Bangladesh Department of Environment/CASE Project
Poribesh Bhaban
E-16, Agargaon, Shere Bangla Nagar
Dhaka 1207
Bangladesh

Norwegian Institute for Air Research
PO Box 100
2027 Kjeller
Norway

Financed by:
Norwegian Agency for Development Cooperation (NORAD)

BAPMAN

PROJECT REPORT

NORAD
DIREKTORATET FOR UTVIKLINGSSAMARBEID
NORWEGIAN AGENCY FOR DEVELOPMENT COOPERATION

Project:	**Bangladesh Air Pollution Management (BAPMAN)**

Emission Inventory Training Seminar

NILU, 25 - 29 October 2010

Prepared by NILU:

Scott Randall, Bjarne Sivertsen, Vo Thanh Dam and Karl Idar Gjerstad

REPORT NO.:	OR 84/2010
NILU REFERENCE:	O-110055
REV. NO.:	12 November 2010
ISBN:	978-82-425-2335-8 (print) 978-82-425-2336-5 (electronic)

Summary

Funding was secured by NILU through NORAD for the 3-year Bangladesh Air Pollution Management (BAPMAN) project from 2010-2013. The objectives of the BAPMAN project are to train local air quality experts in emission inventories, dispersion modeling, instrumentation protocols, and determining health effects. The purpose of this training seminar at NILU was to train the CASE/DoE experts in the collection of data necessary for the emission inventories for Dhaka, which is a part of Task 1 of the project.

This training seminar is specifically part of Task 1.1 of the project, where the project description states: "Training will be given in types of emission inventorying, sources of information, practical matters, and applications for inventorying. This will provide the basis for completion of Tasks 1.2 and 1.3.". Results from this training seminar will go into producing Deliverable 1.1: "D1.1: Report: Emissions Training Programme: Documentation of its implementation and results", in which this report will be a part of.

The following CASE/DoE staff participated in the training seminar:

- Md. Golam Saroar (Scientific Officer), dispersion modeling expert.
- Md. Masud Rana (Senior Coordinator), emission inventory expert.

The following NILU staff contributed to the training throughout the week:

- Bjarne Sivertsen (Associate Research Director), project advisor.
- Scott Randall (Research Scientist), project manager.
- Vo Thanh Dam (Engineer), Task 1 leader and AirQUIS expert.
- Karl Idar Gjerstad (Research Scientist), emissions inventory expert.
- Rune Ødegård (Head of Development), AirQUIS development expert.

The daily general schedule of the training was as follows:

Date	Topic	Place
25 October 2010	Administrative and introductory discussions	Hotell Fagerborg
26 October 2010	Introduction: NILU, BAPMAN Task 1, AQMS, Emission Inventory, Background Data for Dhaka, Project meeting	NILU
27 October 2010	Emission Inventory Training and Exercises	NILU
28 October 2010	AirQUIS introduction and data collection (questionnaires)	NILU
29 October 2010	AirQUIS exercises, GAINS data analysis, Screening Study, Project meeting	NILU

The training can be considered a success. The primary goals were met and the participants were very active. In addition, many relevant decisions were made throughout the week, and specific tasks were assigned to ensure a steady road to building the emissions inventories in Bangladesh.

Contents

Bangladesh Air Pollution Management (BAPMAN) Emission Inventory Training Seminar; 25-29 October 2010, NILU

1 Introduction

NILU received funding from NORAD for a 3-year project for cooperation with the Bangladesh Clean Air and Sustainable Environment Project within the Department of Environment (CASE/DoE) to provide training and tools to establish a solid and sustainable AQ management and monitoring program in Bangladesh. The Bangladesh Air Pollution Management (BAPMAN) project includes institutional building and knowledge/expertise transfer for Bangladesh local experts to best monitor and manage national AQ issues.

A major part of the institutional building includes training for the four various tasks of the project. These training seminars will be conducted in Dhaka, as well as in NILU. This report is a summary of the first training seminar at NILU, which covered Emission Inventory preparation as part of Task 1.

The following CASE/DoE staff participated in the training seminar:

- Md. Golam Saroar (Scientific Officer), dispersion modeling expert.
- Md. Masud Rana (Senior Coordinator), emission inventory expert.

The following NILU staff contributed to the training throughout the week:

- Bjarne Sivertsen (Associate Research Director), project advisor.
- Scott Randall (Research Scientist), project manager.
- Vo Thanh Dam (Engineer), Task 1 leader.
- Karl Idar Gjerstad (Research Scientist), emission inventory expert.
- Rune Ødegård (Head of Development), AirQUIS development expert.

The specific goals of the training were to:

- Strengthen DoE/CASE Emission Inventory competence to begin work back in Dhaka:
    - Data collection
    - Top-down inventory
    - Bottom-up inventory
- Trained staff to become leaders in work and associated sub-tasks at DoE/CASE

2 Training Seminar Presentations, Exercises, and Meetings

Each separate training presentation, exercise, and meeting is presented below with supplemental information and documents contained in the referenced Appendices. The full Training Seminar Program can be found in Appendix A.

2.1 Introduction

DAY 1	26.10.2010
0930-1000	*Introduction and Welcome*
Responsible:	Bjarne Sivertsen

DAY 1	26.10.2010
1000-1030	*Introduction to NILU*
Responsible:	Scott Randall

The introductory presentations on the morning of the first day were focused on welcoming the experts from Bangladesh, and giving an overview of the training seminar particulars (see Appendix B), as well as giving an introduction to NILU and its offices/facilities (see Appendix C).

2.2 AQMS Review

DAY 1	26.10.2010
1030-1100	*AQMS Review*
Responsible:	Bjarne Sivertsen

The AQMS review presentation (see Appendix D) concentrated on refreshing the Bangladeshi experts on the full-day AQMS training course given in Dhaka on 3 August 2010 (Sivertsen and Marsteen, 2010). The presentation briefly discussed the following topics:

- AQMS elements
- Sources and Emissions Inventories
- AQMP Procedures
- Air Pollution Indicators
- Monitoring instruments
- Dispersion Modeling
- Exposure Assessments
- Action Plans (and examples)
- Information Dissemination

2.3 BAPMAN Project Review

DAY 1	26.10.2010
1100-1130	*Project Review*
Responsible:	Scott Randall

Since the BAPMAN project was still in its beginning phase, it was deemed valuable to review the project goals, purpose, and tasks. The project review presentation (see Appendix E) stressed that the purpose of the project is institutional-building which requires training and is the reason why the training seminar is being held. Since the training seminar was concentrating on Task 1 of the project, the purpose and outcomes of this task were specifically reviewed and discussed. The expected results of the training were also discussed, and this included giving the Bangladeshi experts competence is completing top-down and bottom-up inventories when they return to Dhaka.

2.4 Initial Project (Task 1) Meeting

DAY 1	26.10.2010
1200-1230	*Project Meeting (Task 1)*
Responsible:	Scott Randall

A preliminary project meeting was held which focused on the particulars of Task 1 of the project (see Appendix F). The status of Task 1 was fully discussed, and other tasks were briefly covered. It was also preliminarily discussed the future missions to Dhaka and trainings at NILU, as well as the reports needed to be prepared in the coming months.

2.5 Background Data for the Emission Inventory

DAY 1	26.10.2010
1230-1330	*Background Data*
Responsible:	CASE/DoE

It was requested of CASE/DoE to collect and bring necessary data to begin completing the Emission Inventory. CASE/DoE presented a set of GIS files for Dhaka, but unfortunately it was found that this set was missing the necessary reference file (.prj file) and at that time the data could not be viewed. The “Data Needs” Excel sheet (list of all possible data necessary for the emission inventory) was discussed (see Appendix G - *note that this is an updated version of the sheet completed during the final meeting on 29.10.2010*), and some progress was made on how some of the data could be collected.

2.6 Emission Inventory Introduction

DAY 1	26.10.2010
1330-1600	*Emission Inventory Introduction*
Responsible:	Karl Idar Gjerstad

A thorough presentation was given (see Appendix H) as an introduction to emission inventories and how they are prepared using the AirQUIS modeling system. It was demonstrated how emissions data could be collected and the importance of using questionnaires to collect this data. The AirQUIS emission inventory module was presented, as well as the geographical model and map interface. The final AirQUIS

emissions model was also shown as an example when all data has been collected, prepared, and entered into the system.

2.7 Emission Inventory Excercises

DAY 2	27.10.2010
0900-1130	*Emission Inventory Training I*
Responsible:	Karl Idar Gjerstad, Vo Thanh Dam

DAY 2	27.10.2010
1200-1600	*Emission Inventory Training II*
Responsible:	Karl Idar Gjerstad, Vo Thanh Dam

A full day hands-on training was given based on sets of exercises in order to prepare the input templates, and entering these templates into AirQUIS. During this exercise the full suite of Excel input templates were given electronically to the Bangladeshi experts:

- Emissions Inventory Module
  - Point Sources
  - Line Sources
  - Area Sources
  - Look-up data
- Geographical Module
- Measurement Module
- General Look-up
- Import Overview

2.8 AirQUIS Introduction

DAY 3	28.10.2010
0900-1130	*AirQUIS Introduction*
Responsible:	Rune Ødegård

While AirQUIS had already been mentioned and utilized in the training seminar, it was useful to present the theoretical and conceptual format of the model. Specifically the AirQUIS monitoring, modeling, and information modules were presented and discussed (see Appendix I).

2.9 Emissions Inventory and Questionnaires

DAY 3	28.10.2010
1200-1630	*Emission Inventory Training III*
Responsible:	Karl Idar Gjerstad

Additional emissions inventory exercises were performed, with additional training on how to import this data into AirQUIS. It was discovered in an earlier discussion that not much data exists on point sources in Dhaka, emphasis during this training period was then placed on the creation of questionnaires tailored to Dhaka.

Many different questionnaire templates and examples where presented and discussed, resulting in the decision of two separate questionnaires based on a simple template; one questionnaire for brick kiln point sources, and one questionnaire for "other" industrial point sources. The fields for the brick kiln point source questionnaire were decided upon and a draft questionnaire to these specifications was produced (see Appendix J). It was discussed how it was essential to keep this questionnaire simple and limited to the front of one page. The fields for the "other" industrial point source questionnaire were decided upon and a draft questionnaire based on this was produced (see Appendix K). It was decided that this questionnaire should be limited to the front and back of one page.

2.10 AirQUIS Exercises

DAY 4	29.10.2010
0900-1130	*AirQUIS Exercises*
Responsible:	Vo Thanh Dam

A more in-depth and hands-on training was performed to show the Bangladeshi experts the capabilities of AirQUIS and how to present and organize the emissions data within the system. This exercise was achieved through each expert practicing with a test data set within AirQUIS.

2.11 GAINS Data Analysis for Dhaka

DAY 4	29.10.2010
1200-1330	*GAINS intro and Dhaka report*
Responsible:	Scott Randall

A presentation was given on the recent analysis and draft report being conducted through utilizing the GAINS (Greenhouse Gas and Air Pollution Interactions and Synergies) S.ASIA model for Dhaka (see Appendix L). The analysis is being conducted for the following components in Dhaka:

- Carbon dioxide (CO2)
- Nitrogen oxides (NOx)
- Particulate Matter 10 fraction (PM10)
- Particulate Matter 2.5 fraction (PM2.5)
- Sulfur dioxide (SO2)
- Greenhouse Gasses (GHGs)

These components are being analyzed within the following topic areas for Dhaka:

- Economic Activity Pathways (sectors and activities)
- Emission Control Strategies (mitigation)
- Emissions Scenarios (user-specific)
- Emission Control Costs (related to mitigation)
- Impacts (health)

The GAINS model can give a good screening type estimate of the various components for Dhaka, and the sources and activities responsible for these emissions. The model

is innovative in that scenarios can be developed to project how changes in various sources and/or activities will affect the resulting emissions. The model also takes into consideration how various mitigation efforts can reduce emissions, and the costs involved. The purpose of the model is to analyze the most efficient ways to implement mitigation and manage components in regards to reducing the standard urban emissions **and** GHGs simultaneously.

2.12 Passive Sampler Screening Study

DAY 4	29.10.2010
1330-1500	*Passive Sampler Screening Study*
Responsible:	Bjarne Sivertsen

A presentation was given to introduce the Bangladeshi experts to the purpose, goals, and basic design of a typical air pollution screening study (see Appendix M). After the presentation, the design planned for Dhaka was discussed (see Appendix N), and approximately 15 specific sites (of the 60 planned sites) to place samplers in Dhaka were determined using Google Earth. The Dhaka design will be based on previous screening study campaigns performed in different countries by NILU (Hak, 2010; Sivertsen and Hak 2010; Guerreiro et al., 2005).

2.13 Training Closure

DAY 5	29.10.2010
1500-1530	*Training Closure*
Responsible:	Scott Randall

The training seminar ended with a discussion of the importance of the training and the project purpose of institutional-building. It was determined that the goals of the training were met, and that the Bangladeshi expert participation will allow them to be active leaders on the subject when they return to Dhaka. Official training certificates were given to each training participant.

2.14 Final Project (Task 1) Meeting

DAY 5	29.10.2010
1530-1630	*Project Meeting (Task 1)*
Responsible:	Scott Randall

A final project (Task 1) meeting was held to follow-up on the preliminary project meeting held the first day of training, as well as to summarize the various tasks and assignments which were produced during the trainings and discussions throughout the week. The agenda for the meeting is in Appendix O, and the meeting summary with specific task responsibilities as assigned in the meeting is in Appendix P. Note that the "Data Needs" sheet (found in Appendix G) is a part of the meeting summary because this sheet also lists various assignments for each specific task of the list. The meeting also reviewed the various reports due in the coming months, as well as set some general timeframes from future NILU missions to Dhaka, and trainings at NILU.

3 Conclusions from the Training Seminar

The training can be considered a success, where the primary goals were met and the participants were very active. In addition, many relevant decisions were made throughout the week, and specific tasks were assigned to ensure a steady road to building the emissions inventories in Bangladesh (see Appendix P and corresponding Appendix G for task responsibilities). It was initially hoped that more background data could be brought to the training in order to perform exercises with Dhaka specific data, but a plan was made to collect this necessary data for the inventory.

The documents discussed and transferred to the Bangladeshi experts during the training are as follows (these documents are also located on the project portal at http://bapman.nilu.no):

1. All presentations given – See Appendices
2. AirQUIS manuals – see project portal
3. Excel Input Templates – see project portal
4. Questionnaires (kiln and other industry) – see Appendix J and Appendix K
5. Meeting summary – see Appendix O which was used to create Appendix P
6. Data needs sheet – see Appendix G
7. Prelim Screening study design document - see Appendix N

4 References

Guerreiro, C., Laupsa, H. and Sivertsen, B. (2005) Passive sampling of SO_2 and NO_2 in ambient air in Dakar. Preliminary study, June 2005. Kjeller (NILU OR 46/2005).

Hak, C. (2010) Planning ambient air pollution screening study in Burgas, Bulgaria. Winter 2009/2010. Kjeller (NILU OR 27/2010).

Sivertsen, B. and Hak, C. (2010) Ambient air pollution screening study in Burgas, March 2010. Kjeller (NILU OR 40/2010).

Sivertsen, B. and Marsteen, L. (2010) Air quality management and monitoring seminar. Dhaka, 3 August 2010. Kjeller (NILU F 19/2010).

Appendix A

Training Seminar Program

BAPMAN Training Seminar: Emission Inventories

Hosted by the Norwegian Institute for Air Research

Bjarne Sivertsen, Scott Randall, Karl Idar Gjerstad, Vo Thanh Dam, Rune Ødegård

Kjeller, Norway
26 October – 29 October 2010

This training seminar is a part of Task 1.1 of the NORAD financed Bangladesh Air Pollution Management (BAPMAN) project, where the project description states: "Training will be given in types of emission inventorying, sources of information, practical matters, and applications for inventorying. This will provide the basis for completion of tasks 1.2 and 1.3.". Results from this training seminar will go into producing Deliverable 1.1: "D1.1: Report: Emissions Training Programme: Documentation of its implementation and results".

Seminar Schedule for the week:

TIME/DATE	TUESDAY (Oct 26th)	WEDNESDAY (Oct 27th)	THURSDAY (Oct 28th)	FRIDAY (Oct 29th)
900-930	Arrive at NILU	**Emissions Inventory Training I (KiG, VTD)**: Building AirQUIS database using Oslo data	**AirQUIS intro (RuO)**: AirQUIS basics:	**AirQUIS Exercises I (VTD):** Using old Dhaka data, excercises
930-1000	**Introduction and welcome (BS):** present agenda for week and staff involved. [SR, BS, KiG, VTD, RuO, LTA]		Monitoring	Geo data
1000-1030	**Introduction to NILU (SR):** Intro to organization, purpose, projects, offices	Geo data	Portal	Shape Themes
1030-1100	**AQMS Review (BS)**: AQMS summary and how training fits into entire system.	Point sources	Modeling	
1100-1130	**Project Review (SR):** Review project tasks and how training fits in to these tasks and the entire project.	Line sources	Information	
1130-1200	**LUNCH**	**LUNCH**	**LUNCH**	**LUNCH**
1200-1230	**Task 1 Project Meeting (SR):** admin, documents, each task status, project portal review. [SR, BS, VTD, KiG]	**Emissions Inventory Training II (KiG, VTD)**: Area sources	**Emissions Inventory Training III (KiG, VTD):** Running emission model on database	**GAINS Intro and report (SR)**: Introduction to the top-down GAINS Integrated assessment model, and results for Dhaka. Discussion on sources…
1230-1300	**Background Data (CASE):** Data needs sheet [SR, BS, VTD, KiG]			
1300-1330		Exercises	Excercises	
1330-1400	**Emissions Inventory Intro (KiG, VTD):** Training introduction			**Passive Sampler Screening Study (BS)**: Discuss and plan mission to Dhaka to conduct passivie screening study. [SR, VTD]
1400-1430				
1430-1500				
1500-1530				**Training Closure (SR):** Feedback and certificate. [SR, BS, VTD, KiG]
1530-1600				**Task 1 Project Meeting (SR):** admin, documents, future task assignments, project fact sheet public, etc. [SR, BS, VTD, KiG]
1600-1630				
EVENING	**Project Dinner Lillestrøm (SR)** [All invited]		**Dinner Drøbak (SR)**	**Dinner Oslo (SR)**

DAY 1	26.10.2010
0930-1000	*Introduction and Welcome*
Responsible:	Bjarne Sivertsen

<SEE PPT SLIDES>BAPMAN Intro NILU oct2010.ppt

1. Present Agenda for the week
    a. Technical agenda
    b. Social agenda

2. Present Staff involved
    a. Training staff members
    b. Other BAPMAN team members

3. Purpose of training
    a. Institutional-building
    b. CASE/DoE leaders in topic

4. Practical matters
    a. Meeting room UB
    b. Security/alarms

NOTES:

DAY 1	26.10.2010
1000-1030	*Introduction to NILU*
Responsible:	Scott Randall

<SEE PPT SLIDES> NILUintro.ppt

1. NILU Key figures
2. NILU Organization
3. NILU offices and establishments
4. NILU Vision
5. NILU Research (tasks and topics)
6. NILU Labs and tools
7. NILU assignments

NOTES:

DAY 1	26.10.2010
1030-1100	*AQMS Review*
Responsible:	Bjarne Sivertsen

<SEE PPT SLIDES> AQ1-AQM overview BAPMAN.ppt

- Air Quality Monitoring Program (AQMP) overview
- Air Quality Monitoring System (AQMS) objectives
- AQMS elements
- Sources and Emissions Inventories
- AQMP Procedures
- Air Pollution Indicators
- Monitoring instruments
- Dispersion Modeling
- Exposure Assessments
- Action Plans (and examples)
- Information Dissemination

NOTES:

DAY 1	26.10.2010
1100-1130	*Project Review*
Responsible:	Scott Randall

1. Review Project Description
    a. Overall Project Purpose: training, institutional building

2. Review Task 1
    a. Task 1 Purpose
    b. Task 1 Outcomes

3. Expected results of training seminar
    a. Strengthen emission inventory competence to begin work back in Dhaka with remote assistance from NILU
        i. Top-down inventories
        ii. Bottom-up inventories
    b. For two trained CASE/DoE experts to become leaders in task
    c. DISCUSSION and participation!

NOTES:

DAY 1	26.10.2010
1200-1230	*Project Meeting (Task 1)*
Responsible:	Scott Randall

1. Task Status
    a. Task 1
        i. Data needs sheet
        ii. Training
        iii. Top-down assessment (GAINS – more info Friday).
    b. Task 2
        i. Waiting for station maintenance
    c. Task 3
        i. Delayed due to lack of data
        ii. Intro training (Thursday)
    d. Task 4
        i. Collaboration with Sarah Hossain

2. Reports
    a. Mission 1 Report
    b. Dhaka Training Seminar Report
    c. NILU Training Seminar Report (in progress) -> D1.1

3. Mission 2: Emissions Inventory preparation
    a. November?, or combine with Mission 3?

4. Mission 3: Passive Sampling Screening Study
    a. January 2011

5. Project Portal
    a. Task pages
    b. Literature catalog
    c. Internal Documents

NOTES:

DAY 1	26.10.2010
1230-1330	*Background Data*
Responsible:	CASE/DoE

<SEE XLS SHEET> Bottom-up EI for Dhaka_List of input data for AirQUIS_FINAL

1. Presentation of data collected
    a. Checklist
    b. Actual files (place on web portal)

2. Discussion of agencies and contacts needed to collect missing data

3. Prioritization of missing data needed

4. Assistance in collecting missing data

NOTES:

DAY 1	26.10.2010
1330-1600	*Emission Inventory Introduction*
Responsible:	Karl Idar Gjerstad, Vo Thanh Dam

<SEE PPT SLIDES>

1. AirQUIS concept and functionalities
2. Database and data handeling
3. Emission Inventory approaches
4. Emission Sources
5. GIS Features
6. Modelling

NOTES:

DAY 2	27.10.2010
0900-1130	*Emission Inventory Training I*
Responsible:	Karl Idar Gjerstad, Vo Thanh Dam

1. Building AirQUIS data using Oslo example
2. Geo Data
3. Point Sources
4. Line Sources

NOTES:

DAY 2	27.10.2010
1200-1600	*Emission Inventory Training II*
Responsible:	Karl Idar Gjerstad, Vo Thanh Dam

1. Area sources

2. Exercises

NOTES:

DAY 3	28.10.2010
0900-1130	*AirQUIS Introduction*
Responsible:	Rune Ødegård

<SEE PPT SLIDES>

1. Introduction to NILU's Software and Hardware Development Department (SHaDe)
2. AirQUIS Overall Dataflow – from sensor to web
3. ADACS
4. AirQUIS Monitoring
5. AirQUIS Portal
6. AirQUIS Modelling
7. AirQUIS Information
8. Possible solutions for how to integrate WinCollect Database and AirQUIS Database

NOTES:

DAY 3	28.10.2010
1200-1630	*Emission Inventory Training III*
Responsible:	Karl Idar Gjerstad, Vo Thanh Dam

1. Running Emission model on database

2. Excercises

NOTES:

DAY 4	29.10.2010
0900-1130	*AirQUIS Excercises*
Responsible:	Vo Thanh Dam, Karl Idar Gjerstad

<SEE PPT SLIDES>

1. Geographical data of Dhaka in GIS: Regions, Grid, Stations,
2. Shape themes in AirQUIS: River, Road Network, Brick Kilns points
3. Importing measurement data into AirQUIS

NOTES:

DAY 4	29.10.2010
1200-1330	*GAINS intro and Dhaka report*
Responsible:	Scott Randall

<SEE DRAFT REPORT>

1. GAINS intro

2. GAINS access

3. Data results Dhaka
    a. PM2.5
    b. PM10
    c. SO2
    d. CO2
    e. GHGs

4. Scenario development

NOTES:

DAY 4	29.10.2010
1330-1500	*Passive Sampler Screening Study*
Responsible:	Bjarne Sivertsen

<SEE PPT SLIDES>

1. Intro to Passive Sampling Studies

2. Methods based on Burgas study
    a. See Report

3. Dhaka design
    a. Components: NO2, So2, PM, Ozone
    b. City Transects (Dhaka has primary northerly wind)
        a. North of city suburban (but south of brick kilns)
        b. North of city urban
        c. City Center
        d. South of city urban
    c. Microclimates
        a. Roadside
        b. Street canyons
        c. Urban
    d. Vertical
        a. 2-3 meters over street level (majority)
        b. 5 meters over street level (some)
        c. High over street level (one or two) – all components
    e. Also at existing and planned monitoring station locations

4. Local assistance with distributing samplers
    a. Local training
    b. Map of DoE staff

NOTES:

DAY 5	29.10.2010
1500-1530	*Training Closure*
Responsible:	Scott Randall

1. Summary
2. Importance
3. Feedback
4. Certificates

NOTES:

DAY 5	29.10.2010
1530-1630	*Project Meeting (Task 1)*
Responsible:	Scott Randall

1. Task assignments
2. Future missions
3. Documents
4. Project Fact sheet (public)
5. Administrative

NOTES:

Appendix B

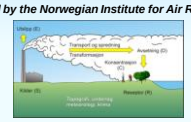
Introduction and Welcome Presentation

BAPMAN

Training Seminar

Emission Inventories

Hosted by the Norwegian Institute for Air Research



Bjarne Sivertsen, Scott Randall, Karl Idar Gjerstad, Vo Dam Tranh, Rune Ødegård

Kjeller, Norway
25 October – 29 October 2010

Purpose and background

General → **Develop expertise at all participating institutions in air quality management**

This visit → **To provide the training necessary to achieve in-house emission inventorying in Bangladesh appropriate to air quality management.**

Today's schedule

930-1000	**Introduction and welcome (BS):** present agenda for week and staff involved. [SR, BS, KiG, VTD, RuO, LTA]
1000-1030	**Introduction to NILU (SR):** Intro to organization, purpose, projects, offices
1030-1100	**AQMS Review (BS):** AQMS summary and how training fits into entire system.
1100-1130	**Project Review (SR):** Review project tasks and how training fits in to these tasks and the entire project.
1130-1200	**LUNCH**
1200-1230	**Task 1 Project Meeting (SR):** admin, documents, each task status, project portal review. [SR, BS, VTD, KiG]
1230-1300	
1300-1330	**Background Data (CASE):** Data needs sheet [SR, BS, VTD, KiG]
1330-1400	
1400-1430	**Emissions Inventory Intro (VTD, KiG):** Training introduction
1430-1500	

19:00 Project dinner Lillestrøm

Schedules

DAY 2	26.10.2010
0900-1400	*Emission Inventory Training I and II*
Responsible	Karl Idar Gjerstad, Vo Tranh Dam

DAY 2	26.10.2010
1400-1600	*GAINS intro and Dhaka report*
Respon	Scott Randall

DAY 3	27.10.2010
0900-1600	*Emission Inventory Training III and IV*
Resp.	Karl Idar Gjerstad, Vo Tranh Dam

DAY 4	28.10.2010
1200-1630	*AirQUIS Excercises*
Responsible:	Karl Idar Gjerstad, Vo Tranh Dam

DAY 4	28.10.2010
0900-1130	*AirQUIS Introduction*
Responsible:	Rune Ødegård

DAY 5	29.10.2010
0900-1030	*Passive Sampler Screening Study*
Resp.	Bjarne Sivertsen

DAY 5	29.10.2010
1030-1130	*Luftkvalitet.info*
Resp:	Scott Randall

DAY 5	29.10.2010
1200-1230	*Training Closure*
Respons.	Scott Randall

DAY 5	29.10.2010
1230-1330	*Project Meeting (Task 1)*
Responsib	Scott Randall

Social Agenda

Monday evening 19:00: Project dinner Lillestrøm
Thursday evening : Dinner at Scott, Drøbak

Friday evening Dinner in Oslo

Sight seeing Oslo
Friday or/and by request

Staff

Name		Title	Expertise	Years of experience
Scott Randall	SR	Scientist	Project management, Air Quality monitoring, GIS and emissions,	10
Bjarne Sivertsen	BS	Research Director	Project lead, Air Quality assessment, AQMplanning, Training	40
Karl Idar Gjerstad	KiG	Scientist	Airquality modelling, Emission inventories, training	11
Rune Ødegård	RuO	Senior Scientist,	AirQUIS, software management, training.	16
Christoffer Stoll	CST	IT expert,	Data transfer, data dissemination, Internet,	6
Leif Marsteen	LM	Senior Scientist	QA/QC, Reference Laboratory specs. training	19
Franck Dauge	FrD	Engineer	Monitoring programme, Instruments, QA/QC	10
Vo Thanh Dam	VTD	Engineer	AirQUIS data handling, training	7
Kyrre Sundseth	KyS	Scientist	Health impacts, scenario analyses Strategy planning	5

Dhaka team

Dr. Mohammed Nasiruddin	Project Management
Mr. Md. Masud Rana	Air Quality Monitoring, Emission Measurement
Mr. Md. Golam Saroar	Air Quality Monitoring, Air Quality Data analysis, Modeling
Mr. Abdul Jalil	
Ms. Sabera Nasrin	
Mr. Ashraf Mahmood	
Mr. Nur Hossain	
Mr. Mohammed Solaiman Haider	Environmental Management. GIS
Md. Asadur Rahman	
Md. Mahbubur Rahman Khan	
Mr. Abdullah Al Mamun	
Mr. Md. Mizanur Rahman	
Mr. Ripon Chandra Sutradar	
Mr. Md. Selim Khan	
Mr. Asudev Kumar Kundu	
Mr. Gazi Md. Mohiuddin	
Mr. Masum Billal	
Dr. Bilkis Ara Begum	Air Quality Monitoring, Data analysis, Receptor Modeling
Dr. Swapan Kumar Biswas	Project Management, Air Quality Monitoring, PM, data anal.

Appendix C

NILU Organizational Information

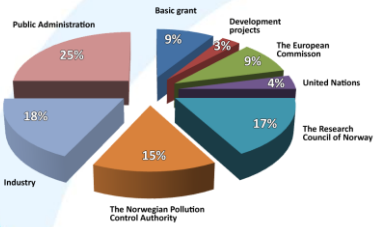
NILU

Making a difference for the environment

NILU's key figures

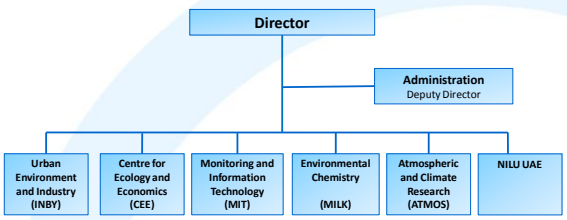
Founded in 1969
Independent foundation from 1986
Annual turnover 164.1 MNOK

181 employees
48 scientists with a PhD



2009

NILU's organisation



Oppdatert 22. mai 2009

NILU's main office…

Is at Kjeller near Lillestrøm

NILU also has 15 employees in the Polar Environment Centre in Tromsø

NILU in the Polar Environment Centre

Focus on
consequenses of pollution and climate change on people in the norhern area

International establishments

NILU is established in:

- Abu Dhabi in The Arab Emirates
- South-Africa and
- Poland

NILUs office in Abu Dhabi

NILU in Abu Dhabi…

is Strategic partner for the Environmental authorities – EAD

Operates the national outdoor air quality monitoring network

Guiding and law preparations on

- Climate change
- Renewable Energy
- Indoor Air and
- Noise Pollution

Our vision

NILU promotes sustainable development and a better quality of life through world class research and science based support within

- climate change
- air quality and
- hazardous substances

Through its research

NILU increases the understanding of processes and effects of

- climate change
- of the composition of the atmosphere
- of air quality
- and of hazardous substances

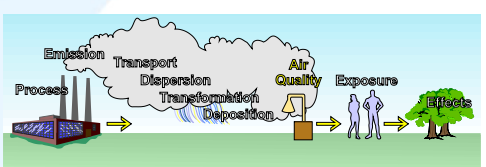
Based on the research

- NILU markets integrated services and products within analysis, monitoring and consulting
- NILU is concerned about increasing the public awareness on climate change and environmental pollution.

NILU's task

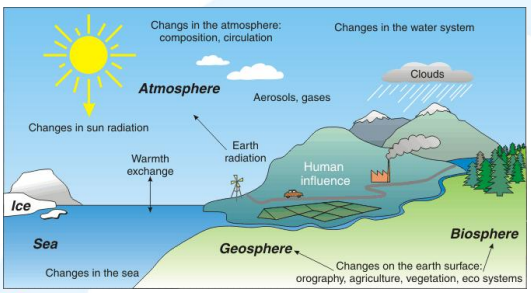
Is to establish quantitative relationships between:

- Emissions
- Dispersion
- Deposition
- Air Quality
- Exposure
- Effects



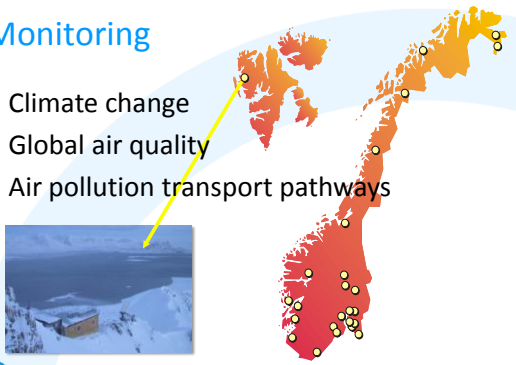
NILU topics

- Atmospheric composition
- GHG and climate forcing agents
- Ozone layer depletion and UV radiation
- Long range transport of air pollution
- Urban and industrial pollution
- Aerosol and particulate matter
- Chemicals and their environmental effects
- Health effect studies
- Ecology and economics



Monitoring

- Climate change
- Global air quality
- Air pollution transport pathways



NILU from pole to pole

NILU monitors climate change, global air quality and air pollution transport pathways

- Zeppelin in the Arctic
- Troll in the Antarctica
- ALOMAR and Birkenes in Norway

Supplying researchers all over the world with important data

Accredited laboratories

Chemical laboratory
- Organic lab
- Inorganic lab

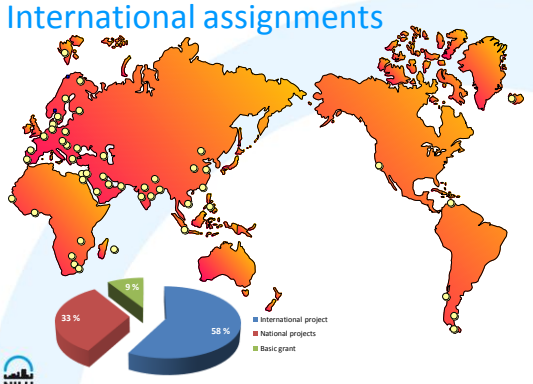
Instruments and IT
- Data transfer and handling
- Instrument development
- Reference laboratory

AirQUIS

A complete Air Quality Management System

- Monitoring
- Data retrieval
- QA/QC
- The GIS database
- Models
- Input data
- EIA
- Forecasts

International assignments



International assignments

Some major NILU clients:

- United Nations Economic Commission for Europe (UNECE),
- European Environmental Agency (EEA)
- European Commission (EC)
- World Bank (IBRD)
- World Meteorological Organization (WMO)
- World Health Organization (WHO)
- United Nations Environment Programme (UNEP)

Development projects:

- NORAD
- DANIDA
- SIDA
- Guangzhou Science and Technology Commission (China)
- Egypt Environmental Affairs Agency
- Department of Mines, Botswana
- HEPA, HCMC Vietnam

NILU

www.nilu.no

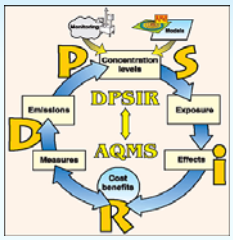
NILU

Appendix D

AQMS Review Presentation

Air Quality Management

Introduction



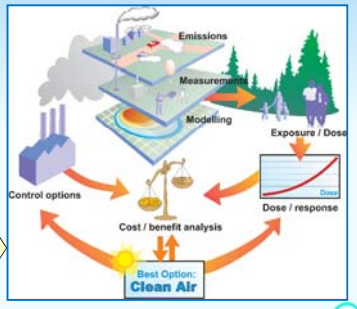
Bjarne Sivertsen, NILU

Sources
Monitoring
Air quality assessment
Modelling
Data dissemination
Abatement planning

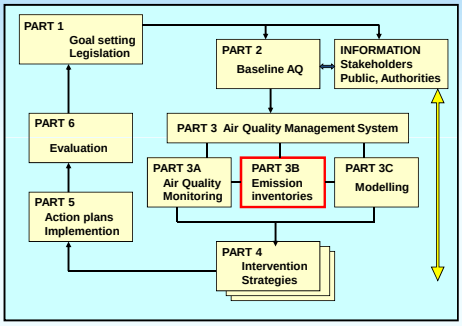
AQMP – main objective

Identify actions to improve air quality

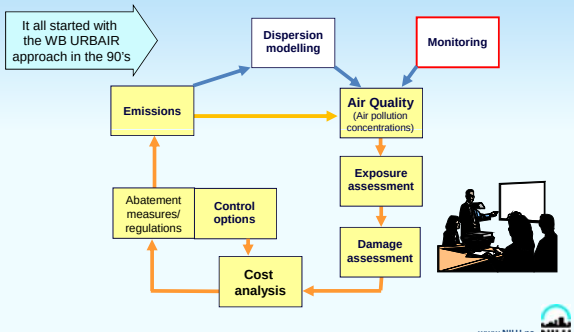
Identify most cost-effective options



AQMP *A dynamic process*



AQ Management Model Concept

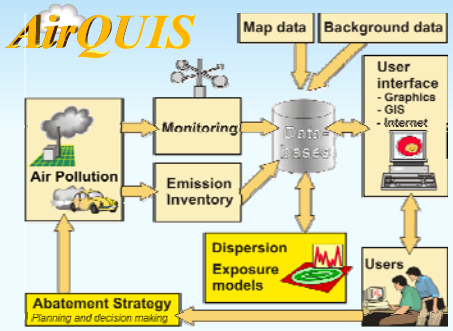


A complete Air Quality Management System

- Monitoring (Air Qual.)
- Meteorological data !
- Data retrieval
- QA/QC
- Databases (GIS based)
- Emission data
- Dispersion Models
- Assessment tools
- Planning tools
- Forecasts (met+AQ)

The AQM SYSTEM

The elements of the AQMS



The emission inventory

" Bottom-up "

Geographical Information System (GIS)

Calculate Emissions → **Modelling**

Point Sources	Line Sources	Area sources
• Industry • Stacks • Consumption • Emission • Production • Emission factors • Time variation	• Static road data (Geography, road classification) • Dynamic traffic data • Emission factors • Time variation	• Consumption • Emission • Production • Source sector • Fuel /Raw material • Emission factors • Time variation

Input data requirements

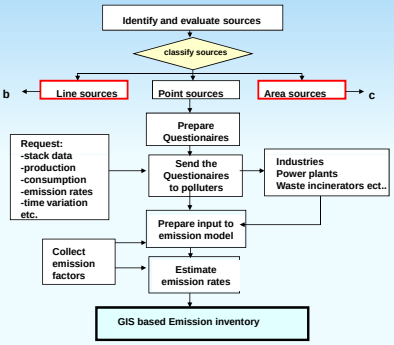
Location

Amount of emission

Variation of the emissions with time (hour of the day, day of the week and year).

- ✓ **Fuel consumption:**
  - various types and qualities of fuel various processes (transport, domestic, industrial)
- ✓ **Traffic activity:**
  - various vehicle classes and traffic data on major roads
- ✓ **Industrial sources:**
  - type, location, production, emissions, emission conditions (stack height, temperature, etc.)
- ✓ **Other sources:**
  - refuse burning, harbour activities etc.
- ✓ **Population data:**
  - geographic distribution within the area
- ✓ **Emission factors:**
  - amount emitted
  - per unit of production per input unit (raw material) per kilometre driven per fuel unit

PART 3 B a: Emission inventories point sources



Point sources

Mainly large emitters that can be attributed to a specific location – defined by:

- ✓ **A single, identified stack**
- ✓ **Geographical co-ordinates,**
- ✓ **Emission generating activities**
- ✓ **and other specific data.**

Emitting activities might be of different types :

- ❖ **combustion activities with fuels and fuel consumption as activity rates**
- ❖ **non-combustion activities without fuels or**
- ❖ **a combination of activities and use of fuels.**

Stacks around the world

Questionnaire

For point sources and industries

EMISSIONS INVENTORY QUESTIONNAIRE

1. GENERAL COMPANY INFORMATION

1.1 Name of company:

1.2 Physical address:	1.3 Postal address:
1.4 Name of contact person:	1.5 Title of contact person:
1.6 Telephone number of contact person:	1.7 Fax number of contact person:

1.8 Site coordinates - X: Y:

1.9 E-mail address of contact person:

1.10 Nature of business:

1.11 Source sector code:

1.12 Total Plant emissions (tons/year)

SO_2	NO_x	PM_{10}	CO	LEAD	TOC	OTHERS

Emission inventory templates

Fuel

Fuel ID	Name
8	Gasoline
19	Diesel
1	Coal
2	Coke

Source Sectors

Source Sector ID	Source Sector Name
1000	Stationary combustion
1100	Industry and energy sectors
1200	Primary industries
1300	Private services
1400	Public administration

Industrial Plant Register

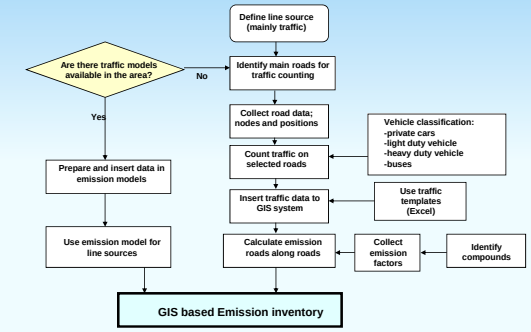
Industrial Plant ID	Name of Industrial Plant	Source sectors Name	Region Name	Owner Name
301005	Industry nr 301005	COMBUSTION INDUSTRIES	Bangladesh	Government
301006	Industry nr 301006	District heating plants	Dhaka	Government
301012	Industry nr 301012	Coal mining, oil / gas extraction, pipeline compressors	Chittagong	Government

Owner ID	Owner Name	Postal Address	Visiting Address	Zip Code	City	Country	Contact person last name	Contact person first name	Title	E-mail	Telephone	Fax
1	NILU	Pb100	Instituttveien 18	2027	Kjeller	Norway	Hansen	Jan	Scientist	HJA@nilu.no	47638988000	47638988500

Stack data

Stack ID	Stack name	X Co-ordinate	Y Co-ordinate	Stack height (m)	Stack Diameter (m)	Gas Temperature (C)	Gas Velocity (m/s)	Gas Flow Rate (m^3/s)	Building Height	Building Width	Industrial Plant Name
30100501	Pipe 301005-1	600669	6645282	10	0.5	130	16.27	3.19	5	10	Industry nr 301005
30100601	Pipe 301006-1	598856	6646044	20	0.5	178	10	2.00	5	10	Industry nr 301006
30101201	Pipe 301012-1	604096	6646518	46	0.9	250	20	6.67	18	28	Industry nr 301012
30101301	Pipe 301013-1	600071	6644966	14	0.4	190	12.6	10.00	6	10	Industry nr 301005
30101502	Pipe 301015-2	598835	6644487	40	3	225	5	35.34	18	40	Industry nr 301006
30101901	Pipe 301019-1	604474	6649890	30	0.8	110	20	10.00	12	18	Industry nr 301012

PART 3 B b: Emission inventories line sources



Line sources

Line sources are:

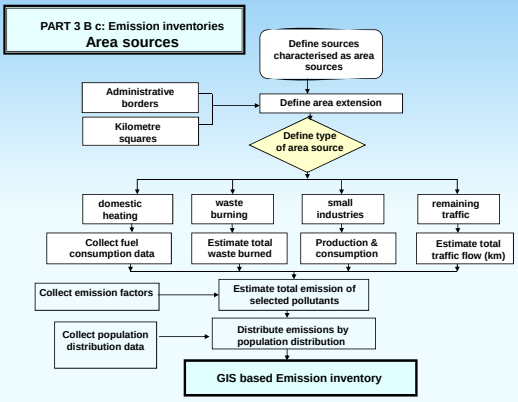
- road transport,
- railways,
- inland navigation,
- shipping or aviation

The lines are sections of the road, railway-track, canal or sea-lane.

Input data

- **Traffic modelling (G-MAT)**
  - **Road network**
  - **ADT**
  - **Vehicle fleet distribution**
- **Traffic counting**
  - **ADT**
  - **Vehicle fleet distribution**
- **Vehicle emission factors**
  - **fuel and technology dependent**

PART 3 B c: Emission inventories Area sources



Area sources

Many small sources
spread over an area
Position not well defined
Normally no or low stacks.

Typical area sources:

- **Stationary source such as residential fuel combustion, domestic heating**
- **Solvent use (e.g., small surface coating operations)**
- **Product storage and transport distribution (e.g., gasoline)**
- **Light industrial / commercial sources, many small enterprises**
- **Agriculture (e.g., feedlots, crop burning)**
- **Waste management (e.g., landfills, open air waste burning)**
- **Miscellaneous area sources (e.g., forest fires, wind erosion, unpaved roads)**

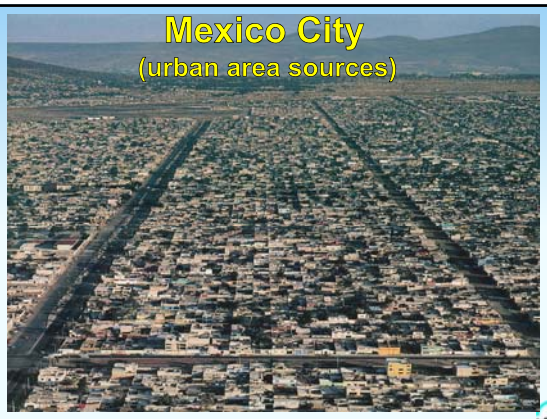
Area sources

Many small diffusive sources in a defined area:

- **Region**
- **County**
- **District**
- **Square kilometre**

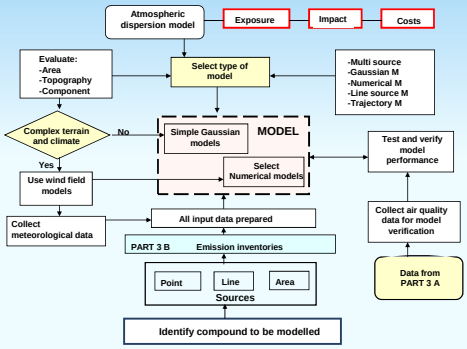
- large number of scattered small sources

Mexico City
(urban area sources)



BS\ NILU \ 2010 www.NILU.no NILU

PART 3 C: Models
Atmospheric dispersion models



BS\ NILU \ 2010 www.NILU.no NILU

AQ monitoring programme Procedures (CASE/WB)

- ✓Planning
- ✓Screening study
- ✓Design monitoring Program
- ✓Instrument procurement
- ✓Installations and QA/QC
- ✓Training
- ✓Data transfer
- ✓Databases
- ✓Data assessment & statistics
- ✓Impact assessment
- ✓Air Q. management planning

BS\ NILU \ 2010 www.NILU.no NILU

Air Pollution Indicators

First priority pollutants

- SO_2 (Sulphur dioxide)
- NO_2 (Nitrogen dioxide)
- PM_{10} (Particles with aerodynamic diameter < 10 micrometer)
- Pb (lead)

Limit values developed for other indicators:

- CO (Carbon monoxide)
- Ozone
- Benzene
- $PM_{2,5}$

PAH (BaP)

BTX

BS\ NILU \ 2010 www.NILU.no NILU

Instruments
instrument procurement

SO_2	➡	fluorescent signal exiting SO_2 with UV
NO, NO_2	➡	chemiluminiscent reaction NO/O
O_3	➡	UV absorption analyser
CO	➡	non-dispersive infrared photometer

Reference instruments !

BS\ NILU \ 2010 www.NILU.no NILU

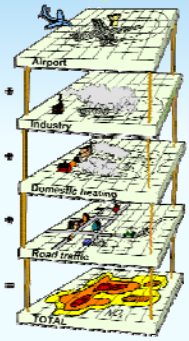
Installation and start-up

- Instrument procurement
- Instrument selections
- Factory Acceptance Test
- Transport of shelter to site
- Installation of equipment inside shelter
- Testing of equipment and telecommunication
- Start-up of systems
- Site Acceptance Test
- Training

CASE

BS\ NILU \ 2010 www.NILU.no NILU

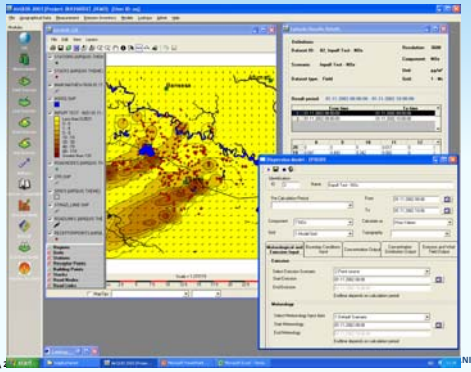
Dispersion modelling



- ✓ Spatial distribution of pollutant concentrations
- ✓ Source contribution quantification
- ✓ Effects of suggested measures
- ✓ Exposure Estimates
- ✓ Forecasting

BS\ NILU \ 2010 www.NILU.no

Dispersion Models

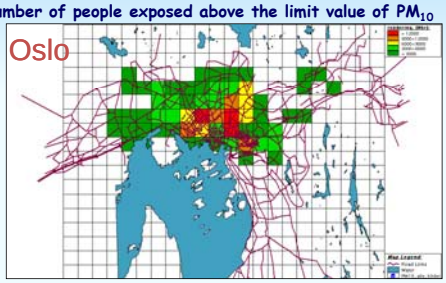


BS\ NILU \ 2010 www.NILU.no

Exposure assessment

Links population data to concentration fields

Number of people exposed above the limit value of PM_{10}



BS\ NILU \ 2010 www.NILU.no

AQMS ➡ Action Plan

AQM tools

- Monitoring /air pollution and meteorology
- Surveys / emissions inventory
- Modelling / air quality and exposure
- Guidelines / Regulations
- Cost Analysis
- Air Quality Information System

assessment

Reduction measures:

- Mobile sources (traffic)
- Stationary sources
- Processes, industries
- Waste handling
- Renewable energy
- Residential sources
- Use of coal

Short term – medium - long term actions

area specific !

BS\ NILU \ 2010 www.NILU.no

Prioritise based on:

Cost of Actions
Sources – Strategies – Technologies
- ✓ Update emission data
- ✓ Validate cost
- ✓ Additional technology
- ✓ Policy options - compliance date
- ✓ Dynamic analyses

A large number og health end points and pollutants
- Chronic mortality from PM
- Infant mortality from PM
- Acute mortality from ozone
- Morbidity impacts from PM
- Morbidity impacts from ozone

Exposure response:
Mortality from chronic exposure: 4 % / 10 µg/m³ PM_{10} (Infant; 0-1 yr)
Increase mortality chronic exposure: 6% / 10 µg/m³ $PM_{2.5}$ (Pope et.al)
Respiratory hospital admission : 1 % / 10 µg/m³ PM_{10} (0-64 yrs)

Value of reduced impacts
Loss of Workhours – illness – death

Cost – benefit !

BS\ NILU \ 2010 www.NILU.no

Planning: examples

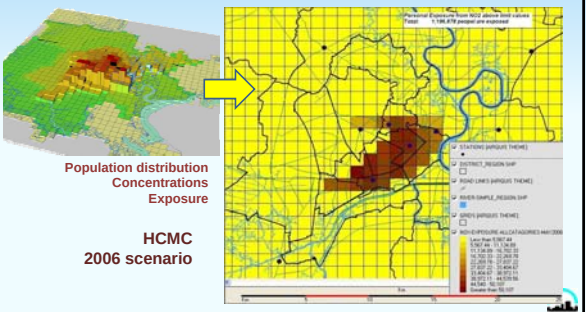
Goal: Cleaner air in HCMC

- ✓evaluate impact of options
- ✓select cost effective actions
- ✓estimate future impacts
- ✓forecast air quality

BS\ NILU \ 2010 www.NILU.no

NO_2 exposure – 1,196 mill people

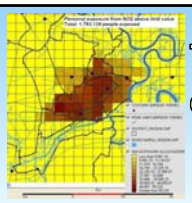
Number of people in areas of NO_2 above limit value for each km²



Population distribution
Concentrations
Exposure

HCMC
2006 scenario

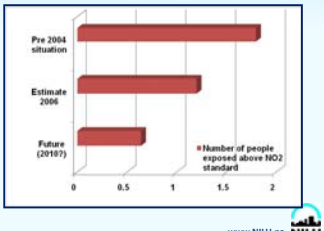
Total NO_2 exposure estimates



Pre 2004 situation: 1,793.139 persons

Future scenario: 639,220 persons

People living in areas with NO2 above limit value: 3 scenarios



费用效益分析
Cost benefit analysis

针对SO_2和TSP的不同控制方案的费用效益分析列表比较（太原）
A comparison of cost-benefit of various control options for SO_2 in Taiyuan

Control option	Conc red.	Cost benefit ratio	
	µg/m3	negative payback	positive payback
Centralized heating	52,0		
Natural gas utilization	20,0		
Clean coal technology	6,2		
Desulphurization in pow	6,5		
Productivity policies	5,8		

-300 -200 -100 0 100 200 300 400

Similar analyses for TSP indicate same top two control options

IPCC YOU CONTROL CLIMATE CHANGE

Co-control, integrated assessment

Climate Change = Our largest threat !

Urban AQ analyses + Green house gas estimates

Urban emission inventories

National inventory

Energy production, fuel consumtion industrial emissions, traffic, waste burning

CO_2 GHG emissions

SO_2, NOx PM, VOC toxics

Reduced CO_2 emissions

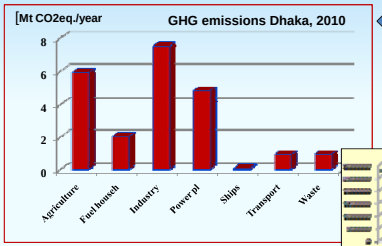
Actions for improved local Air quality

Co-benefit

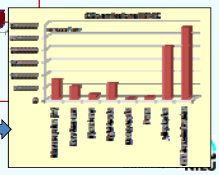
Improve local Air Quality + Reduce green house gas emissions

Top-down + bottom-up

Combined emission approaches



Gains model for overview (integrated emission by sector)



Bottom-up AirQUIS used in HCMC

Information dissemination

Public awareness
Participation
NGO support
Understanding

Concluding remarks

A valuable support tool for decision makers !

In spite of uncertainties in some input data;
(emission inventory, e-factors, meteorology) :

The planning tools (models) are able to:

- ✓ **Estimate source importance**
- ✓ **Exposure to the population (future)**
- ✓ **Relative exposure from traffic**
- ✓ **Impact of planned actions**
- ✓ **Estimate greenhouse gas emissions**

Needs input data !

BS\ NILU \ 2010 www.NILU.no NILU

Appendix E

Project Review Presentation

Project Review

Scott Randall

Kjeller, Norway
25 October 2010

Project Goal

To build up the cross-institutional capability for development of an effective and sustainable air quality management programme in Bangladesh, run by its national institutions, in order that the negative effects of air pollution, particularly upon the health of citizens, may be addressed.

Project Purpose

To develop the technical, institutional and environmental research expertise necessary for effective and sustainable air pollution management in Bangladesh.

The indicators for achievement of this purpose would be:
Establishment of an atmospheric dispersion modelling capability
Establishment of an up to date monitoring and analysis capability
Establishment of a health impact assessment capability
Establishment of a collaborative modus operandi between these.

Task 1 is necessary to complete these indicators

Task 1 Purpose

To provide the training and skills necessary to achieve in-house emission inventorying in Bangladesh appropriate to air quality management.

Training will be given in types of emission inventorying, sources of information, practical matters, and applications for inventorying.

Task 1 Sub-tasks

1.1 Emission Inventory Training

1.1 'Top-down' estimate of total emissions using gross statistical data and available emission factors to identify most of the local air emissions. Data collation and gap identification will be facilitated by contact with local and national traffic and statistical authorities. The necessary four emission categories are: *traffic sources*, *general industrial, shipping and domestic burning*.

1.3 Detailed 'Bottom-up' type/location emission survey for dispersion modelling. The GIS based inventory software integrated in AirQUIS contains the necessary forms and functionalities for producing a complete emissions inventory. Requires completion of Excel templates for point sources, line sources and area sources.

Task 1 Responsibilities

NILU will:
- provide experts and a training course in inventorying of air pollution emissions.
-guide and participate in the actual emissions inventorying work.
-contribute to project reporting (Deliverables).

DOE will:
- provide scientific officers and other personnel to be trained in emissions inventorying. To benefit from continuous training and maximize sustainability, the same individuals will attend successive courses.
-be the responsible partner for developing the actual emission inventories, under NILU guidance. This will involve collection of actual emissions data (activity data such as traffic, consumption data of fossil and other fuels, data on industrial sources, etc.).
-contribute to project reporting (Deliverables).

BAPMAП

Training Expected Results

1. *Preliminary analysis of Dhaka emissions related source data and expereience with exercises.*
2. *Strengthen DoE/CASE Emission Inventory competence to begin work back in Dhaka:*
   - *Data retreival*
   - *Top-down inventory*
   - *Bottom-up inventory*
3. *Trained staff to become leaders in work and associated sub-tasks at DoE/CASE*

DISSCUSION AND QUESTIONS DURING THE ENTIRE TRAINING SEMINAR IS HIGHLY ENCOURAGED!

Appendix F

Initial Project (Task 1) Meeting

Project Meeting

Scott Randall

Kjeller, Norway
26 October 2010

Task Status

TASK 1 (VTD TL):
- Data needs sheet delivered and waiting for results
- Dhaka grid created and approved by DoE/CASE
- Training: this week, and Jan/February/March 2011 Missions
- Prelim Top-down assessment for Dhaka: GAINS

TASK 2 (LM TL):
- Waiting for station maintenance contract for Dhaka, Status?
- Waiting for new stations tender, Status?

TASK 3 (RuO TL):
- Delayed due to lack of monitoring data
- Februrary/March 2011 Mission to install and train AirQUIS

TASK 4 (KyS TL):
- Begin 2nd year
- Contact with Sarah Hossain

Project Reports

1. *Mission 1 Report delivered*
2. *Dhaka Training Seminar Report delivered*
3. *NILU Task 1 Training Seminar Report (D1.1, in progress).*
4. *Future Reports:*
   - Procedures for emissions inventorying for urban areas in Bangladesh (D1.2); NILU and DoE/CASE
   - *NORAD 6 Month status report (February 1, 2011).*
   - AirQUIS establishment: The system established in Dhaka, and personnel trained so that the system can be used sustainably in Bangladesh (D3.1).

Future Project Missions and Training

Mission 2: Passive Sampling Screening Study (Jan/Feb). Include Task 1 Follow-up.

Mission 3: AirQUIS Installation and training (Feb/Mar). Include Task 1 Follow-up.

Task 2 AirQUIS Training at NILU 2011.

Task 1 Emission Inventory Training at NILU 2011.

Project Portal

"Data Needs" Sheet Status

DoE/CASE

Kjeller, Norway
25 October 2010

Appendix G

“Data Needs” Sheet

Geographical data				Priority	Resp.	Available?	Agency/Contact
No.	**Name**	**Definition**	**Type of data**				
1	Regions	Administation borders of different region levels	Digital or paper maps, GIS preferred	1	VTD	obtained	
2	Population	number of people of each region	statistic number, GIS preferred	1	MR	yes	DCC
3	Topography	Height above average see level	Gridded (prefer) or pointed dataset of terrain, GIS	3		?	
4	Road maps	Main traffic system of Dhaka	GIS shape file of road network	1	VTD	obtained	DoE
Historic Measurement data							
No.	**Name**	**Definition**	**Type of data**				
1	Air quality data	Background and urban continuous measurement data in any time resolution: hourly, daily, weekly, annual average	NOx/NO2, O3, CO, PM10/PM2.5, SO2	2	VTD, DoE	historic	DoE
2	Meteorology data	Meteorology data from measurement station or airport or satelite	Wind Direstion (WD), Wind Speed (WS), Upper Temperature (~25m) (UpperT), Lower Temperature (~2m) (LowerT), Delta Temperature (?T), Precipitation, Relative Humidity (RH)	1	VTD	obtained	
Point Sources							
No.	**Name**	**Definition**	**Type of data**				
1	Source sectors	Classifying air pollution industrial sources.	**• Bricks production** **• Smelting** **• Power plants (coal + natural gas)** **• Cement production** • Steel furnace • Glass furnace • Paper production • Plastic • Food processing, Noodle, Vegetable oil • Beverage • Furniture • Textile, dye • Tobaco • Pesticite	1	MR	little	DoE questionaires needed
2	Owner and Plant register	Administrative information	Name, address, contact information	2		maybe	BUET
3	Stack data	The physical and geographical information of each stack within an industry	coordinate, stack height, diameter, gas temperature, gas velocity, gas flow rate, height and width of buildings around the stack	2		maybe	BUET
4	Cleaning device	Cleaning device and it's efficiency used by industry processes	Specific components reduction efficiencies and which stack it is connected to	2		maybe	BUET
5	Process data	Consumption amount of a certain fuel or the direct emission amount for each process	amount of all type of fuels consumption and/or emission from the process	2		maybe	BUET
6	Process emission factor	Emission factors are ratios that relate emission of pollution to an activity at a plant such as amount of fuel used. Process emission factors for each fuel-component	emission factor component, emission factor value	2		maybe	BUET

Line sources							
No.	**Name**	**Definition**	**Type of data**				
1	Road classes	Types of road classes	number of road classes and road types like highways, national roads, city main roads, industrial area roads and some important minor roads	1	MR	yes	
2	Registrated Vehicle Classes (RVC)	Type of vehicles	Light, Heavy and very Heavy Vehicles	1	MR/GS	yes	
3	Road nodes	Road nodes define the start and end point for a road link	(x,y) coordinate and height above ground of the nodes	1	VTD	yes	
4	Static traffic data	Static properties of the road link	Length, direction, total width (not including side walks) for each direction, gradient (%)	1	VTD	yes	
5	Dynamic traffic data	Dynamic data on the road links	ADT (annual daily traffic) is total number of vehicles of all vehicle types for the road link direction, speed limit on the road link in km/h.	3		no	
6	Vehicle distribution	percentage (%) of Registrated Vehicle Classes (RVC) and time variation on each road links	percentage of light, heavy, very heavy vehicles at each road link or road class for each direction	3		no	
8	Emission Calculated Vehicle Classes (ECVC)	The sub class of Registrated Vehicle classes (RVC) is named Emission Calculated Vehicle Classes (ECVC). Classify vehicles into cartegory like motobikes, diesel/gasoline cars, light trucks, heavy duty trucks, busses,...	Separate between different technologies (Precat, EURO1, 2,3...) Average Model Year, Average Driving Distance	2	SR/VTD	no	
9	ECVC – RVC Distribution	The coupling between the Emission Calculated Vehicle Classes (ECVC) and Registered Vehicle Classes (RVC)	percentage of ECVCs for one RVC. The sum of percentage values for one RVC must be 100%.	2	SR/VTD	no	
10	ECVC – Fuel Consumption	the range of fuel consumption for each ECVC depending on the speed	Driving speed (km/h), Fuel consumption (l/km)	2	SR/VTD	no	
11	ECVC Basic and Ageing Facto	The basic factor is the fuel or emission factor for the Average Model Year for a given ECVC. The aging factor adjusts the fuel consumption or emission for the calculation year	Basic factor (g/l if it is fuel based and g/km if it is traffic based), Aging factor for the ECVC.	2	SR/VTD	no	
12	ECVC Speed Dependency Fa	Each ECVC/emission component/speed combination has its own speed dependency factor. Only traffic based emission components are using the speed dependency factors	Driving speed (km/h), Speed dependency factor	2	SR/VTD	no	
Area sources							
No.	**Name**	**Definition**	**Type of data**				
1	Source sectors	Area sources are more diffuse sources of pollution, and are provided on an area basis either for administrative areas, such as counties, municipality etc, or for regular grids	• emissions from coal burning • emissions from Brick plants • emission from wood buring • emissions from small roads • emission from waste burning	2	MR	maybe	ministry of energy, titas
2	Region values	Area source values give the amount of consumption or emission data for each region or grid cell	Type and amount of fuel, Unit (ton/year) or Component and amount of emission, Unit (ton/year) for each region or grid cell	2	MR	maybe	ministry of energy, titas
3	Region Emission Factor Valu	Specify emission factors for each fuel-component -source sector and region	Fuel type and the emission factor is valid for it, Unit (kg/ton)	2	MR	maybe	ministry of energy, titas

Appendix H

Emissions Inventory Introduction Presentation

NILU

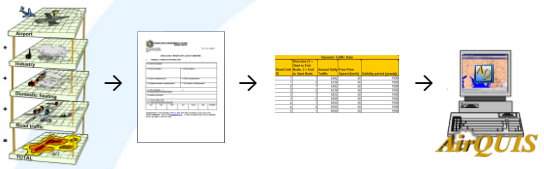
Making a difference for the environment

Agenda- Emission Inventory

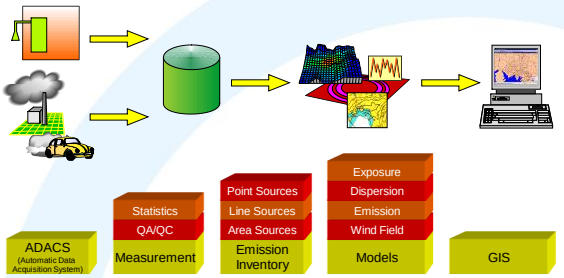
- AirQUIS generally
- Questionnaires
- Emission Inventory Module
- Geographical Module and Map Interface (GIS)
- Emission Model

Information flow

Emission → Questionnair → Templates → AirQUIS



Concept Of AirQUIS



Database

Data are located at one place only and entered only once into the database

The same data are used at several places

Data are defined by references to existing data

AirQUIS Functionality Tools

- Toolbar
- Standard Windows functionality
- Help and tool tips
- Data import and data export
- Overwrite data
- Delete data

Data Import and Export

Data collection
- Excel file templates for data collection

Data import
- Data are imported by drag and drop from xls-files
- Data imported into the presentation spread or import spread

Data export
- Data are exported by copying data from spread

Overwriting and Deleting Data

Overwrite
- It is possible to overwrite data in same way as importing data by using drag and drop. The system checks if the data are new or if a unique key exist.

Delete data
- Data are possible to delete in the presentation spread

Lookup Definition

Simple basis tables used for building more complex data classes

Data that may be different for different locations (projects)

Data that change little in time

General Lookup

Components (partly predefined): Any measured quantity (pollution, meteorology)

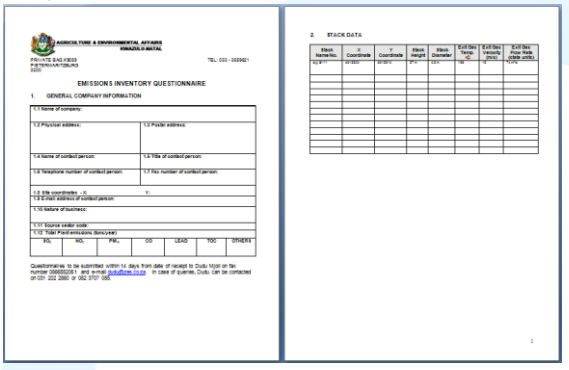
Units (partly predefined): The system has a set of predefined units. All units are assigned to a unit type (e.g. “mass”, “mass per time”)

Validity period (user defined): Predefined time period to use in the system e.g time period to decide for example statistic calculations period and model calculation period

Questionnairs

- First step in building an emission database
- Identify the sources
  - From industry
  - From traffic
  - From houses
  - Other

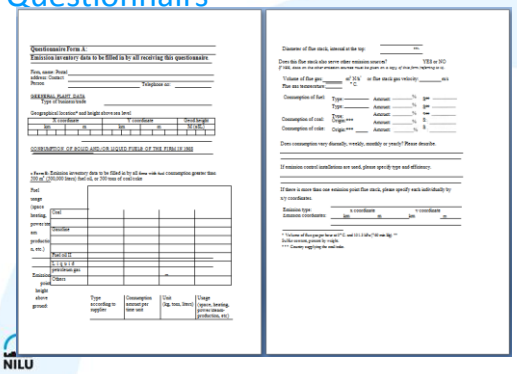
Questionnairs


EMISSIONS INVENTORY QUESTIONNAIRE

1. GENERAL COMPANY INFORMATION

2. STACK DATA

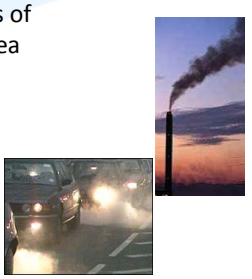
Questionnairs



Air Quality Emission inventories

What is an Emission Inventory?

Atmospheric emissions inventory is a compilation of all sources of air pollution within an area



Emission Inventory Features

Emission inventory Lookups

Point emission

Line emission

Area emission

Why Emission Inventory?

Air quality assessment

Evaluating the sources

Air Quality Management

Abatement strategy

Measure trends over time

How to prepare an emission inventory?

Inventory of emission sources and air pollutants referred to specific geographical areas in defined periods of time

Detailed description of an inventory:

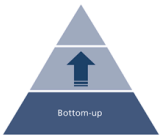
- Geographic area (geographic domain for the inventory)
- Pollutants (purpose the inventory)
- Source Categories (Anthropogenic/Natural sources)
- Modelling (Geographically/time resolution, Pollutant species)
- Spatial resolutions
- Temporal resolution (variability of emissions over time)
- Base year (reference year)

Two different approaches: a) top-down inventory

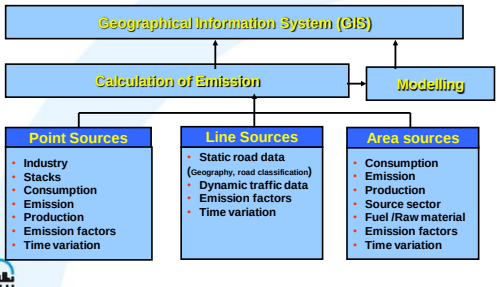
- Activity statistics (consumption,production,vehicle type etc)
- Population statistics, land-use and emission factors
- Detailed information about location not required

Two different approaches: b) bottom-up inventory

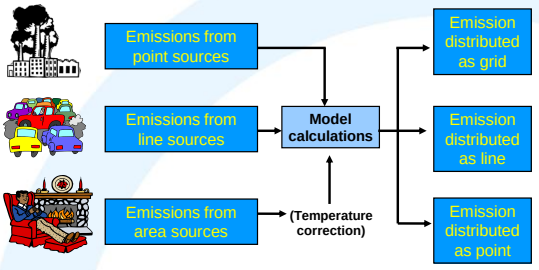
- Detailed knowledge of source types and locations
- Specific emissions for individual sources
- Consumption and or production
- Data using emission factors



AirQUIS organizes and stores data in a bottom up inventory coupled to the integrated GIS



The Emission Inventory Module organizes the emission data by 3 types of sources



AirQUIS

Classification of sources

Source sectors

- classification of emission source sectors, sub-sectors and activities (e.g. Corinair,)

Fuels/Raw Material/Product

Time variations for individual sources and source sectors

Examples of fuels and source sectors:

Fuel	
Fuel ID	Name
8	Gasoline
19	Diesel
1	Coal
2	Coke

Source Sectors	
Source Sector ID	Source Sector Name
1000	Stationary combustion
1100	Industry and energy sectors
1200	Primary industries
1300	Private services
1400	Public administration

Time Variations

Factors for scaling annual emissions/consumptions to weekly, daily,hourly or half hourly emissions

Hierarchical structure (sub-time variations)

Specific validity period (1995, w1-w52 etc)

Sum of factors for all time steps is 1.0

Sub-factors are multiplied to find the most detailed factor

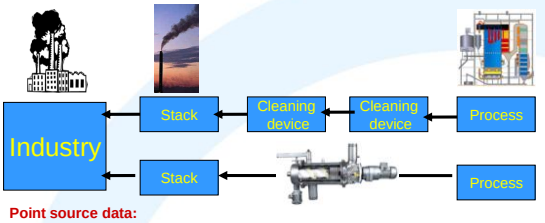
Time Variations - Example

Find traffic TV-factor for Monday 16. January 1998 at 0700:

TV-factor for any week in 1998 is 1/52
TV-factor for Mondays is 3/20
TV-factor for hour 7 on weekdays is 2/25

TV-factor for Monday 16. January 1998 at 0700
=(1/52) * (3/20) * (2/25)

Point sources are single sources



Point source data:

- General facility identification
- Physical and geographical information of each stack
- Emission and release characteristics

Emission Inventory - Point Sources

Owners
Industries
Stack data
} Source identification and description
Position of stacks
Process data
Consumption or production data
Measured emission data

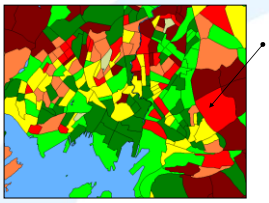
Emission Inventory- Ex.: Stack data

Stack data										
Stack ID	Stack name	X Co-ordinate	Y Co-ordinate	Stack height (m)	Stack Diameter (m)	Gas Temperature (C)	Gas Velocity (m/s)	Gas Flow Rate (m^3/s)	Building Height	Building Width	Industrial Plant Name
30100501	Pipe 301005-1	600669	6645282	10	0.5	130	16.27	3.19	5	10	Industry nr 301005
30100601	Pipe 301006-1	598856	6646044	20	0.5	178	10	2.00	5	10	Industry nr 301006
30101201	Pipe 301012-1	604096	6646518	46	0.9	250	20	6.67	18	28	Industry nr 301012
30101301	Pipe 301013-1	600071	6644966	14	0.4	190	12.6	10.00	6	10	Industry nr 301005
30101502	Pipe 301015-2	598835	6644487	40	3	225	5	35.34	18	40	Industry nr 301006
30101901	Pipe 301019-1	604474	6649890	30	0.8	110	20	10.00	12	18	Industry nr 301012

Emission Inventory- Ex.: Consumption data

Process Fuel and Raw material Consumption Data						
Process ID	Process Name	Fuel name	Consumption Amount	Unit name	Time variation Name	Validity Period
30100501	Prosess 301005-1	Hard coal	190.987	ton/year		1998
30100601	Prosess 301006-1	Brown coal	175.075	ton/year		1998
30101202	Prosess 301012-2	Natural gas	889.427	ton/year		1998
30101201	Prosess 301012-1	Heavy fuel oil	2.74308	ton/year		1998
30101302	Prosess 301013-2	Other liquid fuels	366.362	ton/year		1998

Concept of Area Sources



Area sources
Regions ID
Emission/Consumption Value
Emission factors

Area Sources

Stationary combustion
- Consumption dataset for combinations of source sectors and fuel
- Emission factors for different components for the same combinations

Process emissions and evaporation:
- Emission dataset for combinations of source sectors and components

Area Sources -Input

Regions (polygons) or grids
Fuels/components
Source sectors
Time Variations
Consumption or emission data
Emission factors

Order of Importing Area Sources

Area Source Definition:
- Defines the geographical properties
- Defines the emission properties

Area Source Values:
- Emission/consumption values for each geographical region

Emission Inventory - Area sources

Small or numerous sources not handle individually such as combustion, open air burning, dry cleaners etc. or nonpoint sources that emits over a geographical area e.g. residential cooking and heating
- Consumption/production data for fuel or product for each source sector
- Emission factors for the combination of fuel consumption or product produced for each source sector

Emissions and evaporation:
- Estimated emissions and diffuse leakages for different sources

Area sources

Fuel combustion sources

- Stationary sources (residential cooking, heating etc.
- Open burning (agriculture, waste etc.)

Fugitive sources

- VOC -Domestic LPG, gasoline stations
- PM – dust from roads, agriculture, constructions

Emission Inventory- Ex.: Area sources

Region Data Defintion Emission

Data set ID	Data set name	Source sector Name	Component Name	Dataset unit ID	Region	Ground level source(ground level=0, not ground level=1)
1	Emission from PM2.5 from woddburning	COMBUSTION IN MANUFACTURING IN	PM25	ton/year	4	0
2	Emission from PM2.5 from industry	Other furnaces	PM25	ton/year	4	0
8	Emission from PM10 from industry	WASTE TREATMENT AND DISPOSAL	PM10	ton/year	4	0

Area source emission estimates

Emission factors and activity data

- E.g. fuel used, production rate
- Population/ households/land use

Surveys (measurement/ sampling)

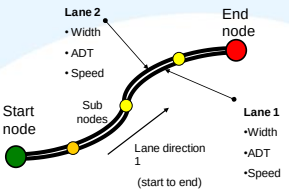
Line Sources are sources emitting over a line

➔ Static data:

- geographical location
- static information (shape, width, gradient, etc).

➔ Dynamic data:

- ➔annual daily traffic
- •average speed
- •vehicle distributions for different vehicle classes



➔ Statistics on distribution of technology classes, fuels and age

➔ Emission factors

AirQUIS

Traffic Emission Factors

- Select the factor set year
  - Emission calculation vehicle classes (ECVC)
  - Emission calculation vehicle classes – Registration vehicle class Distribution
  - Average fuel consumption
  - Basic and aging factors
  - Speed dependency factors
  - Road gradient factors
  - NO2 percentage of NOx
  - PM10 data

Emission inventory – Example traffic data

Dynamic Traffic Data

Road Link ID	Direction (1 = Start to End Node, 2 = End to Start Node	Annual Daily Traffic	Free Flow Speed (km/h)	Validity period (year(s))
1	1	5482	50	1998
1	2	5538	50	1998
2	1	5482	50	1998
2	2	5538	50	1998
3	1	5832	50	1998
3	2	5698	50	1998
4	1	6500	50	1998
4	2	6500	50	1998
5	1	6500	50	1998

Road Vehicle Classes (RVC)

ID number	Road Vehicle Class (RVC) Name	Heavy Duty (0 = not heavy duty, 1= heavy duty)
1	Light duty vehicles	0
2	Heavy duty vehicles	1
3	Buses	1

Data Type

Organize data in the Emission Inventory Module

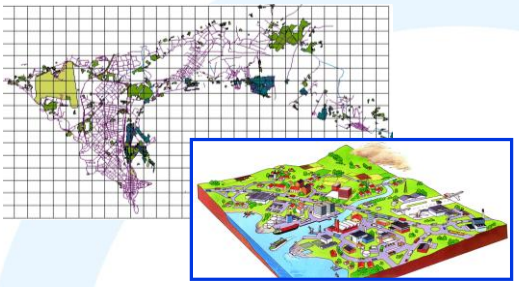
- Consumption
- Emission data

Dataset Type

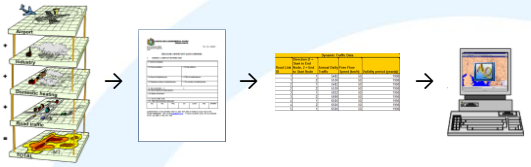
Organise input and model results data

- Region data set
- Field data set
- Building point data set
- Receptor point data set
- Stack data set
- Line data set

The success in urban scale modelling is in the description of the emission sources!



The success in urban scale modeling is in the description of the emission sources!



No chain is stronger than the weakest link

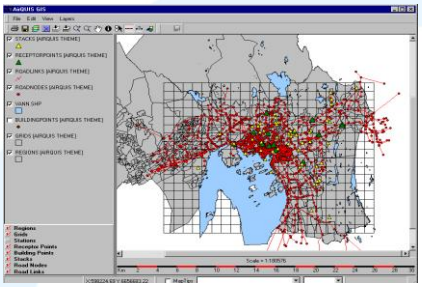
Geographical Information System (GIS)

The GIS functionality of the AirQUIS system is designed to offer several possibilities for understanding the problems of air pollution

Concept of Geographical Information System (GIS)

Visualization information
Showing relationships
Creating and updating data
Solving problems
Presenting results

AirQUIS GIS



GIS Features

Maps and GIS
- AirQUIS themes
- Shape themes

Presentation of data by using GIS

Searching the database through GIS

Entering and editing data through GIS

Regions and region levels

GIS Advantage (I of II)

- GIS makes it easier to place the air pollution sources in the correct locations for example by displaying the road link network in a city.
- GIS makes it easier to search for geographical linked data in the database
- GIS presentation of area distributed consumption and emission data gives a good overview of where to expect high impact of air pollution
- Viewing the measurements station on a map together with the pollution sources will give an idea of what concentrations one expect for different wind directions and the representatively of the stations.

GIS Advantage (II of II)

- Display the model results on a map gives a visual presentation of the geographical distribution of air pollution and regions with high impact.
- Display the model results on a map can be used for public information on pollution levels in different parts of a city

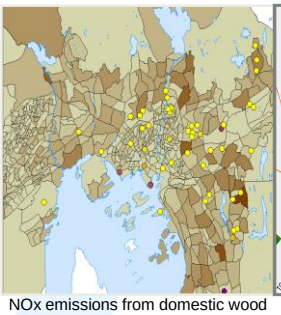
GIS - Map Themes

Shape Themes
- Not connected to data in the AirQUIS database

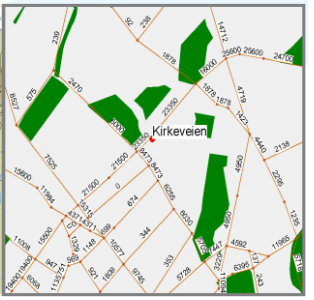
AirQUIS Themes
- Geographically linked data from the AirQUIS database

Data and model results

Connecting emissions to GIS improves the ability to assess and manage the emissions



NOx emissions from domestic wood burning (t/y) and industrial sources (g/s)



Annual Daily Traffic

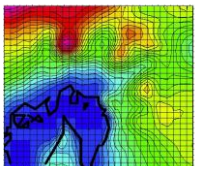
Emission Inventory for Air Quality Modelling

Geographical and temporal resolved emission

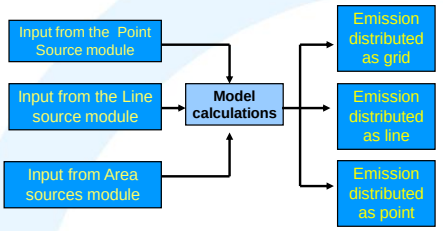
Pollutant species

QA/QC

All sources represented



Emission Model



Emission Model

Area sources:

- Uses emission factors, time variations and temperature variation to calculate hourly emissions from annual consumption of fossil fuels for area sources

Line sources:

- Uses road and traffic data, road and traffic classification, emission factors, traffic dependencies and time variations to calculate emissions from line sources

Point sources

- Uses physical stack data, process consumption or emission data, emission factors and time variations to calculate emissions from point sources

Emission Model Input

Area source emissions

Line source emissions

Point sources emissions

Temperature, Relative Humidity and Precipitation

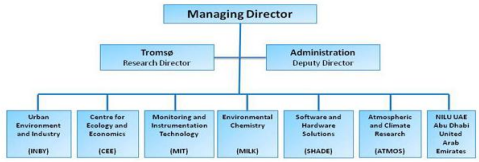
www.nilu.no

Appendix I

AirQUIS Introduction Presentation

Agenda
Introduction to NILU's Software and Hardware Development group
From Sensor to Web
AirQUIS Monitoring
AirQUIS Portal
AirQUIS Information
AirQUIS Modelling
Data Integration

NILU's organisation

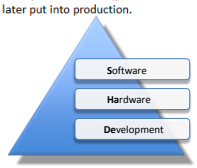


Software and Hardware Development (SHaDe)

SHaDe

The Software Hardware Development group (SHaDe) is an intrinsic part of NILU, having responsibility for the development and maintenance of of NILU's Software and Hardware products, from the cutting edge AirQUIS application line, to project web sites, custom modules and databases.

In addition, SHaDe's Hardware Engineers have decades of real world experience in developing solutions for a wealth of problems. Notable successes include the development of Embedded Data Loggers, the UV Irradiance Meter and Air samplers. Their expertise area covers the creation of schematic designs, development of PCBs (printed circuit boards) and prototypes that are later put into production.

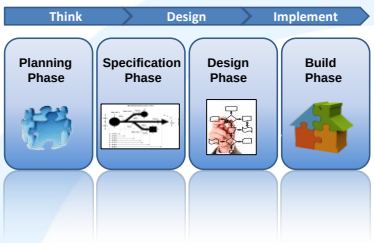


Software and Hardware Development (SHaDe)

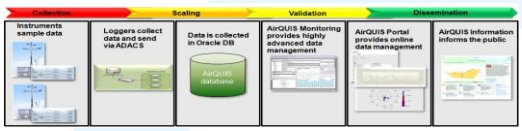
- 8 software developers
- 2 hardware developers
- 2 project assistant
- 2 project coordinators

What we do

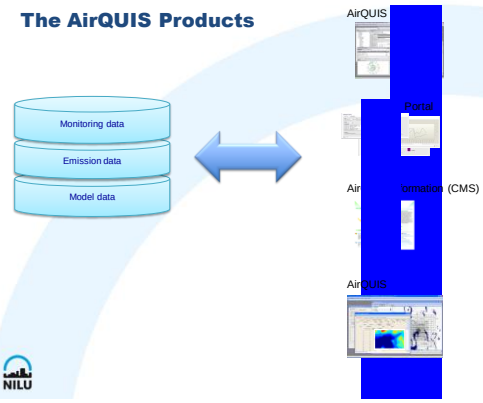
- We develop innovative software and hardware products
- Working primarily within the .Net platform
- We focus on providing quality within the entire Development Life Cycle

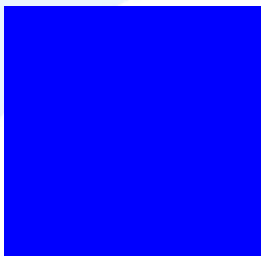


Air Quality and Meteorology data from Sensor to Web

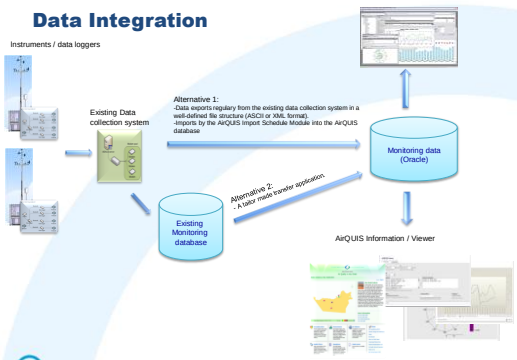


The AirQUIS Products





Data Integration



Appendix J

Brick Kiln Questionnaire (Draft)

EMISSIONS INVENTORY QUESTIONNAIRE: Brick Kilns

1. GENERAL COMPANY INFORMATION

1.1 Name of factory/field:	
1.2 Address:	**1.3 Brick Kiln Type (check type):**
	___BTK ___ZigZag ___FCK ___Hoffman ___OTHER:
1.4 Name of contact person:	**1.5 Title of contact person:**
1.6 Contact information (telephone/fax/email):	**1.7 Other contact information:**
1.8 Site coordinates (X,Y):	

2. STACK DATA (One questionnaire form for each stack)

Stack Name/No.	Stack Height (m)	Stack Diameter (m)	Exit Gas Temp. (^{o}C)	Exit Gas Velocity (m/s)	Exit Gas Flow Rate (state units)	Cleaning Device? (If yes, specify type)

3. PROCESS/BATCH FUEL CONSUMPTION DATA

Process Name/No.	Fuel Name (coal, wood, gas, etc.)	Sulphur Content (%)	Fuel Consumption Rate (State Units)

4. FUEL BURNING PROCESS/BATCH DATA

Process Name/No.	Production Rate (State Units)	Normal Operating Schedule			Start of production season	End of production season
		Hrs/ Day	Days/ Wk	Wk/ Yr	Day, month	Day, month

5. FACTORY PRODUCTION DATA

Factory	Goods produced	Production (State Units)	Year
Brick Kiln	Bricks		2010
	Bricks		2009
	Bricks		2008

DoE/CASE Internal Information

Assigned Factory ID#		*Verify Coordinates (X,Y)*	
Notes:			*DoE QC person and date:*

Appendix K

Other Industry Questionnaire Draft

EMISSIONS INVENTORY QUESTIONNAIRE: Other Industry (not Brick Kilns)

1. GENERAL COMPANY INFORMATION

1.3 Name of factory/field:	
1.4 Address:	**1.3 Industry (check type):**
	__Cement __Fertilizer __Power Prod. __Smelter __Gas __Other:
1.4 Name of contact person:	**1.5 Title of contact person:**
1.5 Contact information (telephone/fax/email):	**1.7 Other contact information:**
1.8 Site coordinates (X,Y):	

2. STACK DATA

Stack Name/No.	Stack Height (m)	Stack Diameter (m)	Exit Gas Temp. (^{o}C)	Exit Gas Velocity (m/s)	Exit Gas Flow Rate (state units)	Cleaning Device? (If yes, specify type)

3. PROCESS/BATCH FUEL CONSUMPTION DATA

Process Name/No.	Fuel Name (coal, wood, gas, etc.)	Sulphur Content (%)	Fuel Consumption Rate (State Units)

4. FUEL BURNING PROCESS/BATCH DATA

Process Name/No.	Production Rate (State Units)	Normal Operating Schedule			Start of production season	End of production season
		Hrs/ Day	Days/ Wk	Wk/ Yr	Day, month	Day, month

4. FACTORY PRODUCTION DATA

Factory	Goods produced	Production (State Units)	Year

5. PROCESS EMISSION DATA (IF AVAILABLE)

Process Name/No.	Stack Name/No. (leave blank if fugitive emission)	Components Emitted	Emission Rate (State Units)	Basis of Calculation (Measurement, emission factor, mass balance)	Year of Measure-ment
		SO_2			
		NOx			
		CO			
		PM_{10}			
		TOC			
		Other:			
		SO_2			
		NOx			
		CO			
		PM_{10}			
		TOC			
		Other:			
		SO_2			
		NOx			
		CO			
		PM_{10}			
		TOC			
		Other:			

DoE/CASE Internal Information

Assigned Factory ID#		*Verify Coordinates (X,Y)*	
Notes:			*DoE QC person and dates:*

Appendix L

GAINS Data Analysis for Dhaka

BAPMAN

GAINS S.ASIA Model

Scott Randall

Kjeller, Norway
29 October 2010

BAPMAN

GAINS Intro

The GAINS model (Greenhouse Gas and Air Pollution Interactions and Synergies):

•developed at IIASA (International Institute for Applied Systems Analysis)

•under the program ADP (Atmospheric Pollution and Economic Development)/CIAM (Centre for Integrated Assessment Modelling)

•The primary purpose of GAINS is to provide linkages between air pollution emissions and GHGs while considering mitigating control options and related costs.

BAPMAN

GAINS Components

- The model considers emissions of:
  - Carbon dioxide (CO2)
  - Methane (CH4)
  - Nitrogen oxides (NOx)
  - Nitrous oxide (N2O)
  - Particulate matter (TSP, PM10, PM2.5 and PM1)
  - Sulfur dioxide (SO2)
  - Volatile organic compounds (VOC)
  - Ammonia (NH3)
  - Carbon monoxide (CO)
  - Fluorinated greenhouse gases (F-Gases)
- Topics:
  - **Economic Activity Pathways** (sectors and activities)
  - **Emission Control Strategies** (mitigation)
  - **Emissions Scenarios** (user-specific)
  - **Emission Control Costs** (related to mitigation)
  - **Impacts** (health)

BAPMAN

PM Excercise

•Visit model: http://gains.iiasa.ac.at/gains/IND/index.login?logout=1

•Login
•Emissions tab
•Select PM
•Select "Totals by GAINS Region"
•Select Scenario (baseline_08), Region (Dhaka), PM Fraction (PM10)
•"Show data table"
•Copy and paste into excel, format cells to numbers
•Insert graph
•Select data
•Format graph

BAPMAN

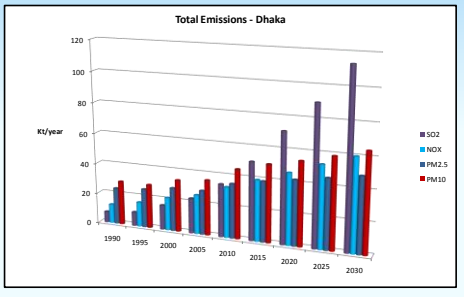
Dhaka Draft Report

•Basic report analyzing following components:
- SO_2,
- NO_X,
- $PM_{2.5}$,
- PM_{10},
- CO_2,
- GHGs (which includes CO_2, CH_4, N_2O, and FGAS)

• Utilizing the following topics:
- *Activity (coal, wood, bensine)*
- *Sector (Transport, Residential, Industrial, Agricultural)*
- *Sub-Sectors (cars, brick kilns, cement factories, cooking stoves)*
- *Sector-Activity (sub-sectors "ie. stoves" from activity "ie. wood")*
- *Controls (mitigation)*
- *Costs (associated with mitigations)*

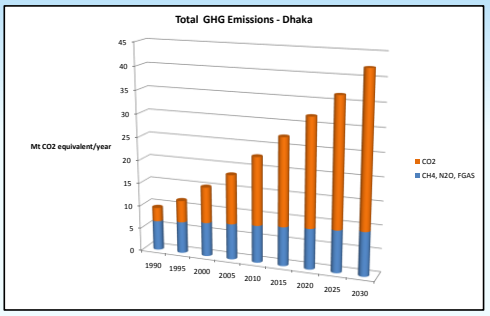
BAPMAN

Dhaka Prelim Analysis



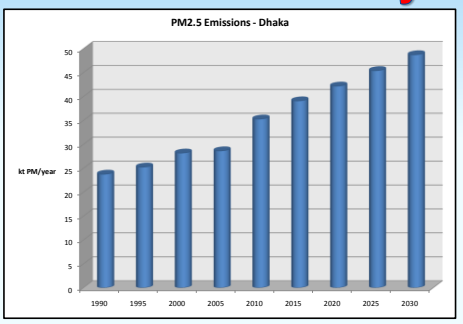
BAPMAN

Dhaka Prelim Analysis



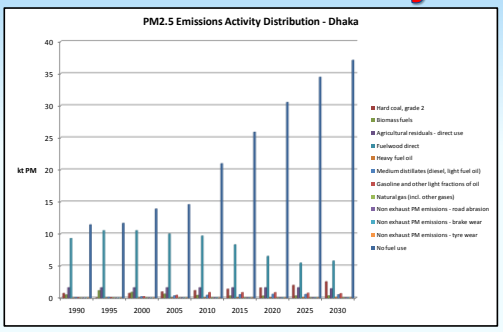
BAPMAN

Dhaka Prelim Analysis



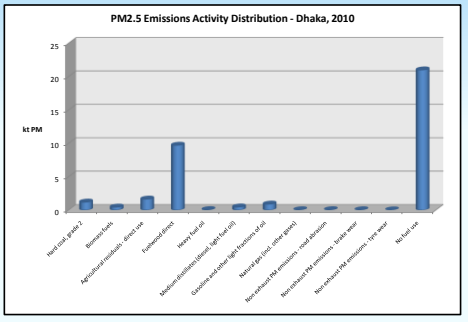
BAPMAN

Dhaka Prelim Analysis



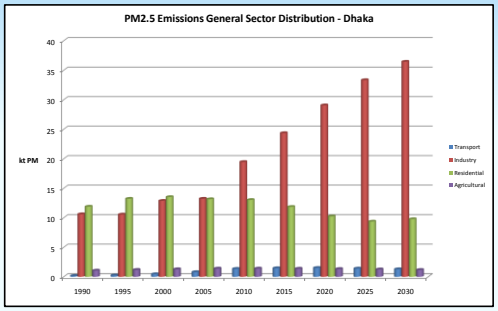
BAPMAN

Dhaka Prelim Analysis



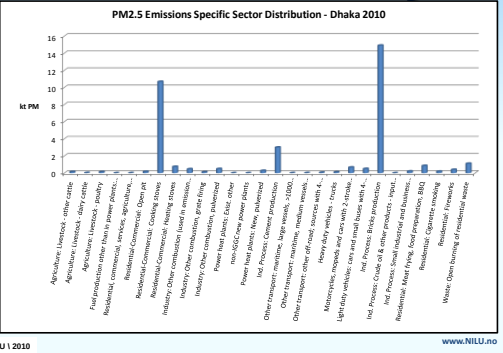
BAPMAN

Dhaka Prelim Analysis



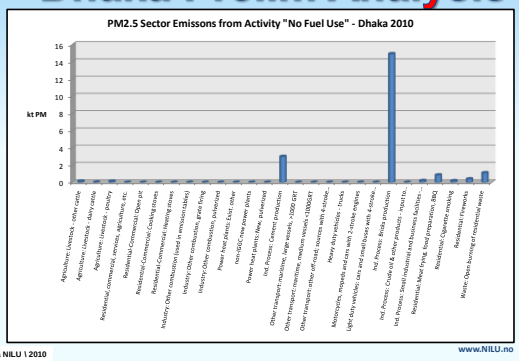
BAPMAN

Dhaka Prelim Analysis



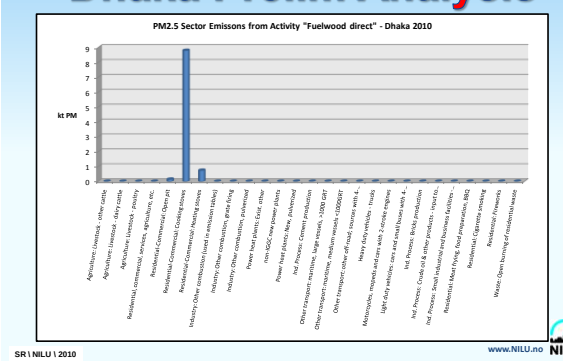
BAPMAN

Dhaka Prelim Analysis



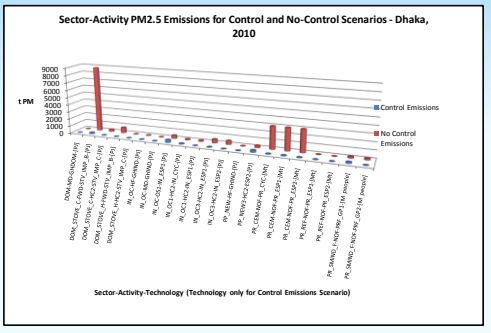
BAPMAN

Dhaka Prelim Analysis



BAPMAN

Dhaka Prelim Analysis



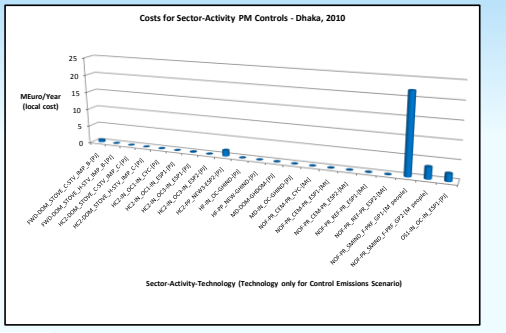
BAPMAN

Dhaka Prelim Analysis

Control Measure	Abbr	with Control (tons)	without Control (tons)	Difference (tons)
1. Residential-Commercial: Cooking stoves-Fuelwood direct-Biomass stove improved-[10^15 Joules]	DOM_STOVE_C-FWD-STV_IMP_B-[PI]	107.96	8702.86	8624.90
2. Residential-Commercial: Cooking stoves-Hard coal, grade 2-Coal stove improved -[10^15 Joules]	DOM_STOVE_C-HC2-STV_IMP_C-[PI]	9.88	278.01	268.13
3. Residential-Commercial: Heating stoves-Fuelwood direct-Biomass stove improved-[10^15 Joules]	DOM_STOVE_H-FWD-STV_IMP_B-[PI]	14.14	740.45	726.31
4. Industry: Other combustion, grate firing-Hard coal, grade 2-Electrostatic precipitator: 1 field - industrial combustion-[10^15 Joules]	IN_OC1-HC2-IN_ESP1-[PI]	1.15	114.49	113.34
5. Industry: Other combustion, pulverised-Hard coal, grade 2-Electrostatic precipitator: 1 field - industrial combustion-[10^15 Joules]	IN_OC3-HC2-IN_ESP1-[PI]	39.42	494.49	455.07
6. Industry: Other combustion, pulverised-Hard coal, grade 2-Electrostatic precipitator: 2 fields - industrial combustion-[10^15 Joules]	IN_OC3-HC2-IN_ESP2-[PI]	4.51	494.49	489.98
7. Ind. Process: Cement production-No fuel use-Cyclone - - industrial process-[Mt]	PR_CEM-NOF-PR_CYC-[Mt]	33.92	2999.34	2965.42
8. Ind. Process: Cement production-No fuel use-Electrostatic precipitator: 1 field - industrial processes-[Mt]	PR_CEM-NOF-PR_ESP1-[Mt]	67.84	2999.34	2931.50
9. Ind. Process: Cement production-No fuel use-Electrostatic precipitator: 2 fields - industrial processes-[Mt]	PR_CEM-NOF-PR_ESP2-[Mt]	38.76	2999.34	2960.58
10. Ind. Process: Small industrial and business facilities - fugitive-No fuel use-Good practice: ind process - stage 2 (fugitive)-[M people]	PR_SMIND_F-NOF-PRF_GP2-[M people]	6.84	205.17	198.33

BAPMAN

Dhaka Prelim Analysis



BAPMAN

Dhaka Prelim Analysis

Control Measure	Abbr	Cost Meuro/year	tons PM2.5 saved	cost Euro/ton PM2.5 saved
1. Residential-Commercial: Cooking stoves-Fuelwood direct-Biomass stove improved-[10^15 Joules]	DOM_STOVE_C-FWD-STV_IMP_B-[PI]	0.6170	8624.9	71.54
2. Residential-Commercial: Cooking stoves-Hard coal, grade 2-Coal stove improved -[10^15 Joules]	DOM_STOVE_C-HC2-STV_IMP_C-[PI]	0.0178	268.13	66.39
3. Residential-Commercial: Heating stoves-Fuelwood direct-Biomass stove improved-[10^15 Joules]	DOM_STOVE_H-FWD-STV_IMP_B-[PI]	0.0649	726.31	89.36
4. Industry: Other combustion, grate firing-Hard coal, grade 2-Electrostatic precipitator: 1 field - industrial combustion-[10^15 Joules]	IN_OC1-HC2-IN_ESP1-[PI]	0.0089	113.34	78.52
5. Industry: Other combustion, pulverised-Hard coal, grade 2-Electrostatic precipitator: 1 field - industrial combustion-[10^15 Joules]	IN_OC3-HC2-IN_ESP1-[PI]	0.1366	455.07	300.17
6. Industry: Other combustion, pulverised-Hard coal, grade 2-Electrostatic precipitator: 2 fields - industrial combustion-[10^15 Joules]	IN_OC3-HC2-IN_ESP2-[PI]	0.0309	489.98	63.06
7. Ind. Process: Cement production-No fuel use-Cyclone - - industrial process-[Mt]	PR_CEM-NOF-PR_CYC-[Mt]	0.0008	2965.42	0.27
8. Ind. Process: Cement production-No fuel use-Electrostatic precipitator: 1 field - industrial processes-[Mt]	PR_CEM-NOF-PR_ESP1-[Mt]	0.0192	2931.5	6.55
9. Ind. Process: Cement production-No fuel use-Electrostatic precipitator: 2 fields - industrial processes-[Mt]	PR_CEM-NOF-PR_ESP2-[Mt]	0.0234	2960.58	7.90
10. Ind. Process: Small industrial and business facilities - fugitive-No fuel use-Good practice: ind process - stage 2 (fugitive)-[M people]	PR_SMIND_F-NOF-PRF_GP2-[M people]	2.3304	198.33	16288.00

Appendix M

Screening Study Introduction Presentation

Screening study

Dhaka, Bangladesh

Bjarne Sivertsen, NILU

BS\ NILU \ 2010 www.NILU.no

Screening study objectives

- Baseline air quality of Dhaka
- Typical concentration levels?
- Concentration distributions ?
- Hot spots?
- Siting studies for new stations!

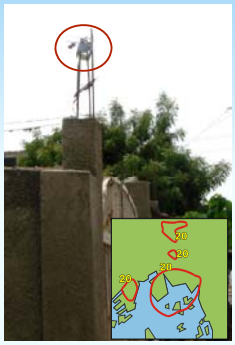
Where should we measure?
What should we measure?
How do we want to present the results?

BS\ NILU \ 2010 www.NILU.no

Siting studies

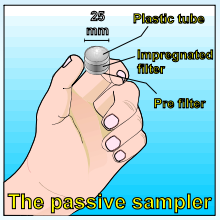
- ✓ Define site locations
- ✓ Evaluate sources and possible impact
- ✓ Perform simple "model estimates"

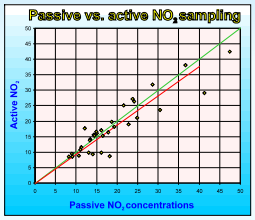
- Investigate the area
- Select relevant indicators
- Complete report covering
  - Instruments
  - Sites
  - Components



BS\ NILU \ 2010 www.NILU.no

Passive samplers for screening studies

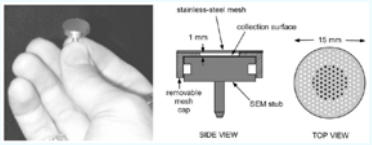




BS\ NILU \ 2010 www.NILU.no

Simple instruments for screening the study

Passive gas samplers: SO_2, NO_2, O3



Passive PM Sampler (PM_{10}, $PM_{2,5}$)

Dust track

BS\ NILU \ 2010 www.NILU.no

Screening Study Design

Components: NO2, SO2, PM, Ozone
City Transects (Dhaka has primary northerly wind)
- North of city suburban (but south of brick kilns)
- North of city urban
- City Center
- South of city urban

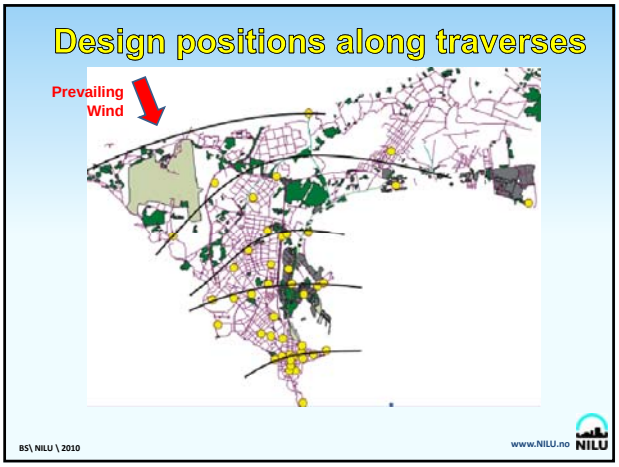
Microclimates
- Roadside
- Street canyons
- Urban

Vertical
- 2-3 meters over street level (majority)
- 5 meters over street level (some)
- High over street level (one or two) – all components

Also at existing and planned monitoring station locations

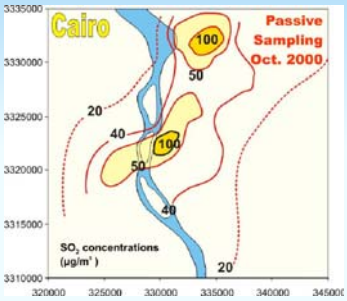
BS\ NILU \ 2010 www.NILU.no

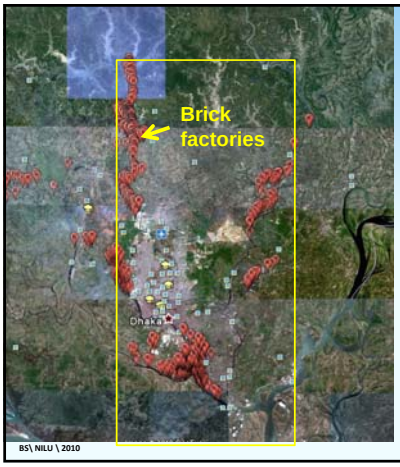
Design positions along traverses



Typical micro environments

SO_2 in Cairo city centre and industrial Shoubra exceeded 100 µg/m³

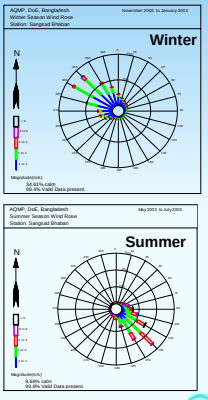


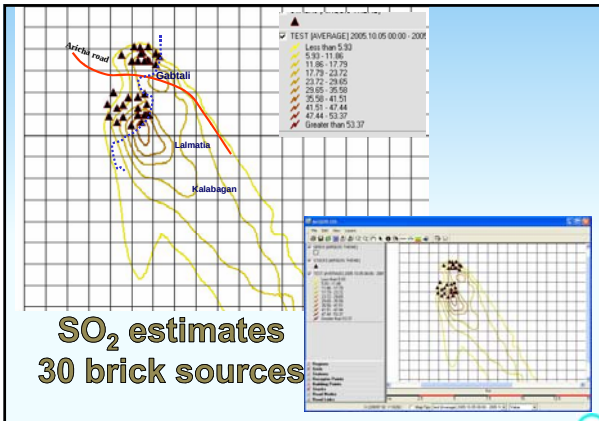


Brick factories

Stack emissions
Ground based emissions

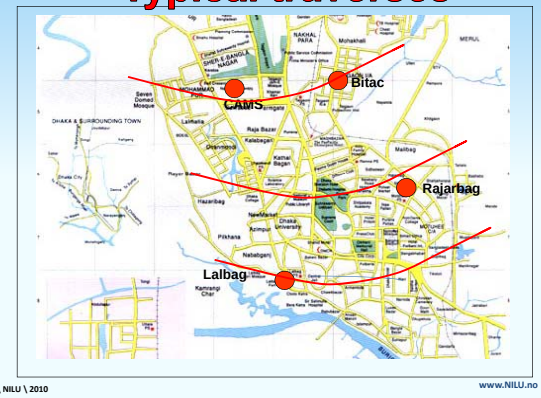
Meteorological data





SO_2 estimates
30 brick sources

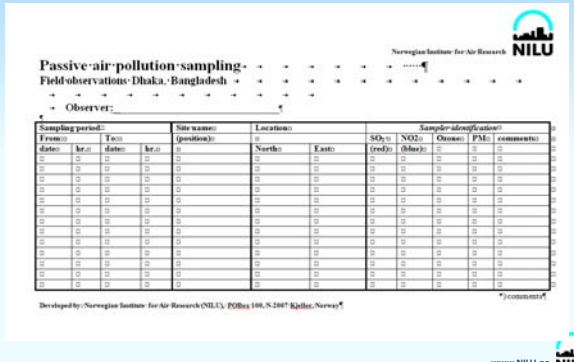
Typical traverses



Procedures

- Appoint personelle
- Identify addresses
- Select sites
- Brief and train
- Distribute samplers and forms
- Place samplers
- Collect PM data (Dust track)

Passive sampler form



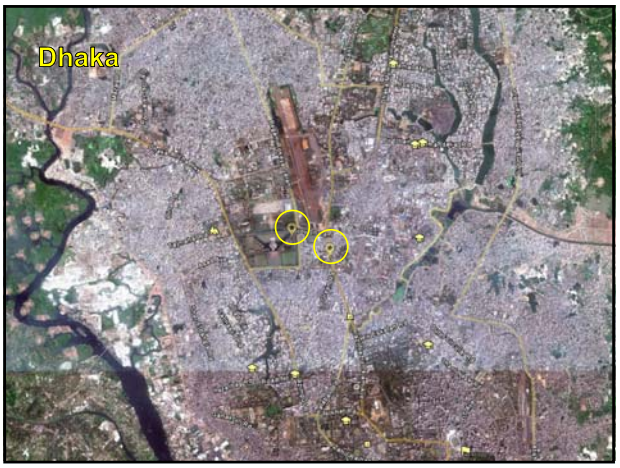
Passive air pollution sampling
Field observations Dhaka, Bangladesh

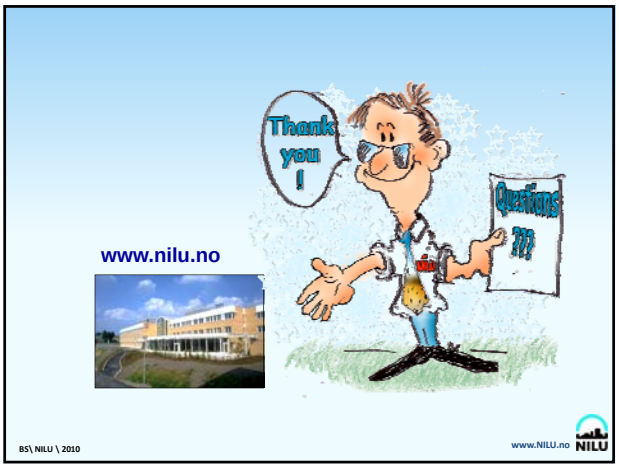
Observer:

Sampling period: From: date: hr. To: date: hr.	Site name: (position):	Location: North: East:	Sampler identification: SO_2 (red): NO_2 (blue): Ozone: PM: comments:

*) comments

Developed by: Norwegian Institute for Air Research (NILU), POBox 100, N-2007 Kjeller, Norway

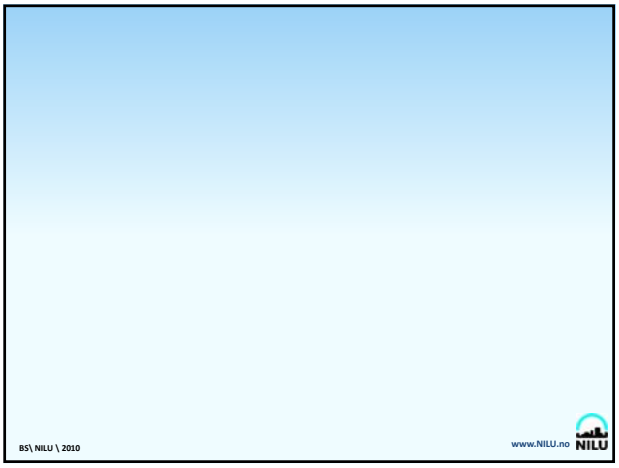




Norwegian Institute for Air Research

NILU
POBox 100
No-2027 Kjeller
Norway
Fax: +4763898050
E-mail: nilu@nilu.no

BS\ NILU \ 2010 www.NILU.no NILU



Appendix N

Draft Screening Study Design for Dhaka

Bangladesh Department of Environment/CASE Project
Poribesh Bhaban
E-16, Agargaon, Shere Bangla Nagar
Dhaka 1207
Bangladesh

Norwegian Institute for Air Research
PO Box 100
2027 Kjeller
Norway

Financed by:
Norwegian Agency for Development Cooperation (NORAD)

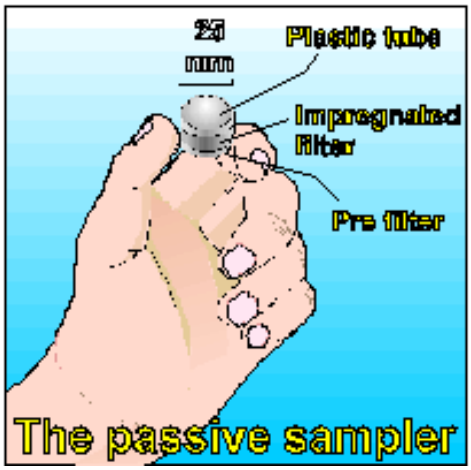
MEMO

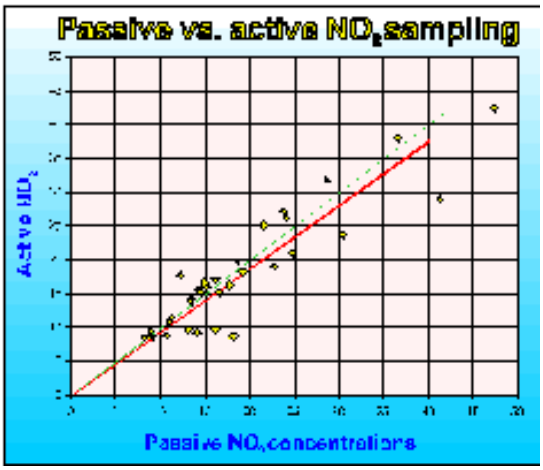
Project:	**Bangladesh Air Pollution Management (BAPMAN)**

Prepared by NILU:

Bjarne Sivertsen and Scott Randall

Screening study
Design and planning
DRAFT





REPORT NO.:	Memo 2010
NILU REFERENCE:	O-110055
REV. NO.:	November 2010

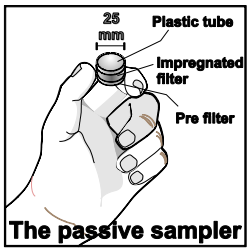
BAPMAN Screening Study Design Plan

Introduction

An air quality screening study will be performed in order to establish a baseline air quality information and lend guidance to the design of the air quality monitoring network for Dhaka. The data shall give a simplified picture of the average concentration distribution of air pollutants over the city. The screening will be performed in February 2011 by NILU with assistance from DoE/CASE under the BAPMAN project.

Passive samplers

Simple samplers for measurements of time integrated concentrations of sulphur, nitrogen and particles are being used. This method has been used worldwide in industrial areas, in urban areas and for studies of indoor/outdoor exposures



These samplers have been used by NILU in a number of studies (Hak, 2010; Hak and Sivertsen, 2010). For sampling of gases they include an impregnated filter inside a small plastic tube. To avoid turbulent diffusion inside the sampler, the inlet is covered by a thin porous membrane filter. Gases are transported and collected by molecular diffusion.

The methods require that these samplers are exposed for at least one week.

Dust track and mini vol samplers for PM

A Real-Time Dust Monitor will be used to monitor ambient PM concentrations. The new DustTrak™ DRX Aerosol Monitor can simultaneously measure both mass and size fraction - no other monitor can do both. The DustTrak DRX handheld monitor is a battery operated, data-logging, light-scattering laser photometers that gives you real-time aerosol mass readings.

Simple time integrated mini-vol samplers have been used in Dhaka in previous studies. We will try to identify how many of these samplers can be used as part of the screening study.

Table 1: List of instruments used for screening.

Component	Sampler	Number	Sampling period	Resolution
SO2	Passive sampler	50	Two weeks	Average for sampling period
NO2	Passive sampler	50	Two weeks	Average for sampling period
O3	Passive sampler	20	Two weeks	Average for sampling period
PM10	Minivol	?	24 h aver 2 weeks	24 h averages
PM	Dust-track	1	Two weeks	Grab samples (typical 30 min aver.)=

A number of selected points in Dhaka

We will select a number of sampling positions in the Dhaka area. We depend upon the positive response from owners of buildings where we might need to place a sampler.

We thus appreciate the co-operation with local authorities and individuals, who will contribute to a better understanding of the air pollution in the area.The small instruments are totally unharmful, and they will be collected by experts after a sampling period of about two weeks.

Passive samplers of NO_2, SO_2, O_3 will be placed in up to 50 locations in Dhaka city and surrounding suburban areas (see *Table 1*).

In addition we will use an automatic hand held sequential PM sampler (DustTrak) at a selected number of monitoring sites in the city centre of Dhaka. These instruments will measure 30 min average concentrations of PM10 and PM2.5.

We will also be interested in placing as many Minivol samplers for PM10 as possible in Dhaka. These instruments may be available at DoE.

The map in Figure 1 gives a picture of the spatial distribution of the preliminary sampling sites selected for Dhaka.

Site location design parameters:

1. City Transects (Dhaka has primary northerly wind)
    a. North of city suburban (but south of brick kilns)
    b. North of city urban
    c. City Center
    d. South of city urban
2. Microclimates
    a. Roadside
    b. Street canyons
    c. Urban
3. Vertical
    a. 2-3 meters over street level (majority)
    b. 5 meters over street level (some)
    c. High over street level (one or two) – all components
4. Also at existing and planned monitoring station locations

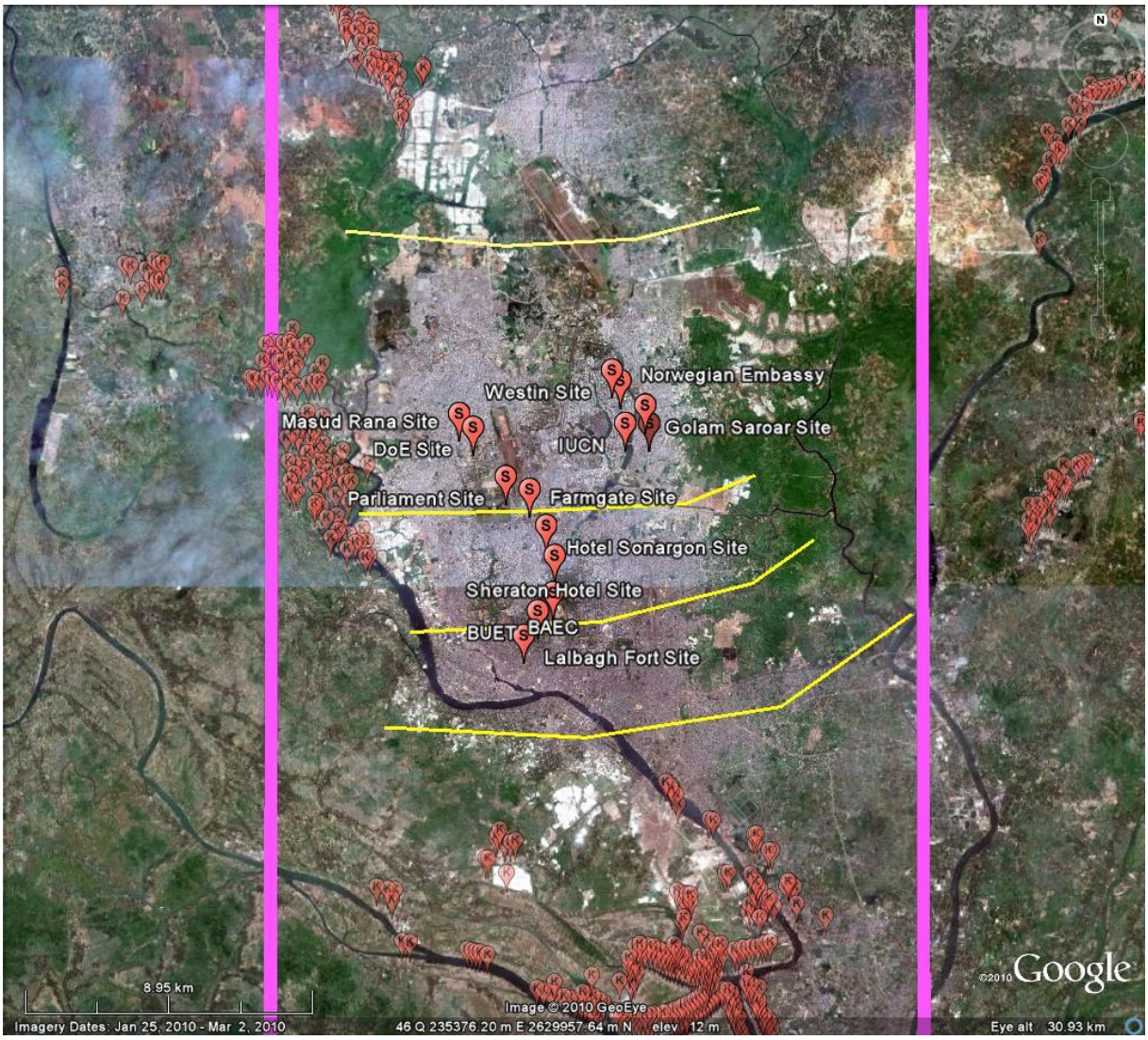


Figure 1: Prelim picture showing transects (Yellow lines), prelim sites (S Markers), and grid (Pink).

So far 14 sites have been appointed as possible measurement sites for the screening study (See Table 2).

These sites were identified during the training seminar at NILU in October 2010. They were selected at points in the city where we know that we have people that can take care of the samplers and some of them are located hotels, where permissions can easily be taken.

We further want to identify another 30-40 sites preferably in areas where we know that people can take care of the samplers (private homes or offices). Locations also have to meet the criteria of spreading out samplers along traverses to obtain a good and representative concentration distribution over the city.Some samplers should also be located within a kilometre downwind from large industrial sources.

The 14 sites selected so far are presented in Table 2 below.

Table 2: Preliminary selection of sites for the screening study.

Site #	Site Name	Responsible	Location	Address	Long	Lat
	BAEC	Scott Randall			90.39671578	23.73044127
	BUET	Scott Randall			90.3929339	23.72649122
	Masud Rana Site	Masud Rana			90.36780797	23.78101156
	DoE Site	Masud Rana			90.37247542	23.77697864
	Westin Site	Scott Randall			90.41511871	23.79245226
	Lalbagh Fort Site				90.38733361	23.71894983
	Parliament Site				90.38770402	23.76003501
	Farmgate Site				90.39292872	23.75912323
	Hotel Sonargon Site	Scott Randall			90.39445639	23.74982247
	Sheraton Hotel Site	Scott Randall			90.39704585	23.74144747
	Golam Saroar Site	Golar Saroar			90.42494955	23.78332682
	Saroar Uncle Market Site	Golar Saroar			90.42604765	23.77798141
	IUCN	Scott Randall			90.41732907	23.77813959
	Norwegian Embassy	Scott Randall			90.41721013	23.79027722

All sites have to be classified according the international classification procedures as given in the table below.

Type of zone	Type of station	Characterisation of zone
Urban (U)	Traffic (T)	Residential (R)
Suburban (S)	Industrial (I)	Commercial (C)
Rural (R)	Background (B)	Industrial (I)
		Agricultural (A)
		Natural (N)
		Res. / Comm. (RC)
		Comm. / Ind. (CI)
		Ind. / Res. (IR)
		Res. / Comm. / Ind. (RCI)
		Agri. / Nat. (AN)

Sampling procedures

All participants will be introduced to the sampling procedures used in screening studies. A specific form will have to be filled in for each of the sampling locations.An example of this form is given on the next page.

Norwegian Institute for Air Research

Passive air pollution sampling

Field observations Dhaka, Bangladesh

Observer: _____

Sampling period				Site name (position)	Location		*Sampler identification*				
From:		To:					SO_2	NO2	Ozone	PM	comments
date	hr.	date	hr.		North	East	(red)	(blue)			

*) comments

Developed by: Norwegian Institute for Air Research (NILU), POBox 100, N-2007 Kjeller, Norway

References

Guerreiro, C., Laupsa, H. and Sivertsen, B. (2005). Passive sampling of SO_2 and NO_2 in ambient air in Dakar. Kjeller (NILU OR 46/2005).

Hak, C. (2010). *Planning ambient air pollution screening study in Burgas, Bulgaria. Winter 2009/2010*. Kjeller (NILU OR 27/2010).

Hak, C. and Sivertsen, B. (2010). *Ambient air pollution screening study in Burgas March 2010*. Kjeller (NILU OR 40/2010).

Appendix O

Final Project (Task 1) Meeting Agenda

Project Meeting II

Scott Randall

Kjeller, Norway
29 October 2010

Task Assigments

TASK 0 (SR TL):
a. Put all training documents on project portal (SR)
b. Report: Training Seminar, D1.1 (SR)

TASK 1 (VTD TL):
a. Data needs sheet and prioritization assignments
(see sheet for assignments, VTD/SR will coordinate)
VTD send mail for coordinate system for GIS files (GS)
Check for traffic data with traffic auth (MR)
Enter historic data (2003?) into AirQUIS (VTD)
b. Questionaire draft (SR -> MR,GS - DoE/CASE)
c. Report: Procedures for emissions inventorying for urban areas in Bangladesh (D1.2) (VTD -> MR,GS - DoE/CASE)
d. Review AirQUIS manuels (GS,MR – DoE/CASE)
e. Screening study: feedback on site locations (MR/GS – DoE/CASE), mini-vol samplers available for use during this campaign (GS – DoE)

TASK 2 (LM TL):
a. Keep NILU updated of status of maintenance contract and G-01 (CASE/DoE).

Future Project Missions and Training

Mission 2: Passive Sampling Screening Study (Jan/Feb 2011). Include Task 1 Follow-up. 10 days

Mission 3: AirQUIS Installation and training (Summer 2011). Include Task 1 Follow-up.

Task 3 AirQUIS Training at NILU Fall 2011. 10 days+

Task 1 Emission Inventory Training at NILU approx. mid2011. 10 days+

DR. NASIR to NILU December 2010?

Project Reports

1. *NILU Task 1 Training Seminar Report (D1.1, in progress).*
2. *All ppt and other files from training were given on memory stick and will be available on BAPMAN portal.*
3. *Future Reports:*
   - Procedures for emissions inventorying for urban areas in Bangladesh (D1.2); NILU and DoE/CASE
   - *NORAD 6 Month status report (February 1, 2011).*
   - AirQUIS establishment: The system established in Dhaka, and personnel trained so that the system can be used sustainably in Bangladesh (D3.1).
4. *Thinking of future scientific publications*

Project Portal

Training Closure

Scott Randall

Kjeller, Norway
29 October 2010

BAPMAN

Summary

- *AQMP and AQMS overview (BS)*
- *AirQUIS overview and methods (KiG)*
- *Emission Inventory templates (KiG)*
- *Building AirQUIS database (KiG)*
- *AirQUIS structure and AirQUIS monitoring (RuO)*
- *Inventory Questionairres and excercises (KiG)*
- *Dispersion demonstration (KiG)*
- *AirQUIS excercies using basic Dhaka data (VTD)*
- *GAINS S.ASIA model (SR)*
- *Passive Sampler Screeing Study methods (BS)*

BAPMAN

Importance

- *Training for Institutional-building*
- *DoE/CASE capacity to understand all aspects, and later sustainably perform work needed*
- *2 Experts as leaders in this task*

BAPMAN

Training Expected Results

1. ***Preliminary analysis of Dhaka emissions related source data and expereience with exercises.***
2. ***Strengthen DoE/CASE Emission Inventory competence to begin work back in Dhaka:***
   - ***Data retreival***
   - ***Top-down inventory***
   - ***Bottom-up inventory***
3. ***Trained staff to become leaders in work and associated sub-tasks at DoE/CASE***

BAPMAN

Technical Feedback?

BAPMAN

Training Seminar Certificates

Appendix P

Final Project (Task 1) Meeting Summary

Norwegian Institute for Air Research
P.O. Box 100, N-2027 Kjeller, Norway
Tel.: +47 63 89 80 00 – Fax: +47 63 89 80 50
Associated with CIENS and the Environmental Research Alliance of Norway
ISO certified according to NS-EN ISO 9001

Meeting Summary/Assignments

SUBJECT: **BAPMAN Project Meeting (TASK 1 Focus)**	
MEETING PLACE: NILU, Room UB	TIME: 14:30-15:30
PARTICIPANTS: SR, BS, VTD (NILU) MR, GS (CASE/DoE)	DISTRIBUTION: All participants and Dr. Nasiruddin, BAPMAN internal website
OUR REF.: BAPMAN 110055	DATE: October 29, 2010

ITEM#	ITEM	RESPONSIBLE	√?
1	**TASK 0 (Admin)**		
A	Put all training documents on project portal • AirQUIS manuels • Emission Inventory Templates • Training Presentations • Screening Study Design	**SR**	**√**
B	Preparation of Training Seminar Report as part of D1.1, see also 5A.	**SR**	
C	6 Month status report due to NORAD on 01 Feburary 2011.	**SR**	
2.	**TASK 1 (Emission Inventories)**		
A	Data Needs sheet assignments and prioritization (**see separate Excel sheet**)! NILU will request GIS files and proper format to GS. Check for possible data traffic or flow reports with Dhaka Traffic Authority. Enter historic Dhaka data into AirQUIS for prelim analysis.	**!** **VTD** **MR** **VTD**	**√**
B	2 draft questionnaires will be made (one simple, one advanced) and sent to MR/GS for review and comment.	**SR**	**√**
C	Review AirQUIS manuels and Excel Templates in preparation for AirQUIS installation Summer 2011.	**GS/MR**	
D	Transfer of Screening Study Design Plans (and GE files) to MR/GS. Check for available CASE/DoE staff to participate in Screening Study in Jan/Feb 2011 and help coordinate their home location in GE file. Check if MiniVol Samplers will be available for use during Screening Study.	**SR** **MR/GS** **MR/GS**	**√**
3	**TASK 2 (Instruments)**		
A	Please keep NILU updated of status of CAMS Maintenance Contract and	**GS**	

ITEM#	ITEM	RESPONSIBLE	√?
	G-01 Tender so LM can properly plan Task 2.		
4	**Future Missions and Training (Preliminary)**		
A	NILU Mission 2 to Dhaka Jan/Feb 2011 for Screening Study, including Task 1 follow-up meetings and discussion. Solidify design plan and procurement of equipment (samplers, satellites, DT)	**SR/BS** **SR/BS**	
B	NILU Mission 3 to Dhaka Summer 2011 for AirQUIS installation and training, including Task 1 follow-up meetings and discussion.	**RuO/VTD**	
C	Task 1 additional Emission Inventory training at NILU in 2011.	**VTD/SR**	
D	Task 3 AirQUIS training at NILU in 2011.	**RuO/VTD/ SR**	
E	Administration and technical meetings with Dr. Nasir at NILU possibly in December?	**BS/SR**	
F	NILU must discuss these preliminary Mission and Training plans with Dr. Nasir.	**SR/BS**	
5	**Reports**		
A	D1.1 preparation “Training Seminar” and publication as part of future D1.1, see also 1B.	**SR**	
B	D1.2 planning “Procedures for emissions inventorying for urban areas in Bangladesh” in coordination with MR/GS.	**VTD**	

NILU – Norwegian Institute for Air Research

P.O. Box 100, N-2027 Kjeller, Norway

Associated with CIENS and the Environmental Research Alliance of Norway

ISO certified according to NS-EN ISO 9001

REPORT SERIES PROJECT REPORT	REPORT NO. OR 84/2010	ISBN: 978-82-425-2335-8 (print) 978-82-425-2336-5 (electronic) ISSN: 0807-7207	
DATE	SIGN.	NO. OF PAGES 118	PRICE NOK 150.-

TITLE	PROJECT LEADER
Bangladesh Air Pollution Management (BAPMAN) Emission Inventory Training Seminar NILU, 25 - 29 October 2010	Scott Randall
	NILU PROJECT NO. O-110055
AUTHOR(S) Scott Randall, Bjarne Sivertsen, Vo Thanh Dam, and Karl Idar Gjerstad	CLASSIFICATION * A
	CONTRACT REF.

REPORT PREPARED FOR

BAPMAN Project

NILU

ABSTRACT

A training seminar was held at NILU 26-29 October 2010 for Task 1 of the Bangladesh Air Pollution Management (BAPMAN) project. The training was conducted by NILU for two experts from the Bangladeshi Department of Environment, Clean Air and Sustainable Environment Program (DoE/CASE). The specific goals of the training were to strengthen DoE/CASE Emission Inventory competence to begin work back in Dhaka, where specifically the experts were trained in data collection, top-down inventory, and bottom-up inventory. The experts were trained to become leaders in this Task 1 work and associated sub-tasks at DoE/CASE.

NORWEGIAN TITLE

KEYWORDS		
Bangladesh	Air Quality Management	Emission Inventory

ABSTRACT (in Norwegian)

** Classification*

A Unclassified (can be ordered from NILU)

B Restricted distribution

C Classified (not to be distributed)

REFERENCE: O-110055
DATE: NOVEMBER 2010
ISBN: ISBN: 978-82-425-2335-8 (print)
978-82-425-2336-5 (electronic)

NILU is an independent, nonprofit institution established in 1969. Through its research NILU increases the understanding of climate change, of the composition of the atmosphere, of air quality and of hazardous substances. Based on its research, NILU markets integrated services and products within analyzing, monitoring and consulting. NILU is concerned with increasing public awareness about climate change and environmental pollution.

NILU Norsk institutt for luftforskning
Norwegian Institute for Air Research