NILU: F 2/2006

NILU: F 2/2006
REFERENCE: O-105154
DATE: FEBRUARY 2006

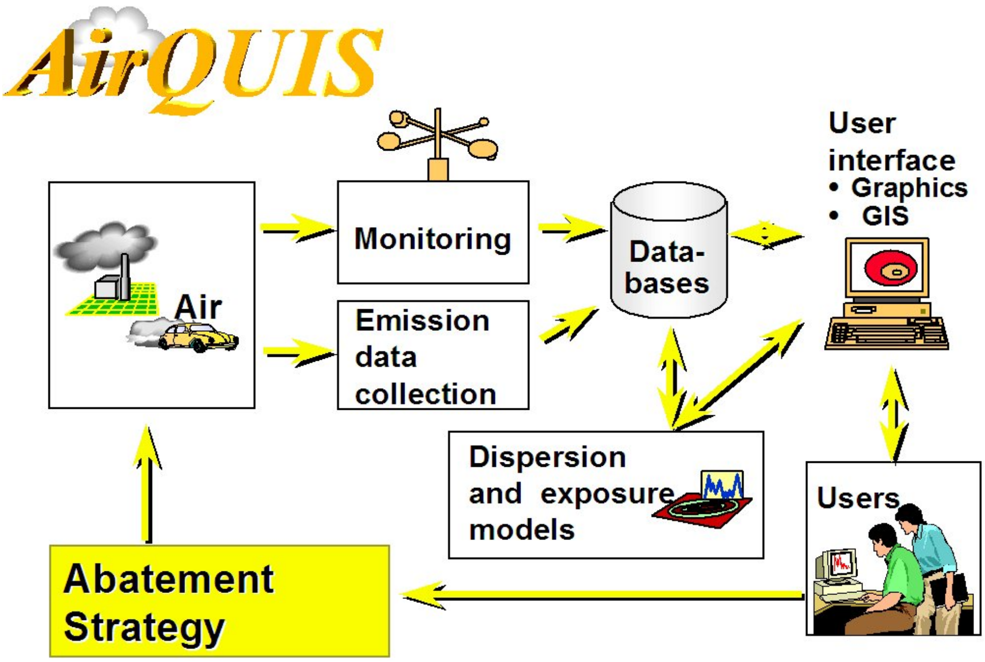
Department of Environment
Dhaka, Bangladesh

Norwegian Institute for
Air Research

**Air Quality Management Project,
Dhaka, Bangladesh, 2006**

Seminar on Air Quality Management Dhaka 23 January 2006

Bjarne Sivertsen and Herdis Laupsa



AIR QUALITY MANAGEMENT SYSTEM APPLICATIONS

Bjarne Sivertsen and Herdis Laupsa
Norwegian Institute for Air Research (NILU),
Kjeller, Norway, bs@nilu.no

1 INTRODUCTION

One of the main challenges in today's society is to have timely and appropriate access to relevant and good quality environmental data. The aim is to enable actions whenever environmental requirements and limits are violated. There is an increasing need for integrated solutions, which include monitoring data and planning tools into one system. A main objective of the modern Air Quality Management System is to enable direct data and information transfer, provide information on how much pollution the population is exposed to, establish a basis for strategies to reduce pollution and estimate air pollution impacts from present and future developments.

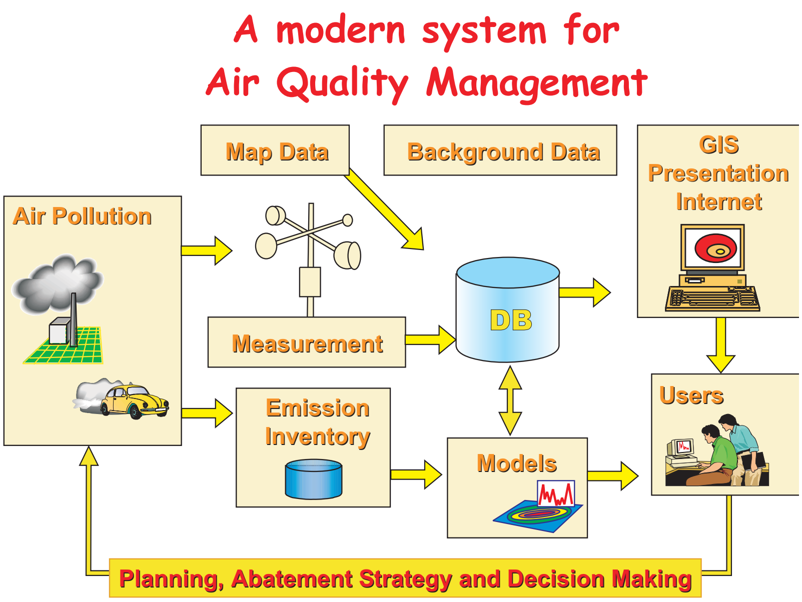
The AirQUIS system developed by the Norwegian Institute for air Research (NILU) includes dispersion and exposure modelling and has been used for forecasting of future air quality and development of cost-effective abatement strategies. The AirQUIS technology has been established in more than 30 locations worldwide and is now being used in air quality management to support integrated pollution prevention and control.

2 THE AIR QUALITY Management platform

The integrated Air Quality Management (AQM) platform, AirQUIS, includes all elements needed to undertake assessment and planning of air quality. AirQUIS provides the basis for air quality management through an integrated tool for monitoring and emission inventorying, air quality modelling and assessment, enabling forecasting of future air quality and development of cost-effective abatement strategies.

The GIS based AirQUIS system includes several modules that can be selected and applied according to the user's needs. Important common parts are the measurement database, and the graphical user interface including the GIS (Geographical Information System).

The user interface is to a large extent a map interface from which spatial distribution of pollution sources, monitoring stations, measurements, model results and other geographically linked objects can be presented. The map interface can also be used as an entrance for making queries to the database



The AirQUIS surveillance and planning system

The GIS (Geographical Information System) functionality of the AirQUIS system is designed to offer several possibilities for understanding the problems of air pollution.

- The GIS makes it easier to place the air pollution sources at the correct location, for example by making it easy to display the total network of road links in a city.
- GIS presentation of area-distributed consumption of fossil fuels and direct emissions gives a good overview of where to expect high impact of air pollution.
- Viewing the measurement stations on a map with the pollution sources will give an idea of what concentrations one may expect to find at the stations for a given wind direction.
- The GIS makes it easier to search for geographically linked data in the database.
- Displaying results of model calculations as a map can be used for public information on pollution levels at different parts of a city.

AirQUIS consists of six components and makes use of an Oracle database. The system has integrated forms and maps, was developed in Visual Basic and Map Object (GIS) and works well on an ordinary NT-server. The different components consist of:

- A manual data entering application,
- An on line monitoring system,
- A module for online data acquisition and quality control,
- A measurement data base for meteorology and air quality,
- A modern emission inventory data base with emission models,
- Numerical models for transport and dispersion of air pollutants,
- A module for exposure estimates and population exposure assessment,

- Statistical treatment and graphical presentation of measurements and modelling results.

All objects described above are integrated in a map and menu oriented user-friendly interface with direct link to the databases for measurements, emissions, modelling results and presentation tools. Advanced import/export wizards allow the user to transfer data easily to and from the AirQUIS system.

AirQUIS has tools for graphical presentation and control of data, and tables for numerical presentation of data and statistical summaries. The information system provides a report generator and the possibility of exporting data and map images

There are three types of data that can be displayed on the map: shape themes, AirQUIS themes and data set.

3 Design the monitoring programme

In the design of a complete sampling and monitoring programme for air quality there are several phases and steps that have to be considered:

1. Define the objectives and strategies for the measurement programme,
2. Define the contents,
3. Perform a screening,
- Problems and relevant air pollution sources,
- Collect available data (meteorology and air quality),
4. Evaluate existing data,
- Representativeness of equipment,
- QA/QC procedures,
5. Plan the programme in detail,
- Siting studies,
- Consider field investigations,
- Emission source locations, simple modelling,
- Select relevant sites,
6. Optimise measurements, (cost/effective design),
7. Procure instruments,
- Specify technical requirements,
- Purchase and test instruments
8. Establish and initiate operation,
- Laboratory control systems,
- Develop standard operational procedures (SOP),
- Define and describe QA/QC procedures,
9. Training.

4 Operational sequence

Once the objective of air sampling is well defined, a certain operational sequence has to be followed. A best possible definition of the air pollution problem together with and analysis of available personnel, budget and equipment represent the basis for decision on the following questions:

1. What spatial density of sampling stations is required?
2. How many sampling stations are needed?
3. Where should the stations be located?
4. What kind of equipment should be used?
5. How many samples are needed, during what period?
6. What should be the sampling (averaging) time and frequency?
7. What other than air pollution data are needed:
    - Meteorology,
    - Topography,
    - Population density,
    - Emissions,
    - Effects and impacts, etc.?
8. What is the best way to obtain the data (configuration of sensors and stations)?
9. How shall the data be communicated, processed and used?

The answers to these questions will vary according to the particular need in each case.

5 The modern air quality monitoring system

A modern air quality monitoring system should include:

- Data collectors; sensors and monitors,
- Data transfer systems and data quality assurance/control procedures,
- Data bases,
- Statistical and numerical models (included air pollution dispersion models and meteorological forecast procedures),
- User friendly graphical presentation systems including Geographical Information Systems (GIS),
- A decision support system,
- Data distribution systems and communication networks for dissemination of results to “outside” users.

The key features of the system described above is the integrated approach that combines monitoring, surveillance, information and planning and enables the user in a user friendly way to not only access data quickly, but also to use the data directly in the assessment and in the planning of actions.

The demand of the integrated system to enable monitoring, forecasting and warning of pollution situations has been and will be increasing in the future. The data may also be used for generating new indicators that relate directly to health impacts. This will require that numerical models are available with on-line data input as a part of the system.

6 Site selection

The urban air quality monitoring programme shall normally provide information to support and to facilitate the assessments of air quality in a selected area. The information shall be available in such a form that it is suitable to:

- Facilitate a general description of air quality, and its development over time (trend);
- Enable comparison of air quality from different areas and countries;
- Produce estimates of exposure of the population, and of materials and ecosystems;
- Estimate health impacts;
- Quantify damage to materials and vegetation;
- Produce emissions/exposure relations and exposure/effect relations;
- Support development of cost-effective abatement strategies;
- Support legislation (in relation to air quality directives);
- Influence/inform/assess effectiveness of future/previous policy.

The assessments should be based upon concentration fields (space-time fields) produced by the monitoring and information network or by a combination of monitoring and modelling, and should cover local as well as regional scale. The modelling efforts are essential in forming the link between emissions on the one hand and exposure and effects on the other hand.

7 Representativity

It is important to bear in mind, when measuring air quality or analysing results from measurements that the data you are looking at is a sum of impacts or contributions originating from different sources on different scales.

The total concentration is a sum of

- a natural background concentration,
- a regional background,
- a city average background concentration (kilometre scale impact),
- local impact from traffic along streets and roads,
- impact from large point sources; industrial emissions and power plants.

To obtain information about the importance of these different contributions it is therefore necessary to locate monitoring stations so that they are representative for the different impacts. This normally means that more than one monitoring site is needed for characterising the air quality in the urban area. It is also important to carefully characterise the monitoring representativeness, and to specify what kind of stations we are reporting data from. An often-used terminology is to classify according to the area type (urban, suburban, rural) where they are located, and according to what type of sources (traffic, industrial, background) dominates the air pollution levels at the station. The background stations are divided into; near-city background, regional and remote background stations.

8 Selection of indicators

It is normally not possible to measure all the air pollutants present in the urban atmosphere. We therefore have to choose some indicators that should represent a set of parameters selected to reflect the status of the environment. They should enable the estimation of trends and development, and should represent the basis for evaluating human and environmental impact. Further, they should be relevant for decision-making and they should be sensitive for environmental warning systems.

The selected set of environmental indicators are being be used by local and regional authorities as a basis for the design of monitoring and surveillance programmes and for reporting the state of the environment.
Air quality indicators should:

- Provide a general picture,
- Be easy to interpret,
- Respond to changes,
- Provide international comparisons,
- Be able to show trends over time.

The most often selected indicators are:
SO_2, NO_2, O_3, CO, PM_{10}, $PM_{2,5}$ and Benzene or BTX).

9 Instrumentation for air pollution measurements

Instruments for measurements of air pollutants may vary strongly in complexity and price from the simplest passive sampler to the most advanced and most often expensive automatic remote sampling system based upon light absorption spectroscopy of various kinds. The following Table indicates four typical types of instruments, their abilities and prices.

Different types of instruments, their abilities and price.

Instrument type	Type of data collected	Data availability	Typical averaging time	Typical price (US $)
Passive sampler	Manual, in situ	After lab analyses	1-30 days	10
Sequential sampler	Manual /semi-automatic , in situ	After lab analyses	24 h	1 000
Monitors	Automatic Continuous, in situ	Directly, on-line	1h	>10 000
Remote monitoring	Automatic/Continuous , path integrated (space)	Directly, on-line	<1 min	>100 000

Relatively simple equipment is usually adequate to determine background levels (for some indicators), to check Air Quality Guideline values or to observe trends. Also for undertaking simple screening studies, passive samplers may be adequate. However, for complete determination of regional air pollution distributions, relative source impacts, hot spot identification and operation of warning systems more complex and advanced monitoring systems are needed. Also when data are needed for model verification and performance expensive monitoring systems are usually needed.

10 Meteorological data

Meteorological data are important input data to a system that is to be used for information, forecasting and planning purposes. Meteorological data are also important for explanatory reasons together with climatological data.

Meteorological data are needed from the surface, normally collected along 10 m towers, and up to the top of the atmospheric boundary layer. Automatic weather stations are currently being used in most large field studies, in remote areas and in complex terrain. Meteorological "surface data" such as winds, temperatures, stability, radiation, turbulence and precipitation are normally located together with the air quality monitoring station and data are being transferred to a central computer via radio communication, telephone or satellite.

11 Data retrieval and QA/QC

When the air quality monitoring programme has been designed and indicators selected, it is important to prepare the Quality Assessment and Quality Control programme.

Procedures for Quality Assessment (QA) and Quality Control (QC) are developed to ensure that the data emerging from the monitoring will at least satisfy the data quality objectives (DQOs) defined by the responsible authorities. Complete QA/QC procedures are rather complex, and they should be documented. A very important element in the quality control procedures is the calibration procedures and the traceability of the calibration standards used in the network/station back to absolute standards of known quality. Institutions responsible for the QA/QC procedures and their follow-up may be national, regional or local

12 Reporting

Reporting procedures may vary from country to country and from one city to another. The requirements are normally given by central authorities and may include:

- Daily reports (AQI)
- Weekly reports (printouts)
- Monthly reports (data summary results)
- Bi-annual summary reports (normally not required)
- Annual report (status, assessment)

13 Dispersion models for future impacts

Numerical and statistical models are being used in air pollution studies of various content and complexity. The models can roughly be divided into two main types:

1. Source oriented models
2. Receptor models

Receptor models use measured concentrations of various air pollutants over long time periods and can by statistical analyses identify source impact and the different sources contribution to the concentration measured at specific receptor points.

The source oriented models combine information about sources (emission inventories), meteorology as well as area characteristics, topography, surface roughness etc. to estimate concentration distributions. To estimate the future impact at ground level from planned emissions of air pollution, different type of source oriented air pollution dispersion models have to be applied.

The **source oriented models** are the only ones that adequately can be used for planning purposes. Receptor models can mainly be used for explaining measured concentrations, and is useful in such cases.

Wide ranges of different models have been published in scientific papers and even a larger number of unpublished models and special model versions exist. Models can be distinguished on many grounds: e.g. the underlying physical concepts, the temporal and spatial scale, and type of component. Contemporary air pollution models deal with "conventional" primary pollutants (mainly SO_2, CO, NOx and VOC).

The models need as input data some background information on;
- Source characteristics and emission data
- Area characteristics (surface roughness, topography etc..)
- Measurement data (measurement type, heights etc..)
- Meteorological data (wind, stability, mixing height, temperatures etc..)
- Dispersion coefficients (type to be used and parameters)
- Dry and wet removal coefficients
- Location of receptor points (distances or grid specifications)

14 Emission inventories

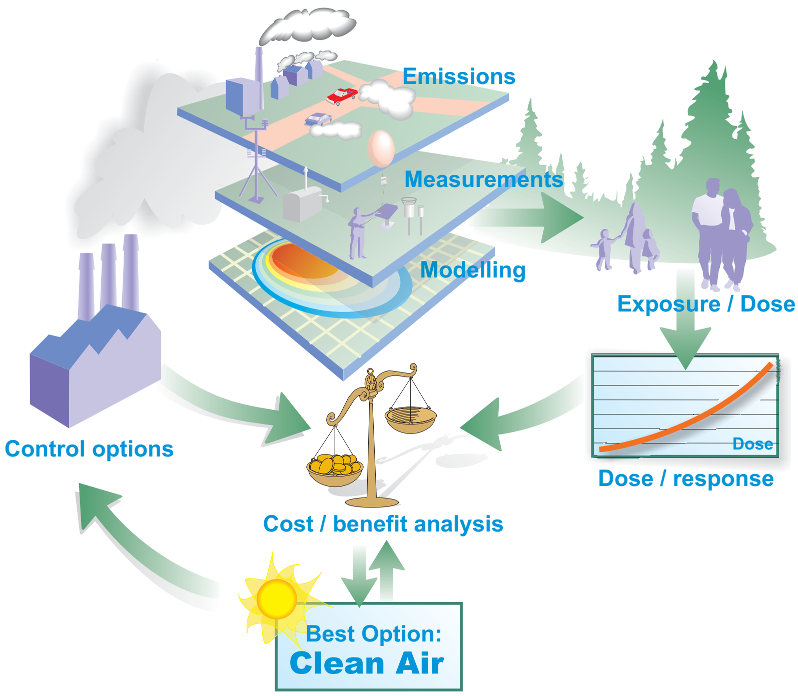
Emission estimates are collected together into inventories or databases which usually also contain supporting data on, for example: the locations of the sources of emissions; emission measurements where available; emission factors; capacity, production or activity rates in the various source sectors; operating conditions; methods of measurement or estimation, etc.

To identify the characteristics of different sources the different air pollution sources are normally divided into:
- Point sources (emissions from stacks, e.g. power plants and industries),
- Line sources (emission from traffic along a road or a street),

- Area sources (e.g. residential heating and other small sources distributed over an area),

15 Cost benefit analyses

When data and models are made available there are several analyses that can be performed to estimate the impacts of planned actions. We will present two examples using the AQM system to estimate the most cost-effective actions to reduce air pollution.



Monetary valuation of control actions, and of the effects on health and the environment, may be different in concept and vary substantially from country to country. The cost-benefit analyses (CBA) are a highly interdisciplinary task. The CBA should provide a benefit-cost ratio based on monetarised costs and benefits, and be accompanied by a description of the non-monetarised items that also should be considered.

NILU has conducted such CBA of possible measures for reducing the extent of pollution damage in several major urban areas in Asia. The World Bank project “URBAIR” was a forerunner for these analyses. All the various possible measures are cost estimated and put together in relation to calculated reductions in air pollution and the consequences for damage impact.

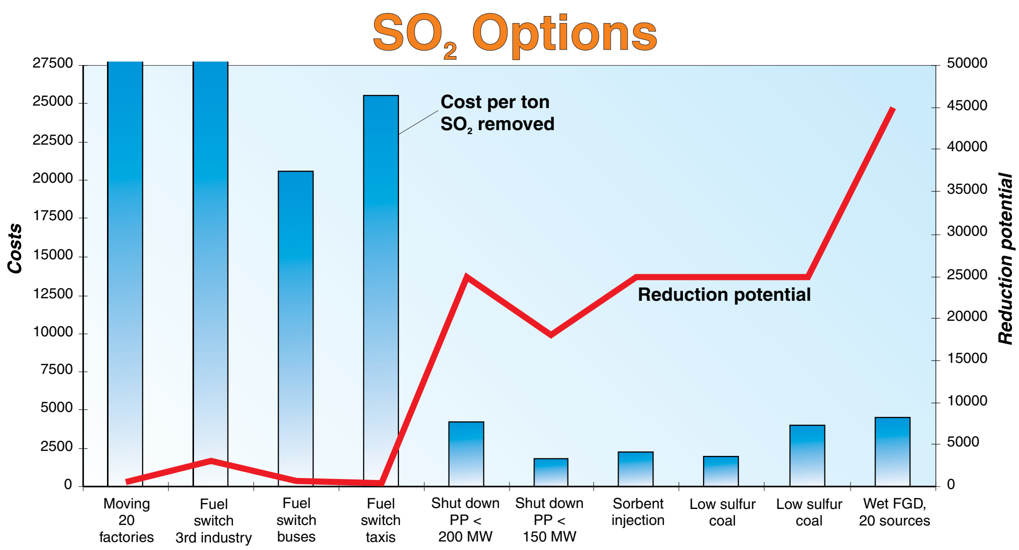
16 Optimal abatement strategies and action plans

Based on defined abatement options and scenarios, cost-benefit analyses can be used to evaluate the best possible options to reduce the air pollution load seen from an economic point of view. The results of such analyses may again lead to the development of action plans.

An Air Quality Management and Planning System (AQMS) was established in the city of Guangzhou (6 mill. inhabitants) in South China. The core of the system was the GIS based AirQUIS system. The system is applied to develop action plans for air quality improvement in a cost-efficient manner.

The essence of the Action Plan dealt with air pollution exposure of the population rather than just emissions. In the action plan, the costs of each control option were calculated in terms of costs per percentage point of exposure reduction, and this is compared with the potential to reduce the pollution exposure that is associated with the option.

Based upon this, the control options are ranked according to their cost-effectiveness. Least cost packages of control options to arrive at a given target for air quality can then be developed. This method is superior to the most used method of looking only at costs of emissions reduction and prioritising according to that, without taking into consideration the large effects that the emission conditions (location compared to the population centres, the stack height, etc.) have on the resulting pollution concentrations and exposure of the population.



Evaluating ten different SO_2 control options indicated that plant shut down and low sulphur coal use are the most cost effective options in Guangzhou.

17 References

Bøhler, T. and Sivertsen, B. (2004) An integrated Air Quality Management System for sustainable development. Presented at Dubai International Conference on Atmospheric Pollution, 21-24 February 2004, Dubai, UAE. Kjeller (NILU OR 4/2004).

Council of the European Communities (CEC) (1999) Council directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air. *Official Journal L 163, 29 June 1999*, 41-60.

European Commission (2001) Commission decision of 17 October 2001 amending the Annexes to Council Decision 97/101/EC establishing a reciprocal exchange of information and data from networks and individual stations measuring ambient air pollution within the Member States. *Official Journal L 282 of 26 October 2001*, 69-76.

Gryning, S.E., Holtslag, A.A.M., Irwin, J.S. and Sivertsen, B. (1987) Applied dispersion modeling based on meteorological scaling parameters. *Atmos. Environ*., *21*, 79-89.

Hanna, S.R., Briggs, G.A. and Hosker, R.P. (1982) Handbook on atmospheric diffusion. Washington D.C., Department of Commerce (DOE/TIC-11223).

Larssen, S. and Laziridis, M. (1999) EUROAIRNET site selection 1998. (EEA Technical Report 16).
URL: http://reports.eea.eu.int/TEC16/en/tech_16.pdf.

Larssen, S., Sluyter, R. and Helmis, C. (1999). Criteria for EUROAIRNET - The EEA Air Quality Monitoring and Information Network. (EEA Technical Report 12).
URL: http://reports.eea.eu.TEC12/en/tech12.pdf.

Larssen, S. et al. (1995) URBAIR - Urban air quality Management Strategy in Asia, Metro Manila City Specific Report. Kjeller (NILU OR 57/95).

Laupsa, H. and Slørdal, L.H. (2002) Estimation of urban air quality with respect to the EC directives on NO_2 and PM_{10}. Presented at "8th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes" in Sofia, Bulgaria October 12-17, 2002.

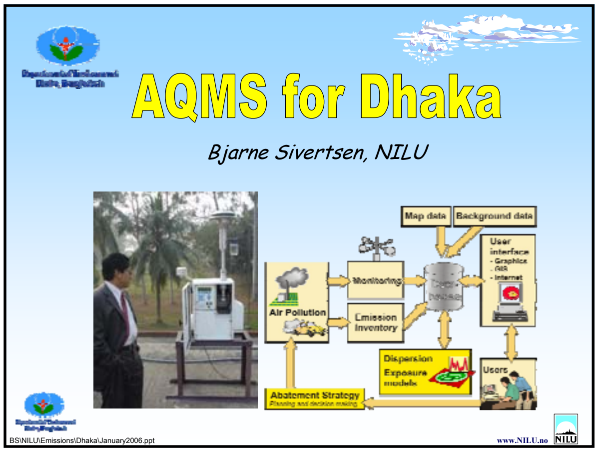
Sivertsen, B. (2001) AirQUIS, Presented at the AirQUIS Workshop, Bucharest, 25 October 2001. Kjeller (NILU F 9/2001).

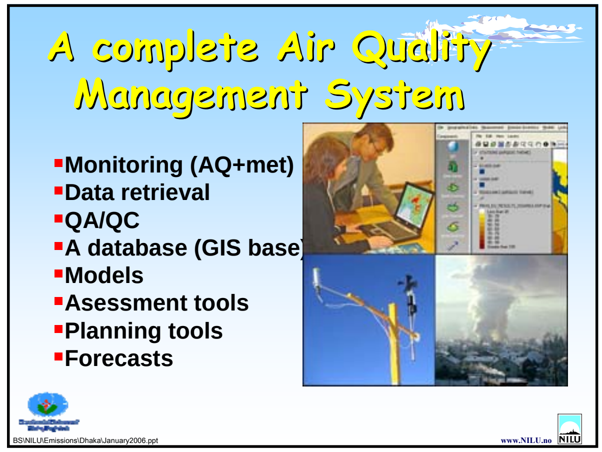
WHO (2000) Guidelines for Air Quality. Geneva, World Health Organization (WHO/SDE/OEH/00.02).

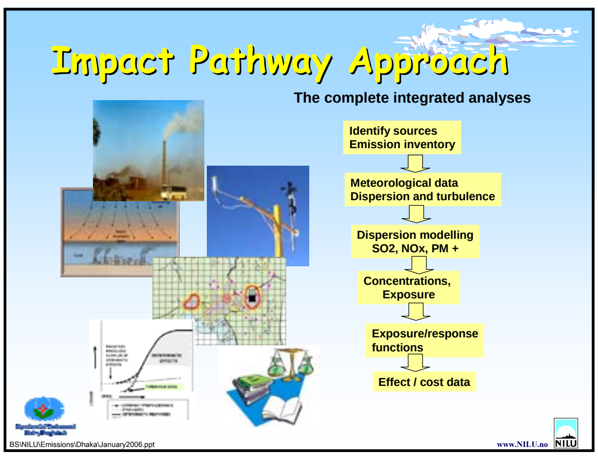
Appendix A

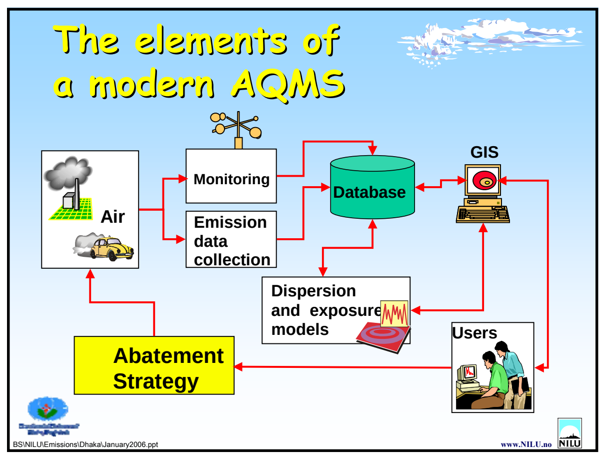
Presentations given during the seminar

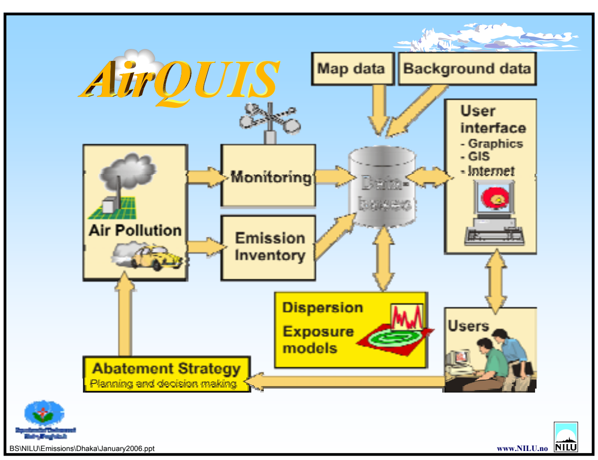
Dhaka 23 January 2006


AQMS for Dhaka
Bjarne Sivertsen, NILU
Map data
Background data
User interface
Monitoring
Air Pollution
Emission inventory
Dispersion Exposure models
Users
Abatement Strategy
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU

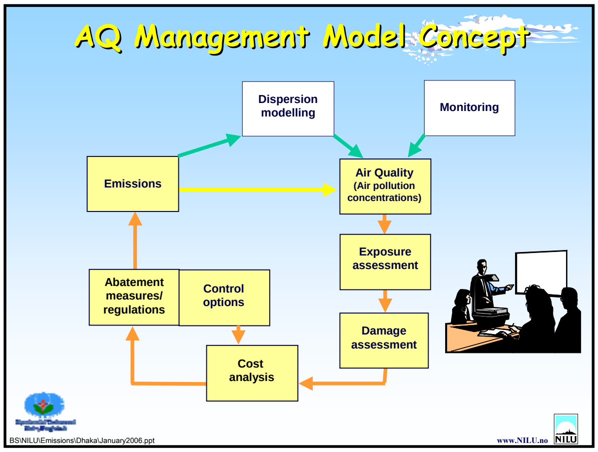

A complete Air Quality Management System
Monitoring (AQ+met)
Data retrieval
QA/QC
A database (GIS base)
Models
Asessment tools
Planning tools
Forecasts
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU

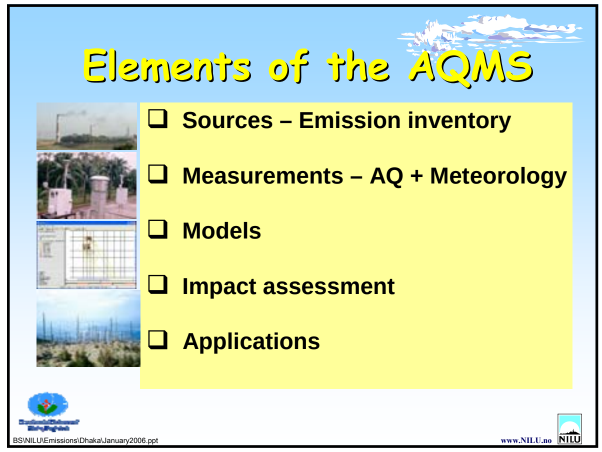

Impact Pathway Approach
The complete integrated analyses
Identify sources Emission inventory
Meteorological data Dispersion and turbulence
Dispersion modelling SO2, NOx, PM +
Concentrations, Exposure
Exposure/response functions
Effect / cost data
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU

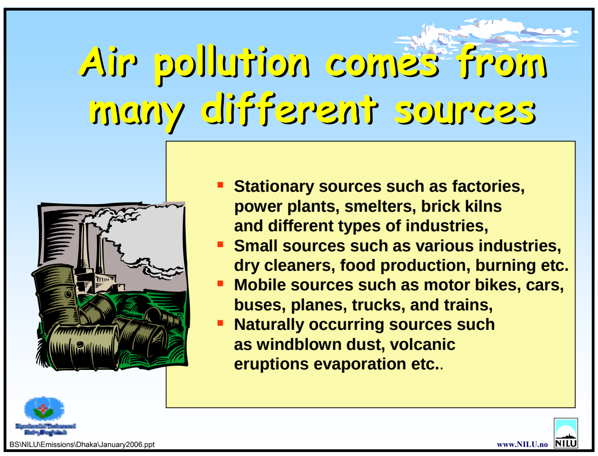

The elements of a modern AQMS
Air
Monitoring
Emission data collection
Database
GIS
Dispersion and exposure models
Users
Abatement Strategy
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU


AirQUIS
Map data
Background data
User interface
- Graphics
- GIS
- Internet
Monitoring
Air Pollution
Emission Inventory
Data-base
Dispersion Exposure models
Users
Abatement Strategy
Planning and decision making
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU

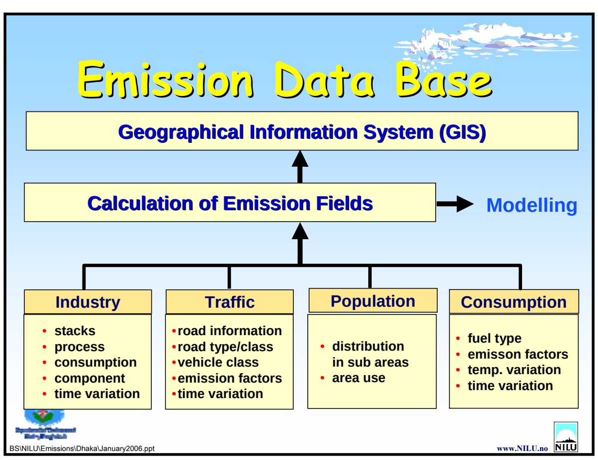

Development of Air Quality Management Strategy Plan
Assessment
Sources
Monitor
Exposure
Source - exposure
Contributions to exposure
Damage
AQMS
Control
Control options
Cost – efficiency/benefit
Control strategy
Investment plan
Masterplan
Surveillance
Develop institutions
AQ Information System
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU

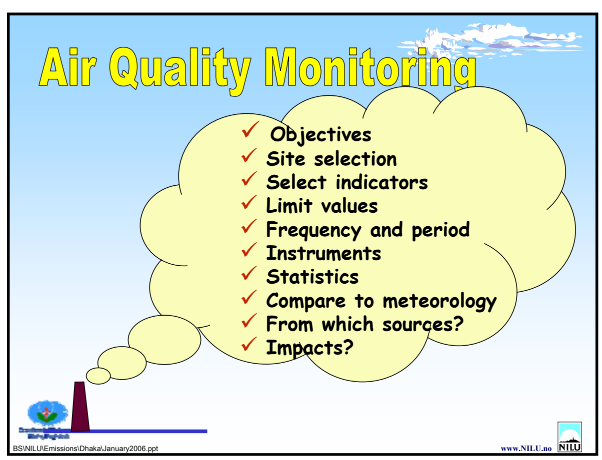

AQ Management Model Concept
Dispersion modelling
Monitoring
Emissions
Air Quality (Air pollution concentrations)
Exposure assessment
Abatement measures/ regulations
Control options
Damage assessment
Cost analysis
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU


Elements of the AQMS
Sources – Emission inventory
Measurements – AQ + Meteorology
Models
Impact assessment
Applications
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU

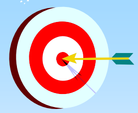

Air pollution comes from many different sources
Stationary sources such as factories, power plants, smelters, brick kilns and different types of industries,
Small sources such as various industries, dry cleaners, food production, burning etc.
Mobile sources such as motor bikes, cars, buses, planes, trucks, and trains,
Naturally occurring sources such as windblown dust, volcanic eruptions evaporation etc..
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU


Air pollution sources in Dhaka
traffic emissions
Open air waste burning
brick factories
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU


Emission Data Base
Geographical Information System (GIS)
Calculation of Emission Fields
Modelling
Industry
stacks
process
consumption
component
time variation
Traffic
road information
road type/class
vehicle class
emission factors
time variation
Population
distribution in sub areas
area use
Consumption
fuel type
emisson factors
temp. variation
time variation
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU


Air Quality Monitoring
Objectives
Site selection
Select indicators
Limit values
Frequency and period
Instruments
Statistics
Compare to meteorology
From which sources?
Impacts?
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU

Indicators



Identified to:

- Provide a general picture
- Be easy to interpret
- Respond to changes
- Provide international comparisons
- Be able to show trends over time
- Identify Needs for and Support the Design of Control Strategies
- Support Input to Management and Policy Changes

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no

Air Pollution Indicators

Not all compound in the atmosphere can be measured !

First priority pollutants

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

Dhaka: PM_{10}, $PM_{2,5}$, SO_2, NO_2, CO, O_3, VOC

Limit values developed for other indicators:

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

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no

Guidelines and Limit values (µg/m³) WHO & AQMP objectives

Pollutant	Averaging Period	WHO Guideline	AQMP Objectives
CO	1-hour average	10 mg/m³	10 mg/m³
	8-hour average	30 mg/m³	40 mg/m³
SO_2	24- hour average	125 µg/m³	365 µg/m³
	Annual average	50 µg/m³	80 µg/m³
NO_2	1-hour average	200 µg/m³	-
	Annual average	40 µg/m³	100 µg/m³
O_3	1-hour average	150-200 µg/m³	235 µg/m³
	8-hour average	120 µg/m³	157 µg/m³
PM_{10}	24- hour average	50 (EU)	150 µg/m³
	Annual average	20	50 µg/m³
$PM_{2.5}$	24- hour average	-	65 µg/m³
	Annual average	-	15 µg/m³

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no

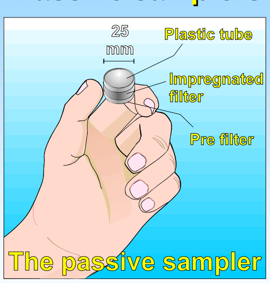
Instruments

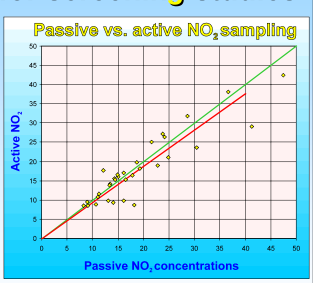
Many kinds:

- Simple passive samplers
- High volume samplers
- Sequential samplers
- Automatic Monitors (in situ)
- Monitors for remote measurements
- Mobile stations
- Automatic weather stations

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no

Passive samplers for screening studies





BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no

Air quality Monitors

SO_2	→	fluorescent signal exiting SO_2 with UV
NO, NO_2	→	chemiluminiscent reaction NO/O_3
O_3	→	UV absorption analyser
CO	→	non-dispersive infrared photometer
HC	→	NMHC, flame ionizator detector (FID)

Reference instruments !

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no

Measurement data

- ✓ Check and verify measurement methods
- ✓ Identify Reference Methods
- ✓ Specify equivalent methods used
- ✓ Report site representativity
- ✓ Describe sampling and analytical methods
- ✓ Specify monitors used

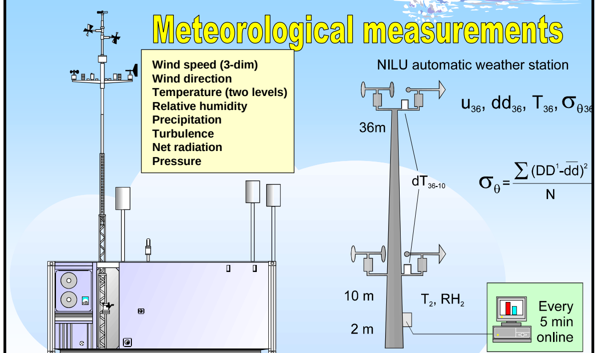
- Sampling time
- Sampling frequency
- Analytical procedures
- Data collection
- QA/QC systems
- Data storage / databases
- Air Quality Statistics

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU

All air quality monitoring programmes include

Meteorological measurements

- Wind speed (3-dim)
- Wind direction
- Temperature (two levels)
- Relative humidity
- Precipitation
- Turbulence
- Net radiation
- Pressure



BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU

A typical monitoring station

Urban background site in HCMC

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU

Quality Assurance

All planned and systematic activities which are needed to assure and demonstrate the predefined quality of data

1) Monitoring Objectives
Determine use of data, e.g. monitoring of trends

2) Data Quality Objectives
Determine necessary data quality to fulfil the Monitoring Objectives

3) Equipment selection
Results must fulfil the DQO. Select best measuring practice

4) Site selection
Must be representative for the Monitoring Objectives

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU

Quality Control

Operational techniques and activities that are undertaken to fulfil the quality requirements

- Calibration and maintenance plan
- Standard Operations Procedures (SOPs)
  - Describe how to perform and document all operations
  - Maintenance, calibration, repairs, data validation, e.t.c.
- All operations are documented in forms
- All forms are stored in files for later reference

No SOP !

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU

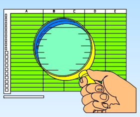
Quality Assessment

Determining the actual quality of the data and if the data fulfils the Data Quality Objectives

- Audits
  - System Audit: Inspection of QA/QC plan and documents
  - Performance Audit: Instrument response is checked at the station using a test standard
- International intercomparisons
  - Instruments measure a test standard in parallel
- Round robin tests
  - A test standard is measured at each laboratory

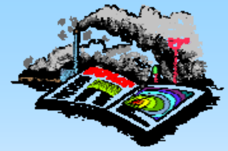
BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU

Reference laboratory



- ✓ Assure quality and consistency
- ✓ Calibrate all monitors before installed in field
- ✓ Keep standards and distribute standard gases
- ✓ Perform Audits to the monitoring sites
- ✓ International comparisons and tests

Reporting requirements



- ✓ Daily (AQI)
- ✓ Weekly (printouts)
- ✓ Monthly (data summary results)
- ✓ (6-months summary?)
- ✓ Annual report (status, assessment)

Daily: Air Quality Index (AQI)

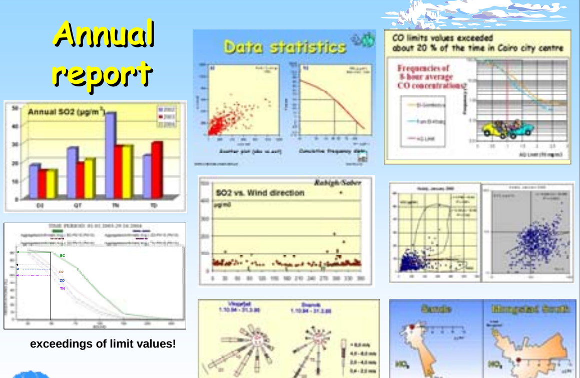
$$AQI = \frac{\text{Pollutant concentration}}{\text{Pollutant limit value}} \times 100$$

The daily index, AQI^d_j, is calculated as:

$$AQI^d_j = Max_i(C^d_{i,j} / S^d_i) * 100$$

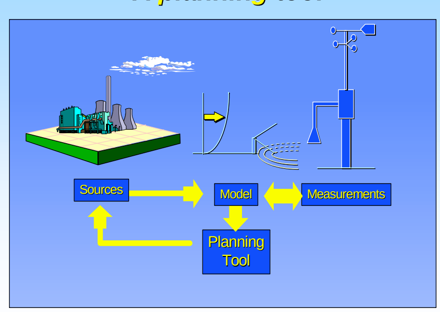
Air Quality Index (AQI) Values	Levels of Health Concern	Colors
When the AQI is in this range:	*...air quality conditions are:*	*...as symbolized by this color:*
0 to 50	Good	Green
51 to 100	Moderate	Yellow
101 to 150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 500	Hazardous	Maroon

Annual report

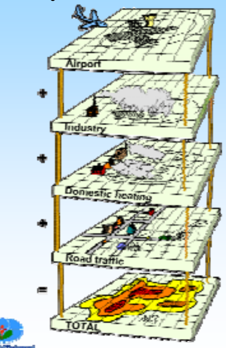


Air pollution Dispersion Models

A planning tool

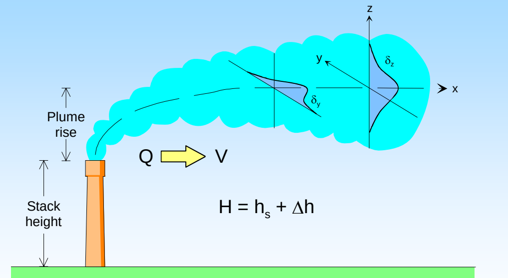


Dispersion modelling



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

The Gaussian plume model



$$\text{Concentration} = \frac{\text{Release rate}}{\text{Wind speed} \bullet \text{dispersion}}$$

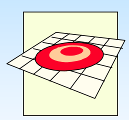
Models in AirQUIS

Wind
- Meteorological pre-processor
- Wind field models

Emission Model
- Traffic and stationary sources

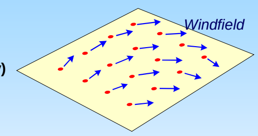
Dispersion Models
- Urban scale grid model
- sub-grid point source model
- street and road models

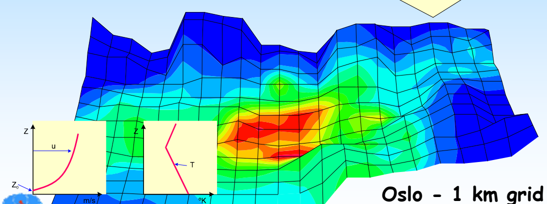
Effect Models
- Population exposure
- Impact on materials and buildings



The Numerical Dispersion Model, EPISODE

Meteorological hourly gridded input data:
- Windfield (u, v, w)
- Temperature at ground level
- Vertical temperature gradient (stability)
- Mixing height
- Turbulence (σ_v and σ_w)



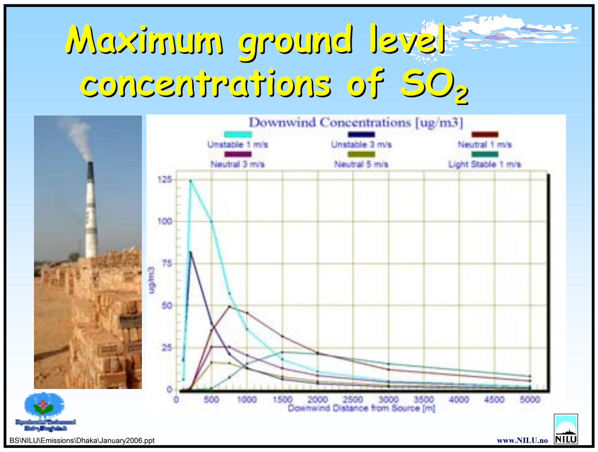


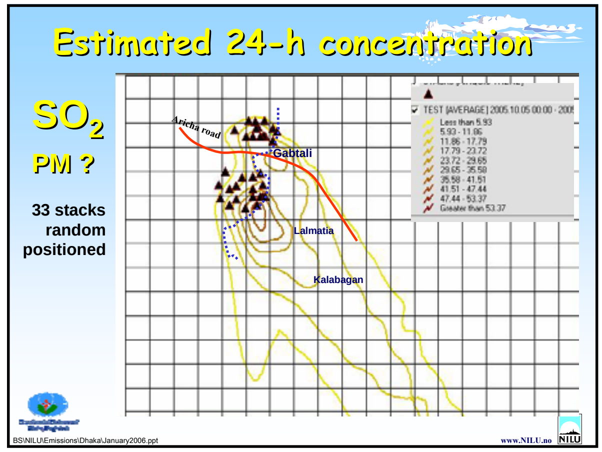
Modelling with AirQUIS

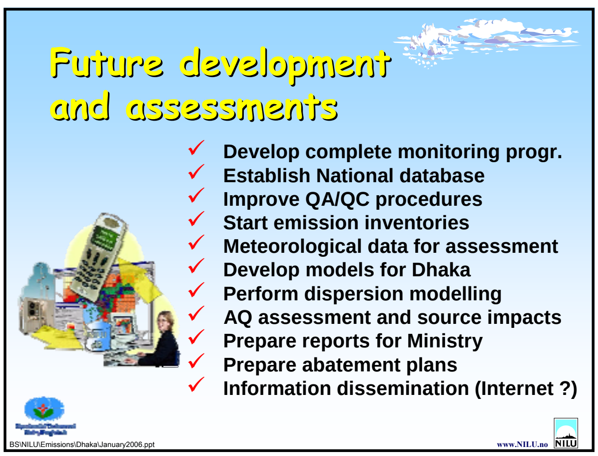
Brick factory emissions

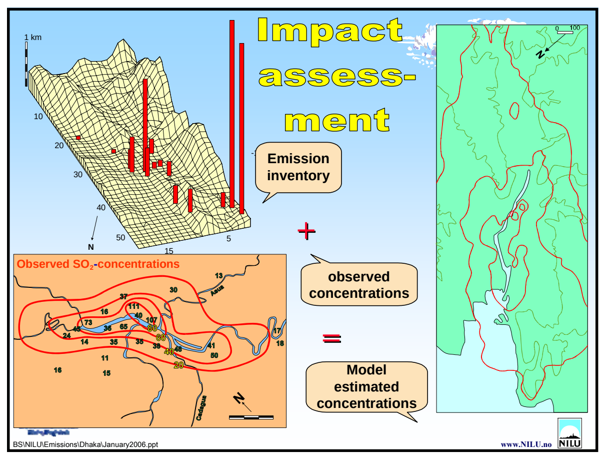
Gabtali area: 108 brick kilns (stacks)

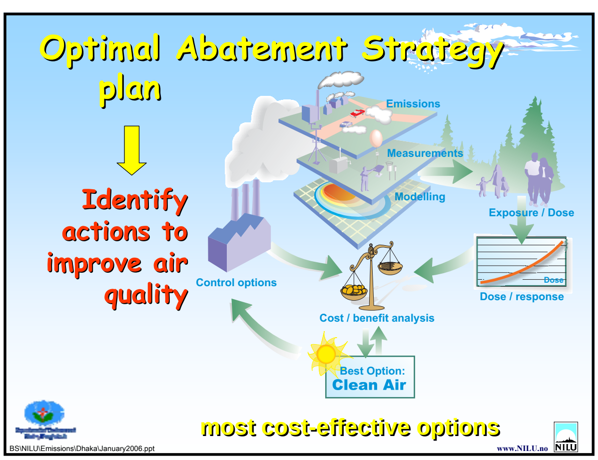
Fuel:	Mainly coal (some wood)
Consumption:	about 4 tons/day
Production:	~ 22 000 bricks/day
Sulphur content:	3-4 % S ?
Ash content:	???
Stack height:	45 m
Outlet stack diametre:	~ 1 m
Exit gas temperature:	?

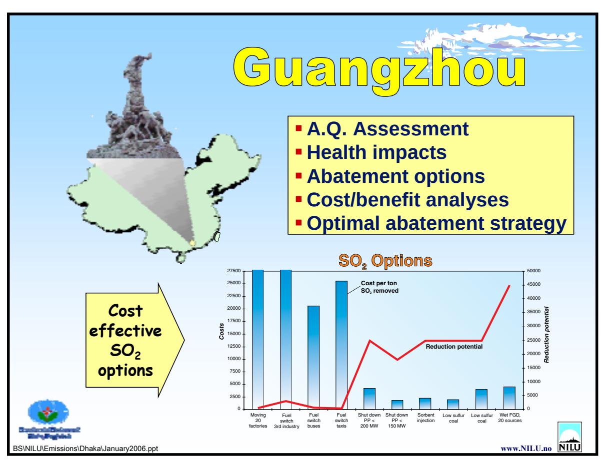

Maximum ground level concentrations of SO_2
Downwind Concentrations [ug/m3]
Unstable 1 m/s
Unstable 3 m/s
Neutral 1 m/s
Neutral 3 m/s
Neutral 5 m/s
Light Stable 1 m/s
ug/m3
Downwind Distance from Source [m]
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU

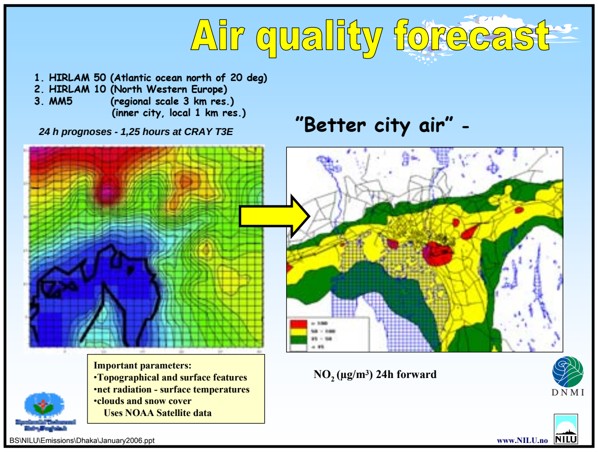

Estimated 24-h concentration
SO_2
PM ?
33 stacks
random
positioned
Aricha road
Gabtali
Lalmatia
Kalabagan
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU


Future development and assessments
Develop complete monitoring progr.
Establish National database
Improve QA/QC procedures
Start emission inventories
Meteorological data for assessment
Develop models for Dhaka
Perform dispersion modelling
AQ assessment and source impacts
Prepare reports for Ministry
Prepare abatement plans
Information dissemination (Internet ?)
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU


Impact assess-ment
Emission inventory
+
Observed SO_2-concentrations
observed concentrations
=
Model estimated concentrations
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU

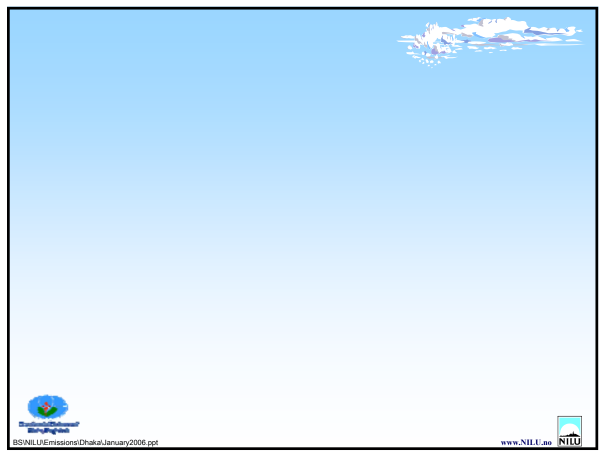

Optimal Abatement Strategy plan
Identify actions to improve air quality
Emissions
Measurements
Modelling
Exposure / Dose
Control options
Dose / response
Cost / benefit analysis
Best Option: Clean Air
most cost-effective options
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU

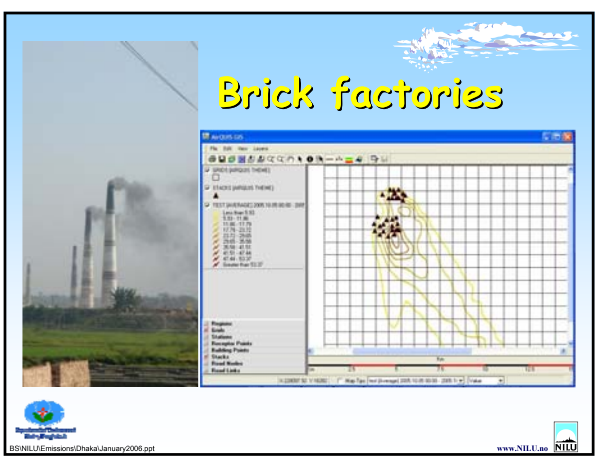

Guangzhou
A.Q. Assessment
Health impacts
Abatement options
Cost/benefit analyses
Optimal abatement strategy
SO_2 Options
Cost effective SO_2 options
Cost per ton SO_2 removed
Reduction potential
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU


Air quality forecast
1. HIRLAM 50 (Atlantic ocean north of 20 deg)
2. HIRLAM 10 (North Western Europe)
3. MM5 (regional scale 3 km res.)
(inner city, local 1 km res.)
24 h prognoses - 1,25 hours at CRAY T3E
"Better city air" -
Important parameters:
•Topographical and surface features
•net radiation - surface temperatures
•clouds and snow cover
Uses NOAA Satellite data
NO2 (µg/m3) 24h forward
DNMI
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU


Air Quality Management
Training needs
Air Quality Assessment
Environmental Damage Assessment
Abatement Options Assessment
Cost Benefit Analysis or
Cost Effectiveness Analysis
Abatement Measures
Optimum Control Strategy
AQMS
Training
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU


Norwegian Institute for Air Research
www.nilu.no
NILU
POBox 100
No-2027 Kjeller
Norway
Fax: +4763898050
E-mail: nilu@nilu.no
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU


BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU


Brick factories
BS\NILU\Emissions\Dhaka\January2006.ppt
www.NILU.no
NILU

Emission inventories

Herdis Laupsa, NILU

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no

What is an Emission Inventory?

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

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no

Why Emission Inventory?

- Air quality assessment
- Evaluating the sources
- Air Quality Management
- Abatement strategy

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no

How to prepare an emission Inventory?

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

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no

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

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no

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

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no

Model for emission estimate

- **Activity statistics** and a typical average **emission factor** for individual activities
- **Emission measurement** over periods of time to enable emission estimates for the required period (e.g. year)

Emission Inventory Features

- **Point source emission** - single activities like industries, energy production linked to single stacks
- **Line emission** - road traffic, ships
- **Area emission** – open air burning, public and private services, agricultural activities etc.,

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU

Emission Data Base

Geographical Information System (GIS)

↑

Calculation of Emission → Modeling

↑

Point Sources
- Industry
- Stacks
- Consumption
- Emission
- Production
- Emission factors
- Time variation

Line Sources
- Static road data (Geography, road classification)
- Dynamic traffic data
- Emission factors
- Time variation

Area sources
- Consumption
- Emission
- Production
- Source sector
- Fuel /Raw material
- Emission factors
- Time variation

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU

Classification of sources

- Source sectors
  - classification of emission source sectors, sub-sectors and activities
- Fuels/Raw Material/Product
- Time variations for individual sources and source sectors

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU

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

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU

Emission Inventory - Point Sources

- Owners
- Industries
- Stack data
- Position of stacks
- Process data
- Consumption or production data
- Measured emission data

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU

Emission Inventory- Ex.:Contact person register

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	4763898000	4763898050

Emission Inventory- Ex.:Industrial plant register

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

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU

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

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU

Emission Inventory- Ex.: Consumtion 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

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU

Emission Inventory- Ex.: Emission factor data

Process Fuel and production Emission factor Data						
Process ID	Process Name	Fuel/product Name	Component Name	Factor	Unit Name	Year
30108101	Prosess 301081-1	Heavy fuel oil	PM10	10	kg/tonn	1998
30108101	Prosess 301081-1	Heavy fuel oil	PM2.5	5	kg/tonn	1998
30108101	Prosess 301081-1	Heavy fuel oil	NOx	0.001	kg/tonn	1998
30108101	Prosess 301081-1	Heavy fuel oil	NO2	0.01	kg/tonn	1998

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU

Emission Inventory- Ex.: Emission data

Process Emission Data						
Process ID	Process Name	Component Name	Amount	Emission Unit Name	Time Variation Name	Validity Period
30108101	Prosess 301081-1	PM2.5	0.218125	ton/year	TV-1082	1998
30108101	Prosess 301081-1	PM10	0.349	ton/year	TV-1083	1998
30108101	Prosess 301081-1	NO2	40.6	ton/year	TV-1084	1998
30108101	Prosess 301081-1	NOx	406	ton/year	TV-1085	1998
30108201	Prosess 301082-1	PM2.5	4.96875	ton/year	TV-1086	1998
30108201	Prosess 301082-1	PM10	7.95	ton/year	TV-1087	1998
30108201	Prosess 301082-1	NO2	12.4	ton/year	TV-1088	1998
30108201	Prosess 301082-1	NOx	124	ton/year	TV-1089	1998

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU

Emission Inventory-Traffic data

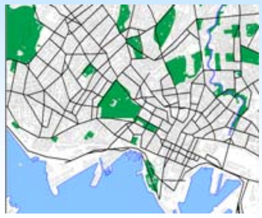
- Static data (road network)
- Dynamic data (Annual Daily Traffic)
- Road link vehicle distribution
- Traffic emission factors

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU

Emission Inventory -Traffic data

ROAD LINK DATA:

- Annual Daily Traffic
- Vehicle distribution
- Emission factors



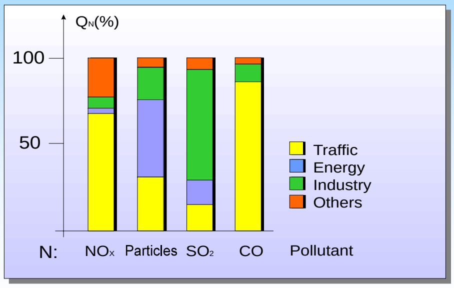
BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU

Emission Inventory – Area sources

- Small sources not handle individually such as combustion, open air burning etc.
  - 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

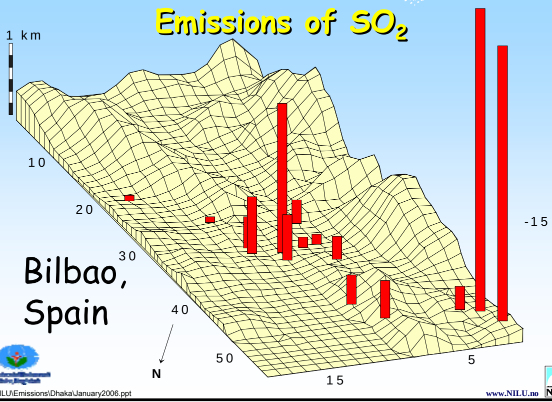
BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU

Urban air pollution sources (Norway)



BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU

Emissions of SO_2



BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU

BS\NILU\Emissions\Dhaka\January2006.ppt www.NILU.no NILU