upscaling process.

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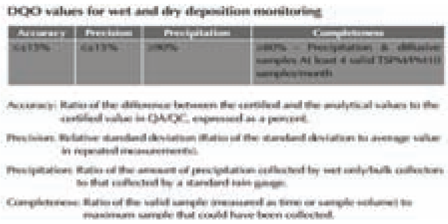
Standard Operating Procedures manual for the Malé Network

S[illegible] Dhara
Cerana Fo[illegible]tion, Hyderaba[illegible]

Objectives of the SOP manual

- SOP manual is a document where required **procedures for various aspects of the monitoring programme are available as easy steps** in one place
- SOP manual is an outline that **NIAs may use to develop their own national SOP manuals**
- SOP manual is meant to **standardize data collection, handling and reporting**
- SOP manual will **help in QA/QC to achieve generation of high quality decision support data**

SOP for monitoring acid deposition

- Scope
  - Criteria for sites
- 

  DQO values for wet and dry deposition monitoring

Accuracy	Precision	Precipitation	Completeness
≤±15%	≤±15%	≥90%	≥80% – Precipitation & diffusive samples At least 4 valid TSP/PM10 samples/month

  Accuracy: Ratio of the difference between the certified and the analytical values to the certified value in QA/QC, expressed as a percent.

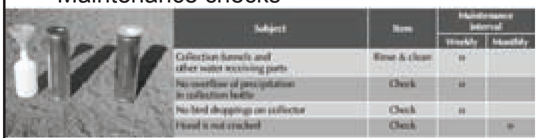
  Precision: Relative standard deviation (Ratio of the standard deviation to average value in repeated measurements).

  Precipitation: Ratio of the amount of precipitation collected by wet only/bulk collectors to that collected by a standard rain gauge.

  Completeness: Ratio of the valid sample (measured as time or sample volume) to maximum sample that could have been collected.
- Preparation of national SOPs
  - Major items to be included in a national SOP
  - Who should use the SOP and where should it be available
  - Human resources

SOP for instruments

- Scope
- Sources for maintenance and operations
- Instrument placement and installation
- Maintenance checks



Subject	Item	Maintenance interval	
		Weekly	Monthly
Collection funnels and other water receiving parts	Rinse & clean	o	
No overflow of precipitation in collection bottle	Check	o	
No bird droppings on collector	Check	o	
Hood is not cracked	Check		o

- Operational procedures
- Vendor's contact

Revisions to SOP

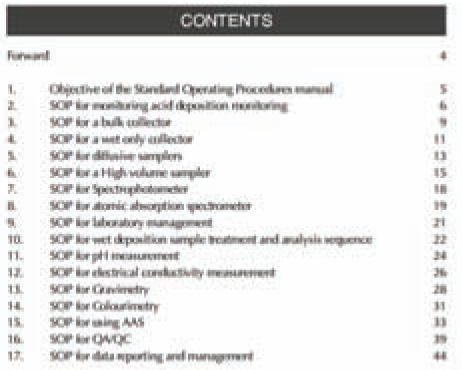
- Analytical methods for anions & cations integrated into single SOPs
- Minor gaps plugged
- Table for recording field experience of problems encountered and how they were solved

Description of problems	Frequency	How the problem was solved	Notes

- All comments & suggestions made re the SOP have been take care of, except:
  - Definition of site
  - Use-friendliness of SOP
- These require further discussion

- Technical manual
  - Vol 1 Introduction to the Malé Network
  - Vol 2 Basic concepts
  - Vol 3 Instruments and analytical methods for the field measurements
  - Vol 4 Instruments and analytical methods for the laboratory
  - Vol 5 Data reporting procedure and formats
  - Vol 6 Quality assurance and control

	Primary vols	Secondary vols
Field data collectors	3, 5	1, 2, 6
Lab scientists	4, 5	1, 2, 6
NIA manager	1, 5, 6	2, 3, 4



CONTENTS

Major items suggested to be included in a national SOP

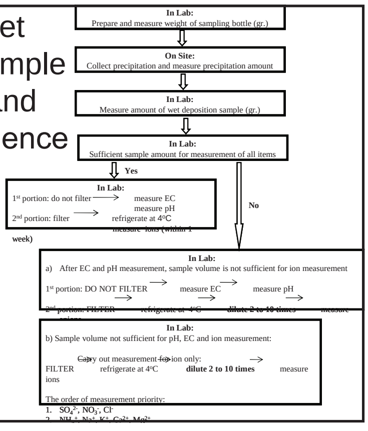
- Sampling
  - Appointment of sampling staff and their supervisors
  - Check for possible changes around the sampling sites
  - Check of sampling instruments apparatus
  - Sampling methods
- Sample transport & storage
  - Transport
  - Storage
- Measurement & chemical analysis
  - Appointment of staff and supervisors for each item
  - Training plan
  - Deionized water
  - Measurement by instruments
  - Operating procedures for instruments
  - Treatment of measurement results

- QA/QC
  - Evaluation of sample collection
  - Evaluation of reliability
  - Evaluation of results
- Management of instruments, reagents & glassware
  - Lab management
  - Instrument management
  - Management of reagents, standards, etc
  - Management of glassware, plastic vessels
- Audits
  - Internal audits
  - External audits

SOP for Lab management

- Scope
- Reference for management method
- Equipment maintenance
- Management of reagents

SOP for wet deposition sample treatment and analysis sequence



- Sample treatment
- Sample analysis sequence

SOPs for various measurements

- Scope
- Reference for measurement
- Range of sensitivity
- Interferences
- Laboratory equipment/Apparatus
- Standard conditions
- Precision and accuracy
- Reagents/Solutions
- Experiment/Measurement
- Computations
- Checking instrument performance
- Calibration
- Precautions
- Causes for errors
- Cleaning method

SOP for QA/QC

- Scope
- References
- Data quality objectives
- Valid sample
- Quality control
- Quality assurance

SOP for data reporting & management

- Scope
- Data types
- Data reporting
- Data reporting formats
- Data storage
- Malé Network secretariat

Thirteenth Session of the Intergovernmental Meeting on
Malé Declaration on Control and Prevention of Air Pollution and
Its Likely Transboundary Effects for South Asia (Malé Declaration)
20 May 2013, Dhaka, Bangladesh

Plan for Phase V of the Malé Declaration (2014-2016)

I. Introduction

1. The implementation of the Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia (Malé Declaration) was envisaged in phases, keeping in mind the Malé Declaration's objectives, content, and thrust. A brief on the progress of each phase is given in the Annex 1.

2. During the last 14 years of implementation, network of policy makers and stakeholders has been established, networks of monitoring and impact assessment have been established, completed several impact assessment studies and communicated to policy makers and stakeholders, and initiated policy measures to control emissions of air pollutants. The Twelfth Session of the Intergovernmental Meeting of the Malé Declaration held in June 2011, agreed to develop source specific protocols to control emissions and agreed on sustainable financing mechanism. Some countries announced financial support for the implementation from the national resources. This provides a unique opportunity to take forward the Malé Declaration.

3. The proposal for Phase V (2014-2016) aims to promote policy measures to control emissions of air pollution including short-lived climate forcers (SLCFs) in South Asia and to ensure the sustainability and ownership of the Malé Declaration in the region. This would be done through the intergovernmental meetings, stakeholders networks, intergovernmental task forces, and Regional Technical Centres for Wet and Dry Deposition Monitoring, Crops and Vegetation Monitoring, Soil Monitoring, Corrosion Impact Assessment, Health Impact Assessment, Emission Inventories, Modelling Atmospheric Transport of Air Pollution, and Pollution Reduction Policies/Strategies.

4. The Malé Declaration conducted an evaluation in the last quarter of 2012, as per Swedish International Development Cooperation Agency (Sida) agreement during phase IV. In summary, the evaluator provided some following recommendations for long-term sustainability. He also provided grading on the performance of the network.

- *More financial independence of the monitoring site comes from internalizing the cost of operation in the national air monitoring schedule. Malé Declaration should try for such a financial inclusion of Malé Declaration activities in the respective country's annual environmental plans.*

- *Malé Declaration is the much needed regional initiative to address one of the most important outcomes of the development – air pollution cutting across boundaries. As in the case of Climate Change, this problem of trans-boundary air pollution also needs response strategies which are "Inter-governmental" in nature and needs significant cooperation among the source and receptor States. Malé Declaration, for the past fourteen years has been largely* *successful in instating the needed mechanism and bringing such coordination. There are few gaps that need to be addressed and also some larger operatives to be brought in such as "regional agreement" to address the trans-boundary air pollution. Therefore, it is very important to build on these foundations created by Malé Declaration in order to fulfill the objective of controlling air pollution and its transboundary effects in South Asia – One of the less developed regions in the World.* ***It is highly recommended that Malé Declaration should continue and help the region fight this trans-boundary problem causing serious health and economic losses****.*

Review Grading of Malé Declaration since its inception (1998-2012)

Review Attributes	***Grading Assigned***
Purpose	*HS*
Means to Attainment of Objectives	*S-HS*
Degree of Attainment of Objectives	*S*
Management of Resources	*S-HS*
Long term Sustainability and Social Relevance	*S*
Overall	*S-HS*

S: Satisfactory
HS: Highly Satisfactory

II. Previous Discussion on Plan for Phase V

5. The Secretariat prepared the draft Plan for Phase V of Malé Declaration and presented during the Third Session of the Task Force on Future Development (TFFD3) held in Chonburi, Thailand in August 2012. The draft plan will be submitted to the IG13 for its review and guidance or approval. Major discussions during the TFFD3 were as follows:

- Strengthening the impact assessment shall be included in the activities for Phase V, i.e. health impact assessment, crop impact assessment and corrosion impact assessment.
- On developing guidelines/standards and protocols, there were suggestions to prioritize by sectors, e.g. automobiles, fuels, brick kilns and other dominant industrial pollutants in the South Asian region.
- Attention was drawn to the need for reduction of emissions of air pollution in the region in response to the observed and expected impact of air pollution on human health, environment, crops and corrosion.
- There was a suggestion to develop a national level master plan for control and prevention of air pollution.
- It was stressed that if the network wants to attract future funding, the link of the Malé Declaration emission activities to the impacts (health and ecosystems) as well as climate change (e.g. Short-lived Climate Pollutants (SLCPs) has to be intensified.

III. Proposed Activities

6. The following are proposed activities for Phase V implementation:

- Develop source specific protocols and guidelines to control emissions of air pollutants

- Strengthening the impact assessment (i.e. health impact assessment, crop impact assessment and corrosion impact assessment)
- Convene meetings of the Task Force on Future Development of Malé Declaration to discuss the future development of Malé Declaration including the source specific protocols and guidelines.
- Convene Intergovernmental Meetings to review the progress and make decisions on further implementation including the source specific protocols and guidelines.
- Convene stakeholders meetings to consult on the implementation of Malé Declaration including the source specific protocols and guidelines, and to raise awareness on air pollution issues.
- Implementation on the activities of the regional technical centres and enable them to conduct studies and communicate the results to policy makers and stakeholders.
- Conduct awareness programmes among policy makers, stakeholders, and youths.

Develop source specific protocols and guidelines to control emissions of air pollutants

7. The analysis of gaps and weaknesses of Malé Declaration should lead to identifying the policy actions at the regional and national level while this should be continuing process. Current experience shows we may have some policy instruments which will complement the on-going national efforts. We could have minimum standards, e.g. automobile, brick kiln, fuels, etc. referring to both terrestrial and non-terrestrial forms. This would be strengthened by technical assistance of experts on standards and thus enable protocols to be drawn up. The phase V implementation will include the development of source specific protocols and guidelines to control emissions of air pollutants.

8. As suggested in TFFD3, on developing guidelines/standards and protocols, we shall make prioritization by sectors, e.g. automobiles, fuels, brick kilns and other dominant industrial pollutants in the South Asian region. The participating countries shall make the listing of the priority areas in their respective countries.

9. In phase V, development of the national level master plan for control and prevention of air pollution will be considered.

Capacity building and strengthening the impact assessment (i.e. health impact assessment, crop impact assessment and corrosion impact assessment

10. Capacity building of national implementing agencies in air pollution, impact assessment and mitigation strategies will continue in Phase V for the MD activities.

11. Impact assessment that involved air pollution and human health and crop loss shall continue in the participating countries. Some studies were undertaken the previous phase and shall be strengthened in the next phase, as suggested in TFFD3.

12. The studies on the link of the Malé Declaration emission activities to the impacts (health and ecosystems) as well as climate change (e.g. Short-lived Climate Pollutants (SLCPs) have to be intensified and strengthened as well.

Convene meetings of the Task Force on Future Development (TFFD)

13. The TFFD will meet in advance so that the outcome can be prepared and presented for the IG meetings. The TFFD will discuss the future development of Malé Declaration including the source specific protocols and guidelines and others, for submission to the Intergovernmental Meeting (IG) every year.

Convene sessions of the Intergovernmental Meeting

14. The sessions of the Intergovernmental Meeting (IG) will be convened annually during the Phase V in order to review the progress and make decisions on further implementation including the source specific protocols and guidelines, etc.

Convene stakeholders meetings

15. The Regional Stakeholders meeting will be convened every 2 years to consult on the implementation of Malé Declaration including the source specific protocols and guidelines, and to raise awareness on air pollution issues in the region. The meeting will also bring together scientific activities on-going in South Asia to inform the Malé stakeholders.

16. The National Stakeholder Meetings will be held in phase V implementation. The design of these meetings will be considered to ensure maximum engagement of the stakeholders at national level.

Implementation on the activities of regional technical centres and enable them to conduct studies and communicate the results to policy makers and stakeholders

17. The basic function of a regional centre is to enhance and exchange knowledge and to support the research and development on air pollution issues in the region on the proposed theme namely: a) dry and wet deposition monitoring; b) soil monitoring c) vegetation monitoring; d) corrosion impact assessment; e) health impact assessment; e) emission inventory compilation f) atmospheric transport modeling; and g) pollution reduction policies/strategies. The activities of the regional centers in accordance with the Terms of Reference adopted by the IG will be implemented and pursued in phase V. The regional centers shall enable to conduct studies and communicate the results to policy makers and stakeholders, among others.

Conduct awareness programmes among policy makers, stakeholders, and youths

18. Regional-level training-cum-awareness workshop will be conducted for policy makers. High-level policy makers in different ministries will also be targeted to broaden the awareness of the issues on transboundary air pollution. Other stakeholders and youth awareness on air pollution issues in the region will be enhanced through trainings and workshops during phase V.

19. The development of newsletter and updating of the MD website at the Secretariat office will continue and enhance.

18. Regional-level training-cum-awareness workshop will be conducted for policy makers. High-level policy makers in different ministries will also be targeted to broaden the awareness of the issues on transboundary air pollution. Other stakeholders and youth awareness on air pollution issues in the region will be enhanced through trainings and workshops during phase V.

19. The development of newsletter and updating of the MD website at the Secretariat office will continue and enhance.

IV. Financial Consideration

20. The Malé Declaration was funded by Sida as part of the Regional Air Pollution in Developing Countries (RAPIDC) Programme. Generous support of Sida is appreciated by the participating countries. The Sida financial support was terminated in December 2012.

21. The contribution of the participating countries is crucial for the successful implementation of Phase V as regional level core activities. Similarly, it is urged that monitoring activities shall continue using national budget.

22. Depending on availability of funding, activities on Malé Declaration will be prioritized in consultation with the member countries.

Regional Level Core Activities

23. The following Table-1 presents the annual budget of each of the core activities under the regional level as agreed by the IG12. It is proposed that for 3 year period of Phase V, the same budget shall apply. Table-2 presents the contributions of the participating countries.

Table-1 for the Budget of Regional Core Level Activities

No.	Activities/Tasks	Estimated Budget (USD)
1	IG Meeting	45,549
2	Regional Stakeholders' Meeting	28,000
3	Regional Refresher Training Workshop on Transboundary air pollution	36,234
4	Regional Training Workshops on Impact Assessment	32,468
5	TFFD of Malé Declaration Meeting	32,517
6	Operational costs and Secretariat cost	47,200
	TOTAL BUDGET	**221,968**

Additional Activities

24. The budget for other activities varies according to the project to be implemented in each of the participating countries.

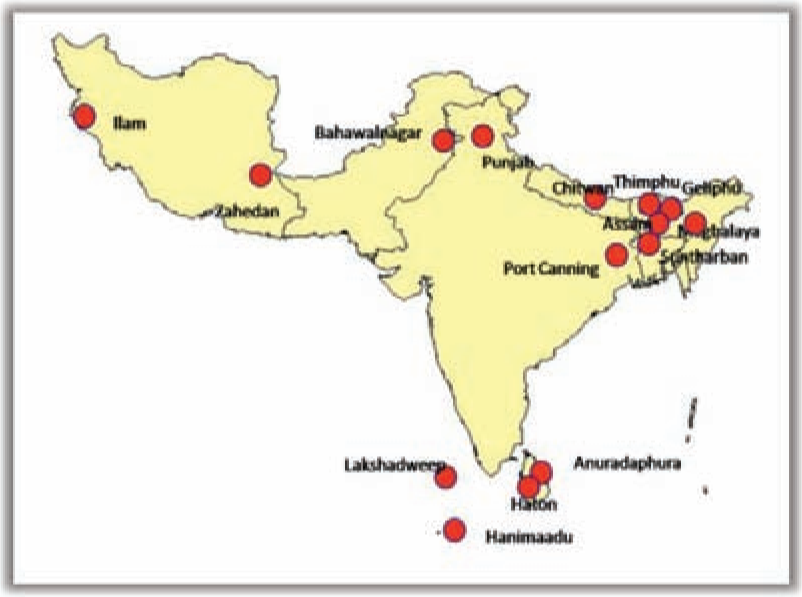
Table 2- Countries Voluntary Contributions for Regional Level Activities in the year 2014-2016 (Annual Basis), for Phase V implementation of Malé Declaration

No.	Name of Country	% in UN Assessment Scale in 2013	% in Malé Declaration	Contributions in US dollar (US $)
1	Bangladesh	0.01	0.87	1,931
2	Bhutan	0.001	0.087	193
3	India	0.666	57.91	128,542
4	Iran	0.356	30.96	68,701
5	Maldives	0.001	0.087	193
6	Nepal	0.006	0.521	1,156.45
7	Pakistan	0.085	7.4	16,426
8	Sri Lanka	0.025	2.174	4,826
Total		1.15	**100**	**US $ 221,968**

Annex 1

THE MALÉ DECLARATION BRIEF

Background



With increasing urbanisation and economic growth, and having a quarter of the world's population, air pollution is an increasing concern in South Asian countries. In 1998, UNEP together with the Stockholm Environment Institute (SEI) drew attention to the possibility of the impacts of transboundary air pollution in South Asia. This initiative led to the adoption of the 'Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia (MD)'. The initiative was funded by the Swedish International Development Cooperation Agency (Sida) as part of the Regional Air Pollution in Developing Countries (RAPIDC) programme. It is the only inter-governmental agreement of its kind covering the eight countries involved.

Participating countries are Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan and Sri Lanka. The South Asia Cooperative Environment programme (SACEP) is also part of the network. Country Governments nominated National Implementing Agencies (NIAs) for the implementation of the MD. UNEP RRC.AP hosts the Secretariat. The implementation is now in Phase IV.

Phase I: 1999-2001

An intergovernmental network was established which governs the MD activities. After Phase I, all the participating countries completed baseline studies and action plans. The baseline studies provided valuable information on air pollution management programmes in the participating countries and clearly identified the gaps in the existing monitoring systems to understand transboundary air pollution.

Phase II: 2001-2004

A capacity building programme was initiated in Phase II which included strengthening the monitoring network and training. National and regional level stakeholders' consultations were also held during this phase. With the completion of Phase II, all the participating countries had established one transboundary air pollution monitoring structure was developed and local capacities in monitoring local and transboundary air pollution had been increased. Common methodology to train technical staff, strengthen monitoring stations and establish scientific and stakeholder networks, was also developed.

One-week hands-on training program on monitoring transboundary air pollution

Phase III: 2005-2008

Phase III implementation continued the capacity building for monitoring initiated during the previous implementation Phase. Capacity building for impact assessment and prevention of air pollution was also initiated. The regional network development was strengthened in a number of ways. Four Intergovernmental Meetings and four Regional Stakeholders cum Regional Coordination meetings and national stakeholder meetings of the MD took place. Capacity on monitoring programme was strengthened though regular regional and national training programme and others activities. A passive sampler Inter-comparison programme and two inter laboratory comparison programmes were conducted for quality assurance and control. Monitoring of ozone O_3 was included as an additional parameter. The emission inventory manual and workbook were continuously improved during Phase III.

An epidemiological study looking into the impacts of particulate matter on asthmatic schoolchildren was successfully undertaken in Bangladesh. The studies and different training workshops on air pollution impact assessment on crops, health, corrosion and rapid urban assessment also presented opportunities for both technical people and policy makers from the ministries to meet hence strengthening the regional and intergovernmental cooperation. Three publications "Past, Present and Future of Malé Declaration; "Good Practices on Prevention and Control of Air Pollution: A Compendium" and "Youth for Clean Air Compendium" were published. An interactive "Youth for Clean Air" CD for youth which contains 4 modules on understanding atmospheric emissions, their sources, impacts and measures to reduce the atmospheric emissions was developed. Bangladesh NIA developed a DVD on "No to Air Pollution, it's Time to Go Healthy" as a part of the public awareness campaign. In addition, the countries and their representatives were kept updated through the quarterly newsletters and the development of MD brochures.

Phase IV: 2010-2012

Phase IV will continue to assist the member countries enhance their regional cooperation, monitoring, impact assessment; strengthen the initiatives started in the first three phases and to initiate new ones. The implementation will follow the institutional arrangement of the MD, which was adopted in IG8 Meeting. A Task Force on Future Development (Task Force) of the MD is established to consider important aspects of the expanding network such as the development of regional centres; development of a regional framework agreement between countries regarding atmospheric emissions of air pollutants; and establishment of a Sustainable Financing Mechanism for the MD. The First Meeting of the Task Force held on 2-3 August 2010 in Thailand, agreed that 1)a mechanism for sustainable financing be developed; 2)a feasibility study on establishing regional centres be conducted; and 3) a feasibility report on strengthening the regional framework on air pollution reduction in South Asia be conducted. Progress on these was reviewed and discussed during the Second Meeting of the Task Force held in Colombo, Sri Lanka, on 29-30 November 2010. The Task Force also agreed to draft a resolution for consideration of the Ministerial Meeting.

A study of the health impact of air pollution on school children, which was carried out during the previous implementation phase will also be conducted in two more MD countries (Nepal and Pakistan). Crop Impact Assessments, to quantify yield losses in relation to prevailing O_3 levels and climate using experimental approaches developed in previous phases of the MD will be conducted in all MD countries. Resulting information will be used to develop risk assessment modelling methods unique for Asia and will be applied for both current day and future conditions to assess macro-scale economic losses for the MD region. A handbook on control and prevention of air pollution which was developed in Phase III will be disseminated to practitioners and policy makers in all the MD participating countries. The national level public awareness campaigns will also be conducted in the countries.

Plan for Phase V 2014-2016

The Secretariat

Introduction

- The implementation of the Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia (Malé Declaration) was envisaged in phases, keeping in mind the Malé Declaration's objectives, content, and thrust. A brief on the progress of each phase is given in the Annex 1.

- During the last 14 years of implementation,
  - network of policy makers and stakeholders has been established,
  - networks of monitoring and impact assessment have been established,
  - completed several impact assessment studies and communicated to policy makers and stakeholders, and
  - initiated policy measures to control emissions of air pollutants..

IG12

- agreed to develop source specific protocols to control emissions and agreed on sustainable financing mechanism.
- Some countries announced financial support for the implementation from the national resources.
- This provides a unique opportunity to take forward the Malé Declaration

Objectives of Phase V:

- This proposal (Phase V) aims to promote policy measures to control emissions of air pollution including short-lived climate forcers (SLCFs) in South Asia and to ensure the sustainability and ownership of the Malé Declaration in the region.
- This would be done through the intergovernmental meetings, stakeholders networks, intergovernmental task forces, and regional technical centres for Wet and Dry Deposition Monitoring, Crops and Vegetation Monitoring, Soil Monitoring, Corrosion Impact Assessment, Health Impact Assessment, Emission Inventories, Modelling Atmospheric Transport of Air Pollution, Pollution Reduction Policies/Strategies.

Evaluation of MD

- The Malé Declaration conducted an evaluation in the last quarter of 2012, as per Swedish International Development Cooperation Agency (Sida) agreement during phase IV. In summary, the evaluator provided recommendations for long term sustainability.

II. Previous Discussion on Plan for Phase V

- Strengthening the impact assessment shall be included in the activities for Phase V, i.e. health impact assessment, crop impact assessment and corrosion impact assessment.
- On developing guidelines/standards and protocols, there were suggestions to prioritize by sectors, e.g. automobiles, fuels, brick kilns and other dominant industrial pollutants in the South Asian region.

- Attention was drawn to the need for reduction of emissions of air pollution in the region in response to the observed and expected impact of air pollution on human health, environment, crops and corrosion.
- There was a suggestion to develop a national level master plan for control and prevention of air pollution.
- To attract future funding, the link of the Malé Declaration emission activities to the impacts (health and ecosystems) as well as climate change (e.g. Short-lived Climate Pollutants (SLCPs) has to be intensified.

III Proposed Activities

1. Develop source specific protocols and guidelines to control emissions of air pollutants
2. Strengthening the impact assessment (i.e. health impact assessment, crop impact assessment and corrosion impact assessment)
3. Convene meetings of the Task Force on Future Development of Malé Declaration to discuss the future development of Malé Declaration including the source specific protocols and guidelines.
4. - Convene Intergovernmental Meetings to review the progress and make decisions on further implementation including the source specific protocols and guidelines.
5. - Convene stakeholders meetings to consult on the implementation of Malé Declaration including the source specific protocols and guidelines, and to raise awareness on air pollution issues including
6. - Implementation on the activities of the regional technical centres and enable them to conduct studies and communicate the results to policy makers and stakeholders.
7. - Conduct awareness programmes among policy makers, stakeholders, and youths.
8.

III Proposed Activities

- **Develop source specific protocols and guidelines to control emissions of air pollutants**
- As suggested in TFFD3, on developing guidelines/standards and protocols, we shall make prioritization by sectors, e.g. automobiles, fuels, brick kilns and other dominant industrial pollutants in the South Asian region. The participating countries shall make the listing of the priority areas in their respective countries.
- 9. In phase V, development of the national level master plan for control and prevention of air pollution will be considered.

Strengthening The Impact Assessment (I.E. Health Impact Assessment, Crop Impact Assessment And Corrosion Impact Assessment)

- Capacity building of national implementing agencies in air pollution, impact assessment and mitigation strategies will continue in Phase V for the MD activities.
- Impact assessment that involved air pollution and human health and crop loss shall continue in the participating countries.
- The studies on the link of the Malé Declaration emission activities to the impacts (health and ecosystems) as well as climate change (e.g. Short-lived Climate Pollutants (SLCPs) have to be intensified and strengthened as well.

Convene meetings of the Task Force on Future Development (TFFD)

- The TFFD will meet in advance so that the outcome can be prepared and presented for the IG meetings. The TFFD will discuss the future development of Malé Declaration including the source specific protocols and guidelines and others, for submission to the Intergovernmental Meeting (IG) every year.

Convene sessions of the Intergovernmental Meeting

- The sessions of the Intergovernmental Meeting (IG) will be convened annually during the Phase V in order to review the progress and make decisions on further implementation including the source specific protocols and guidelines, etc.

2.4 Convene stakeholders meetings

- The Regional Stakeholders meeting will be convened every 2 years to consult on the implementation of Malé Declaration including the source specific protocols and guidelines, and to raise awareness on air pollution issues in the region. The meeting will also bring together scientific activities on-going in South Asia to inform the Malé stakeholders.
- The National Stakeholder Meetings will be held in phase V implementation. The design of these meetings will be considered to ensure maximum engagement of the stakeholders at national level.

CENTRES AND ENABLE THEM TO CONDUCT STUDIES AND COMMUNICATE THE RESULTS TO POLICY MAKERS AND STAKEHOLDERS.

- The basic function of a regional centre is to enhance and exchange knowledge and to support the research and development on air pollution issues in the region on the proposed theme namely:
- a) dry and wet deposition monitoring;
- b) soil monitoring
- c) vegetation monitoring;
- d) corrosion impact assessment; e) health impact assessment; e) emission inventory compilation
- f) atmospheric transport modeling; and
- g) pollution reduction policies/strategies.

- The activities of the regional centers in accordance with the Terms of Reference adopted by the IG will be implemented and pursued in phase V. The regional centers shall enable to conduct studies and communicate the results to policy makers and stakeholders, among others.

Conduct awareness programmes among policy makers, stakeholders, and youths.

- Regional-level training-cum-awareness workshop will be conducted for policy makers.
- High-level policy makers in different ministries will also be targeted to broaden the awareness of the issues on transboundary air pollution.
- Other stakeholders and youth awareness on air pollution issues in the region will be enhanced through trainings and workshops during phase V.
- Newsletter develoment

Financial Contribution

- The contribution of the participating countries is crucial for the successful implementation of **Phase V as regional level core activitie**s. Similarly, it is urged that monitoring activities shall continue using national budget.
- Depending on availability of funding, activities on Malé Declaration will be prioritized in consultation with the member countries.

Regional level core activities

- Annual budget (2014-2016)

	Table for the Budget of Regional Core Level Activities	Estimated Budget (USD)
1	IG Meeting	45,549
2	Regional Stakeholders' Meeting	28,000
3	Regional Refresher Training Workshop on Transboundary air pollution	36,234
4	Regional Training Workshops on Impact Assessment	32,468
5	TFFD of Malé Declaration Meeting	32,517
6	Operational costs and Secretariat cost	47,200
	TOTAL BUDGET	221,968

Additional Activities

- The budget for other activities varies according to the project to be implemented in each of the participating countries.

- Thank you!!!

Thirteenth Session of the Intergovernmental Meeting on
Malé Declaration on Control and Prevention of Air Pollution and
Its Likely Transboundary Effects for South Asia (Malé Declaration)
20 May 2013, Dhaka, Bangladesh

Work Programme in 2013

I. INTRODUCTION

1. The Twelfth Session of the Intergovernmental Meeting (IG12) of the Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia (Malé Declaration) was held in Delhi, India on 30 June 2011. The Session adopted, with modifications the Report of the Task Force for Future Development (TFFD), and its Annexes which include the Draft Resolutions for Consideration of the Ministerial Level Meeting, the Report on the Sustainable Financial Mechanism, the Feasibility Report on the Establishment of Regional Centres, and the Feasibility Report on Strengthening the Regional Framework on Air Pollution Reduction in South Asia. The Workplan 2012 for Malé Declaration was also adopted by the IG12.

2. During the last 14 years of implementation of Malé Declaration, network of policy makers and stakeholders has been developed and established, networks of monitoring and impact assessment have also been established, completed several impact assessment studies and communicated to policy makers and stakeholders, and initiated policy measures to control emissions of air pollutants. The Twelfth Session of the Intergovernmental Meeting of the Malé Declaration held in June 2011, agreed to develop source specific protocols to control emissions and agreed on sustainable financing mechanism. Two countries are already contributing to Malé Declaration while some countries announced financial support for the implementation from the national budget. This provides a unique opportunity to take forward for the Malé Declaration.

3. This report describes the work programme of the Malé Declaration in 2013 discussed at the Third Meeting of the Task Force on Future Development of the Malé Declaration (TFFD3) held in August 2012, and to be adopted at the Thirteenth Session of the Intergovernmental Meeting (IG13).

II. OBJECTIVES

4. Phase IV implementation will continue to focus on assisting the member countries of the Malé Declaration in the reduction of air pollution in the region. The objectives are:

- Strengthen regional cooperation for addressing the air pollution issues in South Asia;
- Strengthen the air pollution monitoring network and conduct regular monitoring;

- Enhance the impact assessment capacity of the national institutions and assess the impacts of air pollution and their socio-economic implications in the participating countries;
- Enhance the capacity of National Implementation Agencies (NIAs) to undertake emission inventory and scenario development, atmospheric transfer modelling of pollutants and Integrated Assessment Modelling;
- Assist the member countries of MD onthe development of air pollution reduction policies and development of the regional framework; and
- Raise awareness for action on air pollution issues through targeted information dissemination.

5. Towards the achievement of the Phase IV objectives, the remaining activities will be done in 2013 based on the availability of resources.

III. STRENGTHEN REGIONAL COOPERATION FOR ADDRESSING AIR POLLUTION ISSUES IN SOUTH ASIA

III-1 Intergovernmental meeting, regional stakeholders cum coordination meeting

6. The Thirteenth Session of the Intergovernmental Meeting (IG13) will be held on 20 May 2013. Countries willing to host the IG13 will be invited to express their intention to the Secretariat. The Secretariat will discuss the date and venue of IG13 with the host country.

7. The following are proposed agenda items for IG13:

- Review of the progress of Malé Declaration activities in 2012;
- Review of the data report and data analysis report on transboundary air pollution monitoring in 2012;
- Review and make decision on the following matters:
  - Draft guidelines for implementation of the sustainable financial mechanism of the MD;
  - Draft guidelines for the next steps of implementation on strengthening the framework on air pollution reduction in South Asia;
  - Draft guidelines for the operation of the regional centres
- Review and guidance on the results of the crop impact assessment studies and health impact assessment studies;
- Review and approval/endorsement of the following reports during the Phase IV implementation activities:
  - Result of 3rd Inter-laboratory Comparison Programme
  - Data Analysis Report 2012
  - Updated Compendium on Good Practices
  - Revised Standard Operating Procedures (SOP)
- Plan for Phase V (2014-2016)
- Consideration and approval of the Work Programme of Malé Declaration in 2013; and
- Any other issues to be raised by the participating countries, etc.

8. The Malé Declaration needs to reach out to, and involve in its activities on various important stakeholders at the regional level. The Seventh Session of the Regional Stakeholders cum Coordination (RSC7) meeting will be held before the IG13 in April 2013. RSC7 may wish to consider the following agenda items, which will be elaborated later by the Secretariat in communication with the participating countries, stakeholders, and representatives of regional initiatives:

- review of the progress of Malé Declaration activities in 2012
- review/discussion on the results of the health impact and crop impact assessment studies conducted under the Malé Declaration
- updates from air pollution related activities in the member countries of MD;
- updates from initiatives focusing on air pollution at regional and sub-regional level; and
- updates from initiatives focusing on air pollution at global level.

III-2 National Stakeholders Meeting

9. The MD also needs to reach out to, and involve in its activities, various important stakeholders at the national levels. All the participating countries have organized national stakeholder meeting in their countries under MD implementation phases. Iran, in cooperation with the Secretariat will convene the national stakeholders in Tehran, Iran on 28-29 May 2013. The major aims of the national stakeholders meetings include:

- increase awareness on transboundary air pollution;
- share and receive stakeholders views and ideas on implementation of the MD; and
- improve the information exchange on the issues relating to tansboundary air pollution.

IV. STRENGTHEN THE AIR POLLUTION MONITORING AND CONDUCT REGULAR MONITORING OF HIGH QUALITY

IV-1 Regional training programme on monitoring

10. The Tenth Regional Refresher training on monitoring transboundary air pollution will be organized during the last quarter of 2013, depending on availability of resources and funds. Major objectives of the training will include:

- review and evaluate the implementation of monitoring programme of MD member countries. including Quality Control and Quality Assurance (QA/QC) programme, specially on the data sampling and analysis;
- Discuss draft report on Malé Declaration in 2011-2012
- Discussion on other issues related to monitoring programme

IV-2 Central compilation, evaluation, and storage of data

11. NIAs will continue to operate the existing monitoring sites. The participating countries will submit the data and related information obtained through the regular monitoring activities to the Secretariat. The Technical Committee (ToC) will conduct a data verification to ensure the quality of the data. After the quality check by the ToC, the data will be added to the regional database. Based on this, a data report for 2011/2012 will be compiled by the Secretariat. After the verifications, the data will be available for the participating countries at http://www.rrcap.ait.asia/male/ website. The data report will also be disseminated to the participating network members.

12. In order to improve monitoring activities at the national level, IG9 decided to develop Standard Operating Procedures (SOP). The SOP manual was finalized for endorsement of the IG13. All NIAs are required to adopt the SOP manual for monitoring stations and translate it to local languages.

V. ENHANCE THE CAPACITY OF NIAS TO UNDERTAKE EMISSION INVENTORY AND SCENARIO DEVELOPMENT, ATMOSPHERIC TRANSFER MODELLING OF POLLUTANTS AND INTEGRATED ASSESSMENT MODELLING

V-1 Emission inventory

13. Most of the participating countries have submitted their national level emission inventories for the year 2000 and 2005. In 2013, NIAs will continue and finalise updating/compiling the emission inventories.

VI. ENHANCE THE IMPACT ASSESSMENT CAPACITY OF THE NATIONAL INSTITUTIONS AND ASSESS THE IMPACTS OF AIR POLLUTION AND THEIR SOCIO-ECONOMIC IMPLICATIONS IN THE PARTICIPATING COUNTRIES

14. National level implementation arrangements for conducting health impact assessment and crop impact assessments studies were conducted in 2011 and 2012. The results of the studies will be presented and discussed during the IG13 and RSC7.

VII. ASSIST THE MEMBER COUNTRIES OF THE MALÉ DECLARATION WITH DEVELOPING AIR POLLUTION REDUCTION POLICIES AND DEVELOPMENT OF A REGIONAL FRAMEWORK

VII-1 Regional workshop on control and prevention of air pollution

15. The first regional-level training-cum-awareness workshop for middle-level policy makers was held on July 2011 at Pathumthani, Thailand. This workshop was designed to place all the information on prevention and control at the fingertips of governments in the region. The

Second Regional Training for Policy Makers will be held in the last quarter of 2013, depending on the availability of the resources.

VIII. RAISE AWARENESS FOR ACTION THROUGH TARGETED INFORMATION DISSEMINATION

VIII-1 Newsletter

16. The MD newsletter was launched in 2002 to disseminate the MD related information to the public and stakeholders. The content of the newsletter has largely been reports on the network's activities. Two issues of the newsletter will be published during 2013 period. NIAs are encouraged to submit articles and news items for the newsletter.

VIII-2 MD website

17. The Secretariat will update the MD website by presenting relevant information on MD activities, such as training programmes, meeting documents, and newsletter. MD website provides useful weblinks to national air quality data from three countries: (i) Central Pollution Control Board (CPCB), India; (ii) Ministry of Environment, Science and Technology, Nepal; and (iii) Air Resource Management Center, Sri Lanka. Other participating countries are encouraged to provide appropriate weblinks to the Secretariat.

Work Programme 2013 of the Malé Declaration

The Secretariat

The Thirteenth Session of the Intergovernmental Meeting (IG13)
20 May 2013, Dhaka, Bangladesh

Phase IV implementation will continue to focus on assisting the member countries of the Malé Declaration in the reduction of air pollution in the region.

Objectives

- Strengthen regional cooperation for addressing the air pollution issues in South Asia;
- Strengthen the air pollution monitoring network and conduct regular monitoring;
- Enhance the impact assessment capacity of the national institutions and assess the impacts of air pollution and their socio-economic implications in the participating countries;
- Enhance the capacity of National Implementation Agencies (NIAs) to undertake emission inventory and scenario development, atmospheric transfer modelling of pollutants and Integrated Assessment Modelling;
- Assist the member countries of MD onthe development of air pollution reduction policies and development of the regional framework; and
- Raise awareness for action on air pollution issues through targeted information dissemination.

Goal: STRENGTHEN REGIONAL COOPERATION FOR ADDRESSING AIR POLLUTION ISSUES IN SOUTH ASIA

ACTIVITIES:

- The Thirteenth Session of the Intergovernmental Meeting (IG13) – 20 May 2013, Dhaka, Bangladesh
- The Seventh Session of the Regional Stakeholders cum Coordination (RSC7) – 18-19 May 2013, Dhaka, Bangladesh
- National Stakeholders Meeting in Iran, 28-29 May 2013, Tehran, Iran

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Goal: STRENGTHEN THE AIR POLLUTION MONITORING AND CONDUCT REGULAR MONITORING OF HIGH QUALITY

- Regional training programme on monitoring
  - The Tenth Regional Refresher training on monitoring transboundary air pollution will be organized during the third quarter of 2013, depending on the availability of resources.
- Central compilation, evaluation, and storage of data.
  - Continued operation of the existing monitoring sites by NIAs
    - Submission of quality data (and report) to the Secretariat with copy to Dr. Parwana
  - Data report 2011-2012 will be compiled and disseminated to the countries
  - Data will be available at http://www.rrcap.ait.asia/male/
  - Adoption of the Standard Operating Operation (SOP) manual for monitoring stations and traslation to local languages

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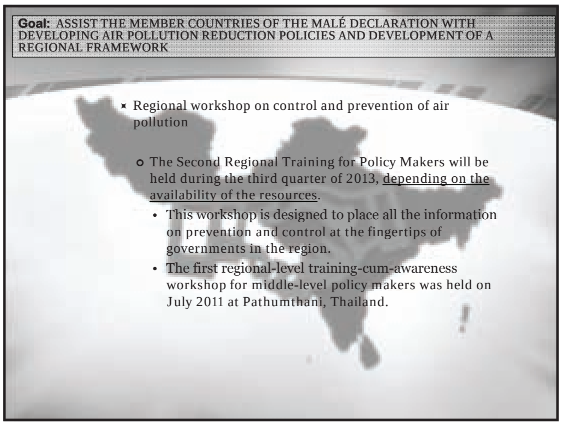
Goal: ENHANCE THE CAPACITY OF NIAs TO UNDERTAKE EMISSION INVENTORY AND SCENARIO DEVELOPMENT, ATMOSPHERIC TRANSFER MODELLING OF POLLUTANTS AND INTEGRATED ASSESSMENT MODELLING

- Emission inventory
  - Most of the participating countries have submitted their national level emission inventories for the year 2000 and 2005. In 2013, NIAs will continue and finalise updating/compiling the emission inventories.

Goal: ENHANCE THE IMPACT ASSESSMENT CAPACITY OF THE NATIONAL INSTITUTIONS AND ASSESS THE IMPACTS OF AIR POLLUTIN AND THEIR SOCIO-ECONOMIC IMPLICATIONS IN THE PARTICIPATING COUNTRIES

- National level implementation arrangements for conducting health impact assessment and crop impact assessments studies were conducted in 2011 and 2012. The results of the studies have just been presented, discussed, and adopted at the IG13 and RSC7.


Goal: ASSIST THE MEMBER COUNTRIES OF THE MALÉ DECLARATION WITH DEVELOPING AIR POLLUTION REDUCTION POLICIES AND DEVELOPMENT OF A REGIONAL FRAMEWORK
Regional workshop on control and prevention of air pollution
The Second Regional Training for Policy Makers will be held during the third quarter of 2013, depending on the availability of the resources.
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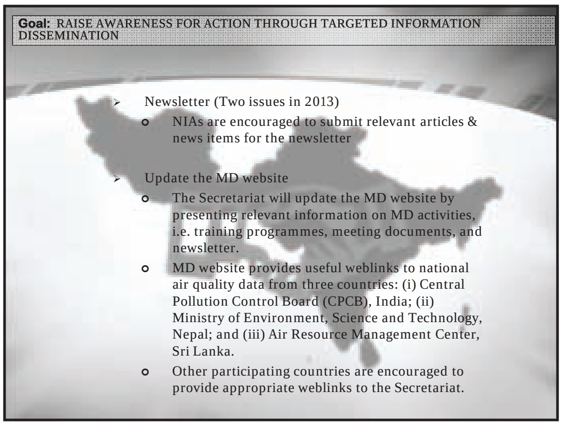
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Newsletter (Two issues in 2013)
NIAs are encouraged to submit relevant articles & news items for the newsletter
Update the MD website
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MD website provides useful weblinks to national air quality data from three countries: (i) Central Pollution Control Board (CPCB), India; (ii) Ministry of Environment, Science and Technology, Nepal; and (iii) Air Resource Management Center, Sri Lanka.
Other participating countries are encouraged to provide appropriate weblinks to the Secretariat.


Goal: RAISE AWARENESS FOR ACTION THROUGH TARGETED INFORMATION DISSEMINATION
Thank you!

Malé Declaration Secretariat, RRC.AP
3rd Floor, Outreach Building, AIT, P.O. Box 4,
Klongluang, Pathumthani 12120, Thailand
Tel: +662-524-5366
Fax: +662-516-2125
E-mail: info@rrcap.ait.asia
URL: http://www.rrcap.ait.asia