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BAPMAN

PROJECT REPORT

NORAD
DIREKTORATET FOR UTVIKLINGSSAMARBEID
NORWEGIAN AGENCY FOR DEVELOPMENT COOPERATION

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

Air Quality Management and Monitoring Seminar

Dhaka, 3 August 2010

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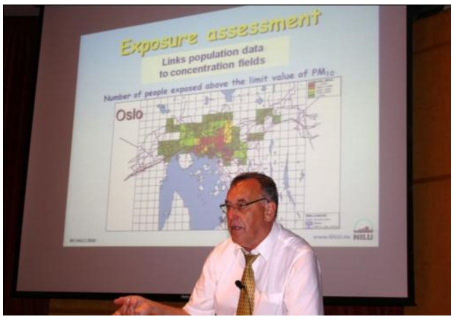

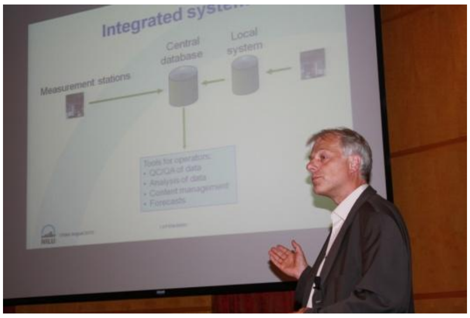

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Contents

Air Quality Monitoring and Management

Training seminar, Dhaka 3 August 2010

1 Introduction

The objective of this training seminar, which at the same time is the kick-off of the new NORAD financed project "Bangladesh Air Pollution Management", BAPMAN, is to introduce the experts selected for the project as well as other invited participants to the content of a air quality management programme. As a background for the development of the BAPMAN project was an evaluation project performed for the World Bank in 2006. (Sivertsen and Laupsa, 2006, Larssen and Marsteen, 2006).

The training course is being presented by NILU experts and divided into 7 separate lectures. The lectures are covering air quality monitoring and management, emission inventories, modelling, data assessment and data dissemination, monitoring operations and quality assurance, validation, analysis and reporting and air quality planning.

The schedule for the presentations is presented in Appendix A and a summary of the topics are the following:

- Air quality management
- Monitoring programme design
- Emission inventories and models

Lunch

- QA/QC and Monitoring operations
- Air quality assessment and reporting
- Data dissemination
- Air quality management planning

- Summary,
- Conclusions and discussions

The Powerpoint slides used during the seminar are presented in Appendix A.

2 Air quality management

An air quality management plan must within the domain of the relevant national department, province or municipality seek to:

- Give effect, in respect of air quality, and relate to National Environmental Management Plans;
- Improve air quality;
- Identify and reduce the negative impact on human health and the environment due to poor air quality;
- Address the effects of emissions from the use of fossil fuels in residential applications;
- Address the effects of emissions from industrial sources;
- Address the effects of emissions from any point or non-point source also other than the ones stated above;
- Implement the nation's obligations in respect of international agreements;
- Give effect to best practice in air quality management.

The Air Quality Management Plan (AQMP) should also describe how the relevant national department, province or municipality would comply with such other requirements as may be prescribed.

The main purpose of the AQMP development process is to establish an effective and sound basis for planning and management of air quality in the selected area. This type of planning will ensure that significant sources of impacts are identified and controlled in a most cost-effective manner. The best air quality management tools and practices may be used in order to assure the most adequate solutions. The ultimate goal will thus be to assure that health effects and impact on building materials and the environment will be avoided in the future.

The development of the AQMP will take into account:

- Air Quality Management System (AQMS) requirements
- Operational and functional structure requirements
- Source identification through emission inventories
- Source reduction alternatives, which may be implemented
- Mechanisms for facilitating interdepartmental cooperation in order to assure that actions are being taken
- Institutional building and training requirements

Important elements of the AQMP is the identification of sources and development of a complete emission inventory, the development and operations of an air quality monitoring programme and the development and application of dispersion models.

Major tasks in this work are to collect the necessary input data. The programme starts with preliminary assessments based on available data and the identification of zones into which the country will be divided. We assume that the setting of standards and regulations is already available.

3 Monitoring programme design

The typical approach to network design involves placing monitoring stations or sampling points at carefully selected representative locations, chosen on the basis of required data and known emission/dispersion patterns of the pollutants under study. This scientific approach will produce a cost effective air quality monitoring programme. Sites must be carefully selected if measured data are to be useful. Moreover, modelling and other objective assessment techniques may need to be utilized to ‘’fill in the gaps’’ in any such monitoring strategy.

Another consideration in the basic approach to network design is the scale of the air pollution problem:

- The air pollution is of predominantly local origin. The network is then concentrated to within the urban area. (e.g NO_2, SO_2, PM_{10}, CO, benzene).
- There is a significant regional contribution to the problem and more emphasis will be on the regional part. (e.g. Ozone, PM).

The design of the air quality monitoring programme will depend upon the measuring strategy, which again depends on the objectives of the monitoring, and the pollutants to be assessed. For the relevant air quality parameters or selected indicators the concentration of pollutants and associated averaging time need to be specified. Specifications are also needed on where, how, and how often measurements should be taken.

In the initial design phase we will have to evaluate:

- The variation of pollutant concentrations in space and time;
- The availability of supplementary information;
- The accuracy of the estimate, that is required.

It may be possible to derive, in quantitative terms, a measuring strategy from this information

The number of monitoring stations and the indicators to be measured at each station in the final permanent network may then be decided upon based on the results of the screening study as well as on knowledge of sources and prevailing winds.

Once the objective of air sampling is well-defined and some preliminary results of the screening study is available, a certain operational sequence has to be followed. A best possible definition of the air pollution problem together with an 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 additional background information is needed:
   - Meteorology,
   - Topography,
   - Population density,
   - Emission sources and emission rates,
   - Effects and impacts.
8. What is the best way to obtain the data (configuration of sensors and stations)?
9. How shall the data be accessible, communicated, processed and used?

4 Air quality legislation

Ambient standards define targets for air quality management and establish the permissible amount or concentration of a particular substance in or property of discharges to the atmosphere, based on what a particular receiving environment can tolerate without significant deterioration.

The relevant laws, regulations, standards and guidelines will be used as mechanisms to obtain information on atmospheric impacts, which in turn will be used to evaluate predicted impacts against the ambient standards.

Part of the development of the air quality management programme includes training, institutional building and information management.

Air quality management education should be integrated in all education programmes, at all levels, in all curricula and disciplines of formal and non-formal education in the national qualification framework.

The EU limit values specify for most of the compounds a certain number of hours or days when the limit value may be exceeded. The Directives also clearly specify the proportion of valid data needed as well as margin of tolerance. A summary of limit values is presented in Table 1 below.

Table 1: Summary of EU limit values.

Pollutant	Averaging time	Limit- and Guidelines Values	
		EU 1)	WHO
Sulphur Dioxide (SO_2)	1 hour	350 (24 x)	500 (10 min)
	24 hours	125 (3 x)	50 *
	Year	-	-
Nitrogen Dioxide (NO_2)	1 hour	200 (18 x)	200
	Year	40	40
Ozone (O_3)	1 hour	-	150-200
	8 hours	120 *)	120
Carbon Monoxide (CO)	1 hour	-	30 000
	8 hours	10 000	10 000
Particles <10 µm (PM10)	24 hours	50 (35 x)	(150) 50
	Year	40	(50) 20
Particles < 2,5 µm PM2,5)	24 hours	-	(75) 25
	Year	25	(25) 10
Benzene	Year	5	-
Lead (Pb)	Year	0,5	0.5-1,0

The EU Directives also specify lower and upper threshold values which indicate levels at which air quality assessment and measurements has to be undertaken.

The development of information dissemination systems could be important elements in the awareness campaigns initiated for air quality management planning, together with training of the provincial environmental departments. The campaigns should be implemented by local government for general air pollution, and the provincial environmental departments for hazardous and industrial emissions.

Air Quality standards have also been developed for Bangladesh. The AQMP, in its work funded by the World Bank, led to development and introduction of National Ambient Air Quality Standards (NAAQS) and of Vehicle Emission Standards (VES) in July 2005 covering carbon monoxide, lead, oxides of nitrogen, particulate matter, ozone and sulphur dioxide. See the Table 2 below.

Table 2: NAAQS and VES for Bangladesh.

Pollutant	Objective	Average
CO	10 mg/m^3 (9 ppm)	8 hours(a)
	40 mg/m^3 (35 ppm)	1 hour(a)
Pb	0.5 µg/m^3	Annual
NO_2	100 µg/m^3 (0.053 ppm)	Annual
PM_{10}	50 µg/m^3	Annual (b)
	150 µg/m^3	24 hours (c)
$PM_{2.5}$	15 µg/m^3	Annual
	65 µg/m^3	24 hours
O_3	235 µg/m^3 (0.12 ppm)	1 hour (d)
	157 µg/m^3 (0.08 ppm)	8 hours
SO_2	80 µg/m^3 (0.03 ppm)	Annual
	365 µg/m^3 (0.14 ppm)	24 hours (a)

The CASE (Clean Air and Sustainable Environment) programme within the DoE (Department of Environment) is funded by the Government of Bangladesh, and by the World Bank supporting its preparatory phase. The government has already created an Air Quality Cell (ARC) under the DoE to handle the core functions on air quality which includes air pollution monitoring and management issues. The CASE project will be implemented by the AQC. As part of the AQMP review work, NILU in its original proposal included the framework for the development of air quality management programme in Bangladesh within such a cell/division.

5 Instrumentation; monitoring and sampling

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. Table 3 indicates four typical types of instruments, their abilities and prices.

Table 3: 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.

The instruments most often applied to measure the main air pollution indicators are automatic monitors. These instruments are developed by several different providers, but they all should be using so called reference methods for analysing the air. Methods and instruments for measuring continuous air pollutants must be carefully selected, evaluated and standardised. Several factors must be considered:

* *Specific*, i.e. respond to the pollutant of interest in the presence of other substances,
* *Sensitive* and range from the lowest to the highest concentration expected,

* *Stable*, i.e. remain unaltered during the sampling interval between sampling and analysis,
* *Precise, accurate* and representative for the true pollutant concentration in the atmosphere where the sample is obtained,
* Adequate for the *sampling time* required,
* *Reliable and feasible* relative to man power resources, maintenance cost and needs,
* Zero drift and calibration (at least for a few days to ensure reliable data),
* Response time short enough to record accurately rapid changes in pollution concentration,
* Ambient temperature and humidity shall not influence the concentration measurements,
* Maintenance time and cost should allow instruments to operate continuously over long periods with minimum downtime,
* Data output should be considered in relation to computer capacity or reading and processing.

If one consider the typical air concentrations of some pollutants of interest in air pollution studies, it is seen that as we go from background to urban atmosphere, the concentration for the most common pollutants increase roughly by a factor 1000. In the next step from urban to emission we see another factor of about 1000. The specified range for the given instrument has therefore to be selected based on the purpose of the measurements.

The measurement reference methods as specified by the European Union was given in the EU Council Directive 1999/30/EC. A brief summary of these reference methods is presented in the course.

6 Monitoring and sampling, network operation

As a basis for operating the air monitoring system all quality system documentation should be compiled into a Quality Manual. When installing quality documentation at a measurement station, copies will be made from relevant documents in the Quality Manual. The documentation at the measurement station is compiled into a Station Manual. The manual includes all Standard Operation Procedures (SOPs), forms and other documentation used at that particular station. At “home” a history log is compiled for each measurement instrument. The history log will include remarks on maintenance, repairs, etc. as well as service and calibration reports. Figure 1 below shows the conceptual design of the quality documentation.

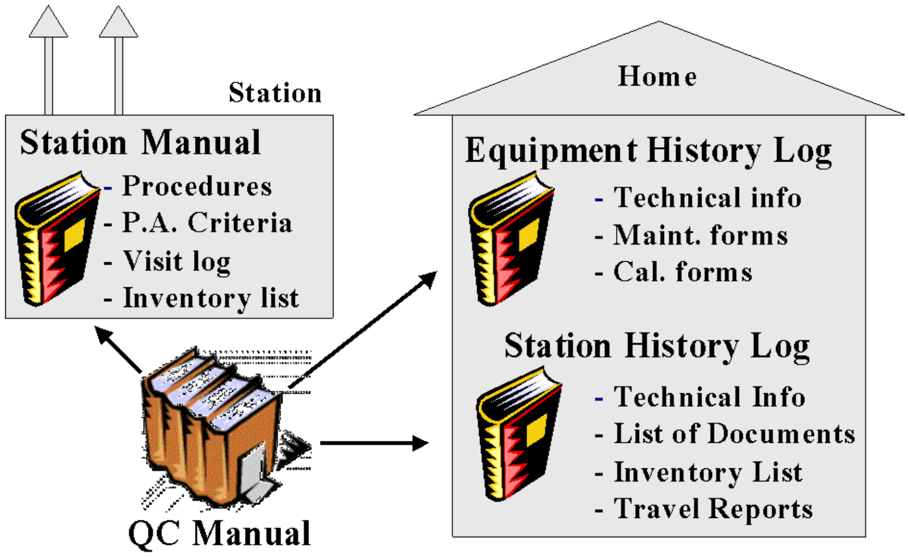

Figure 1: The Quality Manual and distributed documentation.

The content of the SOPs will be based on the instruction manuals delivered with the instruments. References will be made to the instruction manuals as necessary. The aim is to provide easy to read "cookbooks" that secure unified operation of instruments by all operators. All operations that may influence the quality of the measurement results should be covered by SOPs. A specific form in which the operator documents his or her work shall accompany all SOPs. The forms are stored in the history log for later reference.

The following SOPs should be available:

- SOPs on installation, operation and maintenance of instruments
- SOPs on calibration of instruments and gas cylinders
- SOPs/guidance documents on fault finding and trouble shooting
- Action limits specific for each type of instrument
- SOP on data validation
- Description of measurement methods
- Description of traceability in calibrations

7 Quality systems

One of the main challenges in any air quality monitoring programme is to have timely and appropriate access to relevant and good quality environmental data. One aim with collecting good quality data may be to enable actions whenever environmental requirements and limits are violated. Another goal may be to perform long term planning in order to reduce the air pollution load in the area.

Quality Assurance and Quality Control (QA/QC) as well as calibrations and good quality instruments will have to be available at all times. The primary purpose of the Quality Assurance (QA) Programme is to provide an overview of the project, describe the need for the measurements, and define QA/QC activities to be applied to the project, all within a single document. The QA programme should be detailed enough to provide a clear description of every aspect of the project and include information for every member of the project staff, including samplers, lab staff, and data reviewers. The QA programme facilitates communication among clients, data users, project staff, management, and external reviewers. Effective implementation of the QA programme assists project managers in keeping projects on schedule and within the resource budget.

Quality Control (QC) is the overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the customer; that are used to fulfil requirements for quality.

In the case of the Ambient Air Quality Monitoring Network, QC activities are used to ensure that measurement uncertainty is maintained within established acceptance criteria for the attainment of the Data Quality Objectives (DQO).

8 Air quality assessment and reporting

In general it is always necessary to perform standardized statistical analysis in order to assess air quality trends, changes in emissions or impact from specific types or groups of sources. The severity of the air pollution problem or the air quality should be specified relative to air quality guideline (AQG) values, standards or pre defined levels of classification (e.g. good, moderate, unhealthy or hazardous).

The number of hours and days, or percentage of time when the air pollution concentrations have exceeded AQG values should be presented. This will also need minimum requirements of data base completeness. Long-term averages (annual or seasonal) should be presented relative to AQG.

Before undertaking statistical evaluations the data should be presented and validated based upon a form of time series. These data must be evaluated logically to correct for drift in instruments, and eliminate data that are identified to be including errors. It is also important that the data are checked with other relevant information.

Different use of the data collected and different presentations are needed for the different users. Data presentations have been produced to meet the requirements from:

- Specialists on air pollution,
- Policy makers and
- The public.

The ***specialist*** often needs a tool that gives easy access to the data with the ability to treat these data in different ways. The specialist also wants to apply the data and prepare his own way of presenting results graphically.

The ***policy makers*** need presentations that illustrate the conclusions that the specialist has drawn from the information available. This is usually best done through a graphical presentation.

The ***public*** needs information on the general state of the environment. The type of information that is needed is more general than that of the policy maker. It often needs to cover environmental issues that are of special concern to the public. This could be the air quality that is expected to occur in the urban area on this specific day. This information could be given as a short term forecast or based upon actual on-line data.

9 Data dissemination

Data dissemination and information to the public is an important tool in raising public awareness. Data can be prepared and distributed from databases in many different ways to meet the needs of the users. Data presentation systems are often based on the air quality management system. Several applications have also been designed for use directly in Internet presentations, WAP (Wireless Application Protocol) solutions, SMS (Short Message Service) and MMS (Multimedia Messaging Solution) services. Several projects have been designed for utilizing such services and also in international research programmes like EU-Information Society of Tomorrow e.g. through the APNEE (www.apnee.org) project where links to several Web pages in Europe may be found.

10 Air quality management planning (AQMP)

Optimal abatement strategies have been developed based on air quality measurements combined with models, dose response functions and effect/cost estimates. These approaches have produced a list of the most cost effective actions that could be implemented in selected cities in Europe and Asia.

The AQMP approaches have been performed to assist in the design and implementation of policies, based on monitoring, and management in order to restore the air quality in large urban areas. Its goal was to identify the components of a general action plan to manage and control air pollution. Abatement measures in the plan were categorized according to cost-effectiveness, as well as the time required implementing them and when they would become effective.

The air quality management strategy planning system (AQMS) contains the following main components:

- Air quality assessment
- Environmental damage assessment
- Abatement options assessment
- Cost-benefit or cost-effectiveness analyses
- Abatement measures
- Optimum control strategy

Assessment: Air quality assessment, environmental damage assessment and abatement options assessment provide input to the cost analysis, which is also based on established air quality objectives (e.g. air quality standards) and economic objectives (e.g. reduction of damage costs). The analysis leads to an Action Plan containing abatement and control measures for implementation in the short, medium, and long term. The goal of this analysis is an optimum control strategy.

The AQMS depends on the following set of technical and analytical tasks, which can be undertaken by the relevant air quality authorities:

- Creating an inventory of polluting activities and emissions;
- Monitoring air pollution and dispersion parameters;
- Calculating air pollution concentrations with dispersion models;
- Assessing exposure and damage;
- Estimating the effect of abatement and control measures;
- Establishing and improving air pollution regulations and policy measures.

These activities, and the institutions necessary to carry them out, constitute the prerequisites for establishing the AQMS as illustrated in Figure 2 below.

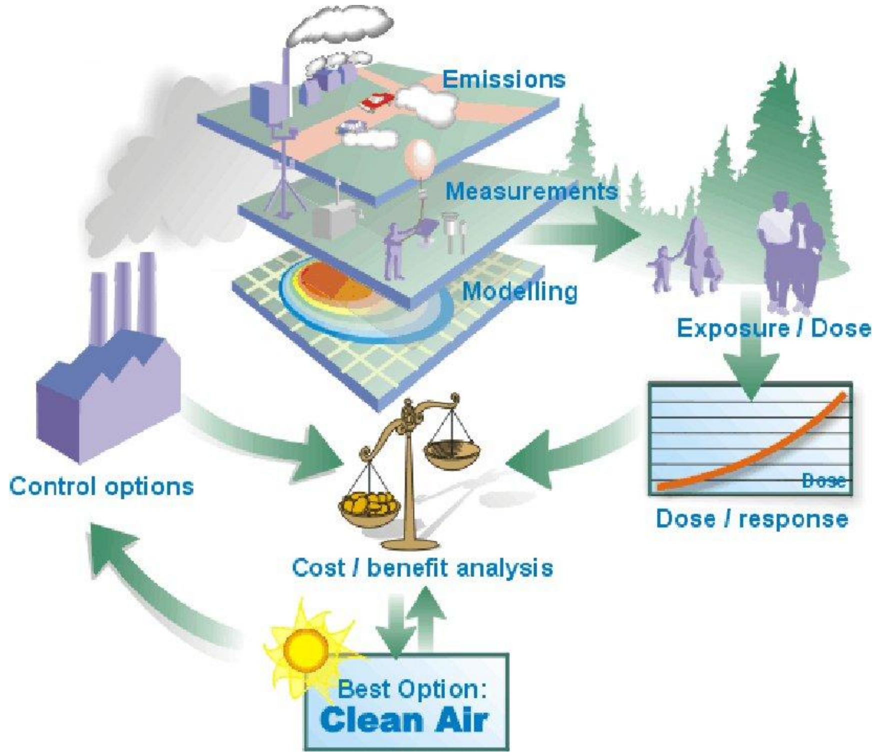

Figure 2: The elements of an optimal abatement strategy planning system.

Action plans and implementation: Categories of "actions" include the following:

- Technical abatement measures;
- Improvements of the factual database (e.g. emission inventory, monitoring, etc.);
- Institutional strengthening;
- Implementing an investment plan;
- Awareness raising and environmental education.

Monitoring: A third essential component of AQMS is continued monitoring, or surveillance. Monitoring is essential to assessing the effectiveness of air pollution control actions. The goal of an Air Quality Information System (AQIS) is, through thorough monitoring, to keep authorities, major polluters and the public informed on the short- and long-term changes in air quality, thereby helping to raise awareness; and to assess the results of abatement measures, thereby providing feedback to the abatement strategy. This part of the AQMS will also include institutional building and training in order to assure sustainability in the system established in the area or region in question.

A system for air quality management requires activities in the following fields:

- Inventorying of air pollution activities and emissions
- Monitoring of air pollution, meteorology and dispersion
- Calculation of air pollution concentrations, by dispersion models
- Inventorying of population, materials and urban development
- Calculation of the effect of abatement/control measures
- Establishing/improving air pollution regulations

The implementation of plans and strategies for air quality improvements is done through the use of policy instruments by ministries, regulatory agencies, law enforcers and other institutions. Indeed, some of these institutions may well be the same institutions as those, which must be in place to carry out the AQMS analysis described above, which ideally is the basis for the plans and strategies. Thus, the existence of relevant institutions, and an organisational institution structure, is part of the basis for AQMS work.

Different levels of government - national, regional and local - have different roles and responsibilities in the environmental sphere. Air quality standards or guidelines are usually set at the national level, although local government may have the legal right to impose stricter regulations. National governments usually assume the responsibility for scientific research and environmental education, while local governments develop and enforce regulations and policy measures to control local pollution levels.

Institutional arrangements, laws and regulations are important parts of an AQMS. Some countries have their own political and administrative hierarchies and technical expertise that affect institutions, laws and regulations related to air pollution control. Some examples of NILU applied AQMS procedures per projects undertaken in China, (such as Guangzhou, and the Shanxi province) and in Vietnam. One of the experiences from these studies is pointing at the importance of clarity in the organisational structures and the division and description of responsibilities and "lines-of-command".

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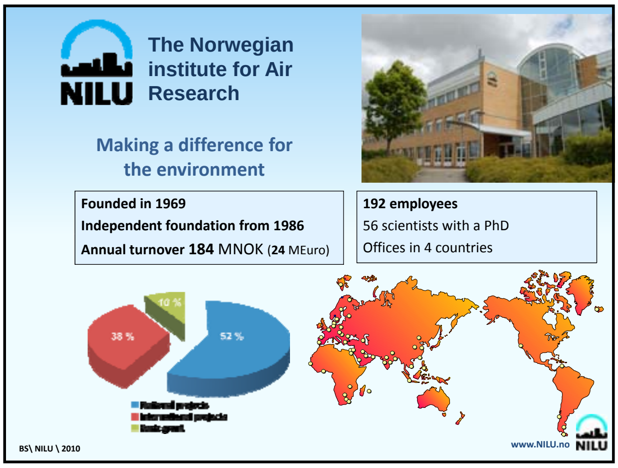
Appendix A

Seminar presentations


NILU
The Norwegian institute for Air Research
Making a difference for the environment
Founded in 1969
Independent foundation from 1986
Annual turnover 184 MNOK (24 MEuro)
192 employees
56 scientists with a PhD
Offices in 4 countries
10 %
38 %
52 %
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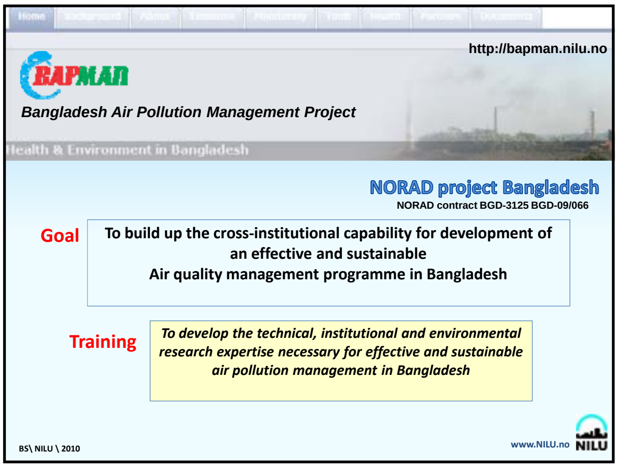
http://bapman.nilu.no
BAPMAN
Bangladesh Air Pollution Management Project
Health & Environment in Bangladesh
NORAD project Bangladesh
NORAD contract BGD-3125 BGD-09/066
Goal
To build up the cross-institutional capability for development of an effective and sustainable Air quality management programme in Bangladesh
Training
To develop the technical, institutional and environmental research expertise necessary for effective and sustainable air pollution management in Bangladesh
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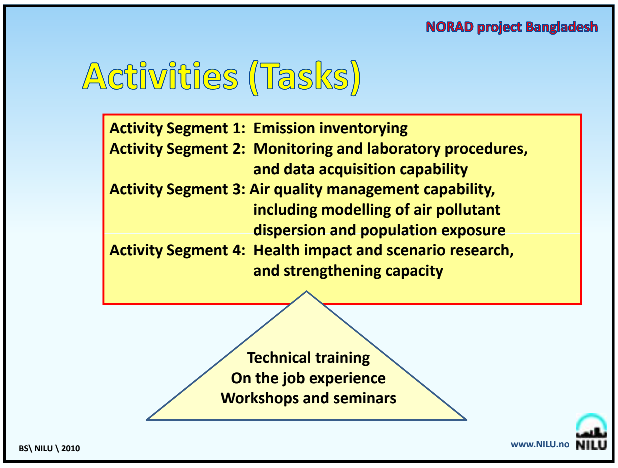
NORAD project Bangladesh
Activities (Tasks)
Activity Segment 1: Emission inventorying
Activity Segment 2: Monitoring and laboratory procedures, and data acquisition capability
Activity Segment 3: Air quality management capability, including modelling of air pollutant dispersion and population exposure
Activity Segment 4: Health impact and scenario research, and strengthening capacity
Technical training
On the job experience
Workshops and seminars
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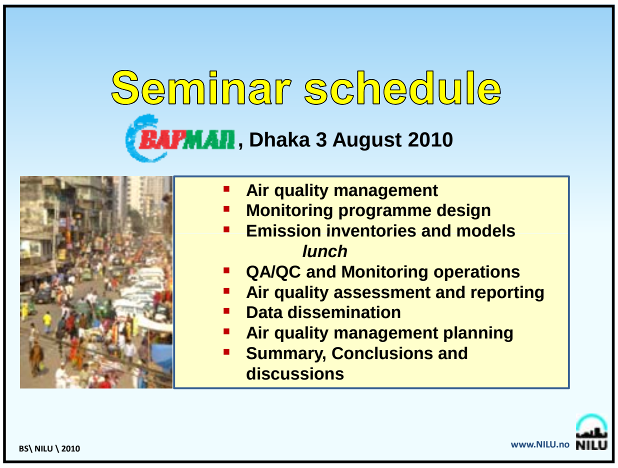
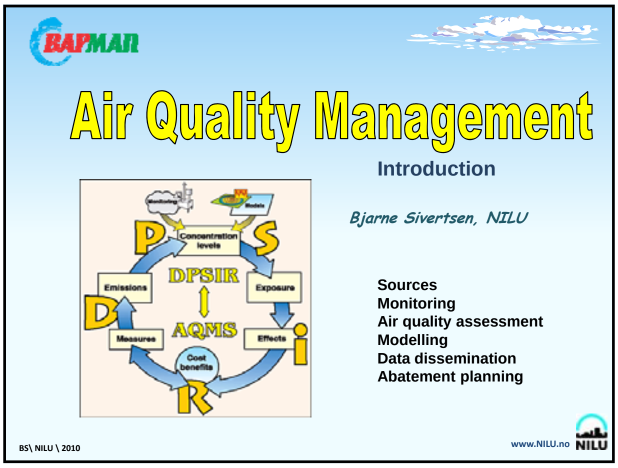
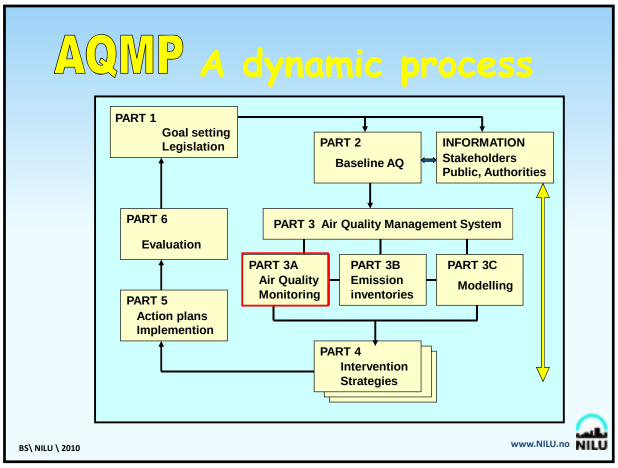

Seminar schedule
BAPMAN, Dhaka 3 August 2010
Air quality management
Monitoring programme design
Emission inventories and models
lunch
QA/QC and Monitoring operations
Air quality assessment and reporting
Data dissemination
Air quality management planning
Summary, Conclusions and discussions
BS\ NILU \ 2010
www.NILU.no


BAPMAN
Air Quality Management
Introduction
Bjarne Sivertsen, NILU
DPSIR
AQMS
Concentration levels
Emissions
Exposure
Measures
Effects
Cost benefits
Sources
Monitoring
Air quality assessment
Modelling
Data dissemination
Abatement planning
BS\ NILU \ 2010
www.NILU.no


AQMP A dynamic process
PART 1 Goal setting Legislation
PART 2 Baseline AQ
INFORMATION Stakeholders Public, Authorities
PART 6 Evaluation
PART 3 Air Quality Management System
PART 3A Air Quality Monitoring
PART 3B Emission inventories
PART 3C Modelling
PART 5 Action plans Implemention
PART 4 Intervention Strategies
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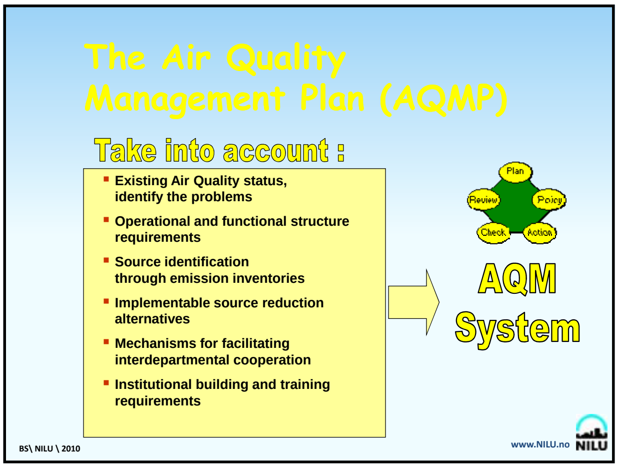
www.NILU.no


The Air Quality
Management Plan (AQMP)
Take into account :
Existing Air Quality status, identify the problems
Operational and functional structure requirements
Source identification through emission inventories
Implementable source reduction alternatives
Mechanisms for facilitating interdepartmental cooperation
Institutional building and training requirements
Plan
Policy
Action
Check
Review
AQM
System
BS\ NILU \ 2010
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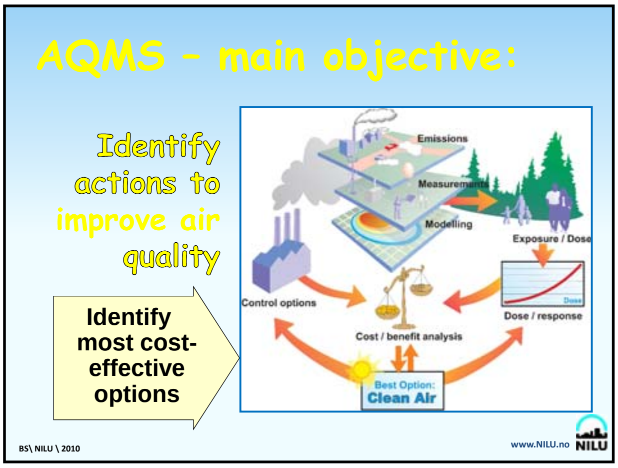
NILU


AQMS – main objective:
Identify
actions to
improve air
quality
Identify
most cost-
effective
options
Emissions
Measurements
Modelling
Exposure / Dose
Control options
Dose / response
Cost / benefit analysis
Best Option:
Clean Air
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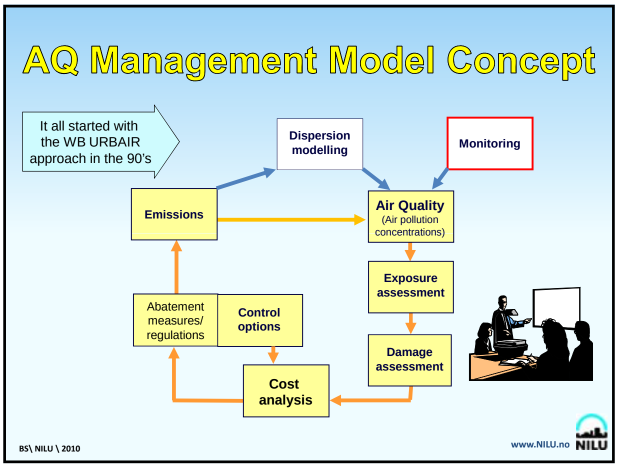
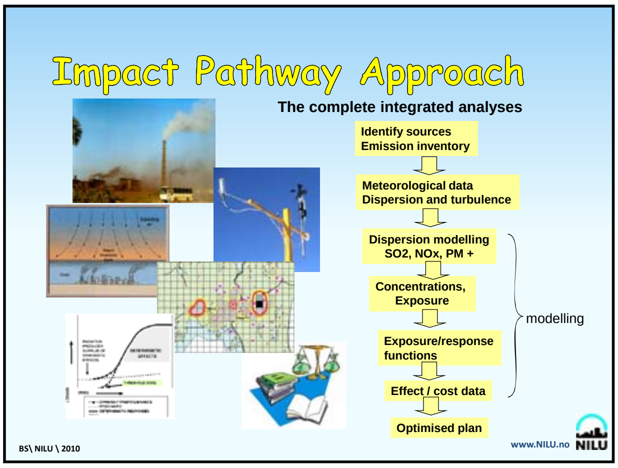
NILU


AQ Management Model Concept
It all started with
the WB URBAIR
approach in the 90's
Dispersion
modelling
Monitoring
Emissions
Air Quality
(Air pollution
concentrations)
Exposure
assessment
Abatement
measures/
regulations
Control
options
Damage
assessment
Cost
analysis
BS\ NILU \ 2010
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
Optimised plan
modelling
BS\ NILU \ 2010
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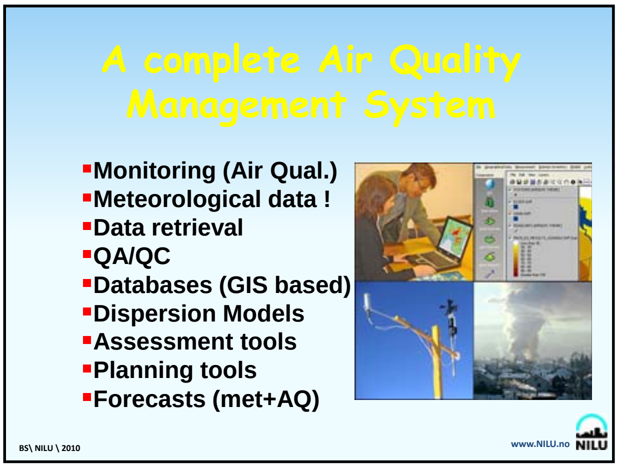
NILU


A complete Air Quality
Management System
Monitoring (Air Qual.)
Meteorological data !
Data retrieval
QA/QC
Databases (GIS based)
Dispersion Models
Assessment tools
Planning tools
Forecasts (met+AQ)
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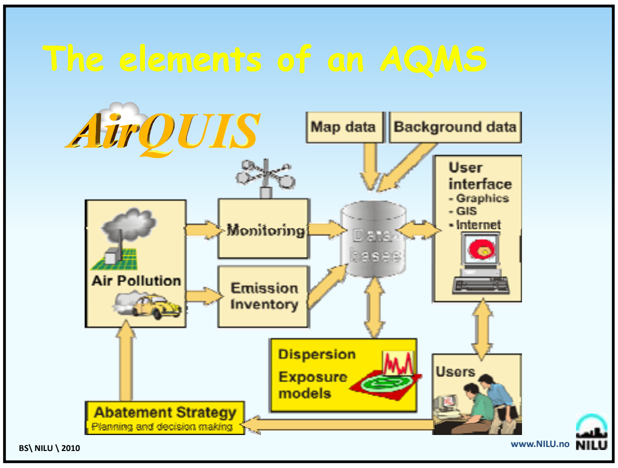
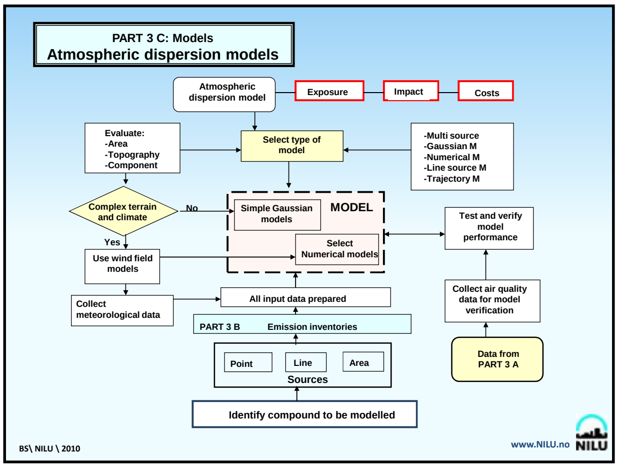
NILU


The elements of an AQMS
AirQUIS
Map data
Background data
User
interface
- Graphics
- GIS
- Internet
Monitoring
Air Pollution
Emission
Inventory
Dispersion
Exposure
models
Users
Abatement Strategy
Planning and decision making
BS\ NILU \ 2010
www.NILU.no
NILU


PART 3 C: Models
Atmospheric dispersion models
Atmospheric dispersion model
Exposure
Impact
Costs
Evaluate:
-Area
-Topography
-Component
Select type of model
-Multi source
-Gaussian M
-Numerical M
-Line source M
-Trajectory M
Complex terrain and climate
No
Yes
Simple Gaussian models
MODEL
Select Numerical models
Test and verify model performance
Use wind field models
Collect meteorological data
All input data prepared
Collect air quality data for model verification
PART 3 B
Emission inventories
Point
Line
Area
Sources
Data from PART 3 A
Identify compound to be modelled
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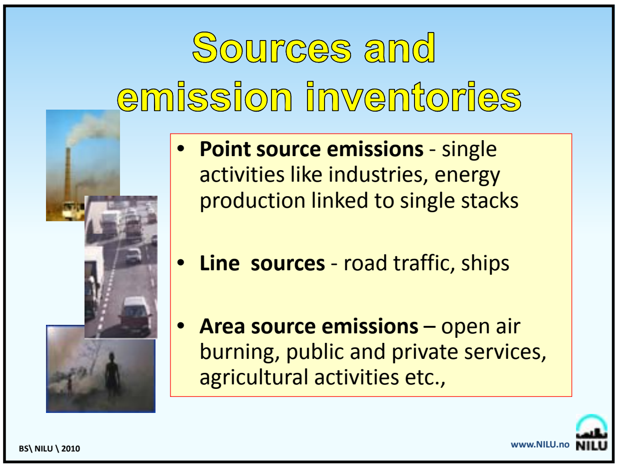
Sources and emission inventories
• Point source emissions - single activities like industries, energy production linked to single stacks
• Line sources - road traffic, ships
• Area source emissions – open air burning, public and private services, agricultural activities etc.,
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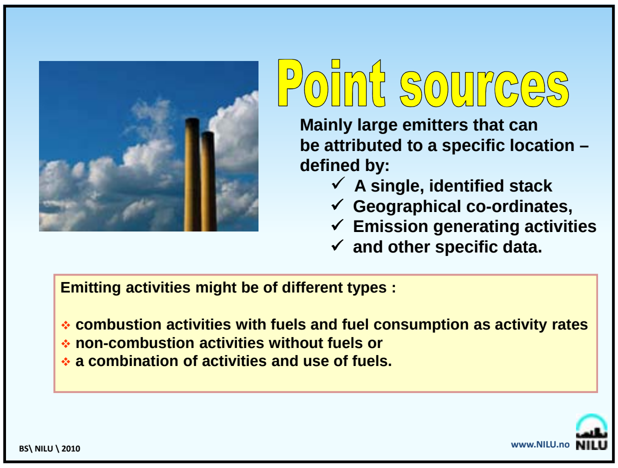
Point sources
Mainly large emitters that can be attributed to a specific location – defined by:
✓ A single, identified stack
✓ Geographical co-ordinates,
✓ Emission generating activities
✓ and other specific data.
Emitting activities might be of different types :
combustion activities with fuels and fuel consumption as activity rates
non-combustion activities without fuels or
a combination of activities and use of fuels.
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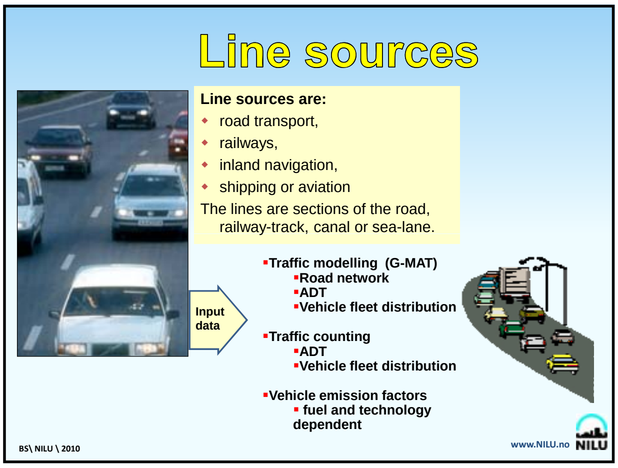
Line sources
Line sources are:
road transport,
railways,
inland navigation,
shipping or aviation
The lines are sections of the road, railway-track, canal or sea-lane.
Input data
▪Traffic modelling (G-MAT)
▪Road network
▪ADT
▪Vehicle fleet distribution
▪Traffic counting
▪ADT
▪Vehicle fleet distribution
▪Vehicle emission factors
▪ fuel and technology dependent
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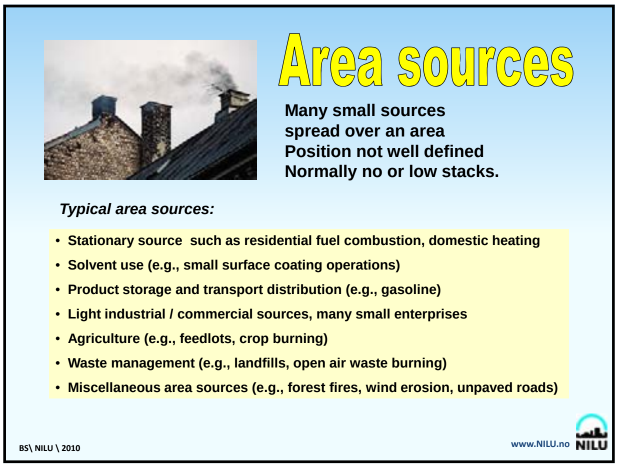
Area sources
Many small sources
spread over an area
Position not well defined
Normally no or low stacks.
Typical area sources:
• Stationary source such as residential fuel combustion, domestic heating
• Solvent use (e.g., small surface coating operations)
• Product storage and transport distribution (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)
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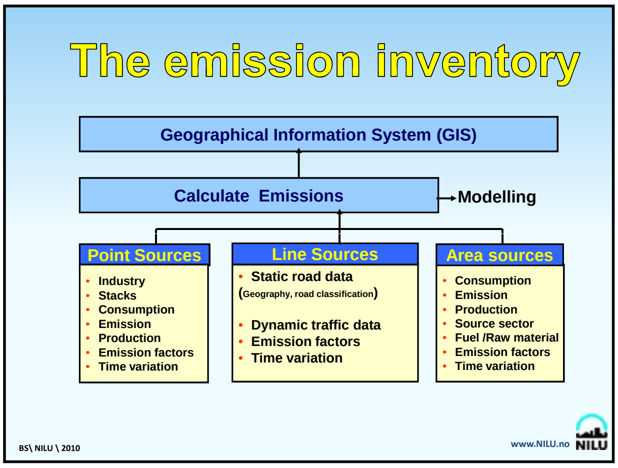
The emission inventory
Geographical Information System (GIS)
Calculate Emissions
Modelling
Point Sources
Industry
Stacks
Consumption
Emission
Production
Emission factors
Time variation
Line Sources
Static road data
(Geography, road classification)
Dynamic traffic data
Emission factors
Time variation
Area sources
Consumption
Emission
Production
Source sector
Fuel /Raw material
Emission factors
Time variation
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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

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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

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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 !

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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

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Dispersion modelling

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

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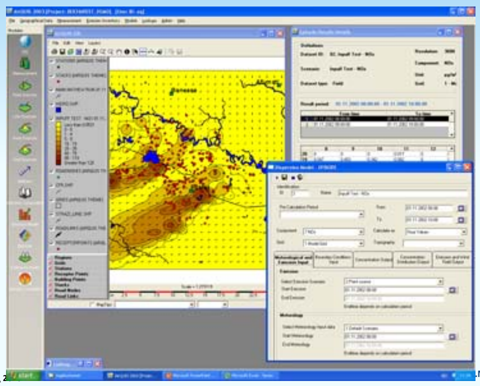
Dispersion Models



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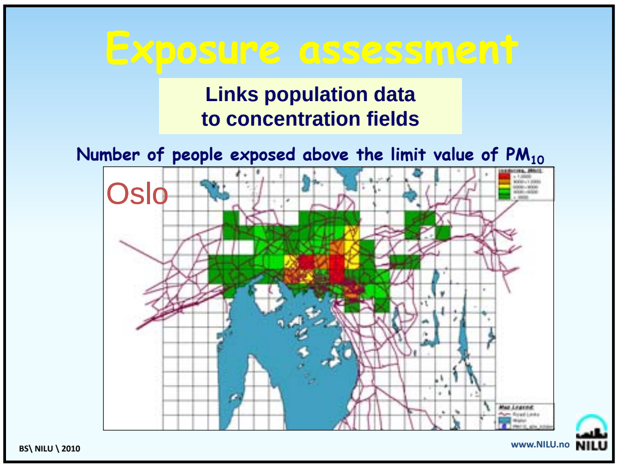
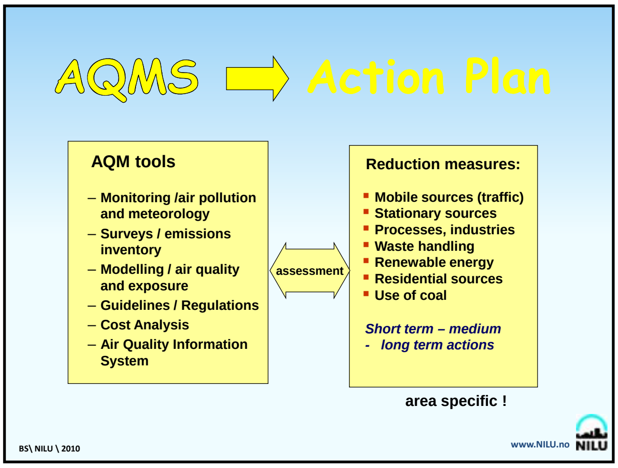

Exposure assessment
Links population data
to concentration fields
Number of people exposed above the limit value of PM_{10}
Oslo
BS\ NILU \ 2010
www.NILU.no
NILU


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 !
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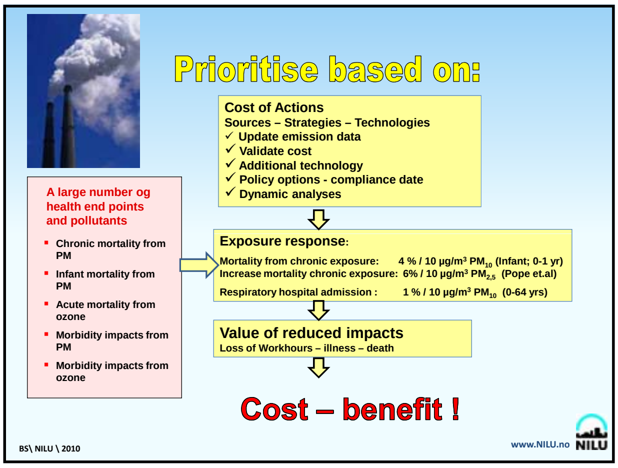
Prioritise based on:
Cost of Actions
Sources – Strategies – Technologies
✓ Update emission data
✓ Validate cost
✓ Additional technology
✓ Policy options - compliance date
✓ Dynamic analyses
A large number og health end points and pollutants
Chronic mortality from PM
Infant mortality from PM
Acute mortality 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 !
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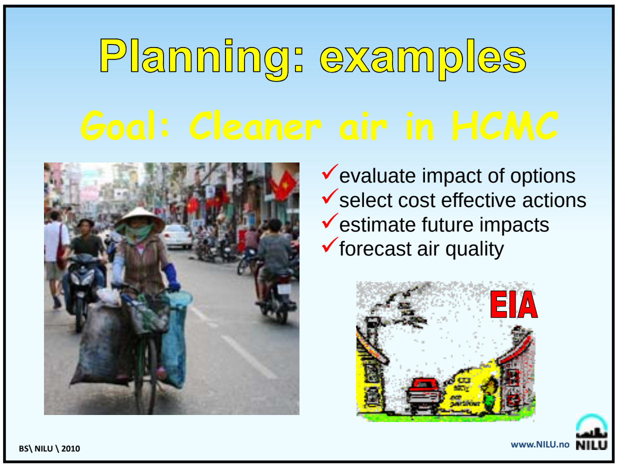
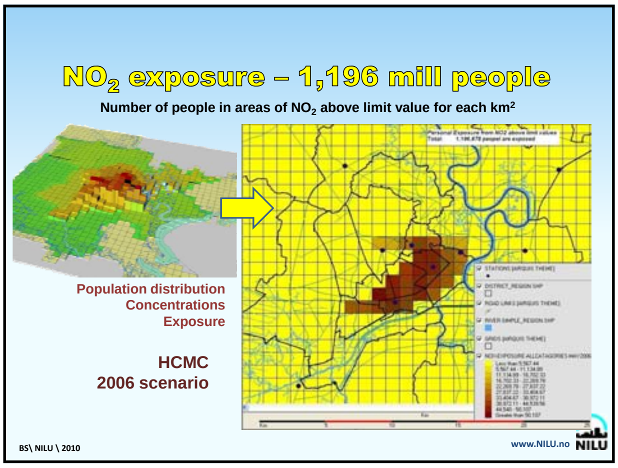

Planning: examples
Goal: Cleaner air in HCMC
✓evaluate impact of options
✓select cost effective actions
✓estimate future impacts
✓forecast air quality
EIA
BS\ NILU \ 2010
www.NILU.no
NILU


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
BS\ NILU \ 2010
www.NILU.no
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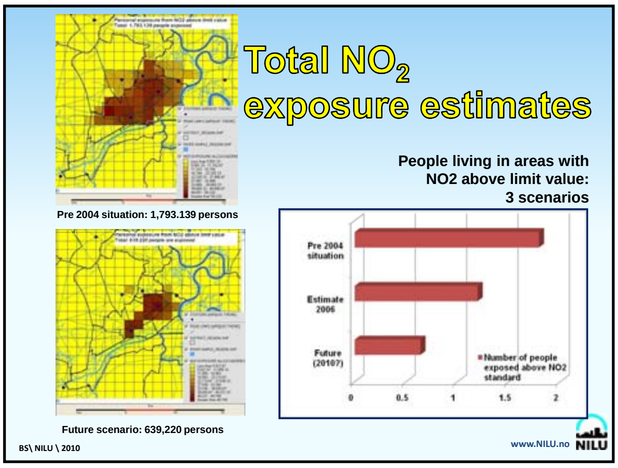
Total NO_2 exposure estimates
Pre 2004 situation: 1,793.139 persons
Future scenario: 639,220 persons
People living in areas with NO2 above limit value: 3 scenarios
Pre 2004 situation
Estimate 2006
Future (2010?)
Number of people exposed above NO2 standard
0
0.5
1
1.5
2
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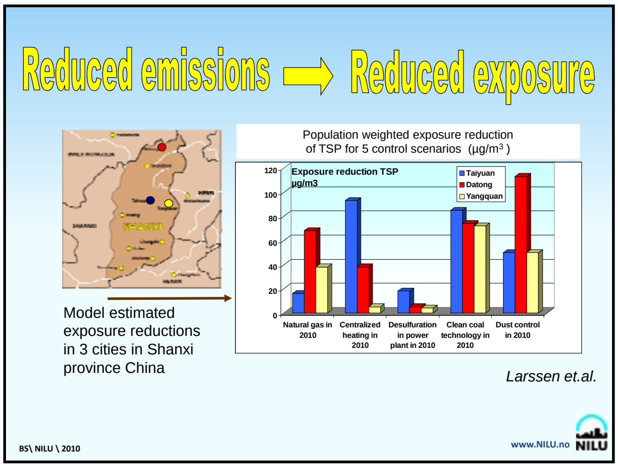
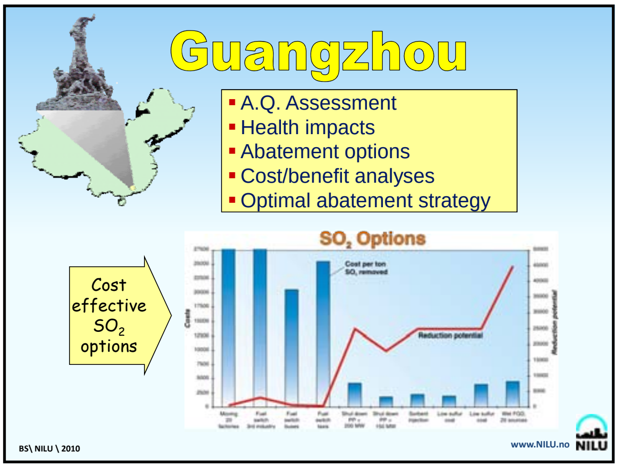
www.NILU.no
NILU



Reduced emissions → Reduced exposure
Population weighted exposure reduction of TSP for 5 control scenarios (µg/m3)
Exposure reduction TSP µg/m3
Taiyuan
Datong
Yangquan
120
100
80
60
40
20
0
Natural gas in 2010
Centralized heating in 2010
Desulfuration in power plant in 2010
Clean coal technology in 2010
Dust control in 2010
Model estimated exposure reductions in 3 cities in Shanxi province China
Larssen et.al.
BS\ NILU \ 2010
www.NILU.no
NILU



Guangzhou
A.Q. Assessment
Health impacts
Abatement options
Cost/benefit analyses
Optimal abatement strategy
Cost effective SO2 options
SO2 Options
Cost per ton SO2 removed
Reduction potential
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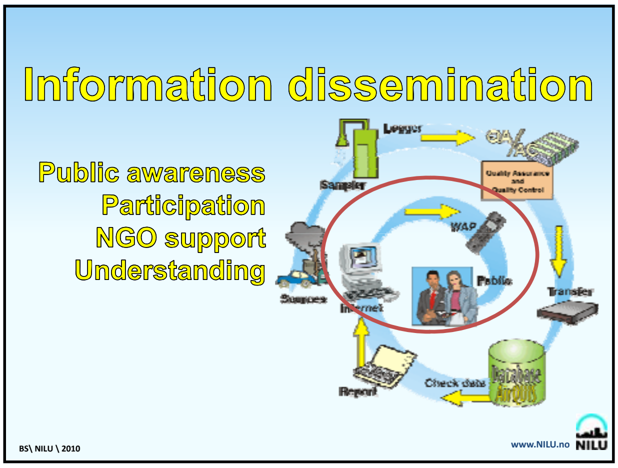
NILU



Information dissemination
Public awareness
Participation
NGO support
Understanding
Logger
Sampler
Quality Assurance and Quality Control
WAP
Public
Transfer
Sources
Internet
Report
Check data
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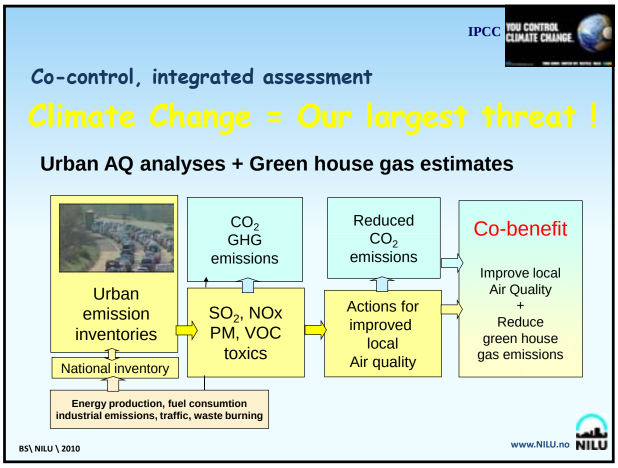

IPCC
YOU CONTROL CLIMATE CHANGE
Co-control, integrated assessment
Climate Change = Our largest threat !
Urban AQ analyses + Green house gas estimates
Urban emission inventories
National inventory
CO2 GHG emissions
SO2, NOx PM, VOC toxics
Reduced CO2 emissions
Actions for improved local Air quality
Co-benefit
Improve local Air Quality + Reduce green house gas emissions
Energy production, fuel consumption industrial emissions, traffic, waste burning
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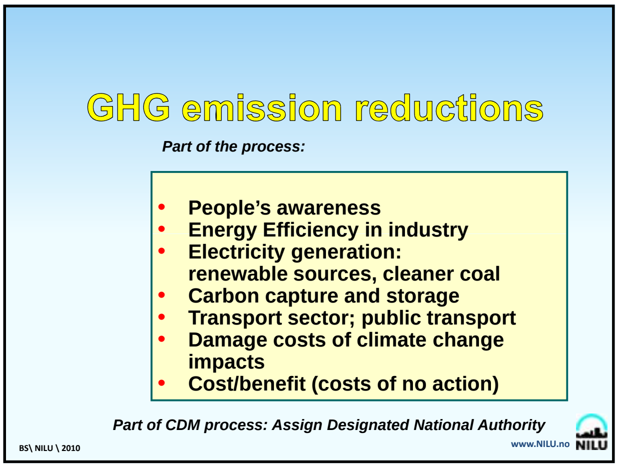

GHG emission reductions
Part of the process:
People's awareness
Energy Efficiency in industry
Electricity generation: renewable sources, cleaner coal
Carbon capture and storage
Transport sector; public transport
Damage costs of climate change impacts
Cost/benefit (costs of no action)
Part of CDM process: Assign Designated National Authority
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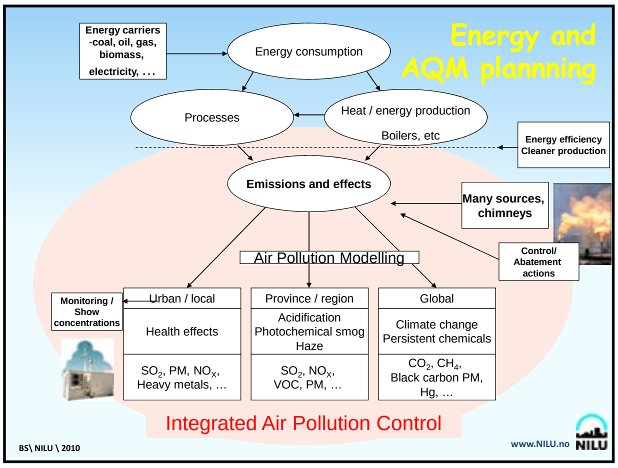
NILU



Energy and AQM plannning
Energy carriers -coal, oil, gas, biomass, electricity, …
Energy consumption
Processes
Heat / energy production
Boilers, etc
Energy efficiency Cleaner production
Emissions and effects
Many sources, chimneys
Control/ Abatement actions
Air Pollution Modelling
Monitoring / Show concentrations
Urban / local
Health effects
SO2, PM, NOX, Heavy metals, …
Province / region
Acidification Photochemical smog Haze
SO2, NOX, VOC, PM, …
Global
Climate change Persistent chemicals
CO2, CH4, Black carbon PM, Hg, …
Integrated Air Pollution Control
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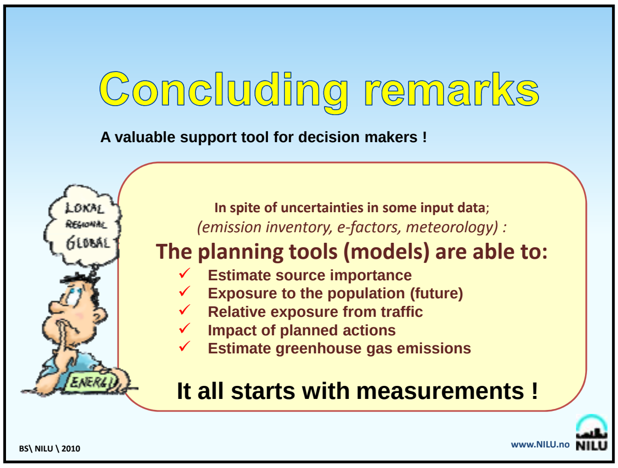
Concluding remarks
A valuable support tool for decision makers !
LOKAL
GLOBAL
In spite of uncertainties in some input data;
(emission inventory, e-factors, meteorology) :
The planning tools (models) are able to:
✓ Estimate source importance
✓ Exposure to the population (future)
✓ Relative exposure from traffic
✓ Impact of planned actions
✓ Estimate greenhouse gas emissions
It all starts with measurements !
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www.NILU.no
NILU


Thank you !
Questions ???
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Air Quality Monitoring Programme Design

Dhaka, Bangladesh 3 August 2010

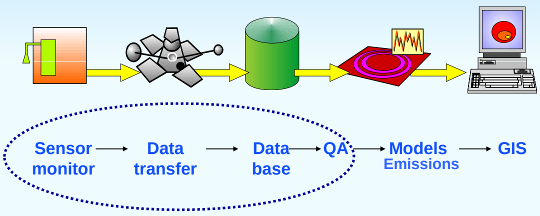
Bjarne Sivertsen, NILU

Programme Design Questions

- Why do we measure?
- Where should we measure?
- What should we measure?
- How shall we measure?
- How do we store data?
- How do we want to present the results?

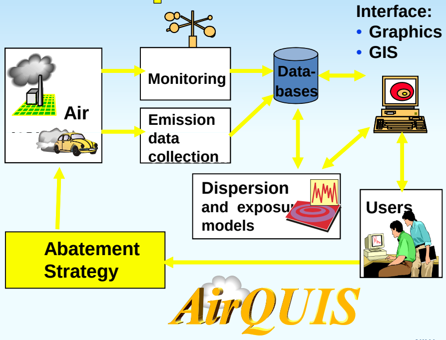
The monitoring programme is part of:

Integrated Pollution Prevention and Control



An AQM platform

User Interface:
- Graphics
- GIS

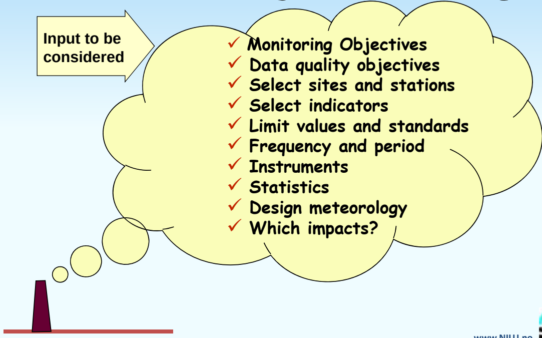


Monitoring programme design

Characteristics of ambient air pollution :

- ✓ source mixture (local, area or regional sources)
- ✓ air pollution vary spatially on different scales.
- ✓ annual and diurnal variations
- ✓ depend upon winds
- ✓ avoid random local impacts

Air Quality Monitoring



Monitoring objectives

- Individual sources
- Impact from outside
- Inform the public
- Warning
- Forecasts

- ✓ Mapping the air quality, current levels, baseline;
- ✓ To judge compliance with ambient air quality standards;
- ✓ To observe pollution trends throughout the region;
- ✓ To evaluate progress made towards meeting standards;
- ✓ To provide a data base for research evaluation of effects;
- ✓ A database for urban, land-use, and transportation planning;
- ✓ Basis for development and evaluation of abatement strategies;
- ✓ Data as input to and development and validation of models;
- ✓ To activate emergency control procedures that prevent or alleviate air pollution episodes.

Influence on design !

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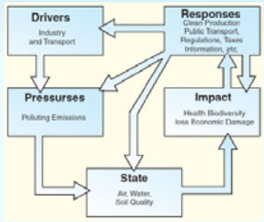
What shall we measure:

Air Quality Indicators

Identified to:

- provide a general picture,
- be easy to interpret,
- respond to changes,
- provide international comparisons,
- be able to show trends over time.



respond to DPSIR

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Air Pollution Indicators

First priority pollutants
(USEPA: Criteria 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

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Which pollutants?

Scale of air pollution problem

- The air pollution is of predominantly local origin.
- Network concentrated in the urban area; (e.g NO_2, SO_2, PM_{10}, CO, benzene)
- Significant regional contribution; (emphasis on e.g. Ozone, PM).
- Large-scale phenomena, smog episodes in Europe or the Asian dust cloud (e.g. PM)
- Avoid local impacts (temporary impacts)

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AQ Limits and Guidelines

Pollutant	Averaging time	Limit- and Guidelines Values	
		EU 1)	WHO
Sulphur Dioxide (SO_2)	1 hour	350 (24 x)	500 (10 min)
	24 hours	125 (3 x)	50 *
	Year	-	-
Nitrogen Dioxide (NO_2)	1 hour	200 (18 x)	200
	Year	40	40-50
Ozone (O_3)	1 hour	-	150-200
	8 hours	120 *)	120
Carbon Monoxide (CO)	1 hour	-	30 000
	8 hours	10 000	10 000
Particles <10 µm (PM10)	24 hours	50 (35 x)	(150) 50
	Year	40	(50) 20
Particles < 2,5 µm PM2,5)	24 hours	-	(75) 25
	Year	25	(25) 10
Benzene	Year	5	-
Lead (Pb)	Year	0,5	0.5-1,0

1) Ref: EU Limit values for protection of human health (2008/50/EC)
(n x) not to be exceeded more than n times
**) not to be exceeded more than 25 days per year (aver over 3 years)*
WHO guideline values 2005 in ( ) are WHO interim target values (IT2)

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QA/QC system

to assure a predefined quality of all data

1. Quality Assurance
2. Quality Control
3. Quality Assessment

Define objectives ⇨ Follow-up controls ⇨ Verify Audit

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Data Quality Objectives (DQO)

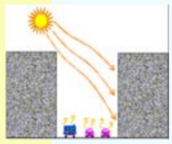
A summary of DQOs

Monitoring programme/ *Monitoring objective*	Compounds	Accuracy	Precision	Data time coverage
EU Regulatory Monitoring 1) *Detect non-compliance with directives*	SO_2, NO_2 PM, Pb	15% 2) 25% 2)		90% annual "
EMEP *Provide basis for control of models*		15-25% 3)		90% annual
WMO-GAW *Detect trends over short term (5 years)*	Examples: O_3 NO_2 $PM_{2.5}$	15% or 3 ppb 20% or 50 ppt 0,05+5% M	10% or 1 ppb 10% or 25 ppt 10%	80% monthly " 90% monthly

1) Minimum DQOs. Final approval of the directive (EC 97/0266(SYN)) is pending (as of July 1998).
2) Combined accuracy and precision.
3) Total "uncertainty (combined accuracy and precision) for sampling and analysis combined). Dependent upon compound.

Where do we locate sites?

- Regional background
  - 3 km < x < 50 km from build up areas
- Urban background
  - in cities (1 km scale)
  - away from local sources (streets, industries etc.)
- Traffic impacts
  - curbside, along streets
- Industrial pollution
  - downwind from industries



Types of Monitoring Stations

Classification system:

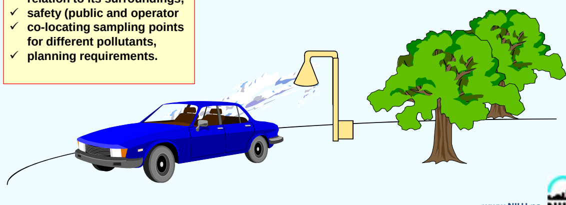
Type of area	Description	Type of station
Urban	Continuously built-up area	Traffic
Suburban	Largely built-up area: continuous settlement of detached buildings mixed with non-urbanized areas	Industrial Background :
Rural	Areas that not fulfil the criteria for urban/suburban areas	- Near city - Regional - Remote

Air intake design - Location

Take into account:

- ✓ interfering sources,
- ✓ security,
- ✓ access,
- ✓ availability of electrical power and telephone,
- ✓ visibility of the site in relation to its surroundings,
- ✓ safety (public and operator
- ✓ co-locating sampling points for different pollutants,
- ✓ planning requirements.

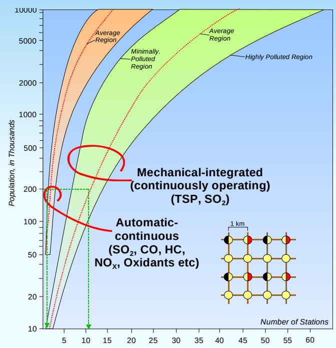
- Same height above ground
- Avoid buildings
- Away from local sources
- Away from vegetation canopies



Number of sites needed depends upon several factors:

- Types of data needed,
- Mean values and averaging times,
- Frequency distributions,
- Geographical distributions,
- Population density and distribution,
- Meteorology and climatology of the area,
- Topography and size of area,
- Location and distribution of industrial areas.

Number of monitoring sites needed in an urban area



Minimum numbers of sampling points for fixed measurement SO_2, NO_2 , particulate matter and lead in

AMBIENT AIR

fixed measurement to assess compliance with limit values for the protection of human health and alert thresholds (EU Directives)

urban areas

Population of agglomeration or zone (thousands)	If maximum concentrations exceed the upper assessment threshold (¹)		If maximum concentrations are between the upper and lower assessment thresholds	
	Pollutants except PM	PM (¹) (sum of PM_{10} and $PM_{2.5}$)	Pollutants except PM	PM (¹) (sum of PM_{10} and $PM_{2.5}$)
0-249	1	2	1	1
250-499	2	3	1	2
500-749	2	3	1	2
750-999	3	4	1	2
1 000-1 499	4	6	2	3
1 500-1 999	5	7	2	3
2 000-2 749	6	8	3	4
2 750-3 749	7	10	3	4
3 750-4 749	8	11	3	6
4 750-5 999	9	13	4	6
≥ 6 000	10	15	4	7

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Minimum numbers of sampling points for fixed measurements of

Ozone in AMBIENT AIR

fixed measurement to assess compliance with target values long-term objectives and alert thresholds where measurements are the only info (EU Directives)

Population (× 1 000)	Agglomerations (urban and suburban) (¹)	Other zones (suburban and rural) (¹)	Rural background
< 250		1	1 station/50 000 km^2 as an average density over all zones per country (²)
< 500	1	2	
< 1 000	2	2	
< 1 500	3	3	
< 2 000	3	4	
< 2 750	4	5	
< 3 750	5	6	
> 3 750	One additional station per 2 million inhabitants	One additional station per 2 million inhabitants	

(¹) At least 1 station in suburban areas, where the highest exposure of the population is likely to occur. In agglomerations at least 50 % of the stations shall be located in suburban areas.
(²) 1 station per 25 000 km^2 for complex terrain is recommended.

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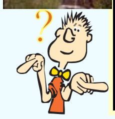
Sampling frequency and sampling time



Pollutant/ Indicator	Unit	Sample resolution	Average needed
Carbon monoxide	mg/m^3	Hourly average	Hourly, 8-hour running average, annual max
Nitrogen dioxide	$\mu g/m^3$	Hourly average	Daily average Annual average Frequency distribution
Ozone	$\mu g/m^3$	Hourly average	Hourly, 8-hour running average, annual max
Particulate matter	$\mu g/m^3$	Daily average	Daily average Annual average Frequency distribution.
Sulphur dioxide	$\mu g/m^3$	Hourly average	Daily average Annual average Frequency distribution.
Lead	$\mu g/m^3$	Annual average	Annual average
Benzene	$\mu g/m^3$	Annual average	Annual average

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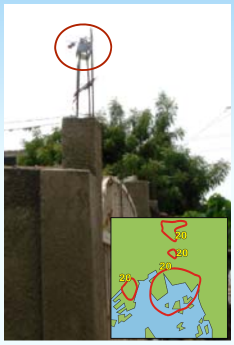
Siting studies

- ✓ Define site locations
- ✓ Evaluate sources and possible impact
- ✓ Perform simple "model estimates"
- Investigate the area
- Select relevant indicators
- Complete report covering
  - Instruments
  - Sites
  - Components



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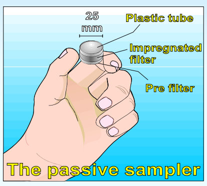
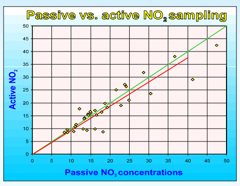
Passive samplers for screening studies





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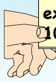
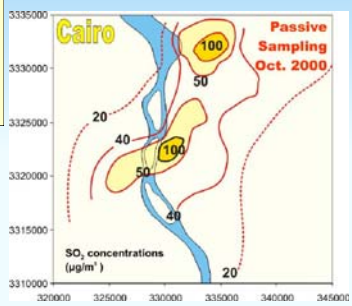
SO_2
in Cairo city centre and industrial Shoubra exceeded 100 $\mu g/m^3$





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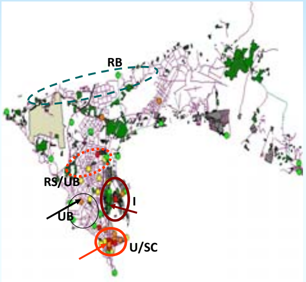
Designing the AQ Monitoring Programme for Dakar



Selected sites:

- The commercial city centre of Dakar, road side station
- An urban road side station in the Medina area
- An urban background station in the northern Dakar city area
- One industrial station in the eastern Dakar, close to the BelAir area
- One regional background station, upwind from the city along the northern coast

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Instruments

Many kinds:

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

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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	20
Sequential sampler	Manual/ semi-auto, in situ.	After lab analyses	24 h	3000
Monitors	Automatic Continuous, in situ.	Directly, on-line	1h	>15 000
Remote monitoring	Automatic Continuous, path integrated	Directly, on-line	< 1 min	>100 000

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Simple instruments for PM_{10} and $PM_{2,5}$

Minivol sampler

Kleinfilter SEQ sampler

Dust track

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Air quality Gas Monitors

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

Reference instruments !

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Additional instruments

- PM_{10} : ➡ Measurement on filter tape using the principles of beta attenuation
- PM_{10} : ➡ TEOM (Tapered element oscillating microbalance) particulate mass collected on a filter
- HC : ➡ Gas Chromatograph (GC) with Flame Ionization Detector (FID)
- VOC: ➡ Collected in canister for GC analyses
- BTEX ➡ Monitor Photo Ionization Detector (PID) as the sensing element.

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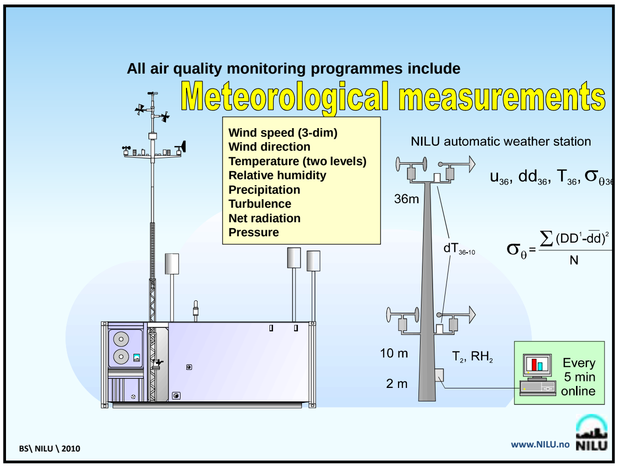
All air quality monitoring programmes include
Meteorological measurements
Wind speed (3-dim)
Wind direction
Temperature (two levels)
Relative humidity
Precipitation
Turbulence
Net radiation
Pressure
NILU automatic weather station
u_{36}, dd_{36}, T_{36}, $\sigma_{\theta 36}$
36m
dT_{36-10}
$\sigma_{\theta} = \frac{\sum (DD^1 - \overline{dd})^2}{N}$
10 m
T_2, RH_2
2 m
Every 5 min online
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Meteorological station
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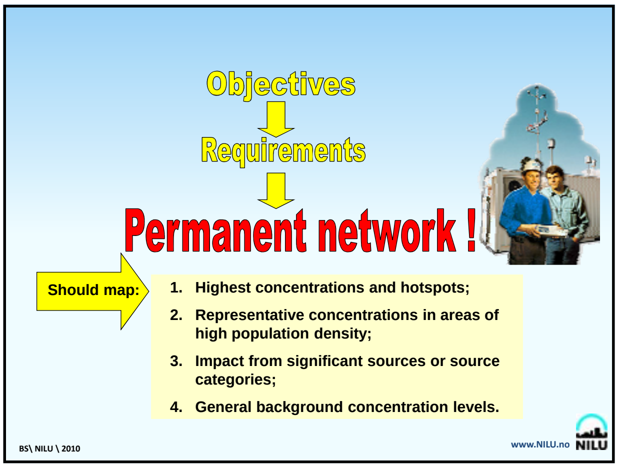
Objectives
Requirements
Permanent network !
Should map:
1. Highest concentrations and hotspots;
2. Representative concentrations in areas of high population density;
3. Impact from significant sources or source categories;
4. General background concentration levels.
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A typical monitoring station
QA/QC !
Urban background site in HCMC
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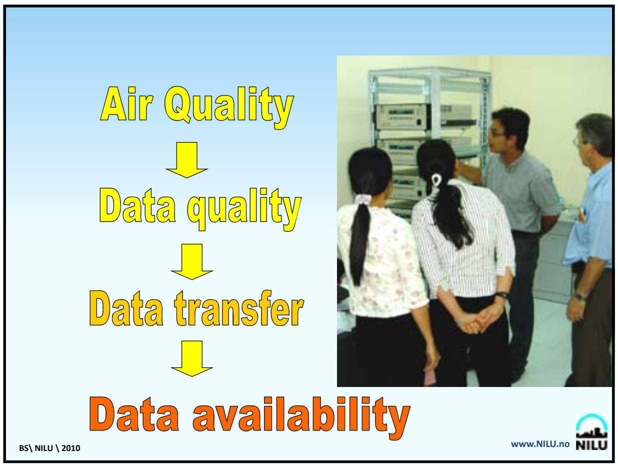
Air Quality
Data quality
Data transfer
Data availability
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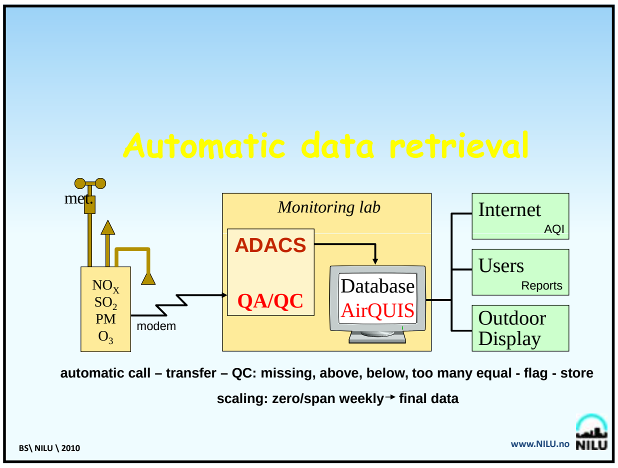
Automatic data retrieval
met.
NO_x
SO_2
PM
O_3
modem
Monitoring lab
ADACS
QA/QC
Database
AirQUIS
Internet
AQI
Users
Reports
Outdoor Display
automatic call – transfer – QC: missing, above, below, too many equal - flag - store
scaling: zero/span weekly→ final data
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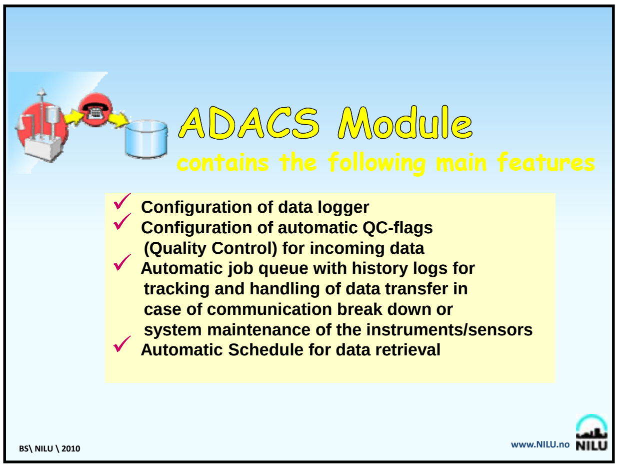
ADACS Module
contains the following main features
Configuration of data logger
Configuration of automatic QC-flags (Quality Control) for incoming data
Automatic job queue with history logs for tracking and handling of data transfer in case of communication break down or system maintenance of the instruments/sensors
Automatic Schedule for data retrieval
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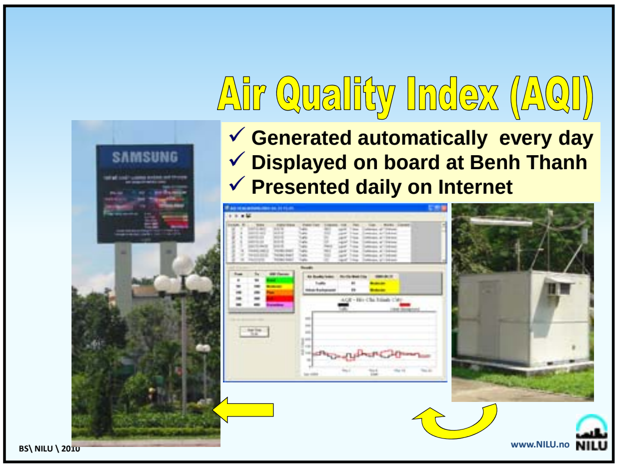
Air Quality Index (AQI)
Generated automatically every day
Displayed on board at Benh Thanh
Presented daily on Internet
SAMSUNG
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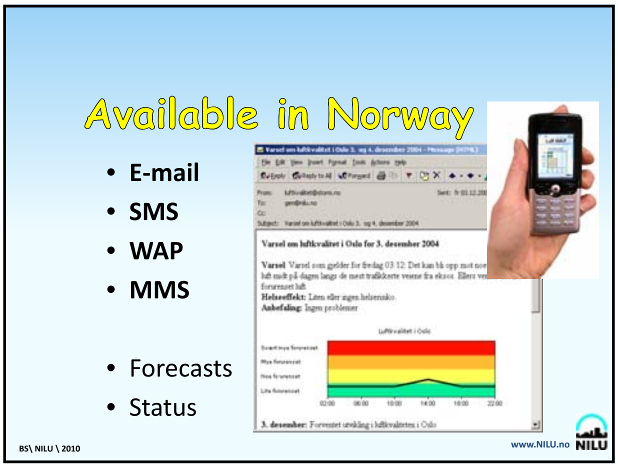
www.NILU.no
NILU


Available in Norway
E-mail
SMS
WAP
MMS
Forecasts
Status
Varsel om luftkvalitet i Oslo for 3. desember 2004
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www.NILU.no
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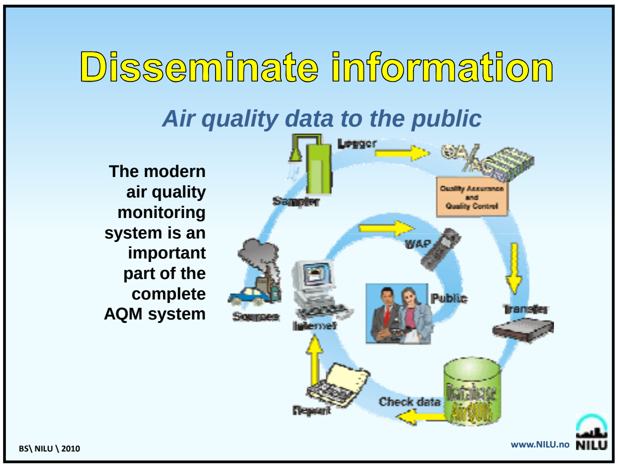
Disseminate information
Air quality data to the public
The modern air quality monitoring system is an important part of the complete AQM system
Logger
Sampler
QA/QC
Quality Assurance and Quality Control
WAP
Sources
Internet
Public
Transfer
Report
Check data
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Thank you !
Questions ???
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E-mail: nilu@nilu.no
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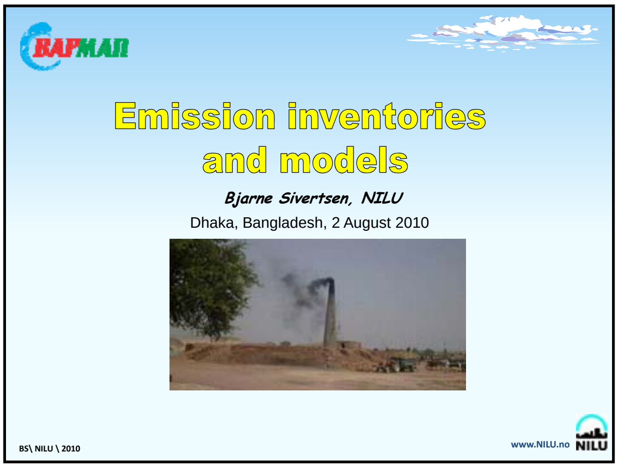
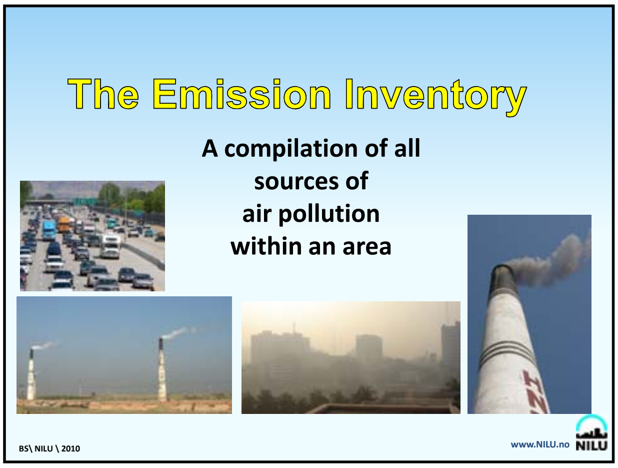

BAPMAN
Emission inventories and models
Bjarne Sivertsen, NILU
Dhaka, Bangladesh, 2 August 2010
BS\ NILU \ 2010
www.NILU.no NILU


The Emission Inventory
A compilation of all sources of air pollution within an area
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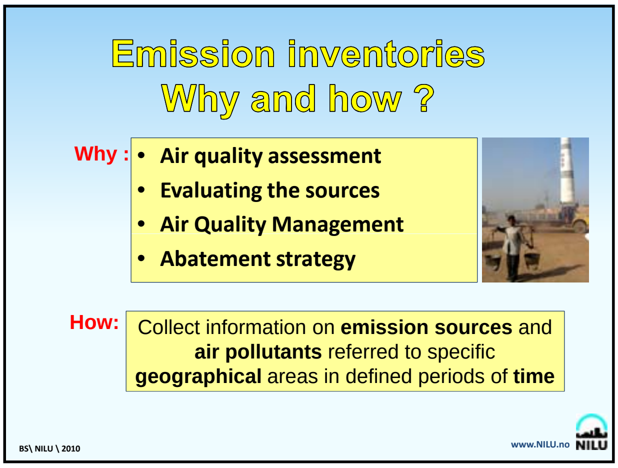
Emission inventories
Why and how ?
Why :
• Air quality assessment
• Evaluating the sources
• Air Quality Management
• Abatement strategy
How:
Collect information on emission sources and air pollutants referred to specific geographical areas in defined periods of time
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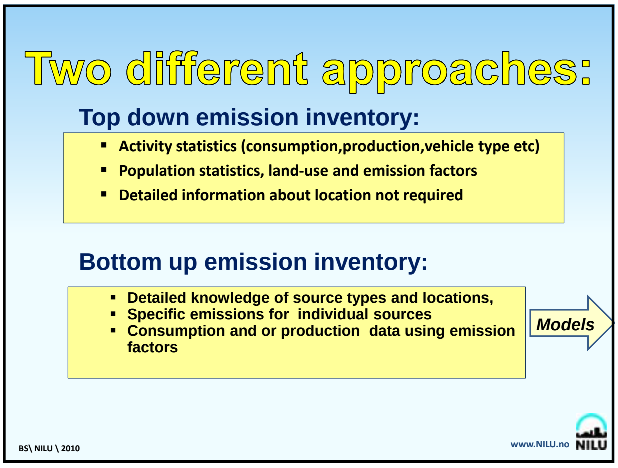
Two different approaches:
Top down emission inventory:
▪ Activity statistics (consumption,production,vehicle type etc)
▪ Population statistics, land-use and emission factors
▪ Detailed information about location not required
Bottom up emission inventory:
▪ Detailed knowledge of source types and locations,
▪ Specific emissions for individual sources
▪ Consumption and or production data using emission factors
Models
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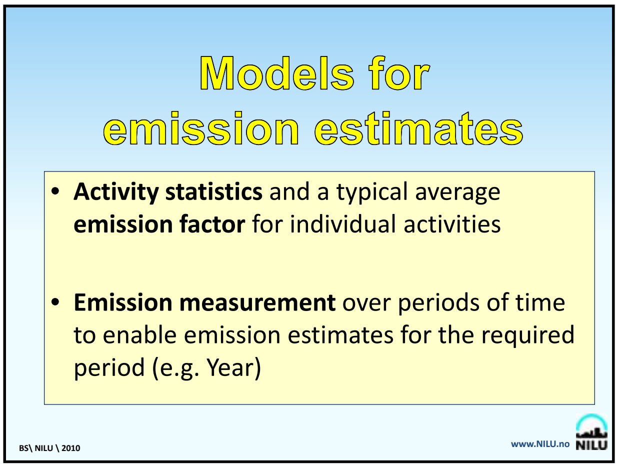
Models for emission estimates
• Activity statistics and a typical average emission factor for individual activities
• Emission measurement over periods of time to enable emission estimates for the required period (e.g. Year)
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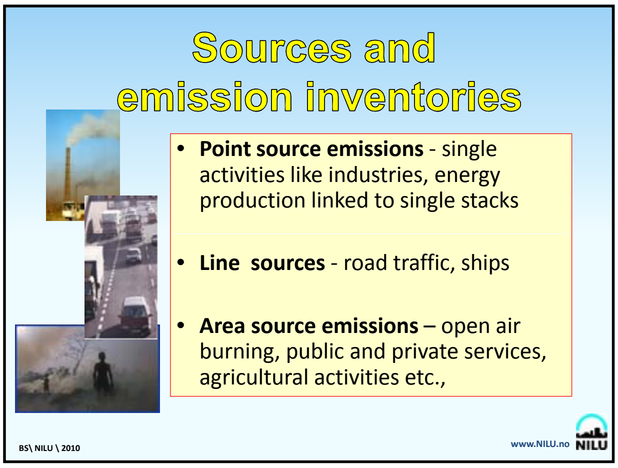
Sources and emission inventories
• Point source emissions - single activities like industries, energy production linked to single stacks
• Line sources - road traffic, ships
• Area source emissions – open air burning, public and private services, agricultural activities etc.,
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Input data requirements

Top-down
Bottom-up

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

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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

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Emission templates from 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

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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

Excel based templates for collection of data !

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Emission Inventory Point Sources

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

Based on questionnaires

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Emission Inventory-Example.: 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

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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

Emission Inventory Example: 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.: 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

Emission Inventory Example: 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

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

Line sources- traffic data

Line sources are:

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

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

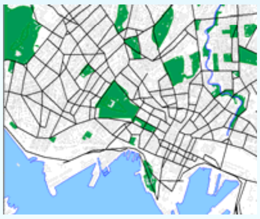
Input data

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

Emission Inventory Traffic data

Road link data:

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



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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)

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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

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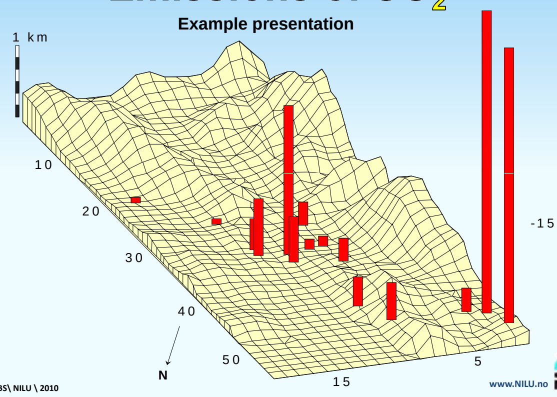
Emissions of SO_2

Example presentation



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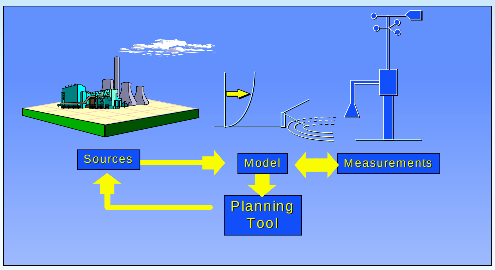
Dispersion models

linking: sources – meteorology – air quality



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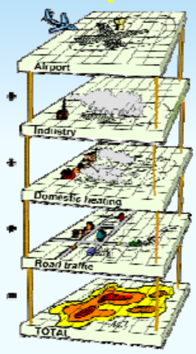
Dispersion modelling



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

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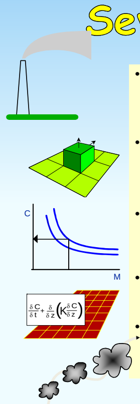
Several types of models



- **Gaussian models**
  - most used models for estimates of dispersion from stacks.
  - available for area sources and urban areas.
- **Box models**
  - based upon budgets analysis
  - used in simple urban air pollution modelling.
- **Statistical models**
  - based upon established relationships.
  - can not be used for planning purposes.
- **Numerical models**
  - based upon numerical solutions of the continuity equations.
  - Several models have been developed and applied.
- **Trajectory / puff models**
  - based upon knowledge of the wind field and the variations of winds
  - suited for dispersion from single sources at larger distances or in cases with space and time variations in meteorology

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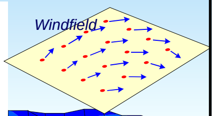
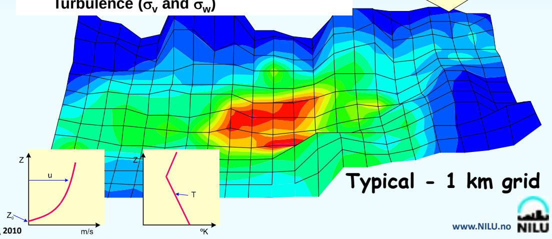
The Numerical Dispersion Model, EPISODE

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)**





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Model input

- source characteristics / emission data
- area characteristics
- measurement data air quality
- meteorological data
- dispersion coefficients
- dry & wet removal
- receptor point locations / grid

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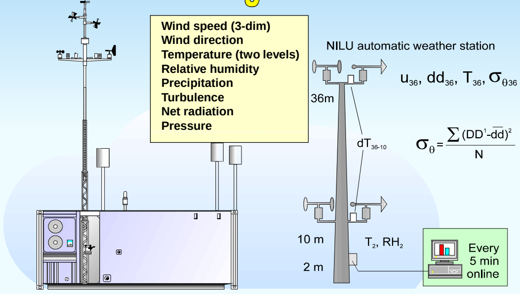
Meteorological measurements



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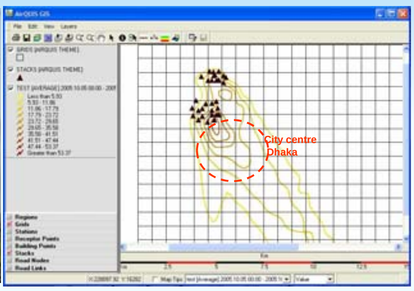
Brick factories Dhaka



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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:	?

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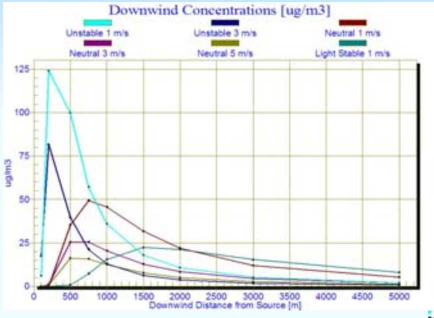
Maximum ground level concentrations of SO_2



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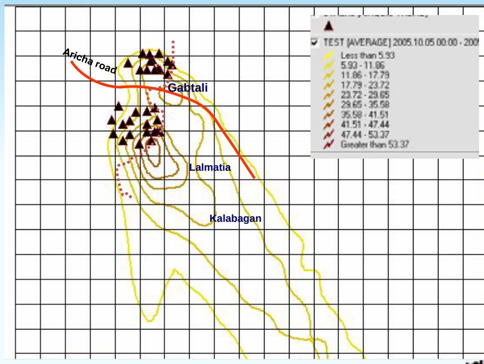
Estimated 24-h concentration

SO_2

PM ?

33 stacks random positioned



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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 ?)

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Air Quality Monitoring
QA/QC and Network Operation

Dhaka, Bangladesh
3 August 2010

Leif Marsteen
NILU

QA/QC - Where does it all begin?

With the instruments!

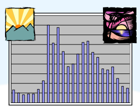
Quality Control / Quality Assurance

Is it information or is it just numbers?

A quality system will increase the information in the numbers

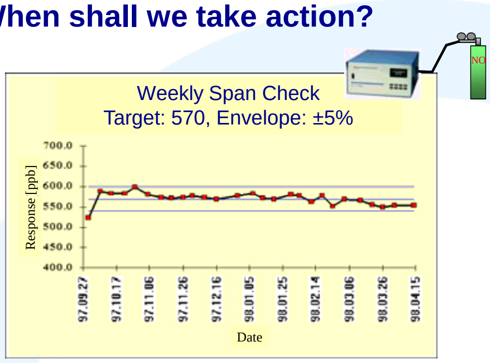
Instrumentation requirements

- Close follow up
- Performance testing
- Preventive maintenance
- Calibrations
- Repairs



We want unified instrument operation

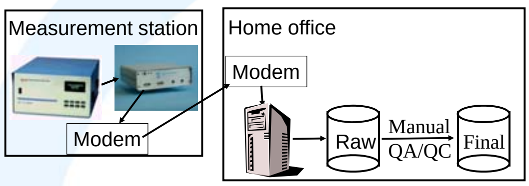
When shall we take action?



We want unified evaluation of test results

How do we validate data?

- Continuous analysers generate results on the fly
- Data collected by a data logger
- Data transfered to data center, e.g. every hour
- Automatic data validation, invalid data flagged
- Data transfer to final data base after manual data validation



We want unified evaluation of measurement data

Which tools do we have?

- Data collection software
  - Collect data from stations automatically and manually
- Statistical and graphing software
  - Evaluate collected data
- Manual call to stations from home
  - Get current status
- Instruction and technical manuals
  - Guidance on maintenance, calibrations and repairs
- Calibration systems
  - Test and adjust analysers

We want unified use of tools

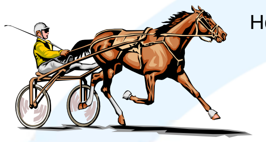
How do we get

- Unified instrument operation
- Unified evaluation of test results
- Unified evaluation of measurement data
- Unified use of tools

We introduce a quality system!

What is quality?

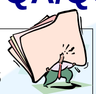
It depends on your needs



Horse racing - Speed

Farming
- Strength

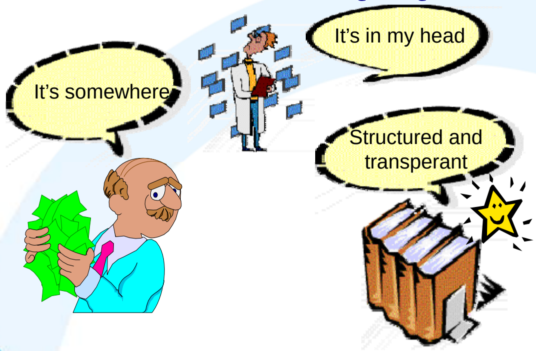
Why QA/QC systems?



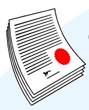
CONTRA	PRO
• Increased costs	• Operations documented
• Conservative	• Results documented
– Resisits changes	• Transparency
– Too much to update	• Easy training
• Extra paper work	– Documentation exists
– No time to do the job!	• Competitive edge
• Too many documents	
– Impossible to learn	
Myths or reality?	Reliable results with known quality

We want information not only numbers

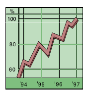
Different levels of QA/QC



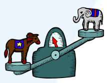
Elements of the quality system



Quality Assurance



Quality Control



Quality Assessment

Quality Assurance

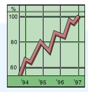
All planned and systematic activities which are needed to assure and demonstrate the predefined quality of data

(ISO 8402, 1994)

Described in the Quality Assurance Plan

Client's assurance that Contractor is in control

Quality Control



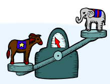
Operational techniques and activities that are undertaken to fulfil the quality requirements

(ISO 8402, 1994)

- Calibration and maintenance plan
- Standard Operations Procedures (SOPs)
  - Describes 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 for later reference

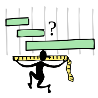
Makes operations traceable for Client

Quality Assessment



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

- Audit performed by an independent institution
- System Audit: Inspection of QA/QC plan and documents
- Performance Audit: Instruments are checked at the station using an independent calibration standard



Client's assurance that the Contractor is actually following his own procedures

Quality system requirements

- Management requirements
- Technical requirements

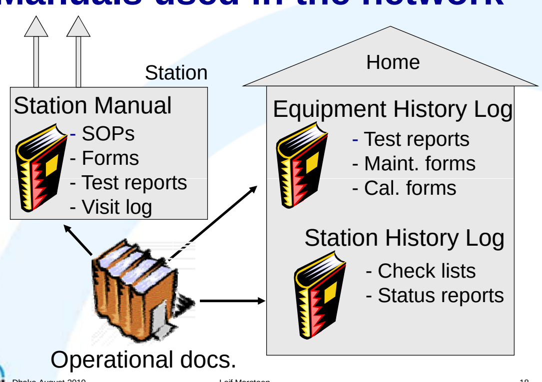
- Requirements found in:

  EN ISO 17025:2005 General requirements for the competence of testing and calibration laboratories

Quality Manual - Example

- Organisation and responsibilities
- Measurement traceability
- Measurement methods
- Task schedules
- Action criteria
- Standard Operating Procedures (SOPs)
- Training
- Internal audits
- Document management system

Manuals used in the network



Network Operation

Why?
To collect data of required quality for its intended use

How?

Is it information or just numbers?

Network operation tasks

Daily:
- Check measurement data from home

Periodicly (e.g. weekly):
- Test instruments at station

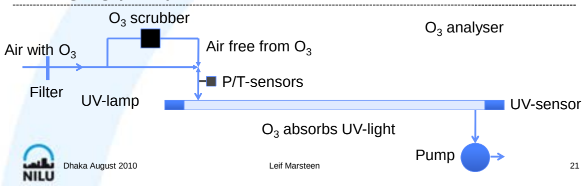
Monthly:
- Prepare data report

Three/six-monthly:
- Perform preventive maintenance on instruments

Yearly (or more often):
- Calibrate instruments

What affects instruments?

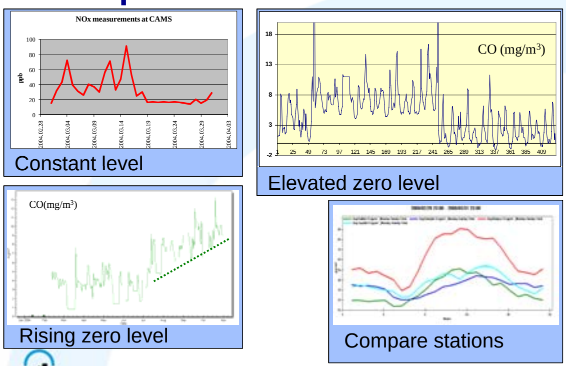
- Indoor temperature and humidity
- Dirt buildup in tubes, valves, inlets, manifold
- Saturation of scrubbers, converters, filters
- Clogged filters, valves, junctions, orifices
- Leaks in junctions, O-rings, valves
- Aging pump



Check measurement data from home

- Look for strange data
- Unstable or noisy values?
- Values not as expected for particular station?
- Compare neighbouring stations, same trend?
- Constant levels, e.g. many hours of zeros?
- Spikes, sudden drops, values below zero?
- Rising/elevated zero level?
- Values never close to zero at night?

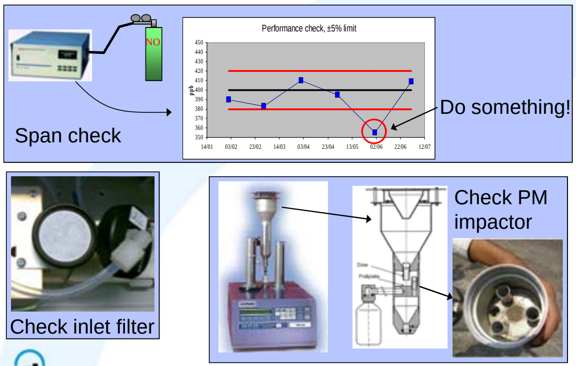
Suspicous data



Periodic check at station

- Record instrument status
- Test analysers (zero/span check)
- Adjust analysers (lamps, gain, e.t.c.)
- Change sample filters on samplers
- Change inlet filters on gas analysers
- Clean gas inlet manifold
- Clean PM impactors

Checks at station



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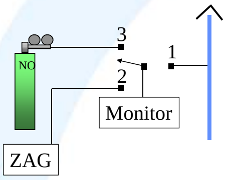
Zero/span check equipment

- Zero/span checks are performed to:
  - Verify instrument response
  - Calculate scale factors for adjustment of measurement data
- ”Normal” concentration gas cylinders
- Zero air generator



Monitor connected to:
1. Inlet – normal operation
2. ZAG – Check zero level
3. Gas – Check span level

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Regular maintenance

Valid data requires maintained instruments

- Change consumables regularly
- Clean air inlets and manifolds
- Clean outdoor sensors and inlets
- Check instrument status
- Maintain air condition
- Keep station tidy
- Look at data every day

No instruments will run without problems but maintenance will prevent some of them

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Preventive maintenance

- According to instrument manuals
- Calibrate analysers
- Calibrate gas cylinders
- Change lamps, scrubbers, valves
- Rebuild pumps
- Leak check analyser

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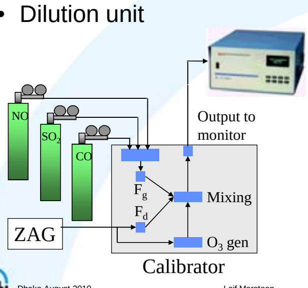
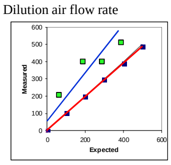
Yearly linearity check on gas analysers

- High concentration reference gas cylinders
- Zero air generator
- Dilution unit



$$OGC = C_{cyl} * \frac{F_g}{F_g + F_d}$$

OGC = Output Gas Concentration
C_{cyl} = Gas Cylinder Concentration
F_g = Gas flow rate
F_d = Dilution air flow rate



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Possible services to client

- Network operation – all included
- Yearly service and calibration of analysers
- Periodic / preventive maintenance
- Calibration of gas cylinders
- Data reporting

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Network operation services

- Client owns instruments
  - Contractor runs network for a fixed sum
  - Sum covers either:
    1. Everything, hours, transport, spare parts, repairs
    2. Hours only, rest paid by Client
- Client rents instruments
  - Contractor runs network for a fixed sum
  - Sum covers everything

Adresses

CEN

- http://www.cen.eu/

ISO

- http://www.iso.org

Accreditation bodies:

- http://www.bab.org.bd/
- http://www.ukas.com/
- http://www.akkreditert.no/en/

EU directive (2008/50/EC)

- http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF

Thank you

Air Quality Assessment and reporting

Bjarne Sivertsen, NILU

Statistics
Air quality and meteorology
Exceeding limit values
Possible impacts (health and nature)
Designing the AQ report

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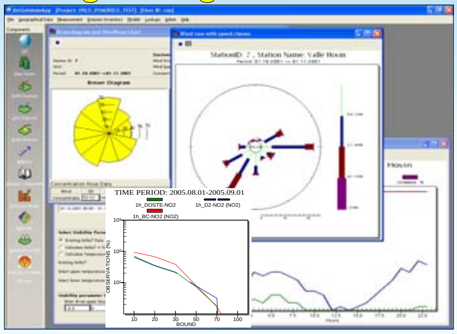
Air Quality assessment using Management software



AirQUIS

QA/QC

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Selected indicators

- SO_2 (Sulphur dioxide)
- NO_2 (Nitrogen dioxide)
- PM_{10} (Particles with aerodyn. diametre < 10 microns)
- $PM_{2,5}$ (< 2.5 microns)
- Ozone
- Benzène (BTX)
- CO (carbon monoxide)

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AQ Limits and Guidelines

Pollutant	Averaging time	Limit- and Guidelines Values	
		EU 1)	WHO
Sulphur Dioxide (SO_2)	1 hour	350 (24 x)	500 (10 min)
	24 hours	125 (3 x)	50 *
	Year	-	-
Nitrogen Dioxide (NO_2)	1 hour	200 (18 x)	200
	Year	40	40
Ozone (O_3)	1 hour	-	150-200
	8 hours	120 *)	120
Carbon Monoxide (CO)	1 hour	-	30 000
	8 hours	10 000	10 000
Particles <10 µm (PM10)	24 hours	50 (35 x)	(150) 50
	Year	40	(50) 20
Particles < 2,5 µm PM2,5)	24 hours	-	(75) 25
	Year	25	(25) 10
Benzene	Year	5	-
Lead (Pb)	Year	0,5	0.5-1,0

1) Ref: EU Limit values for protection of human health (2008/50/EC)
(n x) not to be exceeded more than n times
**) not to be exceeded more than 25 days per year (aver over 3 years)*
WHO guideline values 2005 in ( ) are WHO interim target values (IT2)

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National Ambient Air Quality Standards (NAAQS) for Bangladesh

Pollutant	Objective	Average
CO	10 mg/m³ (9 ppm)	8 hours(a)
	40 mg/m³ (35 ppm)	1 hour(a)
Pb	0.5 µg/m³	Annual
NO_2	100 µg/m³ (0.053 ppm)	Annual
PM_{10}	50 µg/m³	Annual (b)
	150 µg/m³	24 hours (c)
$PM_{2.5}$	15 µg/m³	Annual
	65 µg/m³	24 hours
O_3	235 µg/m³ (0.12 ppm)	1 hour (d)
	157 µg/m³ (0.08 ppm)	8 hours
SO_2	80 µg/m³ (0.03 ppm)	Annual
	365 µg/m³ (0.14 ppm)	24 hours (a)

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Monitoring sites Dhaka 2006

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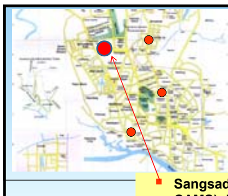
Monitoring sites and data available

1. The monitoring and reporting system in Dhaka
2. Stations in Dhaka and parameters measured
3. Instruments and monitoring status
4. Data retrieval systems and databases
5. The sites selected by AQMP/CASE
6. Quality assurance and quality control procedures



Measurement sites Dhaka 2006

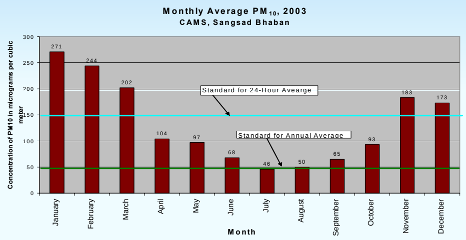
- Sangsad Bhaban (Continuous Air Monitoring Station, CAMS). It is situated in an open, flat area approximately 200-300 meters from two moderately trafficked roads
- Tejgaon (Bitac) (A small industrial area of Dhaka. The instrument should be lifted to about 2 m above roof surface)
- Rajarbag (Urban background station inside the police station in the old town of Dhaka, air intake 2 m above roof surface!)
- Lalbag (Urban/near road site at the roof outside the Lalbag fort)
- Narayangong (Suburban site 40 km south of Dhaka for PM_{10} and $PM_{2.5}$ since 2005
- Tongi (30 km north, urban backgr./ industrial)

Air Quality Indicators

The pollutants that are monitored at CAMS since April 2002 are as follows:

- ✓ Particulate Matter (PM_{10} and $PM_{2.5}$)
- ✓ Carbon monoxide (CO)
- ✓ Oxides of Nitrogen (NO_2 and NO)
- ✓ Sulphur Dioxide (SO_2)
- ✓ Ozone (O_3)
- ✓ Meteorology (ff, dd, ww, T, RH ,p, Rad. Prec)

Data presentations Available 2006

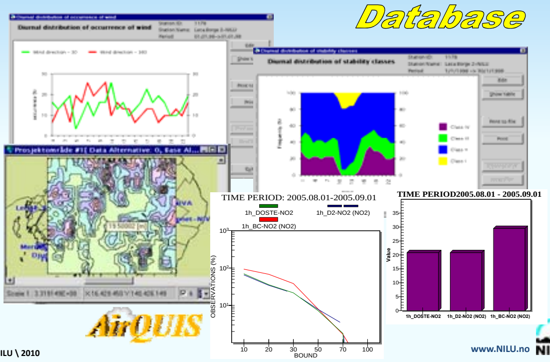


Monthly average concentrations of PM_{10} measured at CAMS during 2003

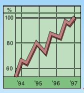
BAPMAN

Data Statistics

Database



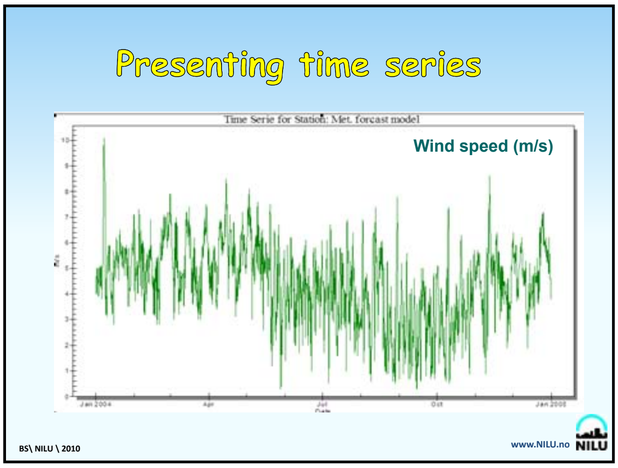
AirQUIS

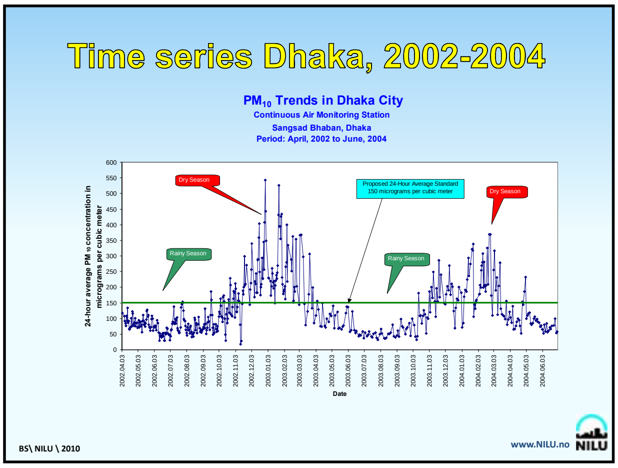


Data quality assured

- Measurements are accurate, precise and credible
- Data are representative of ambient air exposure conditions
- Results that are comparable and traceable
- Measurements consistent over time
- High data capture, evenly distributed
- Optimal use of resources

QA/QC applied !


Presenting time series
Time Serie for Station: Met. forcast model
Wind speed (m/s)
BS\ NILU \ 2010
www.NILU.no
NILU


Time series Dhaka, 2002-2004
PM10 Trends in Dhaka City
Continuous Air Monitoring Station
Sangsad Bhaban, Dhaka
Period: April, 2002 to June, 2004
Dry Season
Rainy Season
Date
BS\ NILU \ 2010
www.NILU.no
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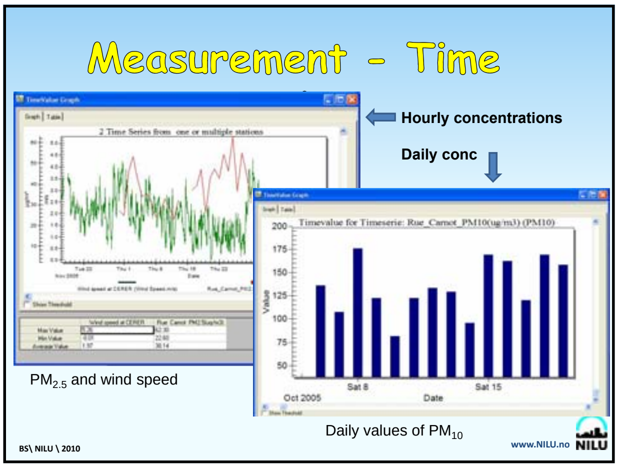
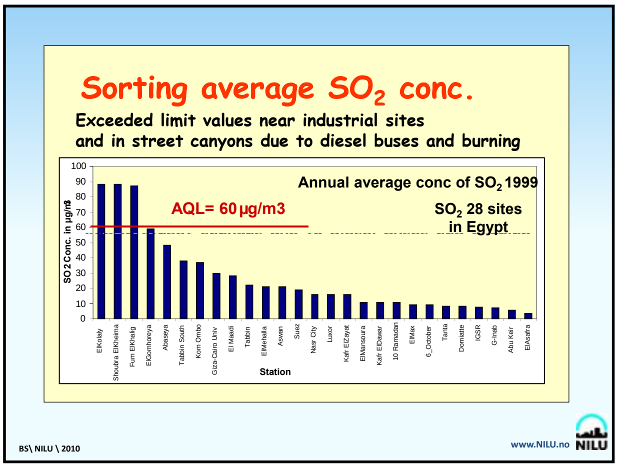
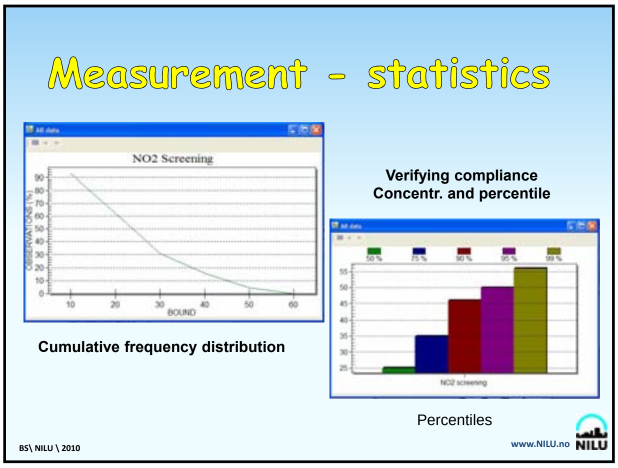
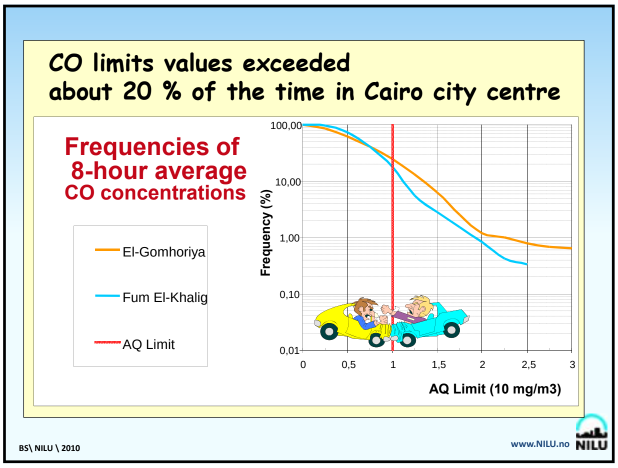
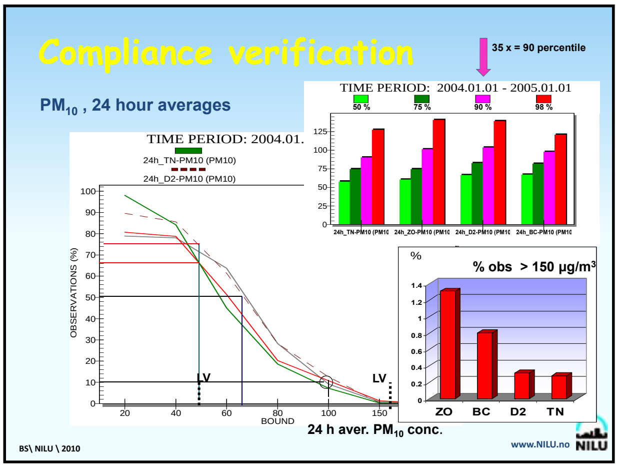

Measurement - Time
Hourly concentrations
Daily conc
PM2.5 and wind speed
Daily values of PM10
BS\ NILU \ 2010
www.NILU.no
NILU


Sorting average SO2 conc.
Exceeded limit values near industrial sites
and in street canyons due to diesel buses and burning
Annual average conc of SO2 1999
AQL= 60 µg/m3
SO2 28 sites
in Egypt
SO2 Conc. in µg/m3
Station
BS\ NILU \ 2010
www.NILU.no
NILU


Measurement - statistics
NO2 Screening
Verifying compliance
Concentr. and percentile
Cumulative frequency distribution
Percentiles
BS\ NILU \ 2010
www.NILU.no
NILU


CO limits values exceeded
about 20 % of the time in Cairo city centre
Frequencies of
8-hour average
CO concentrations
El-Gomhoriya
Fum El-Khalig
AQ Limit
Frequency (%)
AQ Limit (10 mg/m3)
BS\ NILU \ 2010
www.NILU.no
NILU


Compliance verification
35 x = 90 percentile
PM10 , 24 hour averages
TIME PERIOD: 2004.01.01 - 2005.01.01
50 %
75 %
90 %
98 %
TIME PERIOD: 2004.01.
24h_TN-PM10 (PM10)
24h_D2-PM10 (PM10)
OBSERVATIONS (%)
LV
LV
BOUND
% obs > 150 µg/m3
ZO
BC
D2
TN
24 h aver. PM10 conc.
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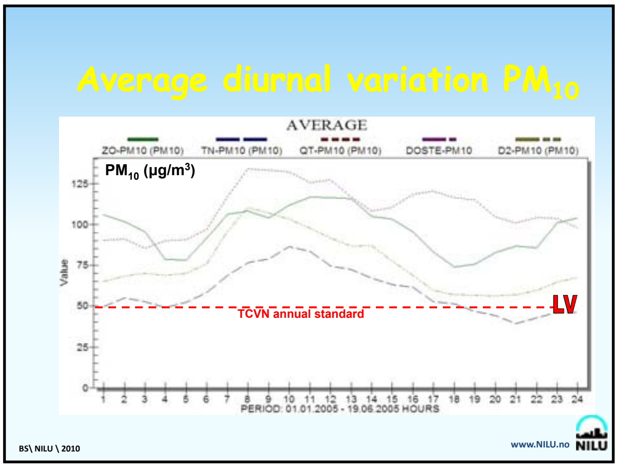
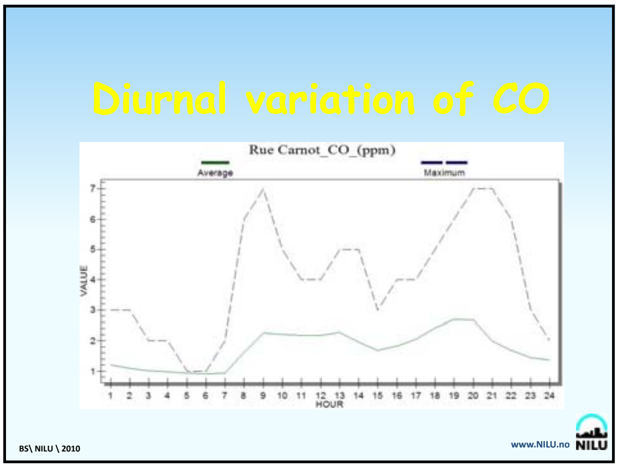
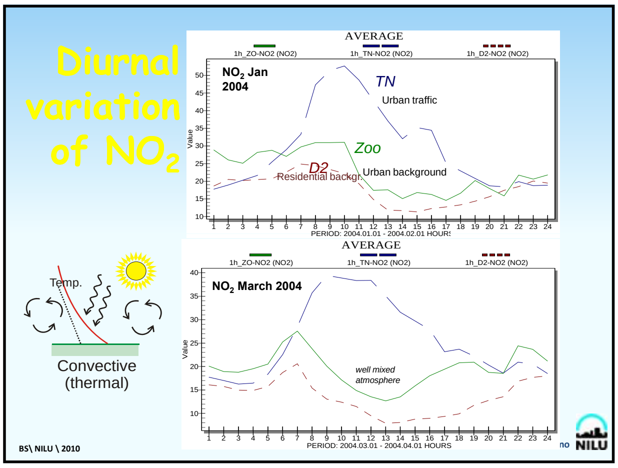
NILU


Average diurnal variation PM10
AVERAGE
ZO-PM10 (PM10)
TN-PM10 (PM10)
QT-PM10 (PM10)
DOSTE-PM10
D2-PM10 (PM10)
PM10 (µg/m3)
Value
TCVN annual standard
LV
PERIOD: 01.01.2005 - 19.06.2005 HOURS
BS\ NILU \ 2010
www.NILU.no
NILU


Diurnal variation of CO
Rue Carnot_CO_(ppm)
Average
Maximum
VALUE
HOUR
BS\ NILU \ 2010
www.NILU.no
NILU


Diurnal variation of NO2
AVERAGE
1h_ZO-NO2 (NO2)
1h_TN-NO2 (NO2)
1h_D2-NO2 (NO2)
NO2 Jan 2004
TN
Urban traffic
Zoo
D2
Residential backgr.
Urban background
PERIOD: 2004.01.01 - 2004.02.01 HOURS
NO2 March 2004
well mixed atmosphere
PERIOD: 2004.03.01 - 2004.04.01 HOURS
Temp.
Convective (thermal)
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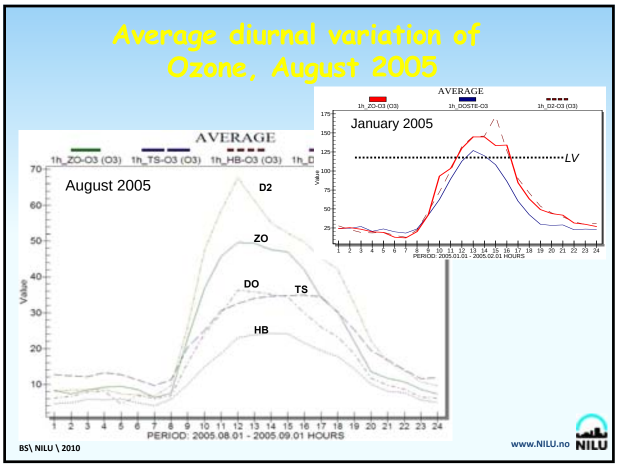
Average diurnal variation of Ozone, August 2005
AVERAGE
1h_ZO-O3 (O3)
1h_TS-O3 (O3)
1h_HB-O3 (O3)
August 2005
D2
ZO
DO
TS
HB
PERIOD: 2005.08.01 - 2005.09.01 HOURS
1h_ZO-O3 (O3)
1h_DOSTE-O3
1h_D2-O3 (O3)
January 2005
LV
BS\ NILU \ 2010
www.NILU.no
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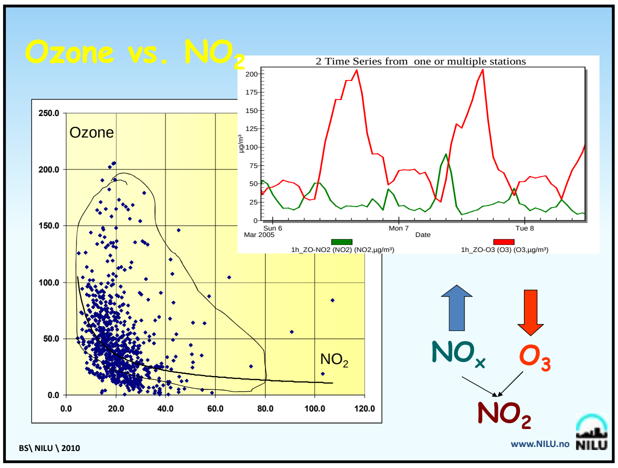
Ozone vs. NO2
2 Time Series from one or multiple stations
Ozone
NO2
Sun 6 Mar 2005
Mon 7
Tue 8
Date
1h_ZO-NO2 (NO2) (NO2,µg/m³)
1h_ZO-O3 (O3) (O3,µg/m³)
NOx
O3
NO2
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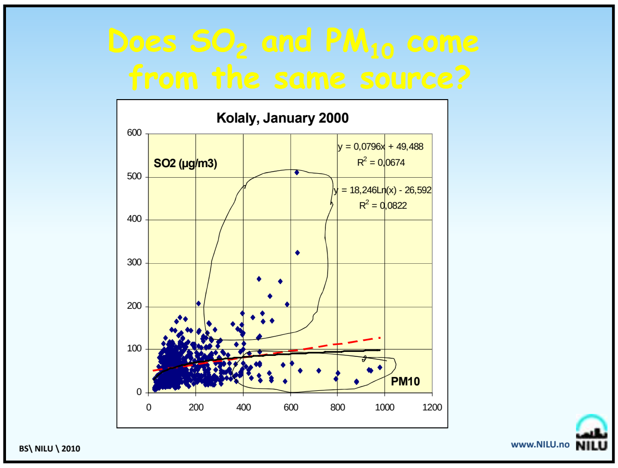
Does SO2 and PM10 come from the same source?
Kolaly, January 2000
SO2 (µg/m3)
y = 0,0796x + 49,488
R² = 0,0674
y = 18,246Ln(x) - 26,592
R² = 0,0822
PM10
600
500
400
300
200
100
0
0
200
400
600
800
1000
1200
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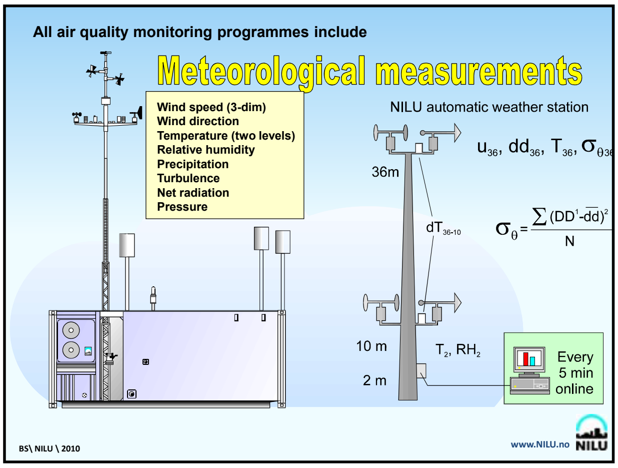
www.NILU.no
NILU


All air quality monitoring programmes include
Meteorological measurements
Wind speed (3-dim)
Wind direction
Temperature (two levels)
Relative humidity
Precipitation
Turbulence
Net radiation
Pressure
NILU automatic weather station
36m
10 m
2 m
T2, RH2
Every
5 min
online
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www.NILU.no
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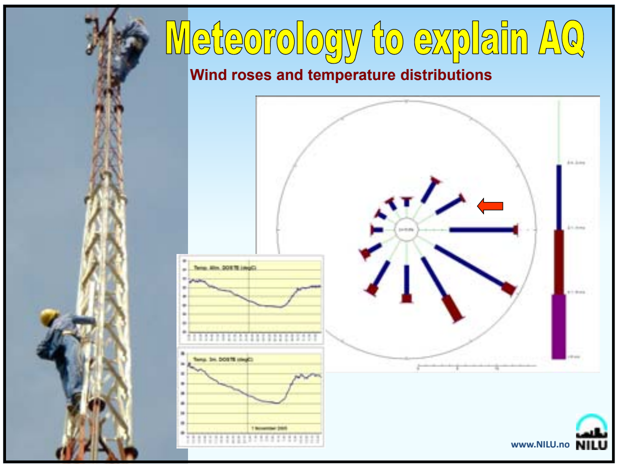
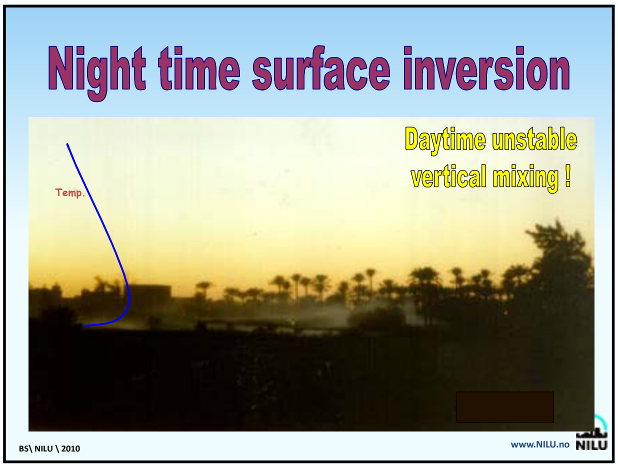
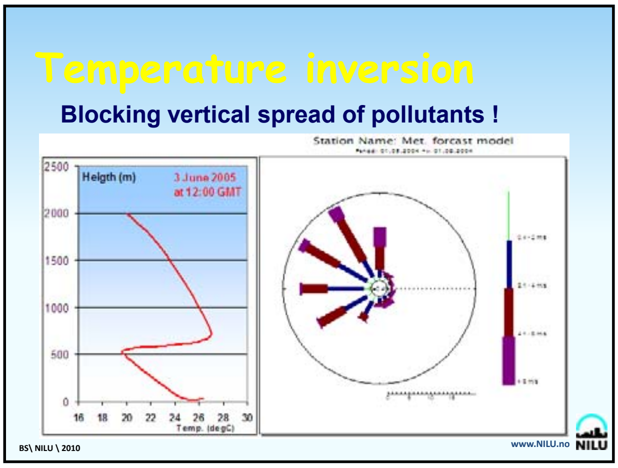

Meteorology to explain AQ
Wind roses and temperature distributions
www.NILU.no
NILU


Night time surface inversion
Daytime unstable
vertical mixing !
Temp.
BS\ NILU \ 2010
www.NILU.no
NILU


Temperature inversion
Blocking vertical spread of pollutants !
Station Name: Met. forcast model
Heigth (m)
3 June 2005
at 12:00 GMT
2500
2000
1500
1000
500
0
16
18
20
22
24
26
28
30
Temp. (deg C)
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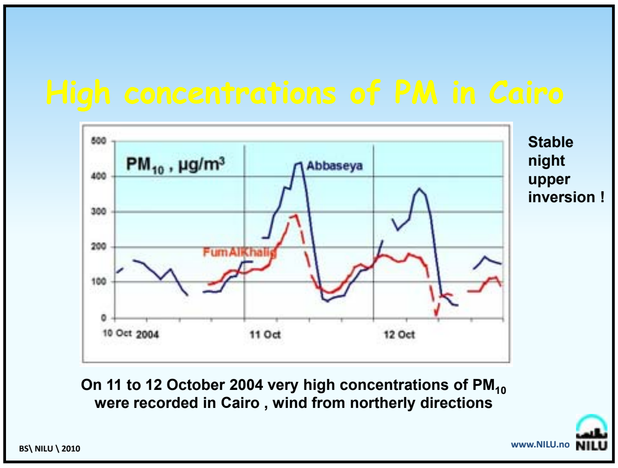
High concentrations of PM in Cairo
PM10 , µg/m3
Abbaseya
FumAlKhalig
500
400
300
200
100
0
10 Oct 2004
11 Oct
12 Oct
Stable night upper inversion !
On 11 to 12 October 2004 very high concentrations of PM10 were recorded in Cairo , wind from northerly directions
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Burning agricultural waste in the Nile Delta, Egypt
October 2004
Alex
Mansura
Kafrzayat
Zagazig
Cairo
BS\ NILU \ 2010
www.NILU.no
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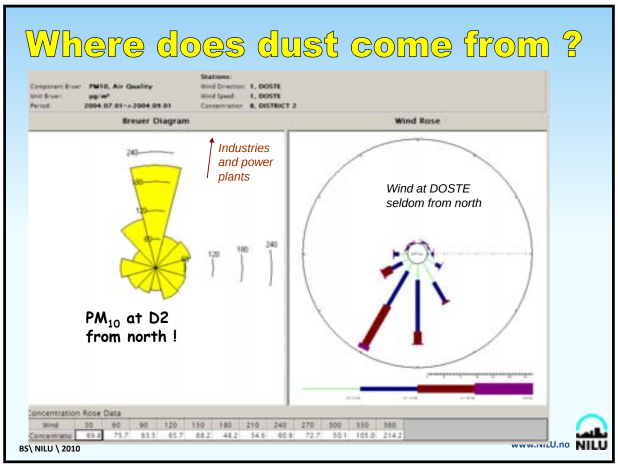
Where does dust come from ?
Breuer Diagram
Wind Rose
Industries and power plants
Wind at DOSTE seldom from north
PM10 at D2 from north !
Concentration Rose Data
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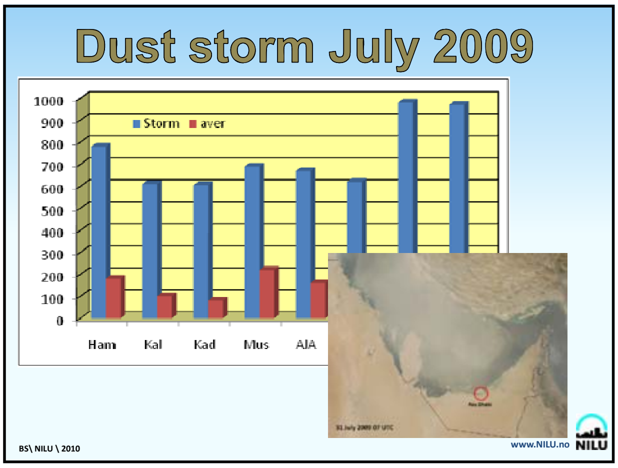
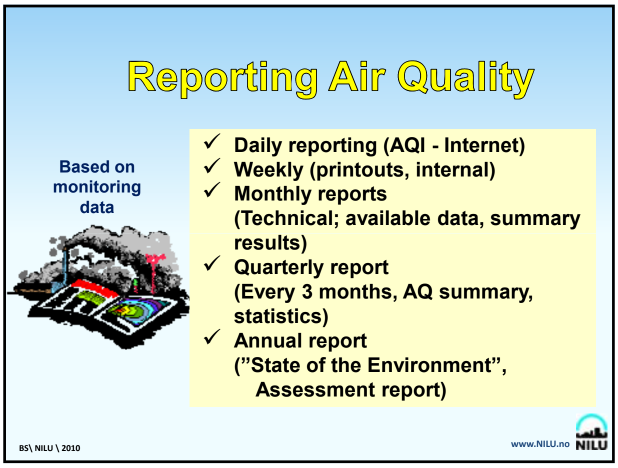

Dust storm July 2009
1000
900
800
700
600
500
400
300
200
100
0
Storm
aver
Ham
Kal
Kad
Mus
AJA
BS\ NILU \ 2010
www.NILU.no
NILU


Reporting Air Quality
Based on monitoring data
✓ Daily reporting (AQI - Internet)
✓ Weekly (printouts, internal)
✓ Monthly reports
(Technical; available data, summary results)
✓ Quarterly report
(Every 3 months, AQ summary, statistics)
✓ Annual report
("State of the Environment", Assessment report)
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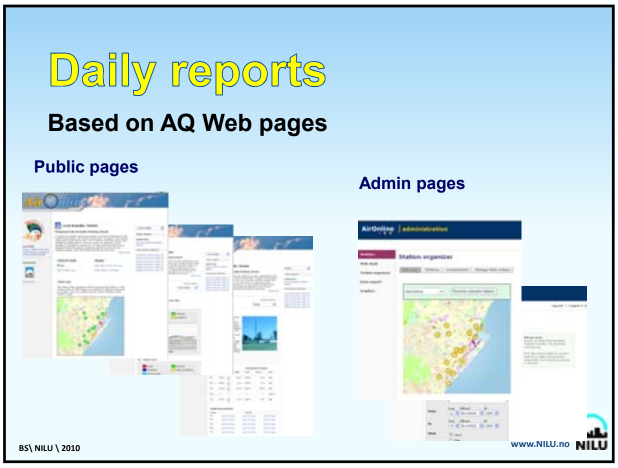
Daily reports
Based on AQ Web pages
Public pages
Admin pages
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Web info "on-line"

Based on simplified presentations

AQI = Air Quality Index

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

The AQI = index for reporting daily air quality:
- how clean or polluted is the air,
- Indicate associated health concerns you should be aware of.

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

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Monthly Reports

- Summary
- Introduction
- Objectives and AQ standards
- Data Capture
- Presentation of measurements
- Meteorology
  - Wind rose
  - Average wind speed per wind sector
  - Diurnal variation of wind directions
  - Temperature, rel humidity and pressure.
- Ambient air quality
- Statistical evaluation
  - Cumulative frequency distribution
  - Percentiles
- Diurnal variation
- Concentration roses (Breuer diagram)
- Discussions/news
- Conclusions

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Data capture

Include:
- Sites with map
- Data quality
- Data availability
- Explain errors
- Simple statistics

Data availability per site and parameter %

No.	Station Name	Parameter									
		SO_2	NO_2	CO	O_3	PM_{10}	H_2S	CH_4	BETX	Met.	Noise
1	Hamdan Street	87.8	96.3	68.6	---	99.4	---	0	0	100	66.6
2	Khadejah School	66.5	66.9	---	67.5	67.1	67.5	0	---	67.5	67.5
3	Khalifa School	99.6	94.3	---	100	74.5	99.1	0	---	100	33.8
4	Mussafah	100	92.7	---	---	99.6	100	0	---	100	0
5	Baniyas School	96.9	99.4	---	100	100	93.3	0	---	93.5	100
6	Al Ain Islamic Institute	94	0	---	100	99.7	91.4	0	---	99	100
7	Al Ain Street	0	85.4	83.2	---	99.9	---	0	98	100	100
8	Bida Zayed	93	0	---	0	99.3	97.9	0	---	97.1	100
9	Gayathi School	90.5	100	---	73.8	100	98.2	0	---	98	100
10	Liwa Oasis	92.4	78.7	---	98.2	100	---	0	---	100	100

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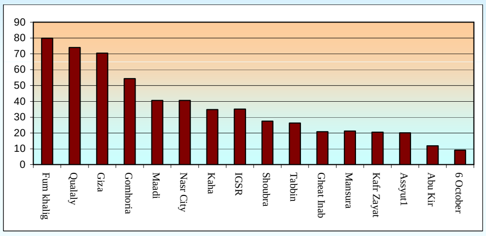
Average concentrations

Summary at sites for different compounds



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A monthly summary

- How good were the data?
- What was the critical pollutant ?
- Any specific episode?
- This month compared to earlier

Discussions and conclusions

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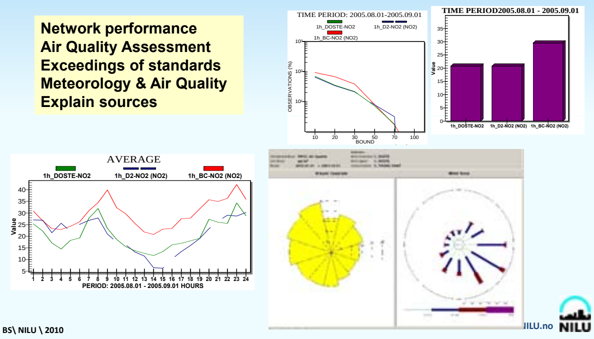
Quarterly reports

- Network performance
- Air Quality Assessment
- Exceedings of standards
- Meteorology & Air Quality
- Explain sources



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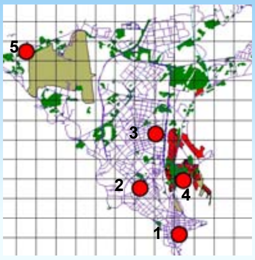
The monitoring programme



		Parameters							
	Site	SO2	NOx	NO2	PM10	PM2,5	O3	CO	Benz
1	Bd.Republique	X	X	X	X	X	X	X	
2	Medina		X	X	X			X	
3	HLM4	X	X	X	X		X		
4	BelAir	X	X	X	X	X			X
5	Yoff		X	X	X		X		

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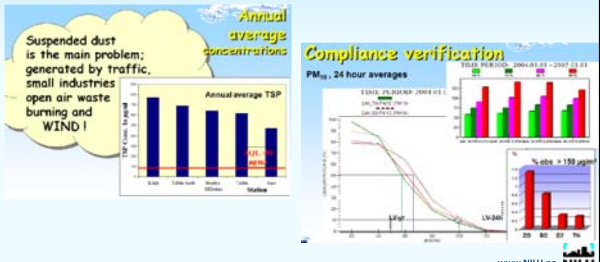
Explain the air quality

Select parameters and statistics that illustrate the main features



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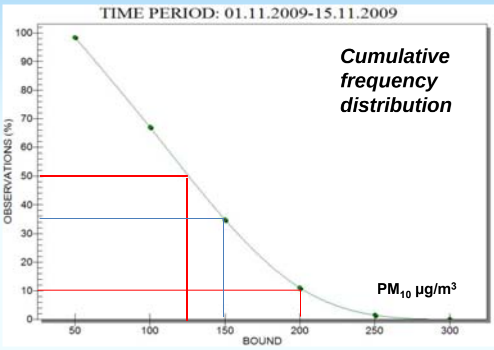
Frequencies and exceedings



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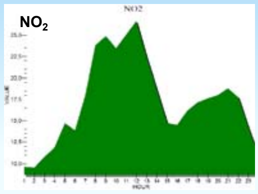
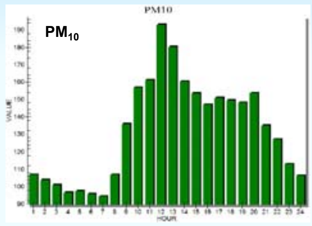
Average diurnal variation



Daytime impact from activities: traffic, transport and industries

Can it explain the impact from traffic/industry ?



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Annual report

State of the environment

1	Introduction
2	Prevailing winds
3	The main features of air pollution in Dakar
4	Suspended dust in the air, PM10
4.1	Annual average PM10 concentrations
4.2	Monthly average concentrations
4.3	Sand storm levels-episodes?
4.4	Exceedings of PM10 standards
5	Gaseous pollutants
5.1	Ozone concentrations
5.2	SO2 and NO2 concentrations
5.3	CO concentrations in streets
5.4	VOC-Benzene
6.	The main air pollution problems in Dakar

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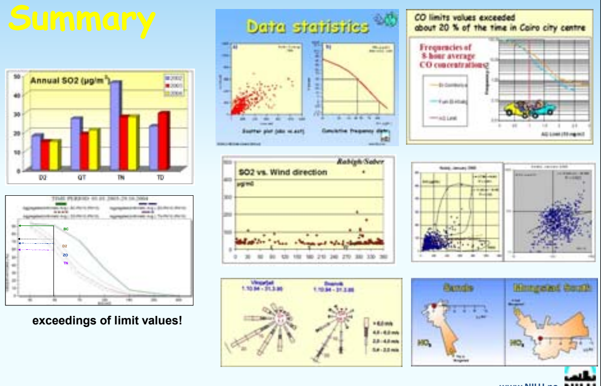
Annual report Summary



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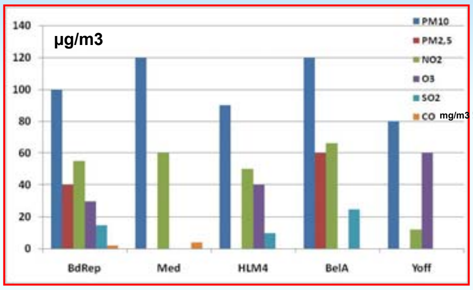
Annual average concentrations summary



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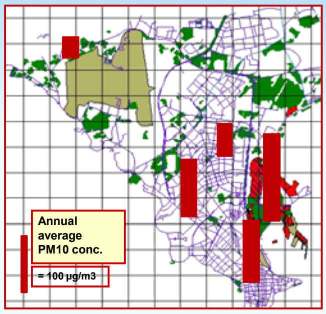
Measured annual average PM_{10} con-centrations



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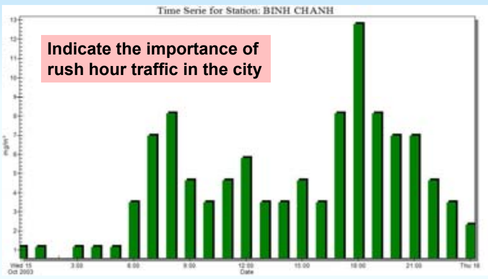
Diurnal variation of CO shows importance of traffic



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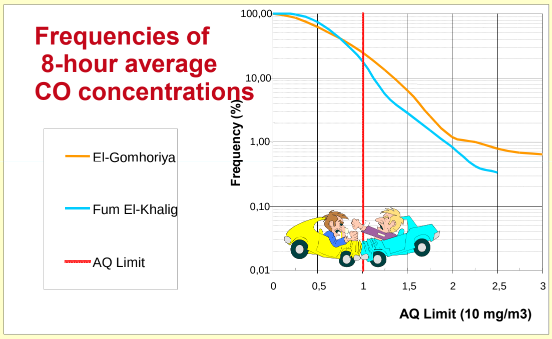
How often are limit values exceeded



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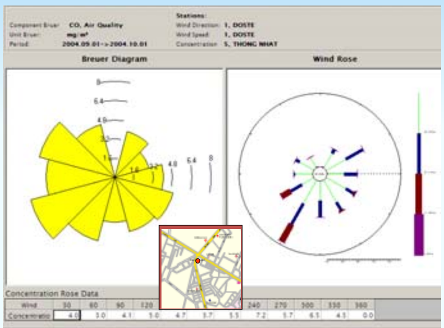
Where does pollution come from: what are the souces?



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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 ?)

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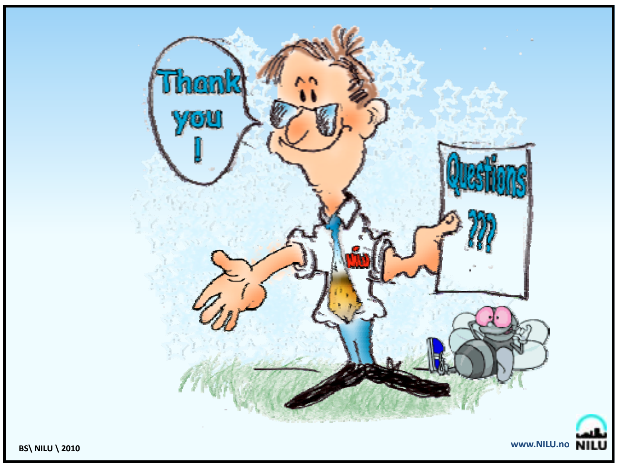
Thank you !
Questions ???
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Data Dissemination

Dhaka, Bangladesh
3 August 2010

Leif Marsteen
NILU

Data transport

Information distribution

Relevant for:

- Informing the public
- Informing governmental organisations
- Informing non-expert decision makers
- Supporting the operators of Environmental Management Systems

Information channels

Internet   WAP

Pull services
- User asks for information

Information Dissemination System

Push services
- System sends information

SMS/MMS   E-mail

Early warning, alarms

Challenges

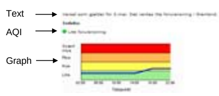
- Present data that is both scientifically correct and being understood by the audience
- Audience: Scientists, decision-makers, public
- Requires different presentation techniques
- Public pages: Keep it simple!
- Simple graphs, color coding, pollution classes, Air Quality Index, not numbers

Requirements

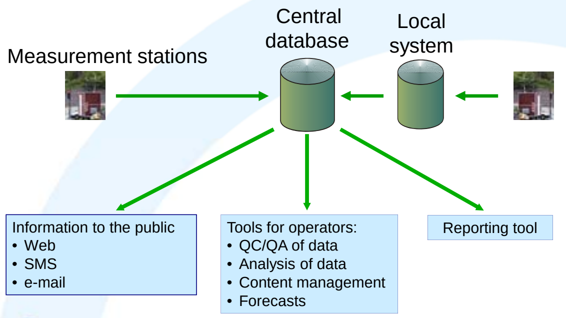
Pollution level
- Little
- Some
- A lot
- Very much

Content
- Health related information
- Effect descriptions for non-experts

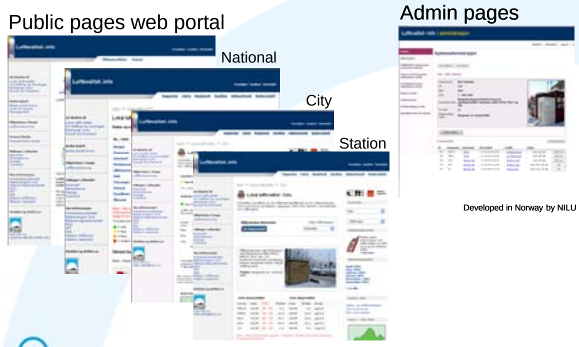
Technical
- Professional databases
- Powerful processing
- Automatic QA/QC
- Efficient data exchange



Integrated system



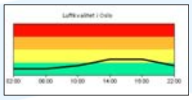
Organising the web portal



Administrative pages

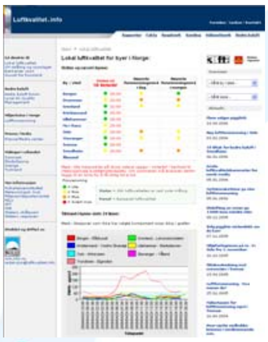
- Contents management
  - Add stations
  - Add/remove parameters at station
  - Edit information
  - Update forecasts
- Data quality control
  - Data validation
  - Data discrmination, flagging

Public pages



- Forecasts
- Health warnings/recommendations
- On-line data
- Statistics
- Compliance views
- Facts on air pollution and regulations
- Service for SMS and e-mail

National page



Contents:
- List of cities
- Status air pollution level
- On-line data
- News

City page

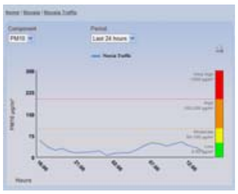
Contents:
- Pollution status now
- Forecast
- Pollution chart
- Map of stations
- Access to:
  - Statistics
  - SMS/ e-mail services
  - Station pages

Station page

Contents:
- Station description
- On-line data
- Historical data
- Compare data from different stations

More examples, Cyprus

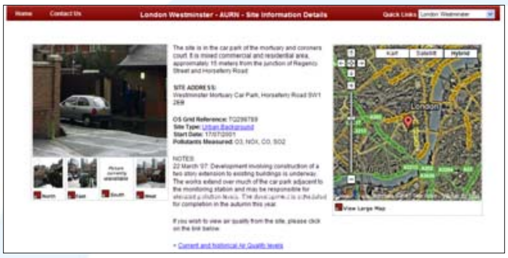
Access to details through map



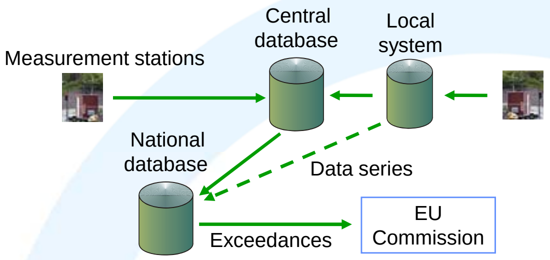
Developed in Norway by NILU

Google Map as added information

UK Automatic Urban and Rural Network (AURN)



National data base



Developed in Norway by NILU

Stores data from stations that report data to the EU Commission

Possible services to client

- Develop web solution
- Maintain web portal and central data base
- Maintain national data base

Adresses

Public air quality web portals:
- http://www.luftkvalitet.info/
- http://www.airquality.co.uk/archive/index.php
- http://www.lanuv.nrw.de/luft/immissionen/aktluftqual/eu_luft_akt.htm
- http://www.airquality.dli.mlsi.gov.cy/
- http://www.casadata.org/Reports/AlbertaMap.asp
- http://www.bv-aurnsiteinfo.co.uk/
- http://www.eea.europa.eu/

Thank you

Air Quality Management Planning

Bjarne Sivertsen, NILU

Models
Emission inventories
(point, area, line-sources)
Concentration distribution and exposure
Impact assessment
Abatement strategies
Action plans – future air – scenario evaluation

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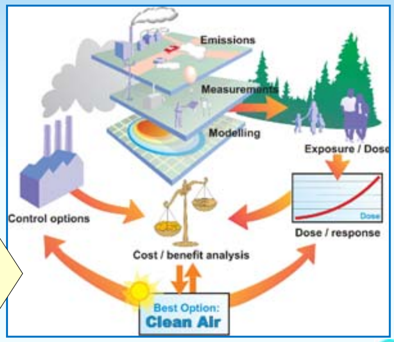
AQ Management Planning

Identify actions to improve air quality

Identify most cost-effective options



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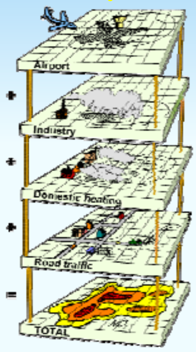
Dispersion modelling



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

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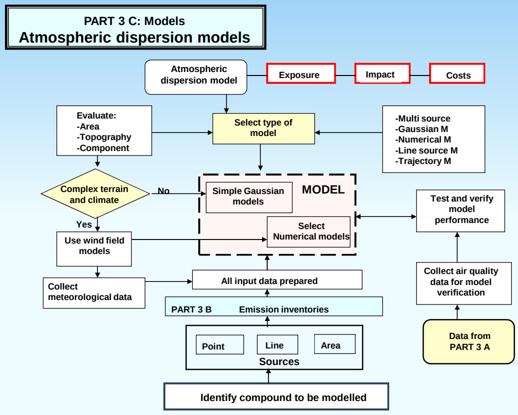

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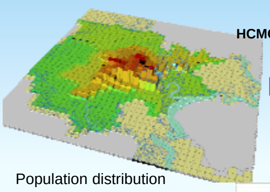
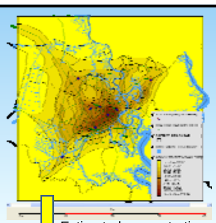
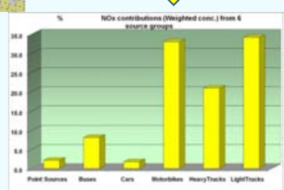
Model results





Population distribution

Estimated concentrations



Relative contributions of sources to the exposure in HCMC

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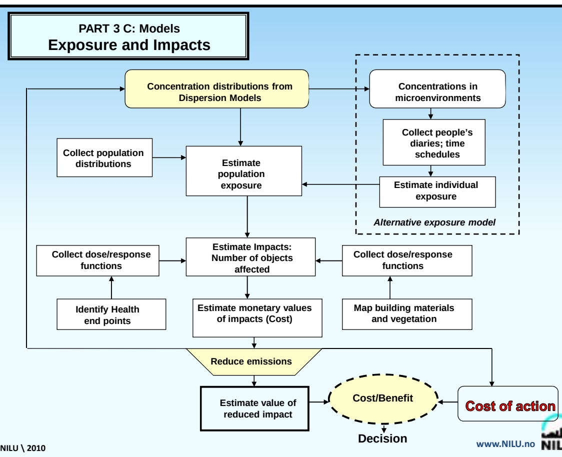

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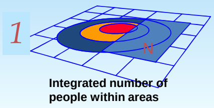
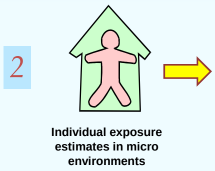
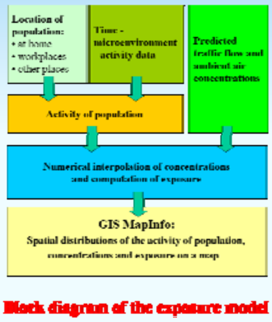
Exposure estimates







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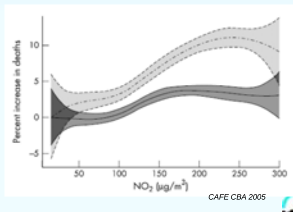
Estimate dose/response

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
- Bronchitis
- Asthmas
- Acute respiratory diseases, PM, NOx
- Hospital admissions
- Reduced working days

Dose/response functions



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Exposure response relationships for PM

Meta-analyses; time series morbidity study in China

Health end point	Diseases	% per µg/m^3 PM_{10}	s.e.
Hospital admission	Resp dis.	0.12	0.02
	Cardiov. Dis.	0.07	0.02
New cases	Chronic Bronchitis	0.48	0.04

Aunan & Pan, 2004

EU Cost Benefit Analyses (CAFÉ CBA 2005)

Mortality from chronic exposure : 4 % / 10 µg/m^3 PM_{10} (Infant; 0-1 yr)
Increase mortality chronic exposure: 6% / 10 µg/m^3 $PM_{2,5}$ (Pope et.al)
Respiratory hospital admission : 1 % / 10 µg/m^3 PM_{10} (0-64 yrs)

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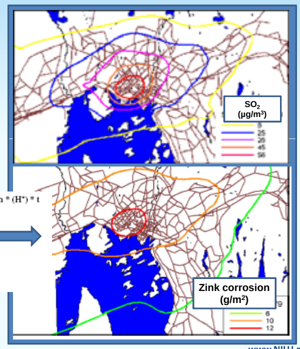
Environmental load

From concentrations to material loss

Mass loss model

$$ML = a * (SO_2)^b * (O_3)^c * RH * \exp[d\,(T-10)] * t^e + f * regn * (H^+) * t$$

ML = vekttap (Mass Loss) i g/m^2 dag
SO_2 = svoveldioksid i µg/m^3
O_3 = ozon i µg/ m^3
RH = relativ fuktighet i prosent
T = temperatur i °C
Regn = nedbør i meter
H+ = hydrogen ionekonsentrasjonen mg/l



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Next step:

Intervention strategies

Aims and targets

- Improve air quality
- Reduce negative impact on human health
- Achieve acceptable air quality
- Reduce negative impact on the environment

Tasks:

1. Assess control options, their feasibility (technical, economic, political) and their costs.
2. Calculate cost-benefit ratios for options, find best control strategies.
3. Implement control strategies,
4. Enforce policies and regulations needed to implement strategies.

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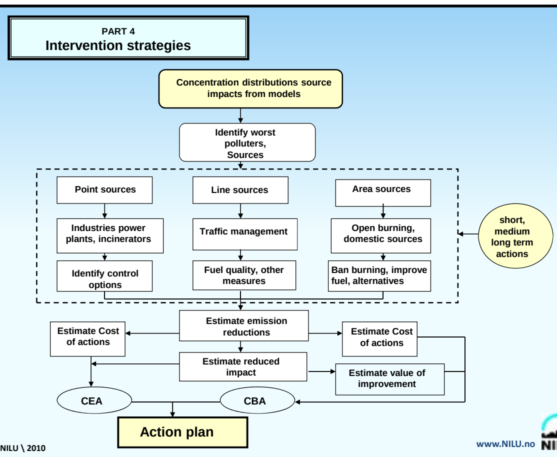

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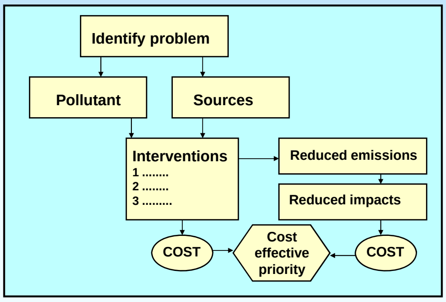
Intervention strategies

Summary:



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Source reductions - Action plans

Possible actions:

- Introduction of scrubbers;
- Shifting to renewable energy (or low sulphur fuel);
- Introduction of cleaner technology;
- Implementation of process equipment changes and process changes;
- Improvement of operating practice;
- Ensuring regular maintenance; and
- Ensuring maximum energy conservation

✓ Actions defined
✓ Cost of actions
✓ Reduced emissions
✓ Reduced exposure

COSTS → Emissions reduced

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Listing possible activites

✓ Combustion
✓ Petroleum industry
✓ Coal gasification
✓ Metalurgical industry
✓ Mineral processing ind
✓ Organic industry
✓ Incineration process
✓ Waste handling
✓ Wood and paper
✓ Animal products

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Possible strategies - compounds

Particulate control
- Mechanical collectors (dust cyclones, multicyclones)
- Electrostatic precipitators
- Bag houses
- Particulate scrubbers

NOx control
- Low NOx burners
- Selective catalytic reduction (SCR)
- Selective non-catalytic reduction (SNCR)
- NOx scrubbers
- Exhaust gas re-circulation
- Catalytic converter (also for VOC control)

VOC abatement
- Adsorption systems, such as activated carbon
- Flares
- Thermal oxidizers
- Catalytic oxidizers
- Bio filters
- Absorption (scrubbing)
- Cryogenic condensers

Acid Gas/SO2 control
- Wet scrubbers
- Dry scrubbers
- Flue gas desulphurisation

Mercury control
- Sorbent Injection Technology
- Electro-Catalytic Oxidation (ECO)
- K-Fuel

Area dependent !

✓ Industry
✓ Domestic fuel burning
✓ Mine tailings
✓ Transport
✓ Regional air movements
✓ Wildfires and
✓ prescribed burning

Other smaller sources that contribute to pollution include:

- Landfills
- Waste treatment works
- Agriculture
- Large scale construction
- Tyre burning

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Short and long term interventions

Emission Reduction Strategies

Short-term (1-2 years):
These include actions that can be taken immediately to reduce emissions and generally involve minimal disruption or would have a major benefit. Examples include: more efficient industrial operating practices; switching to cleaner fuel; vehicle emissions testing.

Medium-term (3-5 years):
These include strategies which require a measure of planning before they can be implemented.

Long-term (> 5 years):
These are interventions that require major changes either socially or require huge investment. Examples include: promotion of public transportation; education campaigns.

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Reduce emissions - mobile sources

✓ Assess the vehicle fleet; vehicle numbers, type, age and fuel usage.
✓ Ensure the integration of air quality into town planning and future road developments.
✓ Introduce effective transportation measures to reduce air pollution
✓ Include traffic calming (speed humps, roundabouts, traffic islands, traffic light synchronisation ec.)
✓ Provide alternative transportation measures to reduce single-occupancy vehicles.
✓ Development regular emissions testing on all vehicles
✓ Create public awareness of motor vehicle related emissions impacts
✓ Disseminate information on pollution concentrations measured in the city.

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Cost/benefit procedure

1 Identify the population and stock/assets at risk due to pollution
All the residents of a polluted area, or a fraction thereof,
The stock-at-risk refers to the area exposed

2. Determine the number of people and objects that are exposed to ambient pollution that exceeds standards or guidelines.

3. Identify relevant dose-response functions
Health impacts may directly be correlated to the concentration
Different concentrations result in differing degrees of symptoms.

4. Calculate marginal physical impact
Multiply population-at-risk and/or the stock-at-risk with the impact

5. Determine monetary values per unit of physical impact
Impacts on e.g. crop production valued with market prices.
Health and ecological impacts more complex relations.

6. Calculate the monetary value of benefits/damage
Change in air pollution impact multiplied with the monetary unit values.

Prioritise: Cost of actions vs. value of improvement

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Prioritise Cost of Actions

Input from Stakeholders and Industries

Sources – Strategies - Technologies

- ✓ **Update emission data**
- ✓ **Validate cost with recent installations**
- ✓ **Expand with additional technology**
- ✓ **Policy options - compliance date**
- ✓ **Dynamic analyses**

Estimated costs (US$) per ton reduced in a specific area					
	NOx	SOx	PM_{10}	CO	HC
Low	5	1000	400	5	200
High	175000	167000	389000	38000	27000
Average	43900	52400	92500	26300	6300

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Cost of Reduced Impacts

Possible 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

Europe

Mortality	Median value	Mean value
Infant mortality	€1,500,000/death	€4,000,000/death
Value of statistical life	€980,000/death	€2,000,000/death
Value of a life year	€52,000/year	€120,000/year

Morbidity	low	central	high
Chronic bronchitis	€120,000/case	€190,000/case	€250,000/case
Respiratory/cardiac hospital admissions		€2,000/admission	
Primary care consultations		€53/consultation	
Restricted activity day (stay in bed)		€130/day	
Minor restricted activity day		€38/day	
Use of respiratory medication		€1/day	
Symptom days		€38/day	

CAFE CBA 2005

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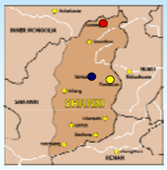
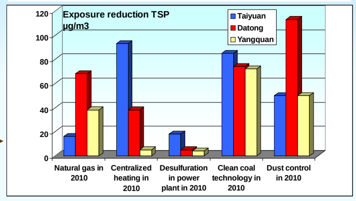
Reduced emissions ⇨ Reduced exposure



Model estimated exposure reductions in 3 cities in Shanxi province China

Population weighted exposure reduction of TSP for 5 control scenarios (μg/m³)



Larssen et.al.

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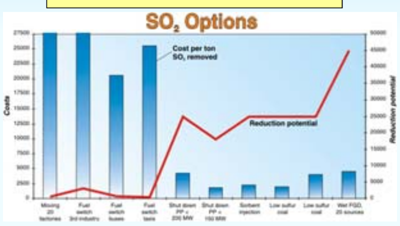
Cost effective SO2 options

- A.Q. Assessment
- Health impacts
- Abatement options
- Cost/benefit analyses
- Optimal abatement strategy

Cost effective SO_2 options



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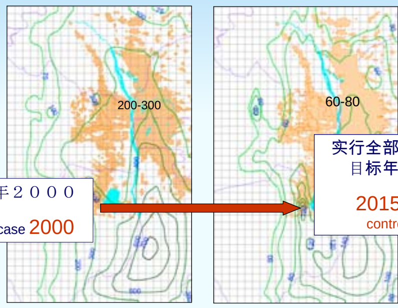
SO_2 modelling example in Taiyuan

SO_2 concentrations, average over the heating season

二氧化硫浓度等值线上，供热季节的平均浓度



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费用效益分析 Cost benefit analysis

A comparison of cost-benefit of various control options for SO_2 and TSP in Taiyuan

Cost benefit analysis:

A comparison of cost-benefit of various control options for SO_2 and TSP in Taiyuan

A comparison of cost-benefits of various control options for SO2 in Taiyuan

	Emission Reduction (t)	Concentration reduction (μg/m³)	Cost-benefit ratio	Rank
Natural gas utilization	20400	19.79	-52	2
Desulfuration in power plants	18460	6.47	115	4
Centralized heating	30000	51.89	-424	1
Implementation of productivity policies	9280	5.75	2000	5
Clean coal technology	36600	6.24	-23	3

A comparison of cost-benefits of various control options for TSP in Taiyuan

	Emission Reduction (t)	Concentration reduction (μg/m³)	Cost-benefit ratio	Rank
Natural gas utilization	31900	16.7	-0.489	2
Centralized heating	69400	90.29	-1.601	1
Implementation of productivity policies	17000	18.57	3.711	5
Clean coal technology	47100	93.13	-0.008	3
Dust control		50	1.813	4

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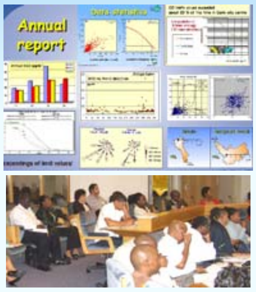
Evaluation and follow-up



- Development and operations of monitoring programmes
- Reporting and assessment of changes in air quality
- Update actions and control options
- Prepare and update Master Plans
- Arrange workshops and seminars
- Involve stakeholders
- Identify gaps and challenges
- Inform the public

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Approval and review process

AQMP submitted to Authorities

Distributed

- All major industries,
- Local and District Municipalities,
- Provincial Authorities,
- Relevant NGOs,
- Public

Stakeholder involvement

Comments

Approval → Implementation

Integrated Development Plan

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AQMP – update for sustainability

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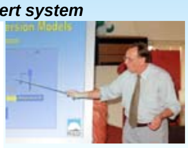
Capacity building and training

AQMS – an expert system

- Need institutional building and training
- Understanding the issues, local and global
- Tools and equipment
- Assure sustainability!



Future needs and priorities

Tools – Policy – Actions – Follow-up

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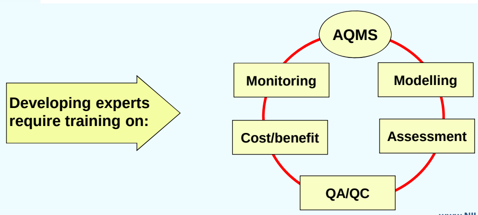
Training needs assessment

Topics identified for one training programme:

- Introduction to Air Quality Management planning;
- Monitoring and modelling skills;
- Presentation of the Implementation Manual;
- Presentation of the Air Quality management regulations
- Discuss Air Quality management regulations;



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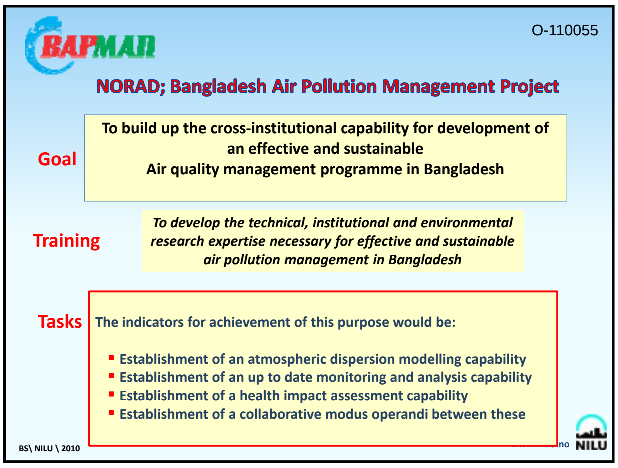
BAPMAN
O-110055
NORAD; Bangladesh Air Pollution Management Project
Goal
To build up the cross-institutional capability for development of an effective and sustainable Air quality management programme in Bangladesh
Training
To develop the technical, institutional and environmental research expertise necessary for effective and sustainable air pollution management in Bangladesh
Tasks
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
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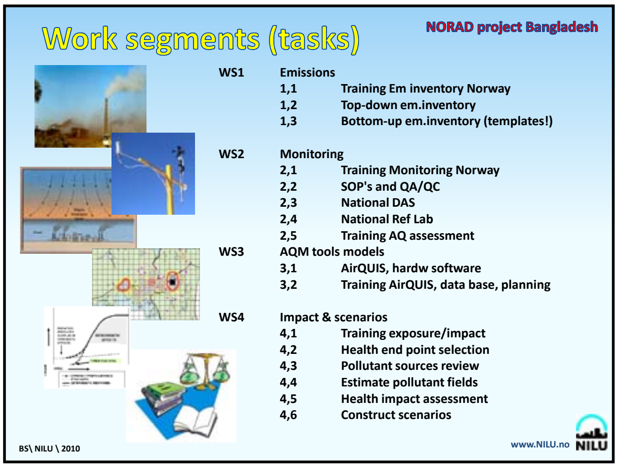
Work segments (tasks)
NORAD project Bangladesh
WS1 Emissions
1,1 Training Em inventory Norway
1,2 Top-down em.inventory
1,3 Bottom-up em.inventory (templates!)
WS2 Monitoring
2,1 Training Monitoring Norway
2,2 SOP's and QA/QC
2,3 National DAS
2,4 National Ref Lab
2,5 Training AQ assessment
WS3 AQM tools models
3,1 AirQUIS, hardw software
3,2 Training AirQUIS, data base, planning
WS4 Impact & scenarios
4,1 Training exposure/impact
4,2 Health end point selection
4,3 Pollutant sources review
4,4 Estimate pollutant fields
4,5 Health impact assessment
4,6 Construct scenarios
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Thank you !
Questions ???
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