Department of Environment
Dhaka, Bangladesh

Norwegian Institute for
Air Research
NILU

Air Quality Management Project, Dhaka, Bangladesh, 2006

Final report

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Herdis Laupsa and Leif Marsteen

NILU: NILU OR 53/2006
REFERENCE: O-105154
DATE: JUNE 2006
ISBN: 82-425-1778-9

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List of Abbreviations

ADACS	Automatic Data Acquisition System
AirMetrics	MiniVol Portable Ambient Air Sampler
AQI	Air Quality Index
AQMP	Air Quality Monitoring Programme
BEMP	Bangladesh Environmental Management Project
CAMS	Continuous Air Monitoring Station
CIDA	Canadian International Development Agency
CO	Carbon monoxide
DoE	Department of Environment
DTAC	Departmental Technical Advisory Committee
EIA	Environment Impact Assessment
EI	Emission inventory
GIS	Geographical Information System
GoB	Government of the People's Republic of Bangladesh
ISO	International Organization for Standardization
NEMAP	The National Environmental Management Action Plan
NILU	Norwegian Institute for Air Research
NO_2	Nitrogen dioxide
NORAD	Norwegian Agency for Development Cooperation
MoE	Ministry of Environment
PM_{10}	Particulate matter with diameter Less than 10 micrometer
$PM_{2,5}$	Particulate matter with diameter Less than 2,5 micrometer
QA	Quality Assurance
QC	Quality Control
SMEC	SMEC International Pty Ltd.
SO_2	Sulphur dioxide
SOP	Standard Operating Procedures
TA	Technical Assistance
TOR	Terms of Reference

1 Introduction

NILU experts have been requested to review the Continuous Air Quality Monitoring Programme under the Air Quality Monitoring Project (AQMP) in Dhaka, Bangladesh. Measurements have been going on for about four years, and the performance of the system as well as the utilization of the data generated was studied and evaluated.

Two experts were appointed to complete the activities as mentioned in the Terms of Reference (ToR) of AQMP in the People's Republic of Bangladesh. The Sub Committee of DTAC (Departmental Technical Advisory Committee) of AQMP has selected the following two experts from NILU as per CVs:

1. Bjarne Sivertsen
2. Steinar Larssen

The project was undertaken during two Missions to Dhaka; Mission 1 in January 2006 and Mission 2 in March 2006. Mr. Bjarne Sivertsen was supported by Ms. Herdis Laupsa, expert on emission inventories and modelling, and Mr. Steinar Larssen was supported by an expert on instruments and QA/QC procedures; Mr. Leif Marsteen.

This report summarises the main conclusions and findings. The contents of the collected information as well as the findings have been reported in a number of reports as shown in the list of project reports in Chapter 4.1.

1.1 Objectives

The main objective of Mission 1 of the project was to review the existing AQM activities in Dhaka, Bangladesh as well as assist in the development of criteria for site selection, development of databases for air quality and meteorological data, updating the training plan, introduce methods for the development of an emission inventory and assist the AQMP staff in the use of dispersion models.

The main objectives of Mission 2 of the project was to review the existing QA/QC systems and plans, evaluate the operations of measurements, review current governmental AQM policies, plans and programs and to suggest future strategies and actions, as well as to assist AQMP in developing a capacity for receptor modelling (source apportionment).

2 Scope of work

The scope of work as given by the Terms of Reference were defined in 11 tasks as follows:

1. Review of the SOP (standard operating procedures) followed at CAMS in terms of air quality monitoring, equipment operation and calibration of all types air quality monitoring equipment available at CAMS and with the AQMP and advise up-gradation where needed including preparation of the upgraded manual.

2. Review manual of the repair and maintenance practice at CAMS and advise improvement to obtain high data capture rate.

3. Evaluate and improve QA/QC plan and practice, which will include calibration methods and frequencies, checklists and logs to record air quality data including maintenance data and data logs. Train and assist AQMP & DOE staff in QA/QC of the air quality monitoring data.

4. Assist in the development of criteria for site selection to get representative spatial data for citywide air pollution and develop a monitoring plan for Dhaka using mobile samplers.

5. Assist in the development of databases for air quality and weather parameters for easy access and dissemination of data.

6. Assist AQMP staff in data management, analysis and report preparation for specific target oriented studies with actual preparation of some such reports.

7. Assists in the development of TOR for small studies and train and assist AQMP with one or more small studies such as Brick Kiln. Assist AQMP staff in preparation of activity of reports as needed.

8. Assist in updating the training plan for AQMP/DoE staff. Review current policies, plans and programs of the Government on air quality management and suggest appropriate strategy for future actions.

9. Help AQMP staff in the methodology for the development of an emission inventory (EI) database for Dhaka city.

10. Assist AQMP staff in the use of open source Dispersion Model to estimate the citywide variation in air pollution level in Dhaka.

11. Assist AQMP staff in the development of methodology and approach on source apportionment using sample from PM sampler at the CAMS.

3 Summary of the reviews, evaluations and recommendations

The project in Dhaka was undertaken based on the scope of work defined in the Terms of reference. The results and main findings from the project are briefly described in the following tasks and presented in the following sections.

- Task 1: Review SOPs and operations at CAMS station.
- Task 2: Review of manual for maintenance and repair.
- Task 3: Evaluate and improve the QA/QC plan and train AQMP staff.
- Task 4: Monitoring sites and site selection
- Task 5: Database for air quality and meteorological data
- Task 6: Data management, analysis and report preparation
- Task 7: Terms of references for small and medium enterprises
- Task 8A: Update training plan for AQMP/DoE staff
- Task 8B: Current policies, plans and programs for AQM
- Task 9, Emission inventory (EI) database for Dhaka city
- Task 10, Dispersion modelling for Dhaka
- Task 11: Source apportionment support to AQMP staff

Our reviews, evaluations and recommendations related to all these tasks are summarised in this chapter.

Task 8A regarding the training plan is put at the end, as a summing up of training needs identified within all of the other separate tasks.

3.1 Tasks 1 and 3: Review SOPs and operations at CAMS station; Evaluate and improve the QA/QC plan and train AQMP staff.

These two tasks are two aspects of the same basic topic, that of QA/QC procedures, and we have found it most effective to discuss them together, both in the Mission 2 report as well as here in the summary report.

Summary of review, evaluation and recommendations:

AQMP is not using any formal quality system nor have they implemented a data quality (QA/QC) plan. They have several forms for documentation of many operations but no Standard Operational Procedures (SOPs) are accompanying the forms. A draft quality manual has been prepared by Mr. John Core, Consultant, which was reviewed by the NILU expert. It contains many useful descriptions of measurement methods and procedures for operating most of the equipment at the CAMS station. The final version of the quality manual was not available at the time of our mission. No training had been given in using the quality manual and hence the procedures and forms had not been put into use. SOPs for some of the instruments can be found in the draft quality manual by Mr. J. Core.

In order to give AQMP a head start in establishing and using QA/QC systems, the framework of such a quality system was proposed and developed during the mission. (The existing draft quality manual was made available to the review team only by the end of out Mission 2. Had we known about it, we would certainly have based our work, review and training upon it. As it were, we developed a new system which, by the way, did not differ much from Mr. Core's). A Quality manual was prepared and installed at CAMS. Some SOPs and forms for gas monitors as well as history log books for most instruments were prepared and made ready for use. Our review and proposals are described in Mission 2 report, Chapters 3.3 and 3.4.

The AQMP staff should follow the procedures in the proposed Quality system. Check lists, calibration sheets and other information on instrument operation and malfunctions should be stored in the history logbooks for later reference. They should further develop the remaining procedures and forms to complete the quality system.

AQMP staff may use the current log books as templates for preparing the remaining logs. Based on the CAM station documentation, AQMP staff may also develop the documentation for the new CAM station in Chittagong.

In the long term and as the number of measurement stations grow, DoE should consider establishing a Reference laboratory. Reference laboratory functions and tasks are briefly described in the Mission 2 report, section 3.4.

Training:

The NILU experts gave introductory training concerning the content of a QA/QC programme such as it should be installed and operated by AQMP. A seminar on Network Operation and QA/QC was given for the staff and the presentation has been reported (see the report list).

We also indicated the future needs for QA/QC training. A useful approach is:

1. AQMP staff to receive initial training, from an external consultant, in basic measurement principles, instrument operations and QA/QC. Typically 2-3 weeks on-site. The goal is to make AQMP staff able to operate the instruments.
2. AQMP staff to receive training in data validation and QA/QC.
3. Follow up training by the consultant two times during the first year. Typically 1-2 weeks per time, on-site. During this training the consultant will check all instruments, initiate preventive maintenance, troubleshooting and do simple repairs together with the AQMP staff. The goal is to advice on necessary repairs, do simple repairs and train AQMP staff in instrument repairs and operation.
4. In dept training on service, repairs and operation, at the consultant.

This approach combines on-the-job training at AQMP site and instrument repairs. The staff receives training and at the same time faulty instruments are diagnosed and some of them repaired. It will result in significantly less instrument downtime, i.e. improved data availability.

3.2 Task 2: Review of the maintenance and repair.

The AQMP staff's experience in instrument maintenance differs depending upon instrument types. The simple AirMetrics MiniVol PM samplers seemed to be known and handled well. However, concerning the use of the automatic monitoring equipment the AQMP staff lacked basic knowledge of the operations and maintenance. This was due to insufficient training or no training at all. Many of the instruments at the CAMS station were not in operation due to breakdowns. Spare parts were available at the CAMS but no repairs had been initiated due to lack of knowledge among the AQMP staff.

A couple of good examples of erroneous procedures that this lack of training resulted in, which seriously affects the quality of monitored data are: For instance the gas analysers were exposed to span gas for only 5 minutes during manual zero/span checks, thus the analysers were set before a stable reading was obtained. When new gas cylinders were installed about one year ago the new gas cylinder concentrations were not updated in the gas calibrator.

Routine and preventive maintenance should be initiated on all instruments in order to prevent breakdowns. It should be considered to hire a consultant to do preventive maintenance at least for a period until the AQMP staffs has received proper training.

All defect instruments should be repaired. It should be considered to discontinue operation of the gas analysers until preventive maintenance is secured either by hiring a consultant or by receiving proper training (see under training, previous task).

Our review and recommendations are described in the Mission 2 report, Chapter 4. Further specific recommendations are found there.

The needed training in monitoring equipment maintenance and repair can be provided by and at NILU.

3.3 Task 4: Monitoring sites and site selection

The NILU experts reviewed the existing AQ monitoring system in Dhaka, and the plans for extending the system, see Mission 1 report, Chapter 3.

The sites selected for measurements of gaseous and particulate matter are mainly to be considered urban background stations, meaning that they are not exposed directly to emissions from any specific source or group of sources, but measure the general concentration level in the area where the station is located.

Gaseous pollutants are measured at only one site, the CAMS station. For PM a total of five additional sites have been identified. During our Mission measurements were being undertaken at 3 of these sites. The expert team visited 4 of the sites. The meteorological station at CAMS measuring the wind speed (horizontal and vertical) and the wind direction in the top of the mast is placed approximately 10-15 m above ground level. The station is located in an open area and seems representative for the general airflow of the rather flat city of Dhaka.

Upgrading of the network

The design of an AQ monitoring network depends upon the monitoring objectives, and this was briefly discussed. Monitoring objectives leads to the need to monitor air pollution in different micro-environments, characterised by influence from various main source categories. European legislation mentions station types like urban background, traffic, industrial, residential, rural background.

In Dhaka, as in other cities, it is important to cover the urban background, since such stations, when well placed, represent the typical, or average, air pollution that the population is exposed to.

It is clear that PM represents the main air pollution problem in Dhaka. The AQ monitoring in Dhaka should concentrate on monitoring of PM_{10} and $PM_{2.5}$, but also NO_X, NO_2, CO, benzene and to some extent ozone must be covered.

Our recommendations regarding network upgrading <u>*in the short term*</u> (1-2 years) include:

- To establish at least one more CAM station, with automatic monitors. The station(s) should measure at least $PM_{2.5}$, PM_{10}, NO_X and NO_2, and CO. PM should be monitored also by automatic instruments (e.g. using the beta absorption method).

  - First priority location is a highly traffic exposed area frequented by people, to get data for the high end of the population exposure distribution.

  - If more than one CAMS can be made available in the short term, the second priority location would be the Lalbagh Fort area.

- It should be considered that one of these new CAMS be acquired as a mobile station, enabling monitoring at different periods at various locations, as part of a screening of hot spot locations in Dhaka, as a preparation for an enhanced monitoring network to be established in the longer term (see below). (See below re. a simpler form of a screening study, using passive/simple sampling equipment).

- To continue to measure $PM_{2.5}$ and PM_{10} at the 5 PM stations now proposed.

- To establish a new PM station located downwind from one of the most polluted industrial areas in Dhaka (e.g. the brick kiln area north of the city).

- To consider to do a screening study of air pollution in Dhaka, using passive sampling methods, as a further basis for selecting the new monitoring locations, to enhance the representativeness of the network to cover average and high population exposure situations in Dhaka.

In the longer term, it is clear that Dhaka needs a much enhanced air quality monitoring network. According to European legislation (AQ Directives), a city with the size and air pollution level like Dhaka (presently about 10 mill inhabitants, and growing fast) should have a minimum number of 10 fixed automatic AQ monitoring stations, the same number as also required by US EPA monitoring network criteria for $PM_{2.5}$. Such an upgraded network should be designed to represent the areas of the city where a significant part of the population is exposed, influenced by the various important source sectors in the city: urban road traffic, various industrial sources and areas, river traffic. The screening studies mentioned above would provide part of the basis for the design of an enhanced network.

NILU can provide training and assistance on design of monitoring networks in Bangladesh.

3.4 Task 5: Database for air quality and meteorological data

The database for storing monitored air quality and meteorological data is a very important part of modern air quality monitoring and management systems. An equally important part is the data acquisition system (DAS) that shall ensure effective transfer of data from the monitors to the database, as well as include functionality for data quality control and correcting data according to established procedures.

The situation in Dhaka at present was reviewed by the NILU experts, see the Mission 1 report, Chapter 4. The WinCollect software installed at AQMP includes a database that could have been used to a larger degree than presently. The main reason is lack of training.

The automatic data retrieval (DAS) system has not worked properly since August 2005. All data are now collected manually from the CAMP station and stored as Excel files on the data acquisition computer.

Presently it seems that new instruments that are provided to AQMP from the World Bank is delivered with another database system. The AQMP staff is worried about having to deal with different data acquisition systems and databases for different stations/cities in Bangladesh, and is concerned that this will hamper the effective and timely data acquisition, which is needed in order to present Air Quality Indicator (AQI) data in the media daily. Also, an effective data acquisition procedure is important for building a quality assured base of air quality data.

During Mission 2 the NILU experts were asked to consider this situation, and make suggestions on how the data acquisition system could be built up to ensure effective and timely operation. This resulted in a Memo (see Mission 2 report, Appendix F), which recommended:

- Use either WinCollect or ScanAir at all CAM stations in Bangladesh, or
- Switch to another, more complete AQM system for all stations and cities, which also has modern capabilities for on-line dissemination of air pollution data to stakeholders, via the Internet or other solutions.

NILU has after the Missions provided an offer concerning data acquisition and database possibilities.

3.5 Task 6: Data management, analysis and report preparation

The daily reports produced by AQMP are based on the generation of an Air Quality Index (AQI). This is presently only used for internal information, and it does not seem to be generated every day and not in real time. The application of this index is thus limited relative to the normal use of such information. The reason is obviously linked to the fact that the monitors are not operating and giving data.

Since PM_{10} represents the main air pollution problem in Dhaka, and PM10 results based upon the weighing of filters at CAMS are available daily, in time for the daily report to be issued, a daily report to the media could be issued based upon PM_{10}.

A monthly report has been generated until 2002 including some air pollution statistics as well as wind roses. Exceeding of standards should be part of this report. We could not see that these reports had been generated during the last year. As far as we were informed only one annual report has been prepared to the World Bank, with the support of an international consultant. This report contained data for 2002 and 2003.

The NILU team recommended that standardised statistical analysis should be performed to assess air quality trends, changes in emissions or impact from specific types or groups of sources. The severity of the air pollution problem or the air quality should be specified relative to air quality limit values, standards or pre defined levels of

classification (e.g. good, moderate, unhealthy, hazardous) (see Mission 1 report, section 5.3).

This type of data management and reporting will need minimum requirements re. database completeness. Long-term averages (annual or seasonal) should be presented relative to limit values.

If DoE/AQMP in the future will limit the studies and assessment of air quality in Dhaka to be based solely on measurements (sampling and monitoring of air pollutants and meteorology) we will recommend that the database system that is presently available at AQMP (WinCollect) be upgraded and adequate training undertaken, so that data can be readily available to AQMP for producing the daily reports to be distributed to the media.

If the objectives are to further develop air quality assessment and planning capability at DoE/AQMP, involving detailed emissions inventories and dispersion modelling, we will recommend that a plan be developed for the establishment of integrated databases and modelling tools, in the form of an integrated AQM system software, including the necessary training needed to operate such systems.

3.6 Task 7: Terms of reference for small and medium enterprises

The studies to be performed for a small and medium sized enterprise would include an impact assessment study. The AQMP staff does not have the proper tools, input data or dispersion models for performing simple preliminary impact assessment studies of polluting industries. AQMP also seems to lack the basic knowledge and background for performing these kinds of investigations.

As an example, we selected to look at the pollution from a brick kiln area in the northwestern outskirts of Dhaka consisting of about 108 stacks. As part of the training the NILU experts together with the AQMP staff visited the area. The data collected as well as the preliminary results of these studies were presented in a seminar the day after the site visit, which has been reported (see the report list).

The AQMP staff was shown how to prepare and produce simple reports for specific target oriented studies of this kind. Some data on these types of industries are available through the permits issued by DoE. A simple Gaussian type dispersion model was also used to generate downwind concentrations from the brick factories. This action was considered part of the initial training in the understanding and use of dispersion models. The model was after the seminar given (free of charge) to the staff at AQMP.

We also prepared a Terms of Reference for the study of impacts from a small industry such as a brick kiln. The first task will be to study and report the impact from one single or a cluster of brick kilns in the Dhaka area. The ToR includes an emission inventory for pollutants emitted from these sources as well as some simple model estimates.

The emissions and the plumes from these factories, which are located quite close to each other, are interacting with each other to the extent that it is necessary to see the whole area as a large area of multiple sources. In addition to the use of dispersion models for impact assessment the ToR also requests to plan and undertake measurements located such that it is possible to evaluate the relative importance of the emissions from these stacks compared to other sources in the area. A report should be submitted to DoE/AQMP.

3.7 Task 8B: Air Quality policy review, and proposed AQM strategy for Bangladesh

3.7.1 Review

The assessments of current policies were based on the Project plan for the AQMP project, the AQMP Project Performa Document of DoE of December 2004, as well as other various documentation made available to us during our Mission 2. These documents gave us a basis for the proposal for development of an air quality management strategy for Dhaka / Bangladesh.

Although some of the elements of an air quality management (AQM) framework has been established within the AQMP project (mostly related to monitoring of air pollutants and reporting of data, establishment of AQ standards and indicators, as well as to the partial control and enforcement of vehicle emissions), an AQM strategy or plan, or a concept for such, has not been formulated. Also, a well-defined AQM policy for Dhaka or Bangladesh, the basis for developing a strategy, has not yet been formulated.

3.7.2 Proposed framework for AQM strategy for Bangladesh

The NILU experts have suggested a framework for the development of an AQM strategy for Bangladesh, to be embedded as a Division or Section on air quality management within the DoE structure (see Mission 2 report, Chapter 6.3).
NILU stated in the Mission 2 report that an air quality management (AQM) strategy should be understood as a structure of organisation, policy formulations based upon analytical elements, and enforcement instruments and awareness raising tools that enables the responsible institution to perform the following tasks:

1. Assess the present air pollution situation, relative to standards and guidelines.
2. Develop control options / potential control strategies based upon firm knowledge of the sources.
3. Analyse the effect of control options and their cost-effectiveness or cost-benefit ratios.
4. Select control strategies for short/medium/long term, and enforce them.
5. Disseminate air quality information to the public and policy makers, including on-line showing of data using the internet.

The strategy / policy formulation represents a necessary foundation for the development of the AQM Plan. The strategy formulation should include a set of main goals and objectives that the AQM Plan is set up to respond to.

An objective for air pollution control activities in Dhaka and BD has been formulated for the AQMP project:
"to reduce the exposure of the population to vehicle pollution in a cost-effective manner".

For the broader AQM Plan and activities in Dhaka and Bangladesh, the objective should be formulated in a more general way, to cover the completeness of the air pollution situation, all sources, and the goal of the activities in the long term must be clear.

The structure we have proposed for the development of air quality strategies for Dhaka is presented in the following Figure.

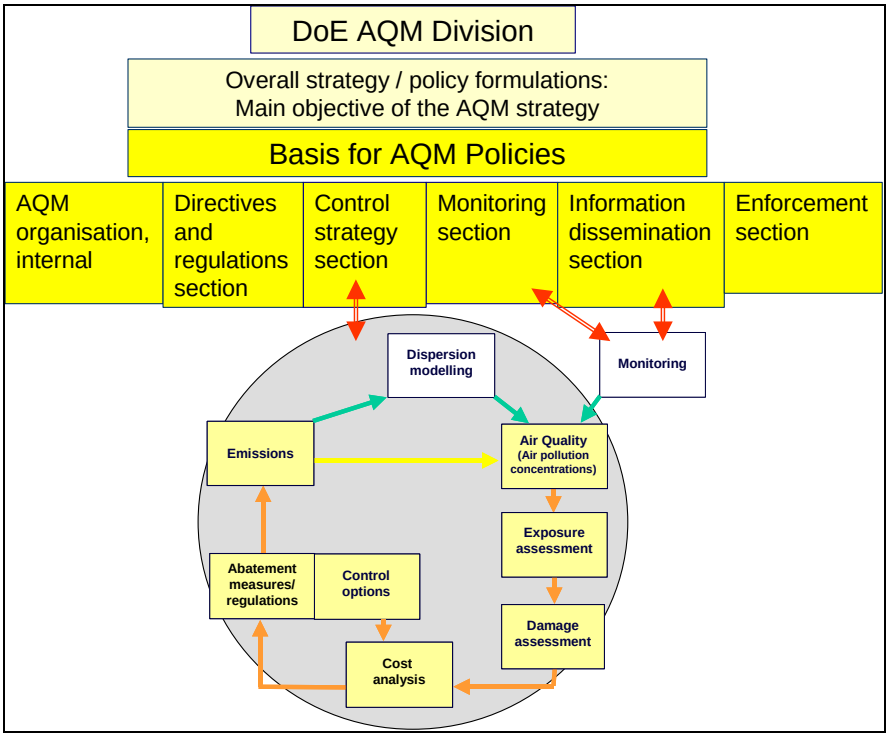

Figure 1: *Suggested structure of activities of an AQM Division or section in DoE with the responsibility of developing strategies and policies for air quality control.*

3.7.3 Institutional capacity

An evaluation of the institutional capacities within DoE for establishing such a division needs to be carried out. Substantial training in air quality management issues and tasks is necessary for the present staff of the AQMP project to start towards the development of such a Division.

3.8 Task 9: Emission inventory database for Dhaka city

A workshop concerning emission inventory was arranged during Mission 1 on 24-25 January 2006. The objectives were to give an introduction to emission inventories and a presentation of how to prepare an emission inventory. The AQMP staff was also given emission inventory templates for collecting emission data. With these tools they could start a process to obtain an emission inventory. Training in how to use the emission inventory templates, exemplified with data from Dhaka was performed during the workshop. Some of the elements in this training workshop were:

1. A short demonstration of how the emission inventory system works as part of an integrated Air Quality Management system.
   - An introduction to emission sources template for point sources, traffic (line) sources and area sources.
     Participants carried out exercise tasks, using the templates to introduce selected sources relevant for the Dhaka emissions situation.

All templates (EXCEL sheets) for making a bottom up emission inventory were given to the AQMP staff.

The work to establish an emissions inventory for Dhaka was discussed with the AQMP staff, on the basis of the work carried out by the Mission 1 experts. Since the road traffic is one of the dominant air pollution sources in Dhaka, emission inventory work could start with mapping the traffic on the streets of Dhaka. Inventorying traffic emissions, as it is detailed in the Excel-based tables (‘templates’) of the AirQUIS emission inventory module, given to the staff could be a good start.

This suggestion was followed-up during Mission 2. A proposal for a classification scheme for road vehicles in Bangladesh was developed, and a traffic counting program set up and presented in a memo. As a training exercise, a traffic counting exercise was carried out on a street close to DoE (Shamoli Street) (see Mission 2 report, Appendix E. Further recommendations on how to continue work on emission inventory was given by the NILU experts, and it was pointed out that a major part of obtaining a proper emission inventory includes training and a continuous collection of source information.

3.9 Task 10: Dispersion Modelling for Dhaka

The staff at AQMP is not familiar with the use of atmospheric dispersion models.

During Mission 1 the NILU experts introduced the AQMP staff to atmospheric dispersion models, and provided them with a simple Gaussian type dispersion model for preliminary impact evaluation for single sources (see Mission 1 report, Chapter 9).

To install and operate complete multi-source dispersion models for a large urban area such as Dhaka will again be a question of training and long-term collection of input data. Training in dispersion modelling is an important part of a basic AQMS training programme.

A variety of different source oriented models are available on the market today. Their complexity depends strongly on the type of problems to be solved. Some models are specifically developed and used for one application only. Very advanced models tend to be used in more research type applications. One should note that it might be an area number of steps in the process from obtaining a model to actually having an operational modelling tool for a city like Dhaka, used correctly by the AQMP staff.

3.9.1 Integrated tools for AQM in Dhaka

The state-of-the-art analytical air quality management framework, which has the aim to develop cost-effective air pollution control solutions for the short, medium and long term, includes the following activities:

a) Assessment of the pollution situation
- Monitoring
- Emission inventorying
- Source contributions from models
- Impact assessment

b) Controlling the sources
- Assess control options,
- Calculating cost-benefit ratios for the options,
- Implement control strategies

c) Information dissemination for public awareness,
- Establish Air Quality Information System
- Long-term operation of the air pollution monitoring network

An AQM Organisation is needed, embedded in the appropriate Government Institution, to formulate policies, develop standards and regulations, and to implement the activities. An integrated AQM software system works as the analytical tool for testing and selecting cost-effective control strategies, as described in Chapter

The first step in approaching the AQM tools and capabilities in Dhaka will be to learn to use the dispersion models and to understand the input requirements.

3.10 Task 11: Source apportionment support to AQMP staff

Source apportionment methods are of two kinds: methods based upon emission inventories and dispersion modelling (from-source-to-receptor), and receptor modelling methods (from receptor-to-source). The methods are complimentary, and both should be used in air quality assessment work.

Source models have not yet been applied to the study of air pollution in Dhaka or Bangladesh (see Task 10 above). Receptor model studies have been carried out rather extensively, through the work of Dr. Bilkis A. Begum and Dr. Swapan K. Biswas of Bangladesh Atomic Energy Centre (BAEC) and their foreign research colleagues. The AQMP staff is not familiar with any of the two main types of source apportionment methods: the use of dispersion models, and the use of receptor models.

A seminar on 'Source apportionment basics' was held during the Mission 2, covering both dispersion modelling techniques (briefly) and receptor modelling methods (see the report list). Dr. Biswas of the BAEC held a two-hour session on receptor modelling during the seminar, which went a bit deeper in the theory of the methods. He also presented in more detail results from his and his colleagues' receptor modelling work in Dhaka and Rajshahi.
A ToR for continued receptor modelling studies was worked out, as well as a memo on the requirements for developing a source apportionment capability within the AQMP project. The AQMP staff needs substantial basic training in source apportionment theory and methods as a basic requirement for developing these capabilities. Regarding receptor modelling, this training can to a large extent be provided by the experts at BAEC in Dhaka. For training in dispersion modelling, training outside Bangladesh is probably needed.

3.11 Task 8A: Update training plan for AQMP/DoE staff

3.11.1 Training needs on specific topics

We have the following impression regarding the training status of the AQMP staff:
- The training given has been mainly on the operation of monitoring equipment. The AQMP staff was trained only for some 15 days per person. Other elements of the institutional building adequate for establishing the knowledge to perform air quality assessment and management has never been given to the staff at AQMP.
- The AQMP staffs is not involved in the ongoing training program for Bangladesh Environmental Management Project (BEMP), which is a joint project of the Government of Canada and the Bangladesh Department of Environment, funded by the Canadian International Development Agency (CIDA). This programme does not seem to include air pollution at all.

There is a need to develop, for Bangladesh, an Air Quality Management (AQM) capability so that the appropriate institution can take the responsibility for working effectively and analytically towards acceptable and better air quality in Bangladesh.

That need should be the basis for the broad primary objective behind an updated training plan for the AQMP leadership and staff.

The training plan needs to include all the aspects of AQM shown in the Figure 1 above, and described in more detail in the Mission 2 report, Chapter 6.3.

The training plan proposed by us includes the technical and analytical aspects related to monitoring and databases, the analytical AQM work needed to develop control strategies, and the information dissemination to stakeholders. Training related to development of regulations and directives, to investigating specific control options for specific sources, and related to enforcement, is not covered in this plan.

Elements of the proposed training plan include:

- Air quality monitoring and QA/QC
- Databases and data assessment
- Emission inventories
- Dispersion and exposure models and modelling
- Receptor modelling
- Air Quality Management

The institutional capacity of DoE needs to be analysed to define gaps and needs relative to the tasks to be handled by an AQM Division. A substantial amount of training is needed for AQMP staff to become more involved with air quality management work, and the development of AQM strategies.

We have indicated the needs for training related to the various tasks that we dealt with in the project, in sections 3.1-3.10 above. An updated offer for a starting, short-term training at NILU has been made to the AQMP Director. A MoU between the relevant institutions in Bangladesh and Norway is being established. This MoU will increase the possibility of more substantial training to be given by NILU.

The elements of the training plan is summarised in the following.

3.11.2 Instrument operations and QA/QC plan and procedures

Specific recommendations on training needs were given as part of Tasks 1, 2 and 3 above.

Training should focus on:

- Measurement principles
- Routine operations at CAMS
- Preventive maintenance
- Troubleshooting and simple repairs
- Validation of status parameters results from tests and calibrations

- Data validation
- QA/QC systems. It is part of all above items.

Training should preferably be performed at the CAM station under normal operating conditions giving the AQMP staff hands-on training on their own instruments and in their own environment. This can be combined with training at an external consultant. NILU can provide this training.

3.11.3 Further training using the available database tools

First priority actions in order to improve the use of the data retrieval and data base system available at AQMP will be to provide more training in the existing WinCollect system. However, this system will always be limited to the measurement and reporting of air quality information collected through samplers and monitors.

For further use of data in air quality assessment and planning there is a need for an integrated tool with a GIS based database system and models for emission inventories and modelling, see under the "Air Quality Management" section below in this chapter.

3.11.4 Emission inventories

Emission inventories need to be developed for cities in Bangladesh. So far, top-down emission inventories have been made for Dhaka, involving only the road traffic sector. If AQMP in the future want to move into Air Quality Management using atmospheric dispersion models is necessary to develop a database for emission data. The full potential of usefulness of emissions inventories is harvested when they are used as part of an integrated AQM process where they are used as input to dispersion modelling. This requires GIS-based bottom-up emissions inventories.

Training in emissions inventorying is a very important part of the AQM training plan. Training to be given in the form of seminars, workshops and on-the-job training. NILU can provide such training.

This training may be part of the development of an integrated air quality monitoring and management system, such as AirQUIS.

3.11.5 Dispersion modelling

A wide range of different atmospheric dispersion models is available on the market and can be purchased. However, air pollution modelling is not a question of having a model but of understanding the physical processes in the atmosphere so that relevant data can be prepared as input. The interpretation and understanding of the output is also necessary to be able to adequately run and use dispersion models.

For this purpose it will be necessary that local experts be trained in the use of models. These experts should preferably have theoretical background in geophysics,

mathematics, meteorology or fluid mechanics. Models can be distinguished on many grounds: e.g. the underlying physical concepts, the temporal and spatial scale, and type of component.

Training in the use of dispersion models is thus highly dependent upon what kind of model is to be applied. General input to modelling can be obtained at the universities or at training courses arranged by various organisations and International Banks. We will propose that the experts selected to run models at DoE follow courses held by providers of models.

NILU can provide a general course on dispersion modelling, as well as special training on NILU models, such as those included in the AirQUIS system.

3.11.6 Receptor modelling

The main objectives in performing receptor modelling or source apportionment methodologies is to quantify source contributions by sector so that appropriate policies can be drafted. Receptor models give the relative contributions of different sources at the site where measurements are collected. Receptor modelling is a complimentary method to dispersion modelling. Receptor modelling is a powerful method for assessing source contributions, and the methods should be part of the capabilities within the AQMP project.

Substantial training is needed for the staff to be able to apply such methods. This training, including also studies of the theories can, for receptor modelling, in principle take place in Dhaka, at BAEC. It can also be part of the activities under the MoU under development between DoE and NILU.

3.11.7 Air Quality Management and development of control strategies

The ultimate aim of all the AQM related work and activities described above is to develop and enforce control strategies. To do this in an analytical and effective fashion, a modern integrated software tool for AQM is needed, as described in Chapter 3.7 above and in more detail in the Mission 2 report, Chapter 6. The establishment and use if such systems in Bangladesh require training, see the section below.

3.11.8 Training on the AQM platform

The following is based on the NILU developed **AirQUIS platform.**
The selection of other platforms may result in a slightly different training programme.

For such training, two to three experts from the AQMP will be invited to Norway for a 6 weeks training session. Working with the system used for emission inventorying, data retrieval, databases, data treatment and presentation, as well as dispersion and exposure modelling will be part of this training.

A summary of capacity building and training activities for the air quality assessment and management component.

Topic	Forum	Trainees
Introduction to the total Air Quality management system	Kick-off seminar	Experts from AQMP
Understanding air quality and the AirQUIS platform	On-the-job in Dhaka, Training at NILU	AQMP experts who will operate the system in the future
Data retrieval and QA/QC	On-the-job in Dhaka, Training at NILU	Experts from AQMP/DoE
Establish complete emission inventories	Workshop and on-the-job	AQMP computer experts
Run air quality dispersion models	Workshop and on-the-job	Experts at AQMP/DoE to run future models
The use of models in air quality planning and abatement strategies	Intro Seminar/ Workshop	AQMP experts
Air quality monitoring and assessment. Meet Norwegian institutions and Authorities	Meetings and seminars in Norway	Experts from MoE/DoE and AQMP
Data treatment, reporting, data dissemination.	Workshop, On-the-job	Experts and users

3.11.9 Possible future co-operation Bangladesh-Norway

In order to support the present AQMP or the future "air quality division", a MoU between DoE and NILU is being developed. This MoU can provide a basis for delivering parts of the training and capacity building needed by AQMP and DoE.

4 Project reports

Larssen, S. (2006a) Air Quality Management Project, Dhaka, Bangladesh, 2006. Air Quality Management (AQM) Seminar and proposed plan for the development of an AQM strategy for Bangladesh. Kjeller (NILU F 7/2006).

Larssen, S. (2006b) Air Quality Management Project, Dhaka, Bangladesh, 2006. Seminar on Source Apportionment Methods. Kjeller (NILU F 6/2006).

Larssen, S. and Marsteen, L. (2006) Air Quality Management Project, Dhaka, Bangladesh, 2006. Final Report Mission 2, 6-17 March 2006. Kjeller (NILU OR 33/2006).

Marsteen, L. (2006) Air Quality Management Project, Dhaka, Bangladesh, 2006. Seminar on Network Operation and QA/QC. Kjeller (NILU F 5/2006).

Sivertsen, B. and Laupsa, H. (2006a) Air Quality Management Project, Dhaka, Bangladesh, Final Report Mission 1, 16-27 January 2006. Kjeller (NILU OR 11/2006).

Sivertsen, B. and Laupsa, H. (2006b) Air Quality Management Project, Dhaka, Bangladesh, Inception Report. Kjeller (NILU OR 10/2006).

Sivertsen, B. and Laupsa, H. (2006c) Air Quality Management Project, Dhaka, Bangladesh, 2006. Seminar on Air Quality Management, Dhaka 23 January 2006. Kjeller (NILU F 2/2006).

Sivertsen, B. and Laupsa, H. (2006d) Air Quality Management Project, Dhaka, Bangladesh, 2006. Seminar on results from Mission 1. Dhaka 26 January 2006. Kjeller (NILU F 1/2006).

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REPORT SERIES SCIENTIFIC REPORT	REPORT NO. NILU OR 53/2006	ISBN 82-425-1778-9 ISSN 0807-7207	
DATE	SIGN.	NO. OF PAGES 23	PRICE NOK 150,-

TITLE	PROJECT LEADER Bjarne Sivertsen
Air Quality Management Project, Dhaka, Bangladesh, Final report.	NILU PROJECT NO. O-105154
AUTHOR(S) Bjarne Sivertsen, Steinar Larssen, Herdis Laupsa and Leif Marsteen	CLASSIFICATION * B
	CONTRACT REF.

REPORT PREPARED FOR
The World Bank

ABSTRACT
NILU experts have been asked by the World Bank to assess and support the Air Quality Assessment work ongoing in Dhaka. This work was undertaken through two Missions to Dhaka in January and March 2006.

A number of tasks were given in the scope of work. This report summarises the findings and conclusions based on 12 tasks identified from the ToR. The NILU expert team has in several occasions pointed to the needs of training. Instruments and manuals had been provided, but the lack of training has lead to break down and malfunctions, especially concerning gas monitors.

Knowledge and methods for Air Quality Assessment, such as emission inventories and models were non-existing. This report also summarises some of the tasks and actions that will have to be taken to bring AQMP in Dhaka to a level when air quality management could be undertaken.

NORWEGIAN TITLE

Air Quality Management Project, Dhaka, Bangladesh, Sluttrapport

KEYWORDS		
Air quality monitoring	Air quality assessment	Dhaka

ABSTRACT (in Norwegian)

** Classification*
A Unclassified (can be ordered from NILU)
B Restricted distribution
C Classified (not to be distributed)