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Air Quality Monitoring and Management

Training Course

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Bjarne Sivertsen and Leif Marsteen

Norsk institutt for luftforskning
Norwegian Institute for Air Research
NILU

Preface

The United Nations Development Programme (UNDP) Country Offices in Western Balkans has developed a regional environmental programme in nine locations in the Western Balkans countries/territories suffering from the legacy of polluting industries and requiring industrial renewal, environmental cleanup and new economic initiatives.

Effective environmental monitoring is essential to understanding, managing, and improving the quality of air of Albania. Monitoring is a crucial factor to improving the quality of the decision-making that will, lead to human health protection, and will support a healthy sustainable economy.

NILU has been asked to conduct a training course in Tirana, Albania, which meets the needs for training consisting of elements that will improve air pollution understanding linked to monitoring and management of the air quality. The programme for this course is presented in this report.

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Air Quality Monitoring and Management

Training course

1 Introduction

The objective of this training course is to raise the standard in monitoring of air pollution in Albania towards internationally accepted standards through a 3 day training course. The participants should be practitioners and experts from environmental monitoring institutes.

The training course is being presented as lectures in a workshop over three days covering monitoring and sampling methods and equipment, EU legislation and directives, WHO guidelines and EU legislation, key air quality parameters, methods of data collection, validation, analysis and reporting and air quality planning.

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

Day 1, 19 May 2010

Air quality management
Monitoring programme design
Air quality legislation
Discussions

Day 2, 20 May 2010

Instrumentation; monitoring and sampling
Monitoring and sampling, network operation
Quality systems
Presentations from Albania (existing AQ monitoring)
Discussions

Day 3, 21 May 2010

Air quality assessment and reporting
Data dissemination
Air quality management planning
Summary,
Conclusions and discussions

The transparencies used during the course are presented in Appendix B.

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 of 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 and
- 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 is 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 the Table below.

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

More details concerning EU limit values is presented in Appendix B.
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.

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

Different types of instruments, their abilities and price.

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

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

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 manpower 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 reference measurement methods as specified by the European Union was given in the EU Council Directive 2008/50/EC and described in CEN (European Standardisation Organisation) documents, see some examples below.

Component	**Measurement method**	**Reference to standard**
NO, NOx, NO2	Automatic Chemiluninecsence	CEN/EN142111, Standard method for the measurement of the concentration of nitrogen dioxide and nitrogen monoxide by chemiluminescence
SO2	Automatic Ultraviolet fluorescence	CEN/EN14212, Standard method for the measurement of the concentration of sulphur dioxide by ultraviolet fluorescence
O3	Automatic Ultraviolet photometry	CEN/EN14625, Standard method for the measurement of the concentration of ozone by ultraviolet photometry
CO	Automatic Nondispersive infrared spectroscopy	CEN/EN14626, Standard method for the measurement of the concentration of carbon monoxide by nondispersive infrared spectroscopy
BTX	Automatic, GC	CEN/EN14662, Ambient air quality - Reference method for measurement of benzene concentrations

6 Monitoring and sampling, network operation

To produce results of known and sufficient quality there is a whole range of tasks to be performed such as periodic status checking, maintenance, calibrations, data evaluation and so on. Failing to perform all or some of these tasks will reduce the data quality. To ensure unified operation both within a monitoring network and across several networks a documented quality system is necessary. All operations must be described in written procedures and documented for later reference. Only then will it be possible to assess the quality of the measured data as required in the EU Air Quality Framework Directive.

6.1 Routine site visit

Routine operation is important to make sure instruments are operating within their required specifications. Based on the equipment different procedures will be necessary.

A typical weekly maintenance procedure for a gas monitor would be:

1. Record time and date of arrival to the station, serial number of instrument and working gas standard and working gas concentration.
2. Record some status parameters, such as sample flow rate, sample temperature, reaction chamber temperature, light intensity.
3. Compare status parameters with last few weeks of status parameters to detect trends, e.g. falling light intensity in an ozone monitor. The objective is to change consumables and spare parts before they reduce the quality of the data or brake down.
4. Disconnect the inlet tube from the inlet and connect it to the zero/span check unit.
5. Test the instrument by feeding zero and span gas to it.
6. Compare the results with the results from last few weeks of zero/span checks to detect trends. Normally there would be a linear decrease in the response. A sudden drop may indicate a problem.
7. Compare the results with the performance acceptance criteria and perform necessary actions if the test results fall outside the performance limits. The instrument response is changed only if it is outside the action limits.
8. Perform regular maintenance as required, such as changing inlet filter.
9. Remember to reconnect the inlet tube to the inlet!
10. Record time of end of operation.
11. Sign the maintenance form.
12. Record the visit in the visit log.

Once the operator is back at the office he/she imediately calculates scale factors (slope and offset) based on the results from the zero/span check. The scale factors are entered into the data acquisition system and used by the system to mathematically correct the acquired data. Data is collected every hour from all stations, scaled and transferred directly for display on the internet.

The results from periodic testing, typically once a week, of instruments, e.g. zero/span checks on gas monitors, are compared to the Performance Acceptance Criterias. If the results fall outside the prescribed limits certain actions has to be taken, e.g. recalibration, troubleshooting or service of the instrument. By using common action criterias across and between measurement networks it is more probable that the operators will evaluate test results equally.

6.2 Data validation

Even if the instruments are maintained in a proper order they may break down. In order to detect malfunctions as soon as possible validation of collected data is required. Continuous display of data on the internet requires some automatic validation, e.g. spikes, too high values, too negative values. In addition a manual data validation is performed as well to cover other kinds of invalid data.

Manual data validation is performed as follows:

1. Every day the operator goes onto the internet and looks at charts from his/her stations. The operator looks for indications of instrument malfunctions, such as constant levels, spikes and negative values.
2. If any measurement data looks suspicous the operator will connect to the station and run a check on the instrument and inspect on-line or one-minute averages for details.
3. Every week the operator enters the scale factors into the system.
4. After the end of the month the last month of data is evaluated. The operator looks for trends in measurement data and scale factors, invalid measurement data, e.g. from zero/span checks and periods of instrument malfunctions are flagged.
5. The monthly data is finally approved and transferred to the central database. It is now ready for use.

7 Quality systems

In ambient and emission air quality measurement systems, the Quality System is concerned with all activities that contribute to the quality of the measurements. The aim of the Quality System is to assure that the results meet the predefined standards of quality. To produce results of known and sufficient quality there is a whole range of tasks to be performed such as periodic status checking, maintenance, calibrations, data evaluation and so on. Failure to perform all or some of these tasks will decrease the data quality.

The Quality System shall assure that:

- Data is reliable for its intended use (fulfils the Data Quality Objectives).
- Data has known quality (fulfils the performance standards).

- Data from different sites can be compared.
- The receiver of the measurement results (management, public, etc.) has confidence in the results.

The quality terms relevant for Quality Assurance/Quality Control (QA/QC) procedures and criteria can be defined as follows (ISO 8402, 1994):

- Quality is the totality of characteristics of an entity that bear on its ability to satisfy stated or implied needs.
- Quality Assurance involves the management of the entire process which includes all the planned and systematic activities which are needed to assure and demonstrate the predefined quality of data, to provide adequate confidence that an entity will fulfil requirements for quality.
- Quality Control comprises the operational techniques and activities that are undertaken to fulfil the requirements for quality.

The Quality Assurance activities cover all the pre-measurement phases, ranging from definition of data quality objectives to equipment and site selection and personnel training. The Quality Control activities cover all operational work such as routine maintenance, calibration, data collection, data validation and data reporting. For emission inventories and modelling it may cover activities such as entering or editing emission data in the emission inventory, running models and reporting results. In addition to Quality Assurance and Quality Control, a third activity called Quality Assessment is usually implemented in the Quality System. The Quality Assessment provides for a periodic external audit of the Quality System and the operational activities. Quality Assurance, Quality Control and Quality Assessment will all be parts of the Quality Plan. They have to be operational and co-ordinated and must be considered as necessary parts of any Air Quality Management System.

7.1 The Quality organisation

A modern integrated Air Quality Management System (AQMS) is a complex system. It may cover very different activities such as instrument maintenance, data collection, emission inventories, running models, data reporting and audits. People working on the system will range from technicians maintaining instruments to planners running air quality models. In addition the AQMS can span several industries and geographical areas.

The quality organisation will typically include the following functions/people:

- Operators focused on Quality Control
- The Quality Manager focused on Quality Assurance
- The Reference Laboratory focused on Quality Assurance and Quality Assessment

The operators run instruments, computer systems and models. They report status on quality matters to the Quality Manager. The Quality Manager has the overall responsibility for the Quality System within the measurement network. It is the responsibility of the Quality Manager to assure that the operators are running the AQMS in compliance with the requirements of the Quality System. The Quality Manager will report any requests for changes or updates in the quality documentation to the Reference Laboratory. The Quality Manager will be responsible for initiating training programs.

A workshop/calibration laboratory will be responsible for service, repair and calibration of instruments. The calibration laboratory will ensure that the measurement instruments are in good working order and calibrated with traceability to the Reference laboratory.

7.2 The Reference Laboratory

Article 3 of the Framework directive calls for the designation of bodies responsible for ensuring accuracy of measurements e.t.c. This implies the appointment of a Reference Laboratory. The Reference Laboratory will be responsible for administration and maintenance of the Quality System. This typically includes preparing new procedures and updating the quality documentation. The Reference Laboratory will also maintain the reference calibration standards. The reference standards will represent the highest level of calibration in the country. The Reference laboratory will provide traceability to the reference standards to all measurement instruments in the monitoring network. This can be accomplished either by having the Reference Laboratory calibrating all calibration materials used in the nework or if the network has a suitable calibration laboratory only calibrating their reference standards.

The Reference Laboratory will perform audits in the measurement network to assess the actual quality of the measurements. Based on the results of the audits the Reference Laboratory will advice the network operators on how to improve the data quality. A yearly data quality assessment report will be submited to the authorities.

The Reference Laboratory will participate in international intercomparison tests to verify its competence and to establish international traceability. It will also participate in international working groups such as the group of National Air Quality Reference Laboratories in Europe (AQUILA) to get exchange information and to harmonise the quality work with other countries.

7.3 The Quality documentation

To ensure unified operation across the AQMS, a documented quality system is necessary. The Quality System will be documented in the Quality Manual. The Quality Manual will consist of two main parts:

- Quality Assurance - Management level.
- Quality Control - The daily work.

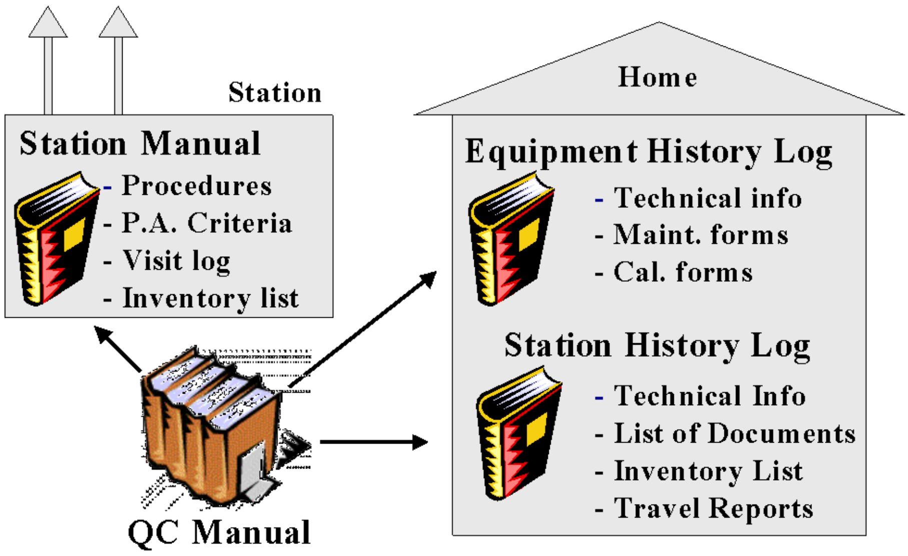
The Quality Assurance part of the Quality Manual will include a description of:

- The overall objective of the Quality system.
- How responsibilities, tasks and functions are shared between the parties involved in the quality work.
- The Data Quality Objectives (DQO) based on the intended use of the data.
- Instrument performance standards and criteria (performance acceptance criteria) based on the DQOs.
- Quality System audits.
- Training programs for operators.
- Document handling and document version control

The performance standard/criteria related to air (and emissions) monitoring are based upon the setting of Data Quality Objectives (DQO). The performance acceptance criteria related to monitoring are then set so that the DQOs specified are fulfilled.

To keep the measurement instruments within the limits of the performance acceptance criteria it is necessary to operate them (maintain, calibrate, service, repair, etc.) according to certain procedures. The computer systems, covering data collection, database maintenance and use of the modelling tools has to be operated according to certain procedures too. These procedures, called Standard Operations Procedures (SOPs), are collected in the Quality Control part of the Quality Manual.

The figure below shows the conceptual design of the quality documentation.



The Quality Manual and distributed documentation

The Quality Control part of the Quality Manual will include procedures on:

- Maintenance of measurement instruments
- Calibration of measurement instruments
- Data collection
- Data validation
- Computer and data systems maintenance
- Quality System audits
- Training

Each SOP will be documented in a specific form. The form will be completed by the operator during the execution of the SOP and stored systematically for later reference.

A station manual is kept at the station containing documents necessary for operating that specific station. At home all equipment and the shelter itself will have a history log book where notes and documentation on the equipment is stored. The main documentation at a site is:

- Standard Operations Procedure (SOP) for each instrument at the site
- A form for each SOP to document the procedure
- Performance Acceptance Criteria specific to the instrumentation at the site

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:

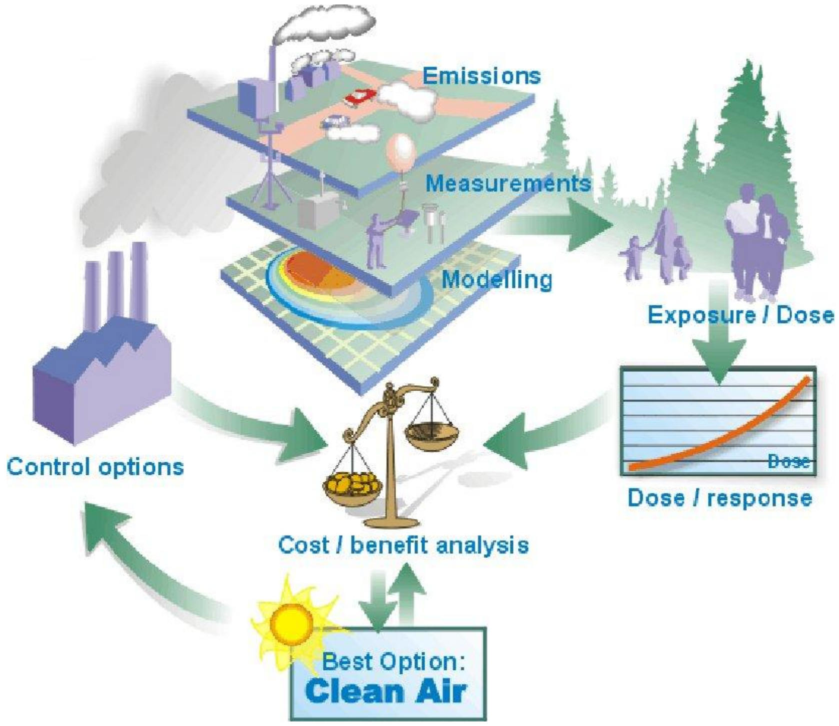
- Air quality assessment
- Environmental damage assessment
- Abatement options assessment
- Cost-benefit or cost-effectiveness analyses
- Abatement measures
- Optimum control strategy

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 the Figure below.



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 are being presented in Appendix B based on project 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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Sivertsen, B. (2005) Ho Chi Minh City Environmental Improvement Project. Air quality assessment and reporting. Presented at DONRE, HCMC, November 2005. Kjeller (NILU F 60/2005).

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URL: http://www.epa.gov/ttn/naaqs/ [2010-05-06].

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URL: http://frwebgate4.access.gpo.gov/cgi-bin/PDFgate.cgi?WAISdocID=152830221851+0+2+0&WAISaction=retrieve [2010-05-06]

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World Health Organization (2000) Air quality guidelines for Europe; second edition. Copenhagen, WHO Regional Office for Europe (WHO regional publications, European series, No 91). Full background material available on URL: http://www.euro.who.int/air/activities/20050223_4 [2010-05-06].

World Health Organization (2005) WHO air quality guidelines global update 2005. Report on a Working Group meeting, Bonn, Germany, 18-20 October 2005. Copenhagen, WHO Regional Office for Europe (EUR/05/5046029).

Web adresses

Gas and PM analysers:
- http://www.teledyne-api.com/
- http://www.synspec.nl/
- http://www.thermo.com/
- http://www.environnement-sa.com/
- http://www.recordum.com/
- http://www.grimm-aerosol.de/
- http://www.tsi.com/
- http://www.horiba.com/
- http://www.opsis.se/

PM samplers:
- http://www.digitel-ag.com/
- http://www.leckel.de/
- http://www.derenda.de/
- http://www.airmetrics.com/

Noise analysers:
- http://www.bksv.com/

Meteorology sensors:
- http://www.metone.com/
- http://www.gill.co.uk/
- http://www.kippzonen.com/
- http://www.lsi-lastem.it/
- http://www.skyeinstruments.com/
- http://www.vaisala.com/

Gas cylinders:
- http://www.airliquide.com/
- http://www.lindegas.com/
- http://www.nmi.nl/
- http://www.scottgas.com/
- http://www.nist.gov/

Data collection:
- http://www.iseo.fr/
- http://www.emcslo.com/
- http://www.ecotech.com/
- http://www.environnement-sa.com/
- http://www.nilu.no/

Shelters:
- http://www.ekto.com/

Accreditation bodies:

http://www.albanianaccreditation.gov.al/
http://www.ukas.com/
http://www.akkreditert.no/en/

AQUILA and JRC:

http://ies.jrc.ec.europa.eu/aquila-homepage.html

CEN

http://www.cen.eu/

ISO

http://www.iso.org

EU directive (2008/50/EC)

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

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/

Appendix A

Contents of the seminar

Day 1, 19 May 2020

Welcome address, UNDP?
Introduction

1 Air quality management
Sources
Monitoring
Air quality assessment
Modelling
Data dissemination
Abatement planning

Coffee break

2 Monitoring programme design
Objectives
Design the programme
Air quality indicators
Operational sequence
Meteorological data
The modern air quality monitoring system
Site selection
Representativity
Sampling Station Density

Lunch

3 Air quality legislation
Guidelines and limit values
WHO guidelines
EU Directives
Framework directives
Daughter directives
Limit values and standards
Monitoring mechanism CO2 and GHG emissions

Discussions

Day 2, 20 May 2010

4. Instrumentation; monitoring and sampling
Fields of application
Measurement principles and standard measurement methods
References to EU directives and the European Standardisation Organisation (CEN)

Data logging and data collection
Shelters
Laboratory requirements
Preparation of filters and post analysis
Operational costs
Procurement, installation and start-up of measurement stations
Commercially available instruments and data collection systems

Coffee break

5 Monitoring and sampling, network operation
Routine operation, site visits
Preventive maintenance
Calibrations, service and repairs
Data validation
Organisational structure, in-house or outsourcing, examples of solutions

Lunch

6 Quality systems
Quality Assurance, Quality Control and Quality Assessment
References to EU directives, tasks of The National Reference Laboratory
Requirements for traceability in calibrations, nationwide and internationally
Inter comparison exercises and demonstration of measurement capabilities
Quality manual overview, examples of procedures
Accreditation and references to ISO 17025

Presentations from Albania (existing AQ monitoring)
Discussions

Day 3, 21 May 2010

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

Coffee break

8 Data dissemination
Requirements for data dissemination with references to EU directives
Different information channels, Web, e-mail, SMS, radio, TV

Information adapted to different audiences, public, experts, decision makers
Information content, online data, historical data, warnings, forecasting, reports, themes
Reporting to the European Commission
Live example (internet connection required)

Lunch

9 Air quality management planning

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

10 Summary,

Conclusions and discussions

Appendix B

The transparencies used during the presentations

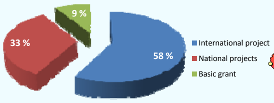
Air Quality Management

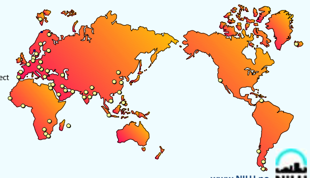
The Norwegian institute for Air Research

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





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Seminar schedule

Day 1, 19 May 2010
1 Air quality management
2 Monitoring programme design
3 Air quality legislation
Discussions

Day 2, 20 May 2010
4. Instrumentation; monitoring and sampling
5 Monitoring and sampling, network operation
6 Quality systems
Presentations from Albania (existing AQ monitoring)
Discussions

Day 3, 21 May 2010
8 Air quality assessment and reporting
9 Data dissemination
10 Air quality management planning
11 Summary,
Conclusions and discussions

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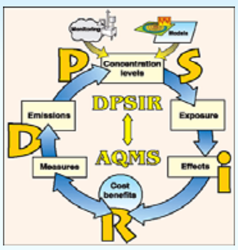
Air Quality Management

Introduction

Bjarne Sivertsen, NILU



Sources
Monitoring
Air quality assessment
Modelling
Data dissemination
Abatement planning

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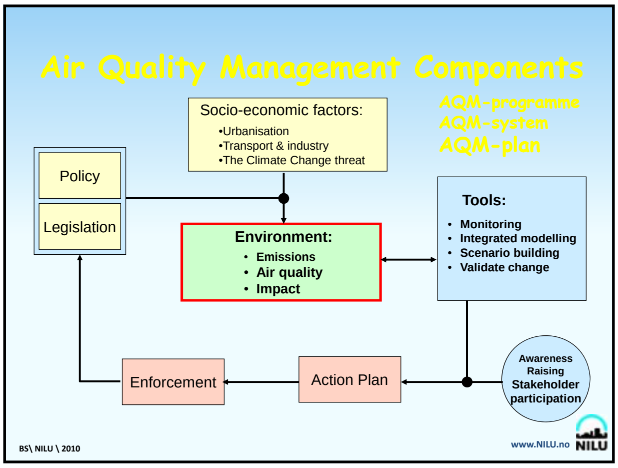
Air Quality Management Components
Socio-economic factors:
•Urbanisation
•Transport & industry
•The Climate Change threat
AQM-programme
AQM-system
AQM-plan
Policy
Legislation
Environment:
Emissions
Air quality
Impact
Tools:
Monitoring
Integrated modelling
Scenario building
Validate change
Enforcement
Action Plan
Awareness Raising
Stakeholder participation
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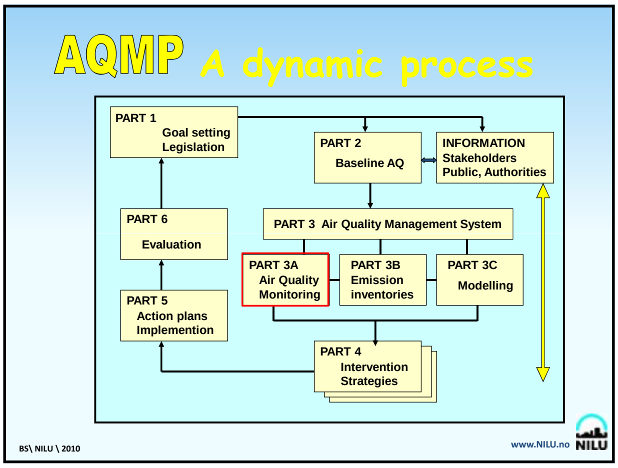
AQMP A dynamic process
PART 1
Goal setting
Legislation
PART 2
Baseline AQ
INFORMATION
Stakeholders
Public, Authorities
PART 6
Evaluation
PART 3 Air Quality Management System
PART 3A
Air Quality
Monitoring
PART 3B
Emission
inventories
PART 3C
Modelling
PART 5
Action plans
Implemention
PART 4
Intervention
Strategies
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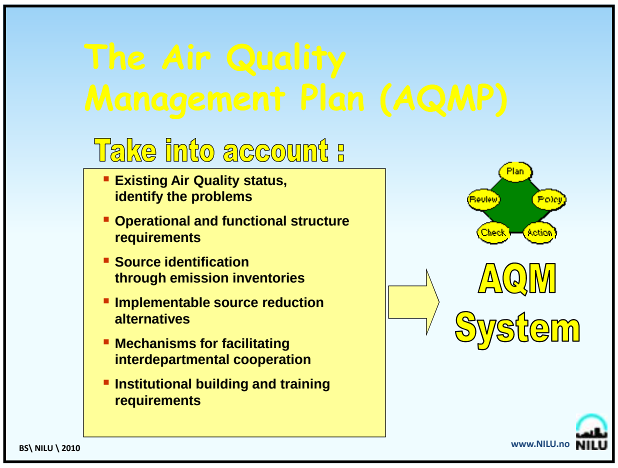
The Air Quality Management Plan (AQMP)
Take into account :
Existing Air Quality status, identify the problems
Operational and functional structure requirements
Source identification through emission inventories
Implementable source reduction alternatives
Mechanisms for facilitating interdepartmental cooperation
Institutional building and training requirements
Plan
Review
Policy
Check
Action
AQM
System
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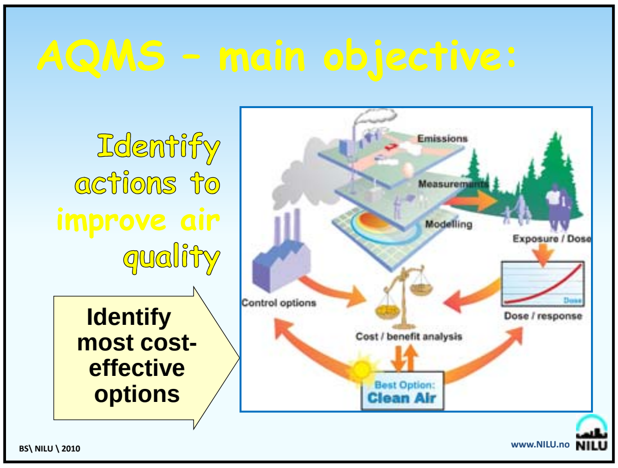
AQMS – main objective:
Identify actions to improve air quality
Identify most cost-effective options
Emissions
Measurements
Modelling
Exposure / Dose
Control options
Dose / response
Dose
Cost / benefit analysis
Best Option:
Clean Air
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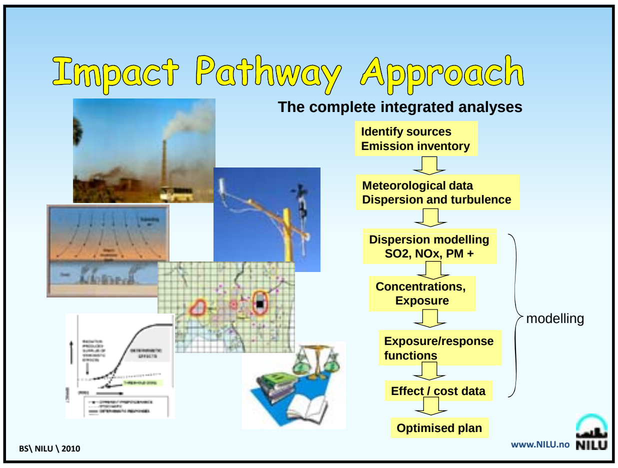
Impact Pathway Approach
The complete integrated analyses
Identify sources
Emission inventory
Meteorological data
Dispersion and turbulence
Dispersion modelling
SO2, NOx, PM +
Concentrations,
Exposure
Exposure/response
functions
Effect / cost data
Optimised plan
modelling
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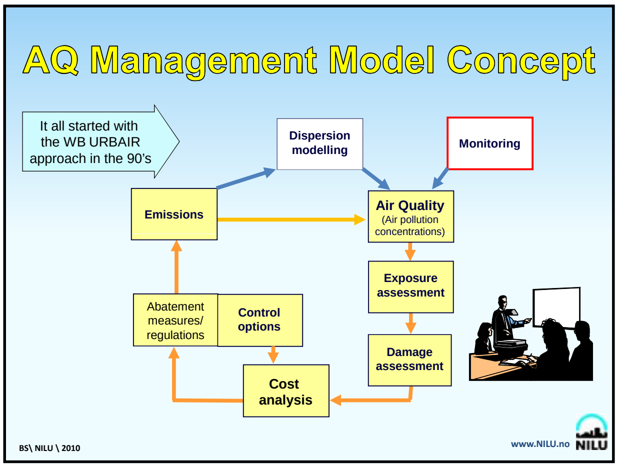
AQ Management Model Concept
It all started with the WB URBAIR approach in the 90's
Dispersion modelling
Monitoring
Emissions
Air Quality
(Air pollution concentrations)
Exposure assessment
Abatement measures/ regulations
Control options
Damage assessment
Cost analysis
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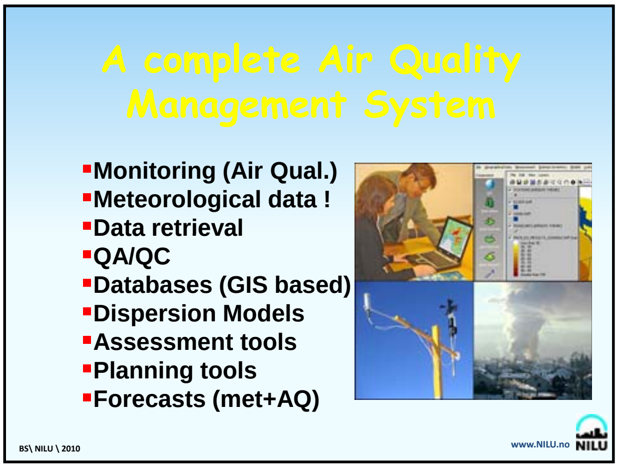
A complete Air Quality Management System
Monitoring (Air Qual.)
Meteorological data !
Data retrieval
QA/QC
Databases (GIS based)
Dispersion Models
Assessment tools
Planning tools
Forecasts (met+AQ)
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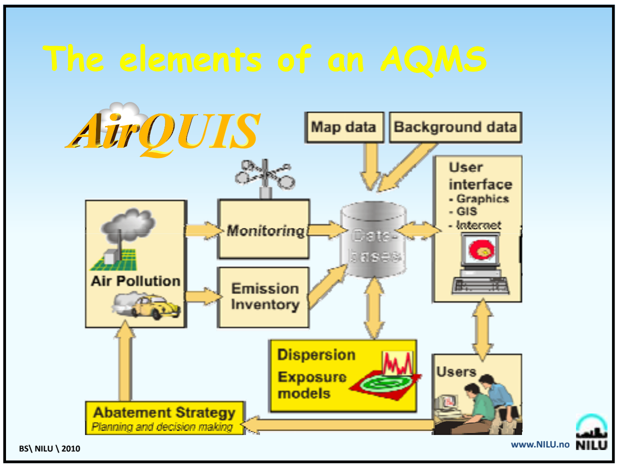
The elements of an AQMS
AirQUIS
Map data
Background data
User interface
- Graphics
- GIS
- Internet
Monitoring
Data-bases
Air Pollution
Emission Inventory
Dispersion
Exposure models
Users
Abatement Strategy
Planning and decision making
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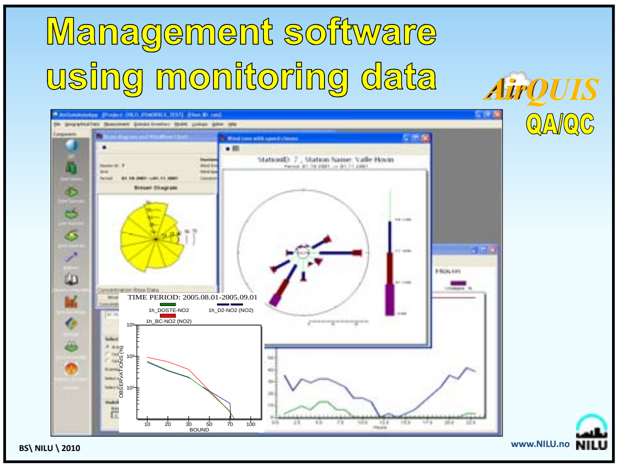
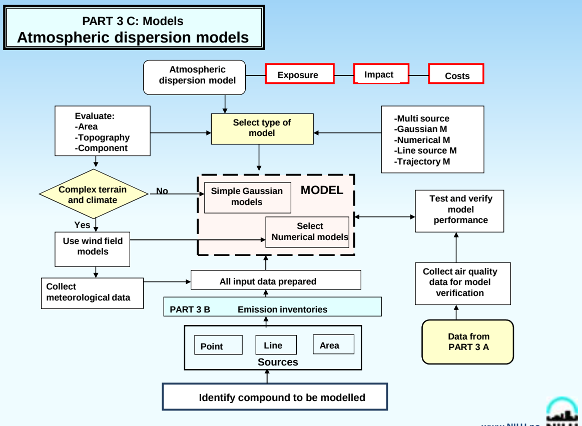

Management software using monitoring data
AirQUIS
QA/QC
TIME PERIOD: 2005.08.01-2005.09.01
BS\ NILU \ 2010
www.NILU.no
NILU



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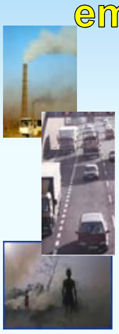
Sources and emission inventories



- **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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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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AQ monitoring programme Procedures

- ✓ 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

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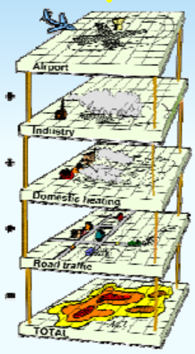
Dispersion modelling



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

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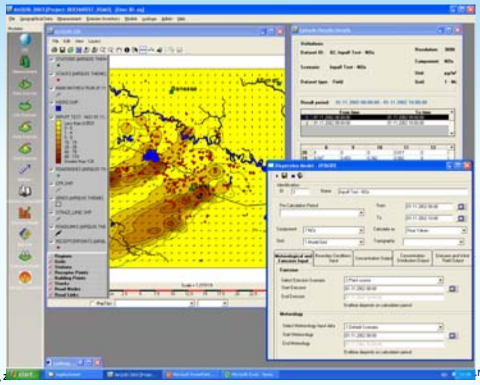
Dispersion Models



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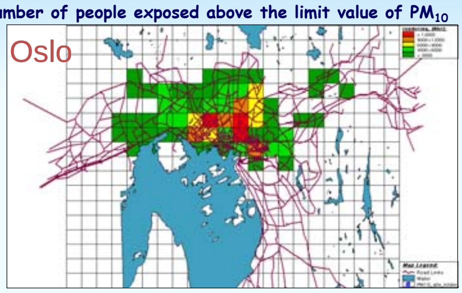
Exposure assessment

Links population data
to concentration fields

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



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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 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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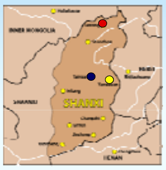
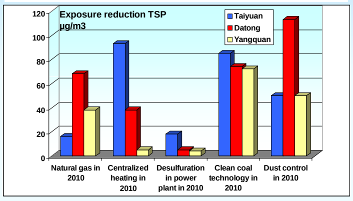
Reduced emissions ⇨ Reduced exposure



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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Exposure response relationships for PM

Meta-analyses; time series morbidity study in China

Health end point	Diseases	% per µg/m³ 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/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)

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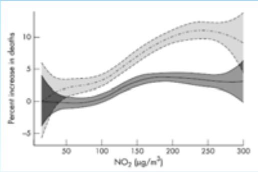
Cost of Reduced Impacts

Dose/response functions →



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

Costs of effect as estimated in 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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Planning: examples

Goal: Cleaner air in HCMC

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

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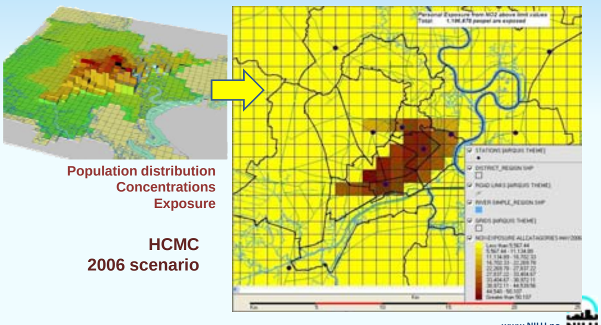
NO_2 exposure – 1,196 mill people

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



Population distribution
Concentrations
Exposure

HCMC
2006 scenario

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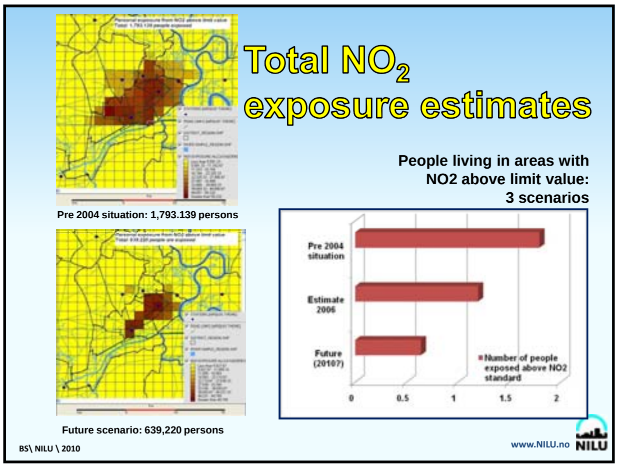
Total NO_2 exposure estimates
People living in areas with NO2 above limit value: 3 scenarios
Pre 2004 situation: 1,793.139 persons
Pre 2004 situation
Estimate 2006
Future (2010?)
Number of people exposed above NO2 standard
0
0.5
1
1.5
2
Future scenario: 639,220 persons
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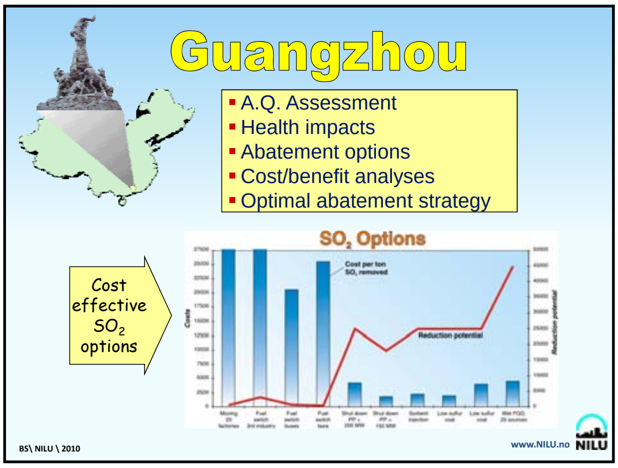
Guangzhou
A.Q. Assessment
Health impacts
Abatement options
Cost/benefit analyses
Optimal abatement strategy
Cost effective SO_2 options
SO_2 Options
Cost per ton SO_2 removed
Reduction potential
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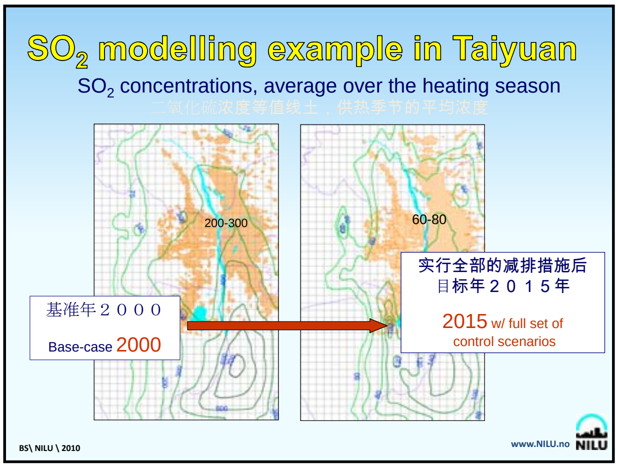
SO_2 modelling example in Taiyuan
SO_2 concentrations, average over the heating season
200-300
60-80
基准年２０００
Base-case 2000
实行全部的减排措施后
目标年２０１５年
2015 w/ full set of control scenarios
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费用效益分析
Cost benefit analysis

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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Information dissemination

Public awareness
Participation
NGO support
Understanding

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IPCC YOU CONTROL CLIMATE CHANGE

Looking forward :

Climate Change = Our largest threat !

Urban AQ analyses + Green house gas estimates

Urban emission inventories

National inventory

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

CO_2 GHG emissions

SO_2, NOx PM, VOC toxics

Reduced CO_2 emissions

Actions for improved local Air quality

Co-benefit

Improve local Air Quality + Reduce green house gas emissions

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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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GHG mitigation or sequestration activities eligible for CDM:

- Renewable energy technologies
- Energy efficiency improvements - supply side and/or demand side
- Fuel switching (e.g., coal to natural gas or to sustainable biomass)
- Combined heat and power (CHP)
- Capture and destruction of methane emissions (e.g. from landfill sites)
- Emissions reduction from industrial processes (e.g. cement prod.)
- Capture/destruct of GHGs other than methane (N2O, HFC, PFCs, and SF6)
- Emission reductions in the transport sector
- Emission reductions in the agricultural sector
- Afforestation and reforestation
- Modernization of existing industries using less GHG technologies

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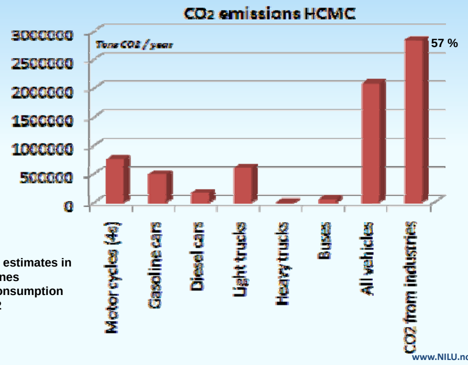
Total CO_2 emissions HCMC



Industrial CO2
Based on SO2 estimates in 9 industrial zones and total oil consumption in HCMC 2002

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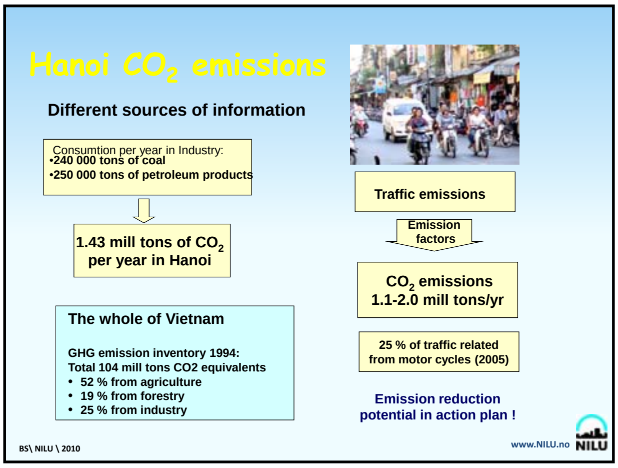
Hanoi CO_2 emissions
Different sources of information
Consumtion per year in Industry:
•240 000 tons of coal
•250 000 tons of petroleum products
1.43 mill tons of CO_2 per year in Hanoi
The whole of Vietnam
GHG emission inventory 1994:
Total 104 mill tons CO2 equivalents
• 52 % from agriculture
• 19 % from forestry
• 25 % from industry
Traffic emissions
Emission factors
CO_2 emissions 1.1-2.0 mill tons/yr
25 % of traffic related from motor cycles (2005)
Emission reduction potential in action plan !
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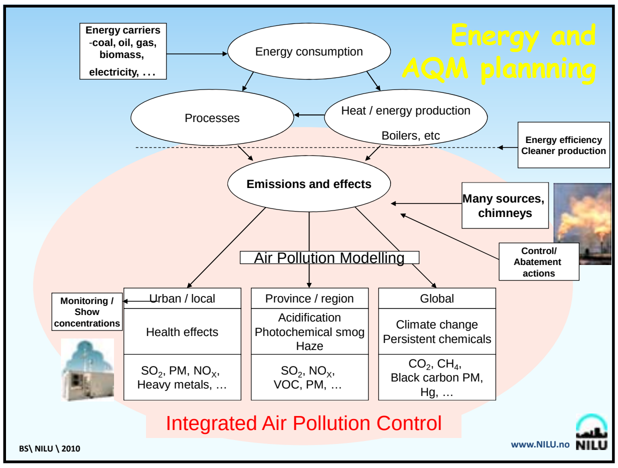
Energy and AQM plannning
Energy carriers -coal, oil, gas, biomass, electricity, . . .
Energy consumption
Processes
Heat / energy production
Boilers, etc
Energy efficiency Cleaner production
Emissions and effects
Many sources, chimneys
Control/ Abatement actions
Air Pollution Modelling
Monitoring / Show concentrations
Urban / local
Health effects
SO_2, PM, NO_X, Heavy metals, ...
Province / region
Acidification Photochemical smog Haze
SO_2, NO_X, VOC, PM, ...
Global
Climate change Persistent chemicals
CO_2, CH_4, Black carbon PM, Hg, ...
Integrated Air Pollution Control
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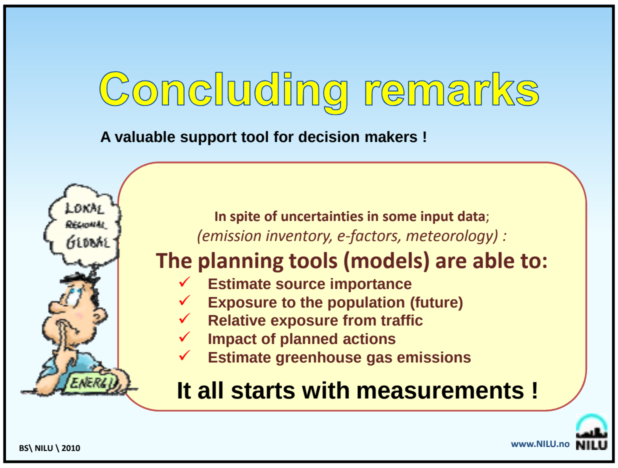
Concluding remarks
A valuable support tool for decision makers !
LOKAL
REGIONAL
GLOBAL
ENERGY
In spite of uncertainties in some input data;
(emission inventory, e-factors, meteorology) :
The planning tools (models) are able to:
✓ Estimate source importance
✓ Exposure to the population (future)
✓ Relative exposure from traffic
✓ Impact of planned actions
✓ Estimate greenhouse gas emissions
It all starts with measurements !
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Thank you !
Questions ???
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Monitoring programme design

Air Quality Monitoring Programme Design

Bjarne Sivertsen, NILU


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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?

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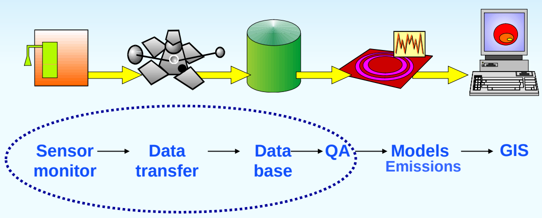
The monitoring programme is part of:

Integrated Pollution Prevention and Control



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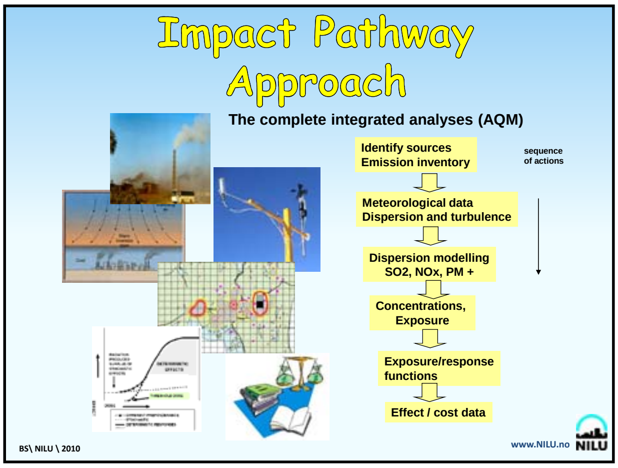
Impact Pathway Approach
The complete integrated analyses (AQM)
Identify sources
Emission inventory
sequence of actions
Meteorological data
Dispersion and turbulence
Dispersion modelling
SO2, NOx, PM +
Concentrations,
Exposure
Exposure/response functions
Effect / cost data
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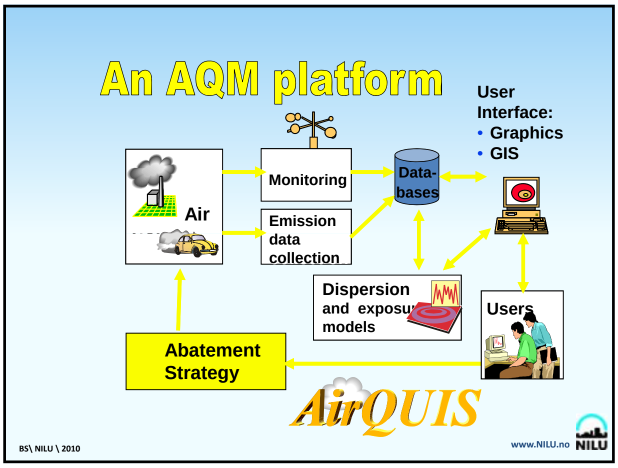
An AQM platform
User Interface:
• Graphics
• GIS
Air
Monitoring
Emission data collection
Data-bases
Dispersion and exposure models
Users
Abatement Strategy
AirQUIS
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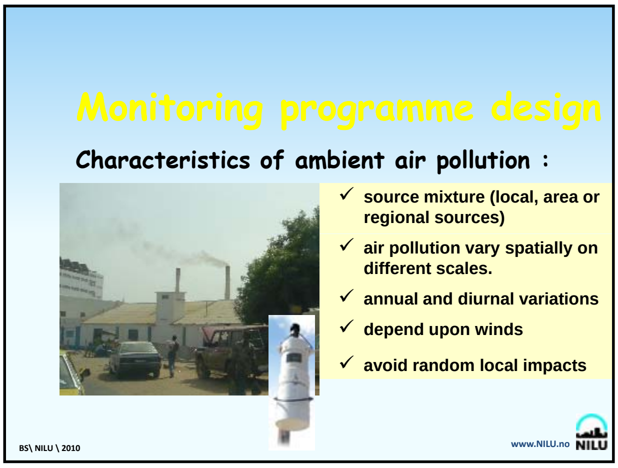
Monitoring programme design
Characteristics of ambient air pollution :
✓ source mixture (local, area or regional sources)
✓ air pollution vary spatially on different scales.
✓ annual and diurnal variations
✓ depend upon winds
✓ avoid random local impacts
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Air Quality Monitoring

Input to be considered

- ✓ Monitoring Objectives
- ✓ Data quality objectives
- ✓ Select sites and stations
- ✓ Select indicators
- ✓ Limit values and standards
- ✓ Frequency and period
- ✓ Instruments
- ✓ Statistics
- ✓ Design meteorology
- ✓ Which impacts?

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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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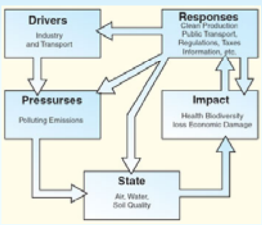
What shall we measure:

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

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)

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)

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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Quality Assurance in Monitoring planning

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

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

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

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

4) Site selection
Must be representative for the Monitoring Objectives

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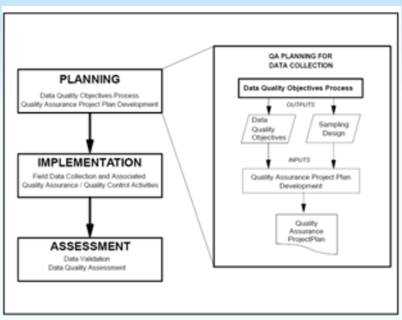
DQO part of the QA/QC process

QA

QC

QA



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Data quality objectives (DQO)

In Europe the objectives that guide the quantification of DQOs, are defined such as to:

- ✓ Enable comparison of air quality across Europe,
- ✓ Enable detection of the trend over a reasonable time period in air quality in Europe, as well as in each area where stations are located,
- ✓ Enable the assessments of exposure.

Data quality objectives

For air quality assessment	Sulphur dioxide, nitrogen dioxide and oxides of nitrogen and carbon monoxide	Benzene	Particulate matter ($PM_{10}/PM_{2.5}$) and lead	Ozone and related NO and NO_2
Fixed measurements (1)				
Uncertainty	15 %	25 %	25 %	15 %
Minimum data capture	90 %	90 %	90 %	90 % during summer 75 % during winter
Minimum time coverage:				
— urban background and traffic	—	35 % (2)	—	—
— industrial sites	—	90 %	—	—
Indicative measurements				
Uncertainty	25 %	30 %	50 %	30 %
Minimum data capture	90 %	90 %	90 %	90 %
Minimum time coverage	14 % (4)	14 % (3)	14 % (4)	> 10 % during summer
Modelling uncertainty:				
Hourly	50 %	—	—	50 %
Eight-hour averages	50 %	—	—	50 %
Daily averages	50 %	—	not yet defined	—
Annual averages	30 %	50 %	50 %	—
Objective estimation Uncertainty	75 %	100 %	100 %	75 %

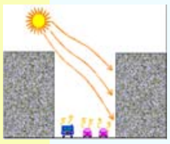
A summary of DQOs

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*



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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

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Area of representativity of station classes (typical values)

Station class	Radius of area
Traffic stations	<10-15 m
Industrial stations	10-1000 m
Background stations:	
- Urban background	0,1-1 km
- Near-city backgr.	1 - 10 km
- Regional stations	25-150 km
- Remote stations	200-500 km

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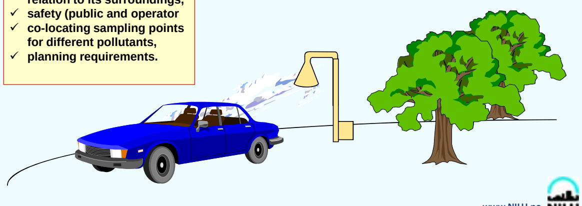
Air intake design – Location

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



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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.

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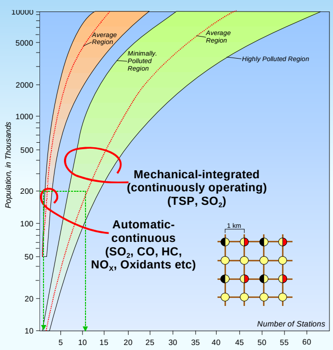
Number of monitoring sites needed in an urban area



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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 (2) (sum of PM_{10} and $PM_{2,5}$)	Pollutants except PM	PM (2) (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 km² 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 km² for complex terrain is recommended.

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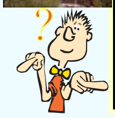
Sampling frequency and sampling time



Pollutant/ Indicator	Unit	Sample resolution	Average needed
Carbon monoxide	mg/m3	Hourly average	Hourly, 8-hour running average, annual max
Nitrogen dioxide	μg/m3	Hourly average	Daily average Annual average Frequency distribution
Ozone	μg/m3	Hourly average	Hourly, 8-hour running average, annual max
Particulate matter	μg/m3	Daily average	Daily average Annual average Frequency distribution.
Sulphur dioxide	μg/m3	Hourly average	Daily average Annual average Frequency distribution.
Lead	μg/m3	Annual average	Annual average
Benzene	μg/m3	Annual average	Annual average

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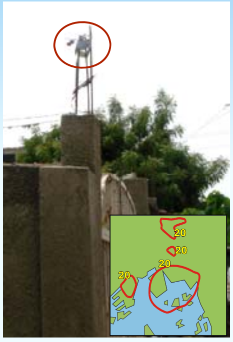
Siting studies

- ✓ 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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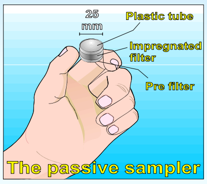
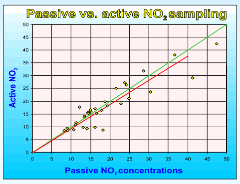
Passive samplers for screening studies





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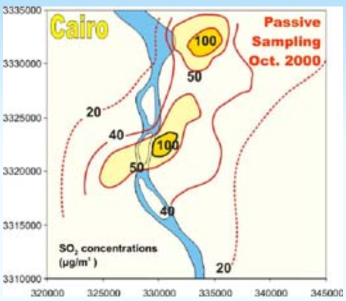
SO_2
in Cairo city centre and industrial Shoubra exceeded 100 µg/m³



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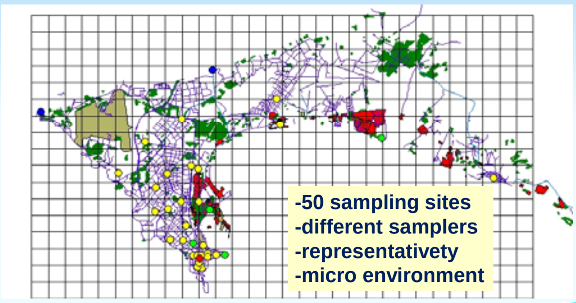
Sampling programme

To map the situation in Dakar



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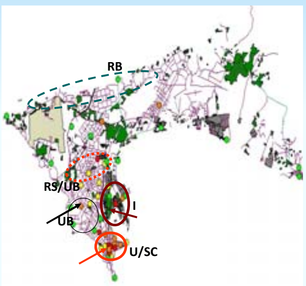
Designing the AQ Monitoring Programme for Dakar



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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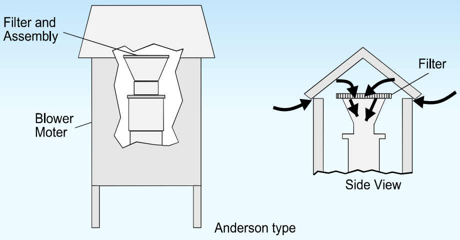
High volume sampler



TSP (total suspended particles) Flow :1-2 m³/min

PM_{10} with size cut-off hood

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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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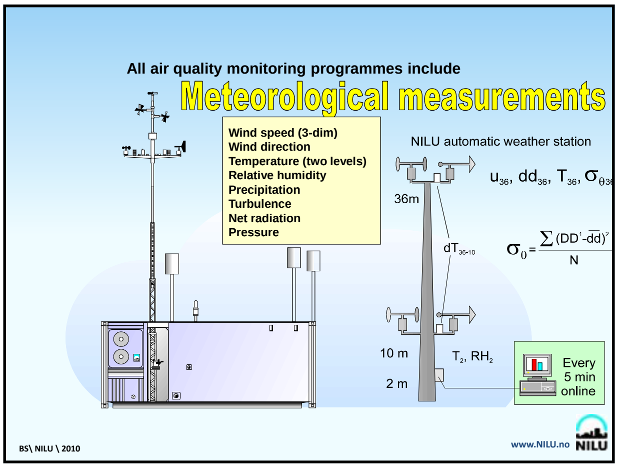
All air quality monitoring programmes include
Meteorological measurements
Wind speed (3-dim)
Wind direction
Temperature (two levels)
Relative humidity
Precipitation
Turbulence
Net radiation
Pressure
NILU automatic weather station
36m
10 m
2 m
T2, RH2
Every 5 min online
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Meteorological station
wireless communication
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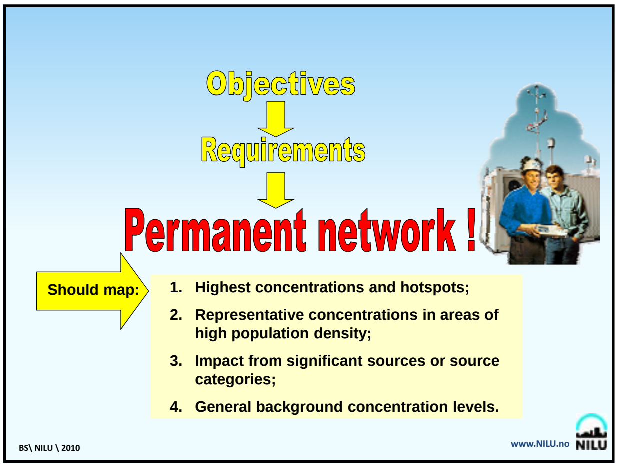
Objectives
Requirements
Permanent network !
Should map:
1. Highest concentrations and hotspots;
2. Representative concentrations in areas of high population density;
3. Impact from significant sources or source categories;
4. General background concentration levels.
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A typical monitoring station
QA/QC !
Urban background site in HCMC
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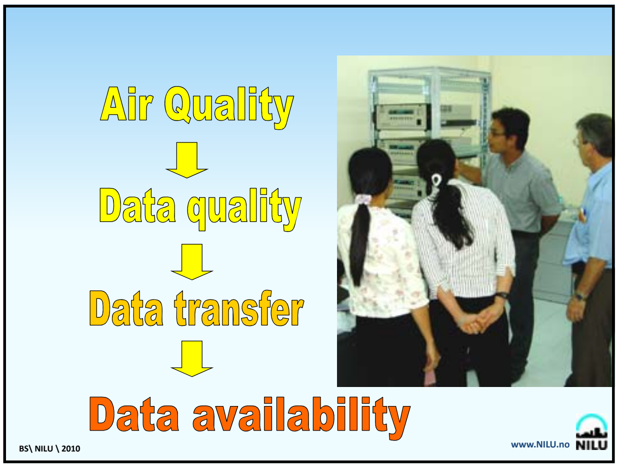
Air Quality
Data quality
Data transfer
Data availability
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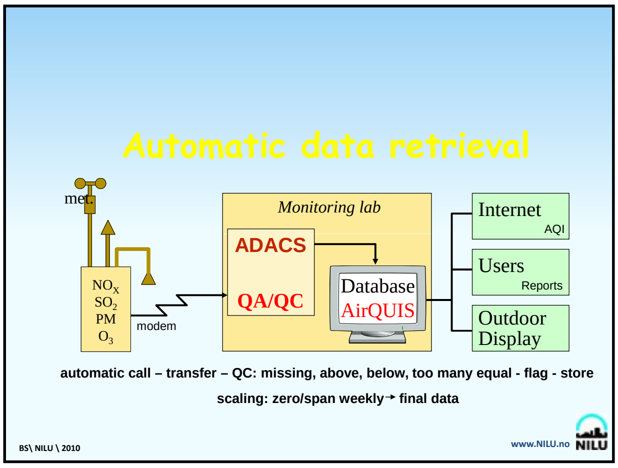
Automatic data retrieval
met.
NO_X
SO_2
PM
O_3
modem
Monitoring lab
ADACS
QA/QC
Database
AirQUIS
Internet
AQI
Users
Reports
Outdoor
Display
automatic call – transfer – QC: missing, above, below, too many equal - flag - store
scaling: zero/span weekly→ final data
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ADACS 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

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Available in Norway

- E-mail
- SMS
- WAP
- MMS

- Forecasts
- Status

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Input to the AQ Management Systems

The modern air quality monitoring system is an important part of the complete AQM system

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Norwegian Institute for Air Research

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

Air quality legislation

Air Quality Legislation

Bjarne Sivertsen, NILU

Guidelines and limit values
WHO guidelines
EU Directives
Framework directives
Daughter directives
Limit values and standards
Monitoring mechanism
CO2 and GHG emissions

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Guidelines ⟺ Standards

Guidelines (WHO):

- Provide basis for protecting public health
- Background information
- Not intended to be standards

Standards or Limit values:

- Level of Air Quality adopted by regulatory authorities
- Enforceable

Concentration + Averaging time

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Air pollutants to be taken into consideration

IN THE ASSESSMENT AND MANAGEMENT OF AMBIENT AIR QUALITY

Pollutants governed by the Directives:
1. Sulphur dioxide
2. Nitrogen dioxide
3. Fine particulate matter such as soot
4. Suspended particulate matter
5. Lead
6. Ozone

II. **Other air pollutants**

7. Benzene
8. Carbon monoxide
9. Poly-aromatic hydrocarbons
10. Cadmium
11. Arsenic
12. Nickel
13. Mercury

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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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EU air quality Directives

Framework D:	(96/62/EEC)	
Daughter D:	(1999/30/EC)	NOx, SO_2, PM_{10} and Pb (first DD)
	(2000/69/EC)	CO, Benzen
	(82/884/EEC)	Pb
	(2002/389/EEC)	Ozone
Council Dir:	(94/C/216/04)	Assessment
	(93/389/EEC)	Monitoring CO2 and GHG
	(2004/107/EC)	As, Cd, Hg, Ni, PAH

World health Organisation (WHO) Guidelines

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EU limit values

- ✓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 clearly specify the proportion of valid data needed as well as margin of tolerance.
- ✓The EU Directives also specify lower and upper threshold values which indicate levels at which air quality assessment and measurements has to be undertaken

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EU Air Quality Directive

EU Directives 1996-2004, summarized 2008 D)
Quality Limit values (µg/m³)

Averaging time	1 h	24 h	annual
SO_2	350 (24)	125 (3)	20*
NO_2	200 (8)	-	40
PM10 2005		50 (25)	30
Pb			0.5

* related to ecosystems D) *Directive 2008/50/EC, 21 May 2008*

(n) = number of exceedings permitted per year

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Sulphur dioxide

Time period		Limit value (µg/m³)
1-hour average value,	24 times (99,3 perc)	350
24-hour average value	99 percentile	125
Yearly average value (critical level vegetation)		20

The yearly average value (calendar year average + average October 1 - March 31) is for areas outside agglomerations and other built-up parts.

DD (1999/30/EC)

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Nitrogen dioxide

Time period	Limit value (µg/m³)
1-hour average value, 18 times (99,5 perc)	200
Yearly average value	40
Yearly average value (ecosystem)	30

The yearly average value of 30 µg/m³ applies for $NO+NO_2$.
Applies outside of agglomerations and other built-up parts as well as in transition areas. The other two values apply every-where from January 1, 2010.

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Particulate matter

Measured as PM_{10} = max. diameter 10 µm, or as $PM_{2,5}$ = max. diameter 2,5 µm.

Time period	Limit value(µg/m³)
PM10:	
24-hour average value, (90 percentile)	50
Yearly average value	40
PM 2,5:	
Annual average (from 2010)	25
Annual average (from 2015)	20

The 90 percentile of the 24-hour average value means that the value may be exceeded at the most 35 times a year.

PM10 already in force since *January 1, 2005*

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Lead

The yearly average limit value of

0,5 µg/m³

is applicable everywhere and takes effect from January 1, 2010 in industrial zones from January 1, 2005 elsewhere.

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Directive 2004/107/EC

Arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air

Target values for arsenic, cadmium, nickel and benzo(a)pyrene:

Arsenic	6 ng/m3
Cadmium	5 ng/m3
Nickel	20 ng/m3
Benzo(a)pyrene	1 ng/m3

For the total content in the PM_{10} fraction averaged over a calendar year

Point sources
For the assessment the number of sampling points for fixed measurement should be determined taking into account emission densities, distribution patterns of ambient air pollution and potential exposure of the population.
Apply BAT as defined by Article 2(11) of Directive 96/61/EC

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Benzene

	Averaging period	*Limit value*	*Margin of tolerance*	*Date by which limit value is to be met*
Limit value for the protection of human health	Calendar year	5μg/m^3	5μg/m^3 on 13 December 2002, reducing on 1 January 2006 and every 12 months thereafter by 1 μg/m^3 to reach 0 by 1 January 2010	1 January 2010

	Annual Average
Upper assessment threshold	70% of limit value (3.5 μg/m^3)
Lower assessment threshold	40% of limit value (2 μg/m^3)

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Sites and techniques

When limit values and alert thresholds are set, criteria and techniques shall be established for:

(a) the measurement to be used in implementing the legislation
- the location of the sampling points,
- the minimum number of sampling points,
- the reference measurement and sampling techniques;

(b) the use of other techniques for assessing ambient air quality, particularly modelling:
- spatial resolution for modelling and objective assessment methods,
- reference modelling techniques.

These criteria and techniques shall be established in respect of each pollutant according to the size of agglomerations or to the levels of pollutants in the zones examined.

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Responsibilities and actions

Ambient Air Quality Assessment and Management Directive

(Framework Directive 96/62/EC + Daughter Directives)

local authorities are responsible for:
- Periodic reviews and assessment of air quality
- Preparation of action plans

CD 94/C/216/04) Assessment

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Air Quality Assessment

Preliminary Air Quality Assessment

Assessment regime
Assessment criteria
Sampling points
Reference methods

- ✓ Define zones & agglomerations
- ✓ Evaluate sampling sites and methods
- ✓ Collect air quality data
- ✓ Evaluate quality and representativity
- ✓ Assess air quality
- ✓ Collect emission data
- ✓ Collect meteorological data
- ✓ Prepare and run models
- ✓ Present modelling results
- ✓ Present total AQ assessment

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EU Directive

Article 6:

Assessment requirements

- divide territory into zones
- levels of pollution within each zone

Member States are required to:
- ✓ divide their territory into zones – whereby an agglomeration is a special type of zone - based on the results of the preliminary assessment
- ✓ perform ongoing assessment requirements related to the levels of pollution within the zones

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EU Directive

Article 5:

Identify levels of air pollution*) within zones

- Undertake representative measurements
- Evaluate and use existing data
- Perform surveys of air the pollution situation
- Present an assessment of the air quality

*) SO_2, NO_2, PM_{10}, Pb

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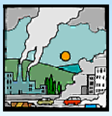
EU Directive

Article 2:

Assessment



"Any method used to measure, calculate, predict or estimate the level of a pollutant in ambient air"

- preliminary air quality measurements
- air emission inventories
- air pollution modelling

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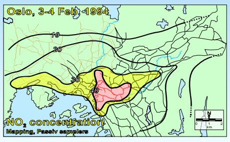
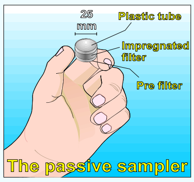
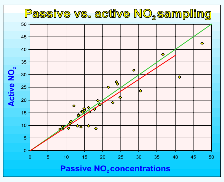
Indicative measurements

- Less accurate than the reference methods
- Mobile laboratory
- Grab samples
- Passive samples (low cost)







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Assessment Tools

Measurements:
- Methods and uncertainties
- Representative location (siting)
- Limited time coverage

Emission inventories:
- Incomplete data
- Improve input data
- Evaluate emission factors

Models
- Prepare relevant models
- Prepare input data
- Emissions and meteorology
- Uncertainties
- Verify models?

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Assessment output included

In local, regional or national programmes for improvement in the ambient air quality

1. Localization of excess pollution
   - region
   - city (map)
   - measuring station (map, geographical coordinates).
2. General information
   - type of zone (city, industrial or rural area)
   - estimate of the polluted area (km²) and of the population exposed to the pollution
   - useful climatic data
   - relevant data on topography
   - sufficient information on the type of targets requiring protection in the zone.
3. Responsible authorities

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Classification of monitoring stations

Station classes		*Relevant for exposure of* Popula-tion	Mate-rials	Eco-systems
Traffic stations (TRA)	Street type Traffic volume Traffic speed	x	(x)	
Industrial stations (IND)	Type of area	x	x	x
Urban backgr.stations (URB)	Location (geogr) within the city Type of zone	x	x	(x)
Near city backgr. stations (NCB)		x	x	x
Regional (rural background) stations (REG)		x	(x)	x
Remote stations (REM)				x

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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

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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 (2) (sum of PM_{10} and $PM_{2,5}$)	Pollutants except PM	PM (2) (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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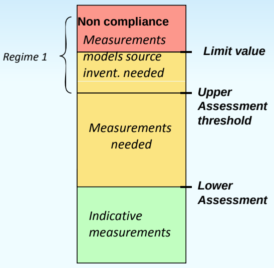
Upper and Lower Assessment Thresholds

Exceedances of upper and lower assessment thresholds must be determined on the basis of concentrations during the previous five years where sufficient data are available.



UAT:

SO_2 : 60 % (24-h aver.): 75 µg/m3
60 % winter limit conc.

NO_2 : 70 % (1-h aver.): 140 µg/m3
80% annual limit

PM_{10} : 60 % (24-h aver.): 30 µg/m3
70% annual limit

Pb (lead) : 70 % annual limit

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Assessment requirements

Regime 1 (> UAT):
High quality monitoring mandatory (+models)

Regime 2 (LAT – UAT) :
Measurments mandatory, fewer, less intensive, other sources

Regime 3 < LAT) :
a) Agglomeration : one measurement site combined with modeling, indicative measurements
b) Zones: Modelling, indicative measurements

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Assessment requirements

Maximum pollution level in agglomeration or zone	Assessment Requirements*
Regime 1: Greater than the upper assessment threshold	High quality measurement is mandatory. Data from measurement may be supplemented by information from other sources, including air quality modelling.
Regime 2: Less than the upper assessment threshold but greater than the lower assessment threshold	Measurement is mandatory, but fewer measurements may be needed, or less intensive methods may be used, provided that measurement data are supplemented by reliable information from other sources.
Regime 3: Less than the lower assessment threshold	
a. In agglomerations, only for pollutants for which an alert threshold has been set**	At least one measuring site is required per agglomeration, combined with modelling, objective estimation, indicative measurements.
b. In non-agglomeration zones for all pollutants and in all types of zone for pollutants for which no alert threshold has been set	Modelling, objective estimation, and indicative measurements alone are sufficient.

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Margins of tolerance

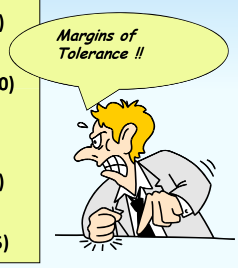
SO_2 : + 150 µg/m³ (1-h aver.)
(1 Jan 2001 – 1 Jan 2005)

NO_2 : + 50 % (1-h aver.)
*(1 Jan 2001 – 1 Jan 2010)

+ 50 % (annual aver.) *

PM_{10} : + 50 % (24-h aver.)
(1 Jan 2001 – 1 Jan 2005)

+ 20 % (annual aver.)
(1 Jan 2001 – 1 Jan 2005)



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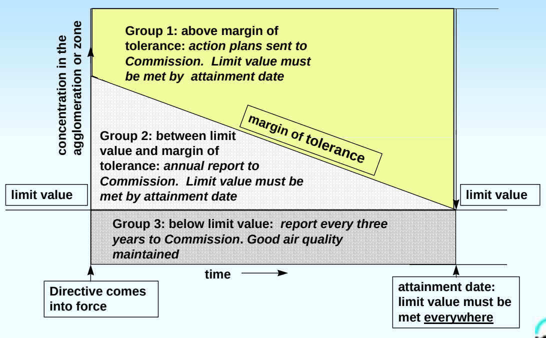
Margin of tolerance



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Action plans

- Member States shall draw up action plans indicating the measures to be taken in the short term where there is a risk of the limit values and/or alert thresholds being exceeded, in order to reduce that risk and to limit the duration of such an occurrence.
- Such plans may, depending on the individual case, provide for measures to control and, where necessary, suspend activities, including motor-vehicle traffic, which contribute to the limit values being exceeded.

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Anthropogenic CO_2 and other greenhouse gases (GHG)

The monitoring mechanism for anthropogenic CO_2 and other greenhouse gases was established in June 1993, following the adoption of Council Decision 93/389/EEC, by the Council of Environment Ministers.

This was revised in April 1999, (Council Decision 99/296/EC) to allow for the updating of the monitoring process in line with the inventory requirements incorporated into the Kyoto Protocol .

Almost all Member states compiled a complete inventory for CO2, CH4 and N2O emissions for the full period from 1990 to 1999.

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Greenhouse gas emission estimates

Council Directive: 93/389/EEC

GHG:
Carbon dioxide (CO_2)
Methane (CH4)
Nitrous Oxide (N2O)
Hydrofluorocarbons (HFCs)
Perfluorocarbons (PFCs)
Sulphur Hexafluoride (SF6)

For each site for which emissions are calculated:
- Activity data;
- Emission factors;
- Oxidation factors;
- Total emissions; and
- Uncertainty.

The verifier shall prepare a report on the validation process stating whether the report pursuant to Article 14(3) is satisfactory. This report shall specify all issues relevant to the work carried out

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Area of representativity of station classes (typical values)

Station class	Radius of area
Traffic stations (TRF)	<10-15 m
Industrial stations (IND)	10-100 m
Urban background stations (URB)	100m-2 km
Near-city background stations (NCB)	2-10 km
Regional stations (REG)	25-150 km
Remote stations (REM)	200-500 km

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Selection of monitoring areas and stations for EUROAIRNET

For population exposure

Type of area	Criteria	
	Area selection	Station selection
Agglomerations		
>0.5 mill	All cities	All stations, (up to 20 stations) All station categories represented in the city
0.25-0.5 mill	At least 25% of the cities	High, medium and low levels of industrialization
0.05-0.25 mill	At least 10% of the cities	High, medium and low levels of industrialization
Rural areas	At least 50% of the areas with population density >2	One station to represent each of the selected areas.
Industrial areas outside cities	All areas with air pollu tion above the WHO AQ Guidelines	All existing monitoring stations in these areas.

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Selection of compound and indicators to be included in EUROAIRNET

	Population exposure	Materials exposure	Ecosystems exposure
Priority 1	Air 1h : SO_2, NO_2, NO_x, O_3 1h or 24h : PM_{10}, $PM_{2,5}$ 24h or longer : Pb	Air: SO_2, O_3, NO_2, temp. relative humidity. Precip.: mm, pH Materials: steel panels	Air: 1h : O_3, VOC* 24h : SO_2, SO_4, NO_2 Precip.: 24h : SO_4, NO_3, NH_4, Ca, pH, (H^+)
Priority 2	1h : CO 1h or 24h : SPM (or TSP), BS 24 h or longer : Benzene, PAH, Cd, As, Ni, Hg	Air: HNO_3 (gas). Precip.: Cl^-, SO_4, NO_2 Materials: zinc	Air: VOC, NO_x
Priority 3	Other compounds	Materials: copper, calcareous stone	UV radiation?

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Air Quality EU-directives for PM_{10} , Pb ($\mu g/m^3$) (Council Directive 1999/30/EC of 22 April 1999), Daughter directives for benzene ($\mu g/m^3$) and CO (mg/m^3) (COM (1998) 591 final)

Compound	PM_{10}	PM_{10}	Pb	Pb	Benzen	CO
Date for meeting the limit	01.01.10	01.01.10	01.01.05	01.01.10	01.01.10	01.01.05
Averaging time	24 timer	Calendar year	Calendar year	Calendar year	Calendar year	8 timer
Limit value for health impact (nr exceed/yr.)			0,5	0,5 (1,0 from 01.01.05)	5*	10
Guideline value for health impact	50 (7 x))	20				
Tolerance margin health		10 (50% 01.01.05)	0,5 (100%)		5 (100%)	5 (50%)
Upper assment threshold (UAT) (exceed/yr)	30 (7)	14	0,35		3,5	7
UAT Ecosystem						
UAT vegetation						
Lower AT Health (ex. per year)	20 (7)	10	0,25		2	5
LAT ecosystem						
LAT vegetation						

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Air Quality EU-directives for SO2 and NO2

Compound	SO_2	SO_2	SO_2	NO_2	NO_2
Date meeting the limit	01.01.05	01.01.05	19.07.01	01.01.10	01.01.10
Averaging time	1 hour	24 hours	winter-half year	hour	Calendar year
Limit value for health impact (nr exceed/yr)	350 (24 times)	125 (3 times)		200 (18 times)	40
Limit value, ecosystem			20		
Limit value vegetation					
Tolerance margin health	150 (+43%)			100 (50%)	20 (50%)
Limit value for warning (3 consec. hrs)	500			400	
Upper assm. T. (no. Exceed per year)		75 (3 times)		140 (18)	32
UAT Ecosystem			12 Winter		
Lower AT Health (ex. per year)		50 (3)		100 (18)	26
LAT ecosystem			8 (winter)		
LAT vegetation					

(Council Directive 1999/30/EC of 22 April 1999),

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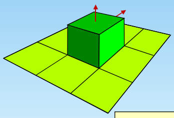
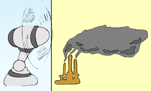


A Q Modelling

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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Instrumentation; monitoring and sampling

Monitoring and Sampling Instrumentation

Bajza Hot Spot Project
Tirana, ALBANIA
19-21 May 2010

Leif Marsteen
NILU

Purpose of presentation

Look at various types of air quality measurement instruments and their application

Equipment selection

1. Monitoring Objectives
   - Why measure? Trends, warnings, compliance
2. Site selection
   - Must be representative for Monitoring Objectives
3. Data quality objectives
   - Determine data quality necessary to fulfil the Monitoring Objectives
4. Equipment selection
   - Results must fulfil the Data Quality Objectives Select best measuring practice

Equipment selection
- Example

1. Monitoring Objectives
   - Compliance with Directive 2008/50/EC
2. Site selection
   - Road side, Nitrogen dioxides (ref. directive)
3. Data Quality Objectives
   - Maximum 15 % uncertainty (ref. directive)
4. Other considerations
   - Warning/Information to the public (ref. directive)
5. Equipment selection
   - Automatic NOx analyser (ref. directive)

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EU Directive 2008/50/EC
on ambient air quality and cleaner air for Europe

- Covers SO_2, NO_x, Pb, PM_{10}, $PM_{2.5}$, Benzene, CO, O_3
- Defines Data Quality Objectives
  - Uncertainty, data capture, time coverage
- Defines measurement methods
  - Reference method, or any method that is tested
  - Refers to CEN standards for equivalence testing
- Requires public to be informed

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

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Testing analysers

- Is analyser within the uncertainty specified in the air quality directive?
- Done by a test house, e.g. TÜV
- According to CEN standard
- Done once and after design changes
- Test is valid in all EU countries

Ask for test report before buying

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CEN standards

- Describes measurement methods
- Describes test procedure (equivalence testing)

Component	Measurement method	Reference to standard
NO, NOx, NO2	Automatic Chemiluninecsence	CEN/EN142111, Standard method for the measurement of the concentration of nitrogen dioxide and nitrogen monoxide by chemiluminescence
SO2	Automatic Ultraviolet fluorescence	CEN/EN14212, Standard method for the measurement of the concentration of sulphur dioxide by ultraviolet fluorescence
O3	Automatic Ultraviolet photometry	CEN/EN14625, Standard method for the measurement of the concentration of ozone by ultraviolet photometry
CO	Automatic Nondispersive infrared spectroscopy	CEN/EN14626, Standard method for the measurement of the concentration of carbon monoxide by nondispersive infrared spectroscopy
BTX	Automatic, GC	CEN/EN14662, Ambient air quality - Reference method for measurement of benzene concentrations

http://www.cen.eu/cen/Products/Pages/default.aspx

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Air Quality Instrumentation

Two basic types:

- Manual samplers
- Automatic analysers

Thermo
PM High vol

Thermo
PM Beta gauge

Horiba
Gas analyser

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Manual samplers
When to use

- Detect several components
  - Chemical analysis
- Components not detectable by analysers
  - No automatic detection method
  - Low concentrations
- Trend analysis
  - Modest diurnal variation
  - Detect long term changes
  - Typical at background sites

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Manual samplers

- Samples air or particulates on a filter, 24 hours
- Determination of mass, PM_{10} and $PM_{2.5}$
- Multicomponent chemical analysis
- Relatively cheap to buy and maintain
- Labour intensive, daily filter change
- Sequential sampler automatic filter change
  - 14 days maintenance period
- Passive sampler, 2 – 4 weeks exposure
- Rain fall/dust fall samplers, 4 weeks

Manual samplers
Some more types

- Low volume sampler
  - Road side and urban background sites
  - 1,0 - 2,3 m^3/h, 24 hrs
- High volume sampler
  - Background sites
  - 30 m^3/h, 24 hrs
- Evacuated canisters
  - 1 min (grab sampling), 1-24 hrs

Leckel

Digitel

Manual samplers
Some examples

Brands:
- TEI
- Leckel
- Derenda
- Digitel

Parameters:
- PM_{10}, $PM_{2.5}$, TSP
- Gaseous components
- Water soluble components
- VOC
- PAH

NILU

Filter impregnated for acidous or hydroxide components
More filters possible

Sampler inlets

- Separate large particles from smaller
- Typically PM_{10}, $PM_{2.5}$ and PM_1
  - PM_x = Particle size less than x µm

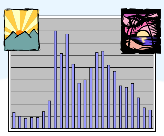
USEPA standard
PM_{10} with $PM_{2.5}$
cyclone
Flow rate 1 m^3/h

EN12341 standard
$PM_{10}/PM_{2.5}$
interchangeable
nozzles
Flow rate: 2,3 m^3/h

Manual samplers
Cost considerations

- Cost of low volume single filter sampler
  - € 14 000,00
- Cost of high volume single filter sampler
  - € 17 000,00
- Preparation of filters and filter analysis
- Frequent site visits

Automatic analysers
When to use



- Document diurnal variations
  - Rush hours, human activity
- Pinpoint pollution sources
  - Together with wind speed/direction/stability
- Air pollution information/warning to the public
  - Radio, TV, Internet, SMS

Requires high time resolution, usually 1 hour or 30 minutes

Automatic analysers

- Continous analysis at the site
- Local or remote sensing techniques
- Data usually stored in an external data logger
- Automatic data transfer to center
- Usually only one parameter per instrument
- Expensive to buy
- Expensive to maintain
- Not easy to repair

Automatic analysers
Some types

- Gasous
  - NO_x, CO, SO_2, H_2S, O_3, nMHC, BTEX
  - One analyser for each component
- Particulates
  - Principles: Beta gauge, TEOM, scattered light
  - PM_{10}, $PM_{2.5}$, PM_1
  - Same inlets as samplers

Automatic analysers
Meteorology

Meteorological sensors:
- MetOne
- Young
- Gill
- Skye

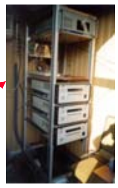
Parameters:
- Wind speed and direction, Rain fall, Temperature, RH, BP, Net radiation

Automatic analysers
Cost considerations

- Cost of gasous analyser
  - € 10 000,00
- Cost of particulate analyser
  - GRIMM PM_{10}+$PM_{2.5}$+PM_1 € 25 000,00
  - Thermo Beta gauge € 20 000,00

Data logging and collection

- Continous analysis at site
- Data stored in a data logger
- Automatic data transfer to center



Data logger

Data logging

Data logging sequence:

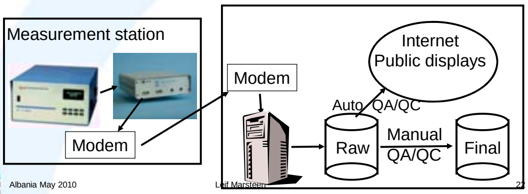
1. The monitor generates new values every 10 s
2. The logger reads the instrument continously
   - Computes and stores e.g. 10 min. averages
   - Other averaging times may be possible

Data logging concepts:

- Analog - Voltages, only measurement values
- Digital - Measurement values
  - Instrument status parameters

Data transfer

- Center calls data logger automatically
  - Once every hour or more often
- Transfer techniques:
  - Public telephone lines,GSM/GPRS, leased line, radio link, Internet, manual

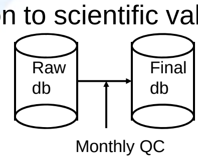


Data storage
Automatic quality control on raw data

- Some tests performed on raw data
  - Data integrity – Correct components?
  - Missing data - Call station again
  - Statistics on missing stations and data
  - Conversion to scientific values
- Daily reports on network status
- Alarms to operators on malfunctions e.t.c.

Data storage
Final quality control

- Typically monthlty (manual)
- Performed on raw data
- Data validation, removing not valid data
- Flag data as OK or not
- Conversion to scientific values (SI units)



Data logging and collection
Some types

- SAM / XR (Iséo)
- Station / System Manager (EMC)
- WinCollect (Ecotech)
- ADACS / AirQUIS Monitoring (NILU)
- ScanAir (Environnement SA)
- Envista (Envitech)

Often data loggers and data collection system is integrated forcing you to buy both from the same company

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Shelter

Stand alone instruments

- No shelter required

Delicate instruments

- Shelter required

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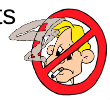
Shelter requirements

- Easy access
  - Inspections, repairs - '24 hours'
  - Heavy loads - Car parking nearby
- Protection against
  - Theft and damage – Install fence, lock
  - Sunshine - No windows
  - Outdoor environment - Air conditioned
- Data communication line
- Benches or racks for instruments
- No smoking, clean workplace



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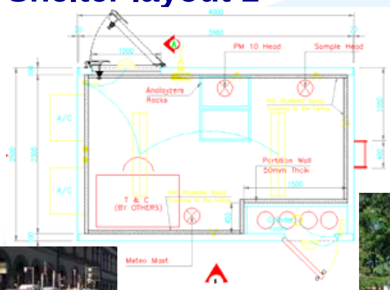
Shelter layout 1



Types:
- Fixed
- On wheels
  - Towable
- On truck

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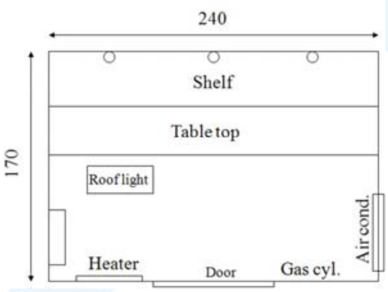
Shelter layout 2
a simpler solution



Shelters can be made locally

Important:
Leak tight around inlets through roof

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Summary
Instrument selection

1. What is the purpose of monitoring?
2. What shall you measure?
3. Select a representative site
4. What is the required data quality?
5. Determine data averaging time
6. Select equipment

Always keep it as simple as possible!

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Procurement of equipment

- Decide on turnkey installation or not
  - Will you install anything yourself?
- Use as few suppliers as possible
  - Narrows responsibility
- Include instrument specifications in tender
  - Use internet to find them
- Require FAT and SAT
  - FAT = Factory Acceptance Test
    System test before shipping to site
  - SAT = Site Acceptance Test
    System test after installation at site
  - No pay unless SAT is successfull

Installation at site

- Electrical power
- Telephone line or GSM
- Concrete pad necessary?
- Fence and lock necessary?
  - Install in secure areas if possible, school, university, police/fire station, e.t.c.
- Meteorological tower with guy wires

Shelter Surroundings

- Inlets approx 1.5 m above rooftop
  - Prevents resuspension of dust from roof
  - Easy access during cleaning
- Free sight to the pollution source, e.g. road
- Avoid:
  - Trees and constructions close to shelter/ met. tower
  - Dusty ground - resuspension (PM10)
  - Vent outlets, e.g. shelter air condition

Laboratory requirments

- Workshop
  - Repair and maintenance of instruments
- Calibration facilities
  - Calibration of instruments
- Chemical lab facilities
  - Preparation of filters
  - Post analysis of filters

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Workshop

- Tools
- Spare parts, gas cylinders, instruments
- Repair parts
- Consumables
- Storage room

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Calibration lab

- High concentration reference gases
- Dilution unit
- Zero air generator
- Flow calibrator
- Calibrate analysers
  - After repair and yearly service
- Calibrate gas cylinders
  - Before use and every 3 months

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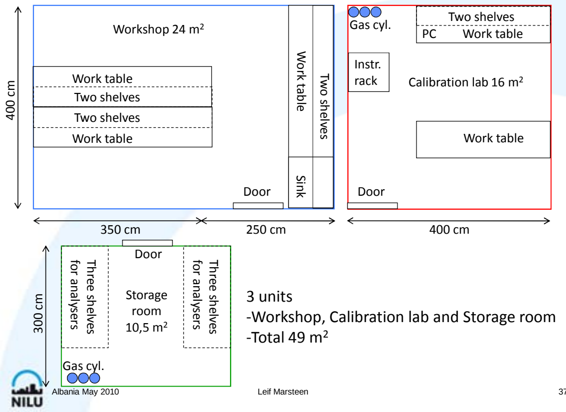
Workshop and Calibration lab with storage room layout



3 units
-Workshop, Calibration lab and Storage room
-Total 49 m²

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Chemical lab

- Clean room - Filter handling
- Balance - Filter weighing
- Ion chromatograph - Analysis of anions and kations in precipitation
- ICPMS - Metal analysis
- GC – PAH analysis

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Possible services to client

- Local agent for instruments, data loggers/data collection systems and gas cylinders, install systems
- Shelter manufacturer
- Preparation of sites before installation
- Repair, maintenance and calibration
- Chemical analysis

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Adresses

Gas and PM analysers:
- http://www.teledyne-api.com/
- http://www.synspec.nl/
- http://www.thermo.com/
- http://www.environnement-sa.com/
- http://www.recordum.com/
- http://www.grimm-aerosol.de/
- http://www.tsi.com/
- http://www.horiba.com/
- http://www.opsis.se/

PM samplers:
- http://www.digitel-ag.com/
- http://www.leckel.de/
- http://www.derenda.de/
- http://www.airmetrics.com/

Noise analysers:
- http://www.bksv.com/

Shelters:
- http://www.ekto.com/

Meteorology sensors:
- http://www.metone.com/
- http://www.gill.co.uk/
- http://www.kippzonen.com/
- http://www.lsi-lastem.it/
- http://www.skyeinstruments.com/
- http://www.vaisala.com/

Gas cylinders:
- http://www.airliquide.com/
- http://www.lindegas.com/
- http://www.nmi.nl/
- http://www.scottgas.com/
- http://www.nist.gov/

Data collection:
- http://www.iseo.fr/
- http://www.emcslo.com/
- http://www.ecotech.com/
- http://www.environnement-sa.com/
- http://www.nilu.no/

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Thank you

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Monitoring and sampling, network operation

Air Quality Monitoring Network Operation

Bajza Hot Spot Project
Tirana, ALBANIA
19-21 May 2010

Leif Marsteen
NILU

NILU Standardisation unit desember 2009 Leif Marsteen 1

Purpose of presentation

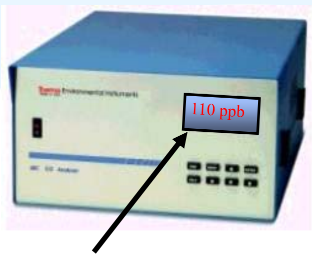
Look at how an air quality monitoring network is operated

NILU Standardisation unit desember 2009 Leif Marsteen 2

Purpose of network operation

Collect data of required quality for its intended use

HOW?



Is it information or just numbers?

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Network operation

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

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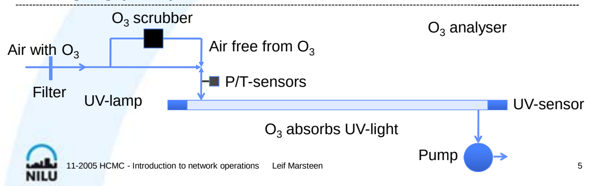
What affects instruments?

- 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



NILU 11-2005 HCMC - Introduction to network operations Leif Marsteen 5

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?

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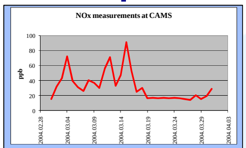
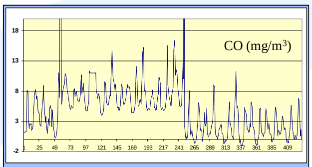
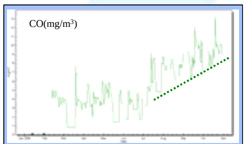
Suspicous data



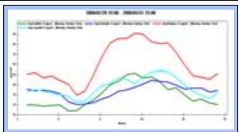
Constant level



Elevated zero level



Rising zero level

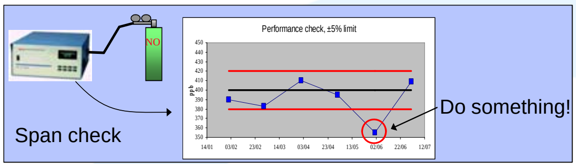


Compare stations

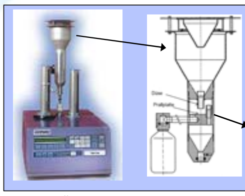
Periodic check at station

- 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

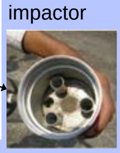
Checks at station



Check inlet filter

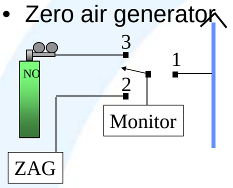


Check PM impactor



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

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

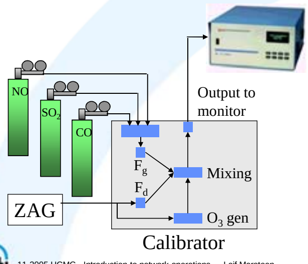
No instruments will run without problems but maintenance will prevent some of them

Preventive maintenance

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

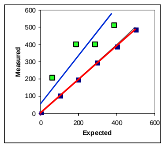
Yearly linearity check on gas analysers

- 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



11-2005 HCMC - Introduction to network operations Leif Marsteen 13

Possible services to client

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

Standardisation unit desember 2009 Leif Marsteen 14

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

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Thank you

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Quality systems

Quality Systems

Bajza Hot Spot Project
Tirana, ALBANIA
19-21 May 2010

Leif Marsteen
NILU

Albania May 2010 Leif Marsteen 1

QA/QC - Where does it all begin?

With the instruments!

Standardisation Unit June 2009 Leif Marsteen 2

Quality Control / Quality Assurance

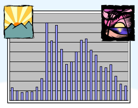
Is it information or is it just numbers?

A quality system will increase the information in the numbers

Standardisation Unit June 2009 Leif Marsteen 3

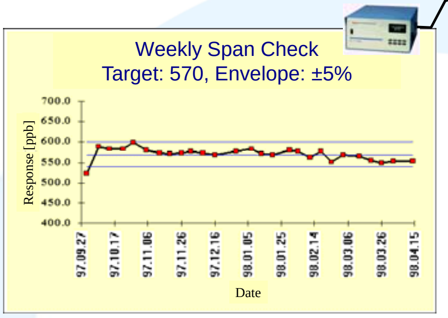
Instrumentation requirements

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



We want unified instrument operation

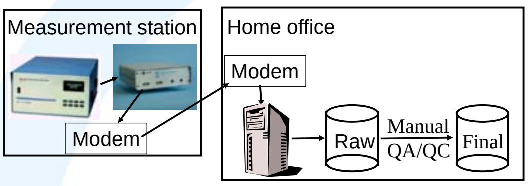
When shall we take action?



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

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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!

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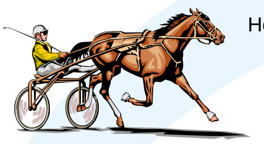
What is quality?

It depends on your needs



Horse racing - Speed

Farming
- Strength

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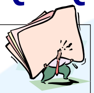
Why QA/QC systems?



CONTRA
- Increased costs
- Conservative
  - Resisits changes
  - Too much to update
- Extra paper work
  - No time to do the job!
- Too many documents
  - Impossible to learn

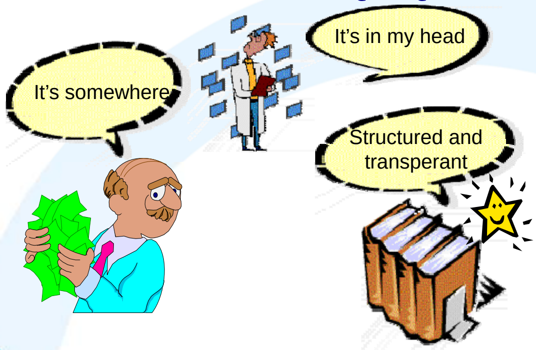
Myths or reality?

PRO
- Operations documented
- Results documented
- Transparency
- Easy training
  - Documentation exists
- Competitive edge

Reliable results with known quality

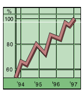
We want information not only numbers

Different levels of QA/QC

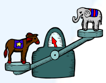


Elements of the quality system

Quality Assurance



Quality Control



Quality Assessment

Quality Assurance

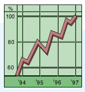
All planned and systematic activities which are needed to assure and demonstrate the predefined quality of data

(ISO 8402, 1994)

Described in the Quality Assurance Plan

Client's assurance that Contractor is in control

Quality Control

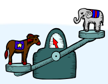


Operational techniques and activities that are undertaken to fulfil the quality requirements
(ISO 8402, 1994)

- 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

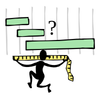
Makes operations traceable for Client

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

Legal background for QA/QC systems

- EU directive (2008/50/EC)
- Defines responsibilities
- Defines measurement methods and refers to CEN
- Requires a QA/QC system and refers to ISO17025

Article 3 – Responsibilities
EU directive (2008/50/EC)

Member States shall designate at the appropriate levels the competent authorities and bodies responsible for the following:

(a) assessment of ambient air quality;

(b) approval of measurement systems (methods, equipment, networks and laboratories);

(c) ensuring the accuracy of measurements;

(d) analysis of assessment methods;

(e) coordination on their territory if Community-wide quality assurance programmes are being organised by the Commission;

(f) cooperation with the other Member States and the Commission.

The Reference Laboratory

- Implements Article 3 requirements
- Appointed by the national authority
  - E.g. by the Environmental agency
- Legally responsible for the quality assurance of measurements in their Member State
- Participates in AQUILA meetings (The European Association of Air Quality Reference Laboratories)

Roles of the Reference Lab

- Implementing a quality system in the laboratory
- Approving measurement systems (instruments, laboratories, networks)
- Ensuring the traceability of the measurements at national level, by providing/certifying reference materials to networks
- Organizing intercomp./round robin tests at national level
- Participating in EC QA/QC programmes (intercomp.)
- Exchanging information through the organisation of training sessions, workshops, conferences and guidance documents

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ANNEX I - DATA QUALITY OBJECTIVES

EU directive (2008/50/EC)

C. Quality assurance for ambient air quality assessment: data validation

1. To ensure accuracy of measurements and compliance with the data quality objectives laid down in Section A, the appropriate competent authorities and bodies designated pursuant to Article 3 shall ensure the following:
   - that all measurements undertaken in relation to the assessment of ambient air quality pursuant to Articles 6 and 9 are traceable in accordance with the requirements set out in Section 5.6.2.2 of the ISO/IEC 17025:2005,
   - that institutions operating networks and individual stations have an established quality assurance and quality control system which provides for regular maintenance to assure the accuracy of measuring devices,
   - that a quality assurance/quality control process is established for the process of data collection and reporting and that institutions appointed for this task actively participate in the related Community-wide quality assurance programmes,

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Reference to measurement methods

EU directive (2008/50/EC)

- CEN develops standards (documents)
  - Measurement methods and QC measures
  - Laboratories must follow the standards
- ISO 17025 describes the quality organisation
  - Used by laboratories to develop quality systems
  - Used by accreditation bodies when auditing labs

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Some CEN standards

Component	Measurement method	Reference to standard
NO, NOx, NO2	Automatic Chemiluninecsence	CEN/EN142111, Standard method for the measurement of the concentration of nitrogen dioxide and nitrogen monoxide by chemiluminescence
SO2	Automatic Ultraviolet fluorescence	CEN/EN14212, Standard method for the measurement of the concentration of sulphur dioxide by ultraviolet fluorescence
O3	Automatic Ultraviolet photometry	CEN/EN14625, Standard method for the measurement of the concentration of ozone by ultraviolet photometry
CO	Automatic Nondispersive infrared spectroscopy	CEN/EN14626, Standard method for the measurement of the concentration of carbon monoxide by nondispersive infrared spectroscopy
BTX	Automatic, GC	CEN/EN14662, Ambient air quality - Reference method for measurement of benzene concentrations

Quality system requirements

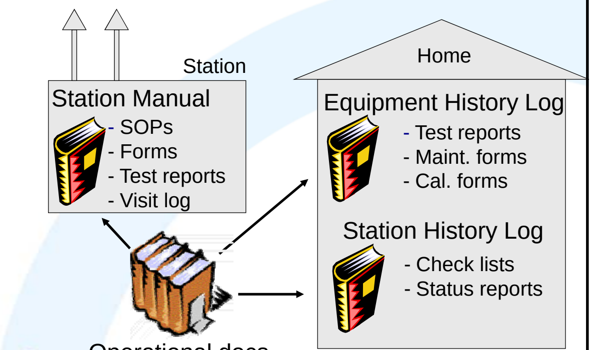
- Management requirements
- Technical requirements

- 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



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Proofing of quality system
Accreditation

- Acceptance by an accreditation body
- Assures that your operation is according to ISO 17025

Most countries have an accreditaion body
- UKAS in England
- DPA in Albania
- NA in Norway

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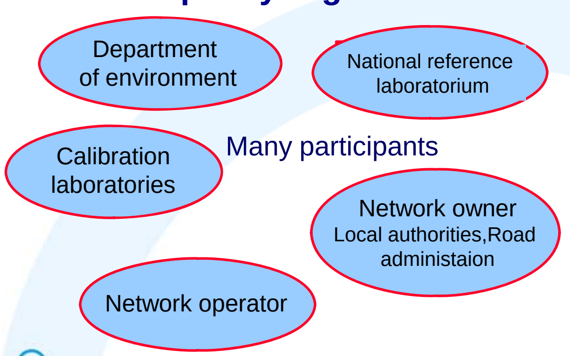
The quality organisation



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Tasks and responsibilities

Network operator - Reference lab

Task	NO	RL
Measurement network design	X	X
Select monitoring sites	X	
Select instruments	X	
Maintain monitoring sites	X	
Calibrate instruments and gas cyl.	X	X
Data validation, collection and storage	X	
Maintain the central data base		X
Provide traceability		X
Maintain the national reference std.		X
Maintain the quality system		X
Audits, once a year		X

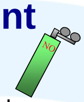
Reference lab services

- Measurement network design
  - Components, methods, locations
- Calibration
  - Certify new cylinders and recertify old
- Central data base
  - Storage area for national data
- Training
- Audits

Services- Provide traceability

- Calibrate gas cylinder that is used to adjust analyser at the station
- All anlysers in all networks will be adjusted according to the same reference
- Measurements from different stations and networks can be compared

Gas calibration equipment



- Gas calibrator with
  - National reference standard gas cylinders
  - NO, SO2, CO, H2S, BTEX, nMHC, HC
- Analysers for
  - NO, SO2, CO, H2S, BTEX, nMHC, HC, O3
- Procedure
  - Calibrate analyser
  - Measure secondary standard gas cylinder
- Ozon calibrator

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Traceability – Gas monitors

NIST/NMI
Buying cylinders

JRC
Intercomparisons

Standardisation Unit
- Maintains national reference standars
- Provides international traceability

Yearly audit
Transfer standard

Yearly calibration of
reference std.

Network Operator
- Monitors
- Working standards
  Weekly Z/S check

3 months
Transfer std.

Cal. new
working std.

Calibration Laboratory
- Calibrators
- Reference standards
- Transfer standards

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Flow calibration equipment

- Flow calibrators
- Calibration of
  - Samplers
  - PM analysers
  - Gas calibrators

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Services – QA/QC system

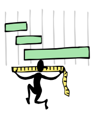
- Adapting QA/QC system to networks
- Based on ISO 17025 standard
  - Organisation and responsibilities
  - Network traceability
  - Measurement methods
  - Task schedules
  - Action criteria
  - Standard Operations Procedures (SOPs)
  - Training
  - Document management system

Services - Training

- Using the QA/QC system
- Documenting network operation
- How to maintain traceability
- Calibration of analysers
- Data validation
- Reporting data to the central data base

Services - Audits

- Determining the actual quality of the data
- System Audit
  - Inspection of QA/QC plan and documents
- Performance Audit
  - Instruments are checked at the station using an independent calibration standard
- Aim is to improve data quality
  - No ”police” but cooperation



Summary

The Reference lab can offer

- Help on network design
- Certification of gas cylinders
- Traceability in calibrations
- Quality system development
- Training
- Audits

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Adresses

Accreditation bodies:

- http://www.albanianaccreditation.gov.al/
- http://www.ukas.com/
- http://www.akkreditert.no/en/

AQUILA and JRC:

- http://ies.jrc.ec.europa.eu/aquila-homepage.html

CEN

- http://www.cen.eu/

ISO

- http://www.iso.org

EU directive (2008/50/EC)

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

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Thank you

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Air quality assessment reporting

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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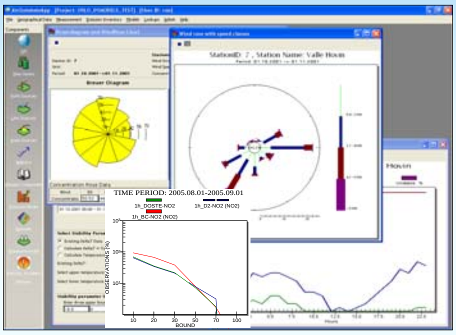
Air Quality assessment using Management software



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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Air Quality Standards and Limit Values (µg/m³)

	SO2 Year	SO2 Day	NO2 Year	NO2 Day	NO2 Hour	PM10 Year	PM10 Day	Ozone 1-8 hours
Europe		125 (3)	40		200 (18)	40	50 (35)	120 (26) 8h
USA	80	365 (1)	100			50	150 (1)	157 (4) 8 h
Australia	50	200 (1)	57		225 (1)		50 (5)	160 (1) 4h
Japan		105 (0)		75-115			100 (0) SPM	160 (0) 1h
China,cl2	60	150	80	120	240	100	150	160 1h
India, res.	60	80	60	80		60	100	
Thailand	100	300			320			200
Vietnam	50	125	40			50	150	120

(#) Number of allowed exceedances per year

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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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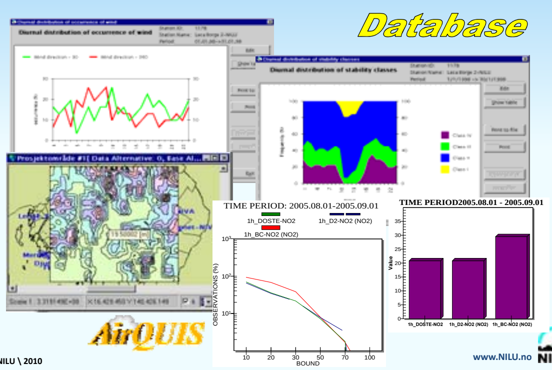
Data Statistics



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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 !

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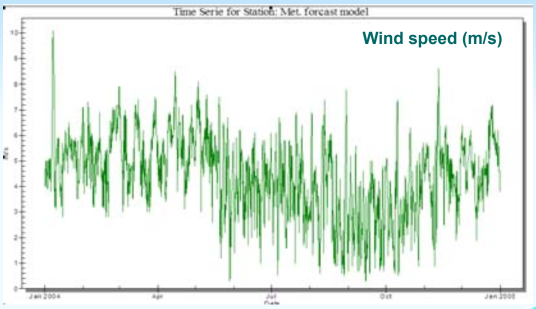
Presenting time series



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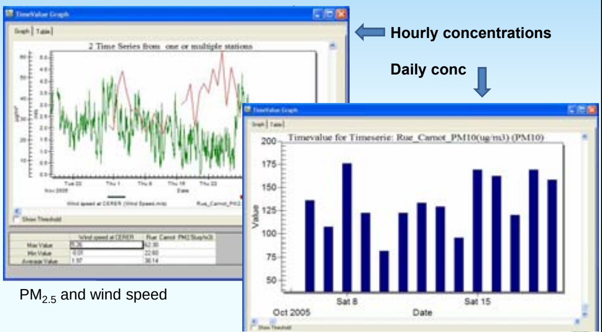
Measurement – Time



Hourly concentrations

Daily conc

$PM_{2.5}$ and wind speed

Daily values of PM_{10}

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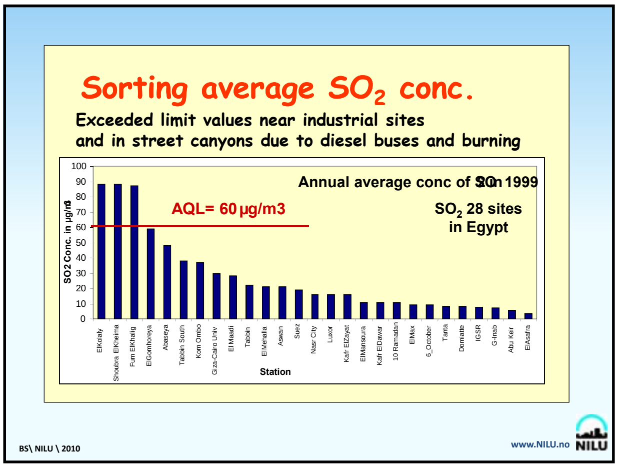
Sorting average SO2 conc.
Exceeded limit values near industrial sites
and in street canyons due to diesel buses and burning
Annual average conc of SO2 in 1999
AQL= 60 µg/m3
SO2 28 sites
in Egypt
SO2 Conc. in µg/m3
Station
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www.NILU.no
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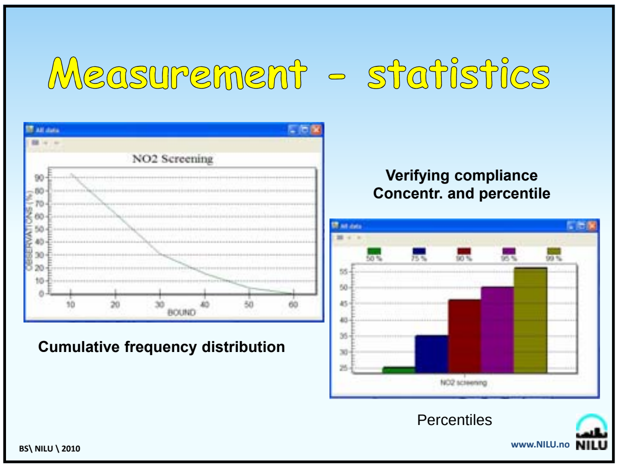
Measurement - statistics
NO2 Screening
Verifying compliance
Concentr. and percentile
Cumulative frequency distribution
Percentiles
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www.NILU.no
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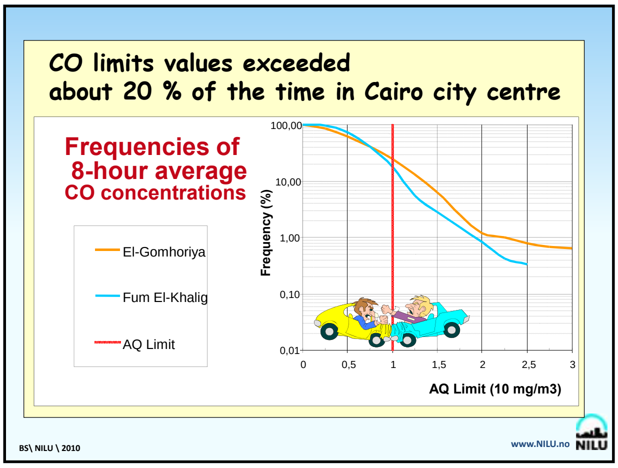
CO limits values exceeded
about 20 % of the time in Cairo city centre
Frequencies of
8-hour average
CO concentrations
El-Gomhoriya
Fum El-Khalig
AQ Limit
Frequency (%)
100,00
10,00
1,00
0,10
0,01
0
0,5
1
1,5
2
2,5
3
AQ Limit (10 mg/m3)
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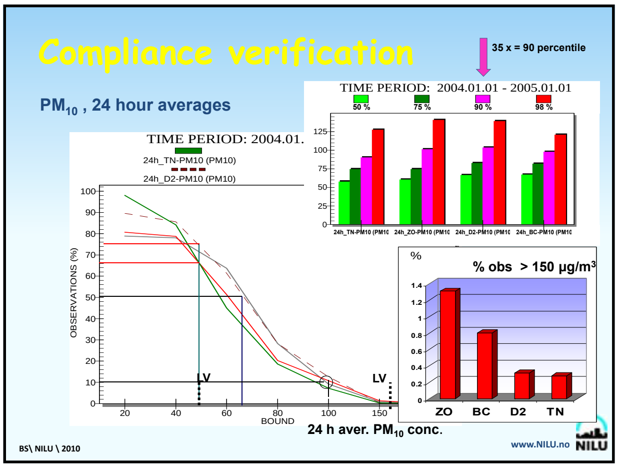
Compliance verification
35 x = 90 percentile
PM10 , 24 hour averages
TIME PERIOD: 2004.01.01 - 2005.01.01
50 %
75 %
90 %
98 %
TIME PERIOD: 2004.01.
24h_TN-PM10 (PM10)
24h_D2-PM10 (PM10)
OBSERVATIONS (%)
% obs > 150 µg/m3
ZO
BC
D2
TN
LV
LV
BOUND
24 h aver. PM10 conc.
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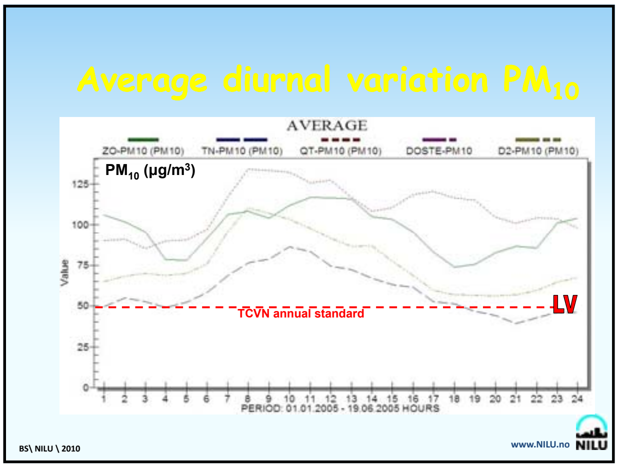
Average diurnal variation PM10
AVERAGE
ZO-PM10 (PM10)
TN-PM10 (PM10)
QT-PM10 (PM10)
DOSTE-PM10
D2-PM10 (PM10)
PM10 (µg/m3)
Value
TCVN annual standard
LV
PERIOD: 01.01.2005 - 19.06.2005 HOURS
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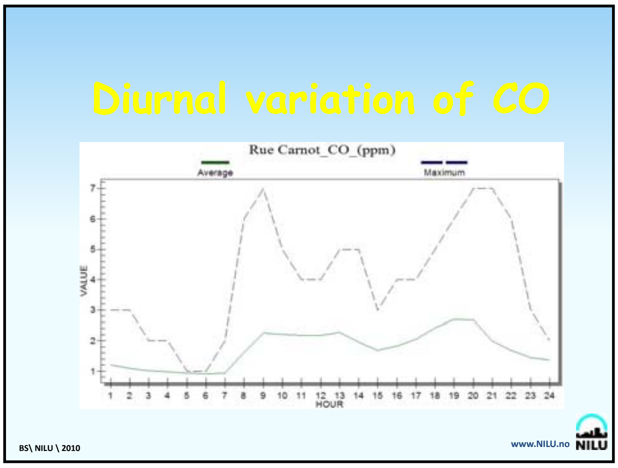
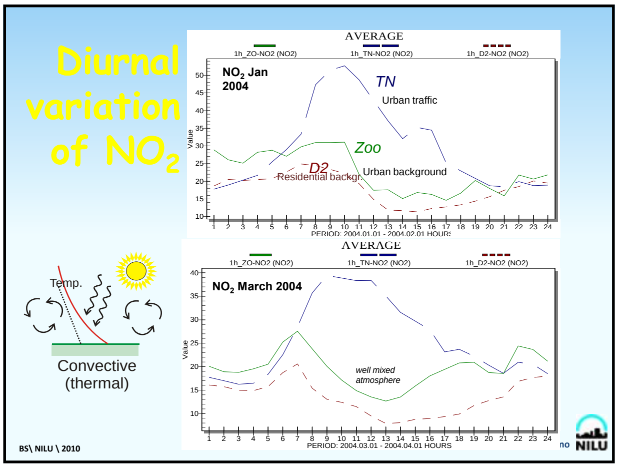

Diurnal variation of CO
Rue Carnot_CO_(ppm)
Average
Maximum
VALUE
HOUR
BS\ NILU \ 2010
www.NILU.no
NILU


Diurnal variation of NO2
AVERAGE
NO2 Jan 2004
TN
Urban traffic
Zoo
Urban background
D2
Residential backgr.
NO2 March 2004
well mixed atmosphere
Temp.
Convective (thermal)
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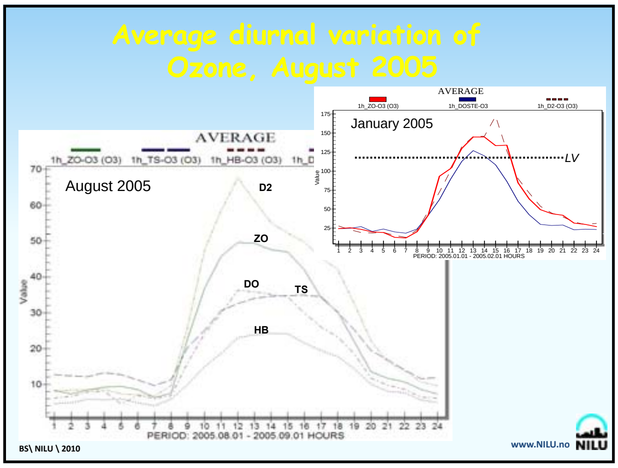
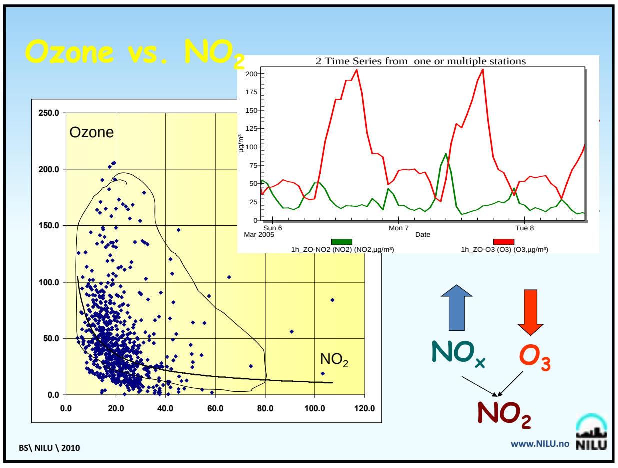

Average diurnal variation of Ozone, August 2005
AVERAGE
August 2005
D2
ZO
DO
TS
HB
January 2005
LV
BS\ NILU \ 2010
www.NILU.no
NILU


Ozone vs. NO2
2 Time Series from one or multiple stations
Ozone
NO2
NOx
O3
NO2
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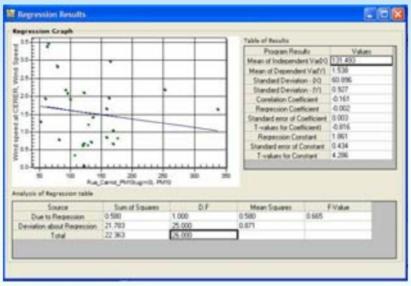
Measurement - statistics

Regression analyses



Regression: PM_{10} v.s wind speed

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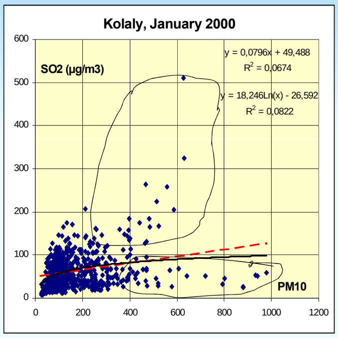
Does SO_2 and PM_{10} come from the same source?



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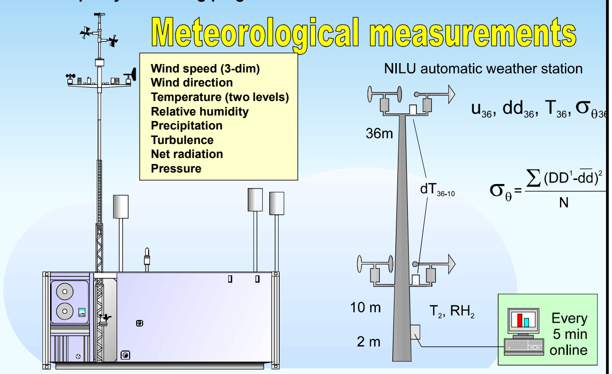
All air quality monitoring programmes include

Meteorological measurements



u_{36}, dd_{36}, T_{36}, $\sigma_{\theta 36}$

$$\sigma_\theta = \frac{\sum (DD^i - \overline{dd})^2}{N}$$

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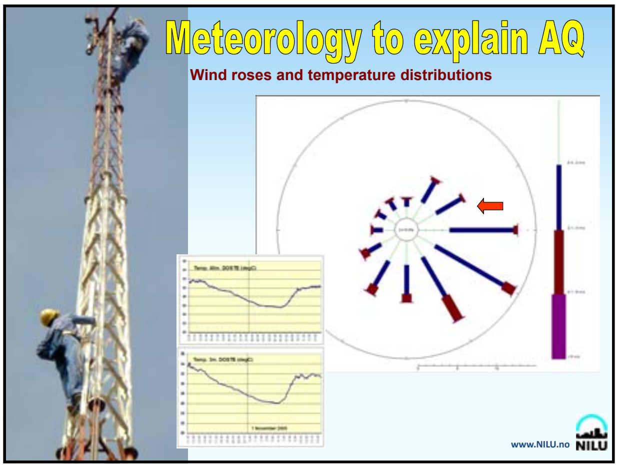
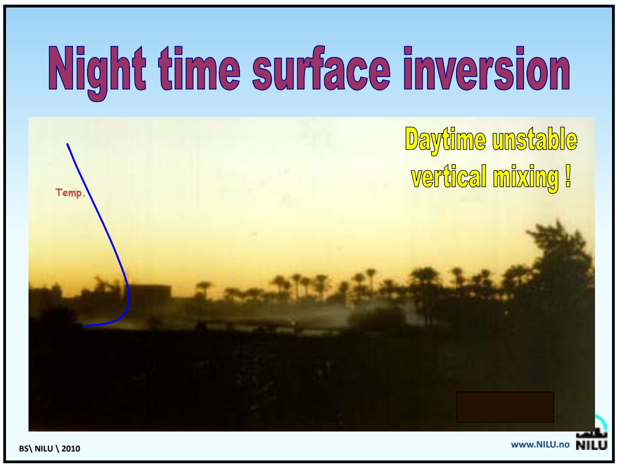

Meteorology to explain AQ
Wind roses and temperature distributions
www.NILU.no
NILU


Night time surface inversion
Daytime unstable
vertical mixing !
Temp.
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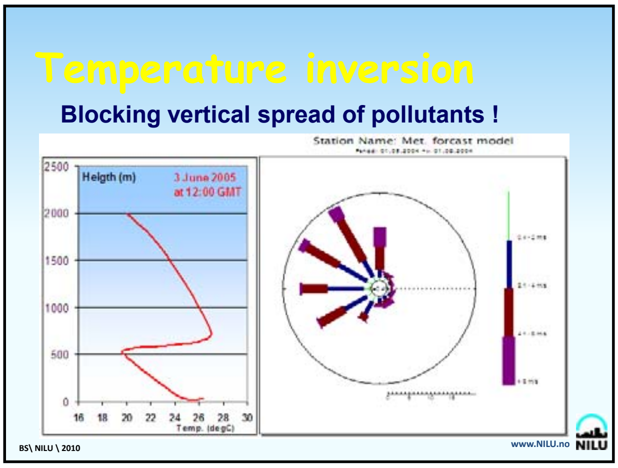
Temperature inversion
Blocking vertical spread of pollutants !
Station Name: Met. forcast model
Heigth (m)
3 June 2005
at 12:00 GMT
2500
2000
1500
1000
500
0
16 18 20 22 24 26 28 30
Temp. (degC)
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High concentrations of PM in Cairo

Stable night upper inversion !

On 11 to 12 October 2004 very high concentrations of PM_{10} were recorded in Cairo , wind from northerly directions

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Burning agricultural waste in the Nile Delta, Egypt

October 2004

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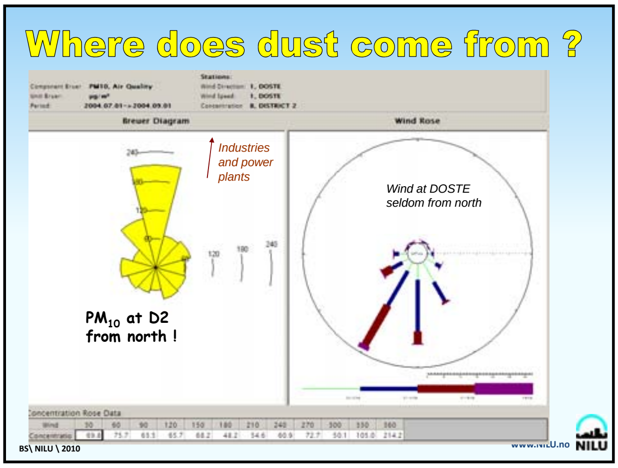
Where does dust come from ?
Stations:
Component Bruer: PM10, Air Quality
Unit Bruer: µg/m³
Period: 2004.07.01->2004.09.01
Wind Direction: 1, DOSTE
Wind Speed: 1, DOSTE
Concentration: 8, DISTRICT 2
Breuer Diagram
Wind Rose
Industries and power plants
Wind at DOSTE seldom from north
PM10 at D2 from north !
Concentration Rose Data
Wind 30 60 90 120 150 180 210 240 270 300 330 360
Concentratio 69.8 75.7 63.5 65.7 68.2 48.2 54.6 60.9 72.7 50.1 105.0 214.2
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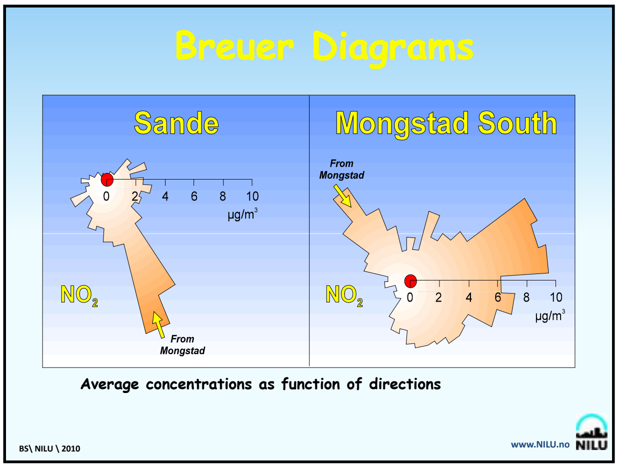
Breuer Diagrams
Sande
Mongstad South
0 2 4 6 8 10
µg/m³
NO2
From Mongstad
Average concentrations as function of directions
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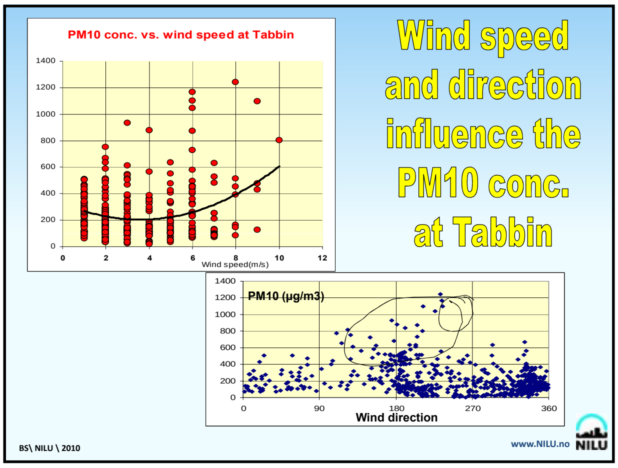
PM10 conc. vs. wind speed at Tabbin
Wind speed(m/s)
Wind speed and direction influence the PM10 conc. at Tabbin
PM10 (µg/m3)
Wind direction
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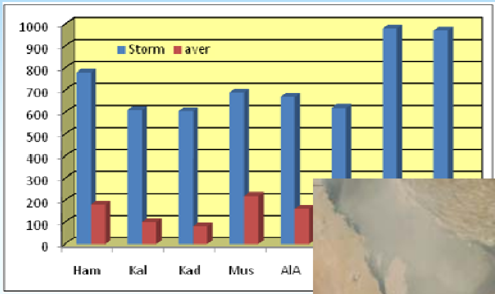
Dust storm July 2009



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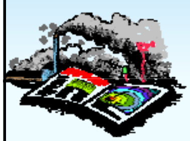
Monitoring

Reporting Air Quality



- ✓ 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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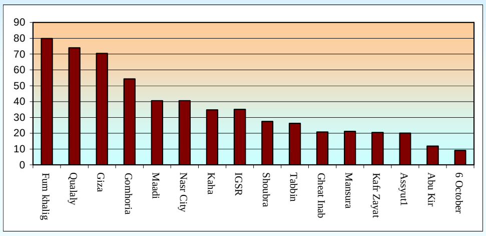
Average concentrations

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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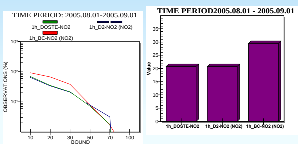
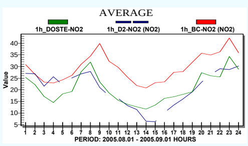
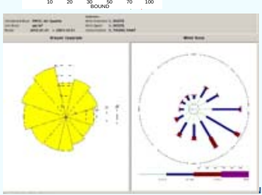
Quarterly reports

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







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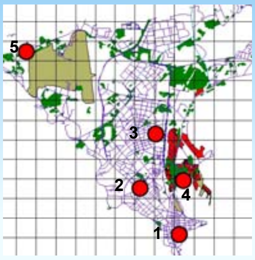
The monitoring programme



		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	Bel Air	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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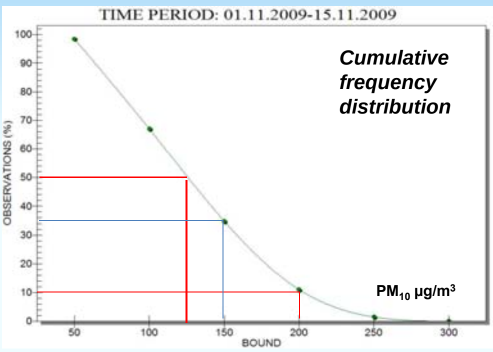
Frequencies and exceedings



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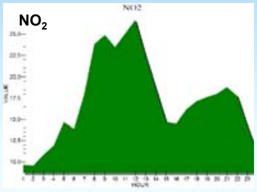
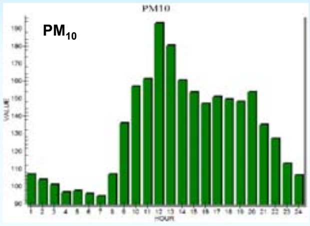
Average diurnal variation



Can it explain the impact from traffic/industry ?

Daytime impact from activities: traffic, transport and industries



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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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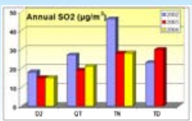
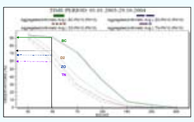
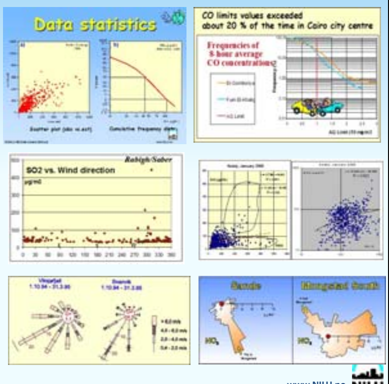
Annual report
Summary





exceedings of limit values!



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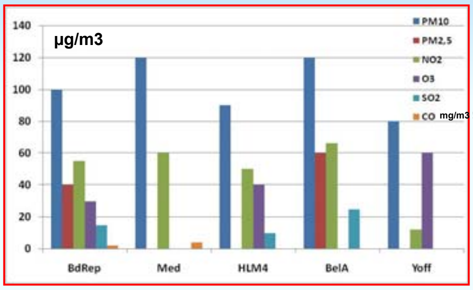
Annual average concentrations summary



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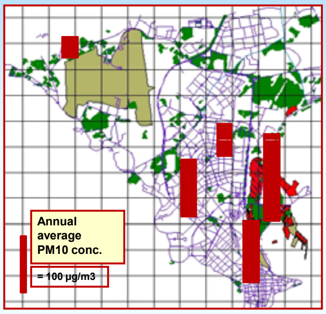
Measured annual average PM_{10} con-centrations



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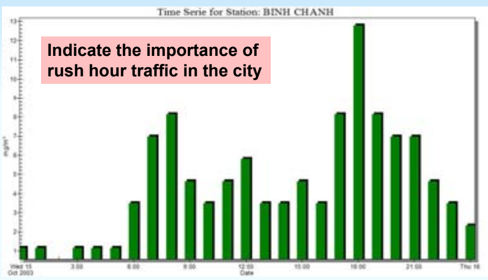
Diurnal variation of CO shows importance of traffic



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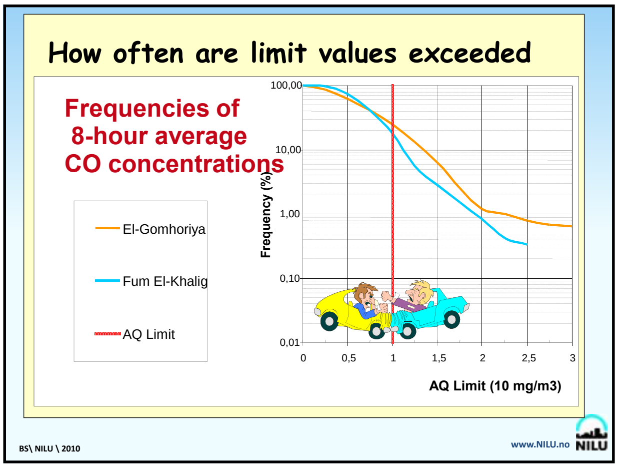
How often are limit values exceeded
Frequencies of 8-hour average CO concentrations
El-Gomhoriya
Fum El-Khalig
AQ Limit
Frequency (%)
100,00
10,00
1,00
0,10
0,01
0
0,5
1
1,5
2
2,5
3
AQ Limit (10 mg/m3)
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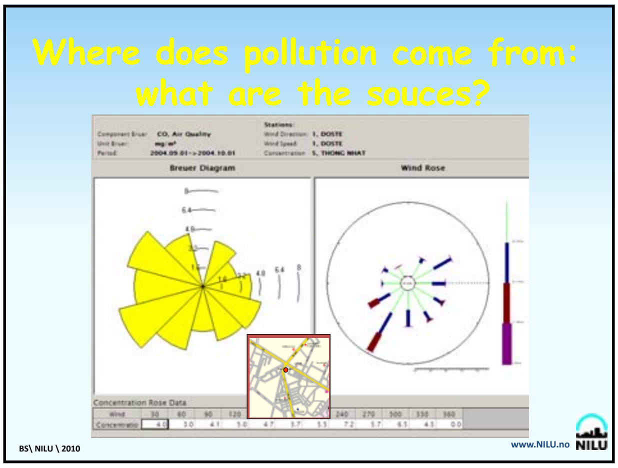
Where does pollution come from: what are the souces?
Breuer Diagram
Wind Rose
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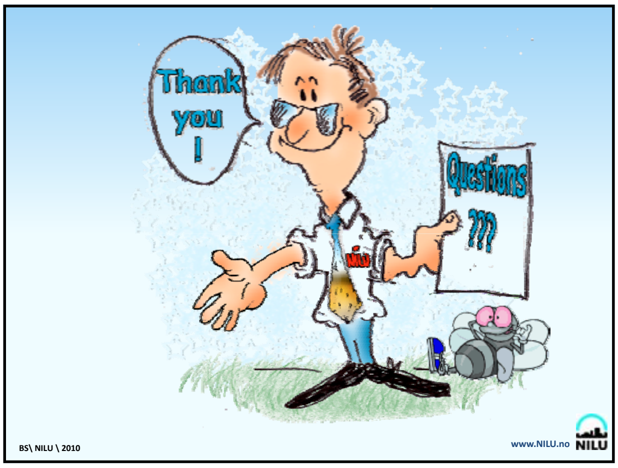
Thank you !
Questions ???
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Norwegian Institute for Air Research

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

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Data dissemination

Data Dissemination

Bajza Hot Spot Project
Tirana, ALBANIA
19-21 May 2010

Leif Marsteen
NILU

Data transport

Information distribution

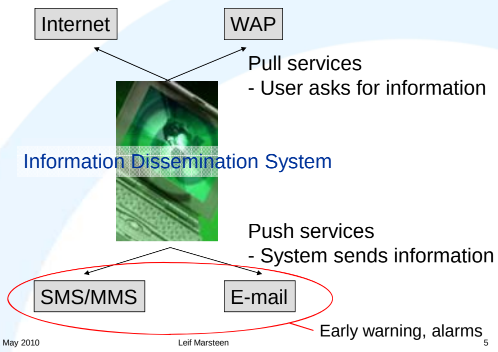
Relevant for:

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

Legal background

- Directive 2003/4/EC on public access to environmental information
- Directive 2008/50/EC on ambient air quality and cleaner air for Europe
  - The public shall be informed

Information channels



Challenges

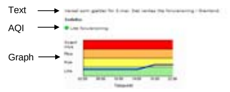
- Present data that is both scientifically correct and being understood by the audience
- Audience: Scientists, decision-makers, public
- Requires different presentation techniques
- Public pages: Keep it simple!
- Simple graphs, color coding, pollution classes, Air Quality Index, not numbers

Requirements

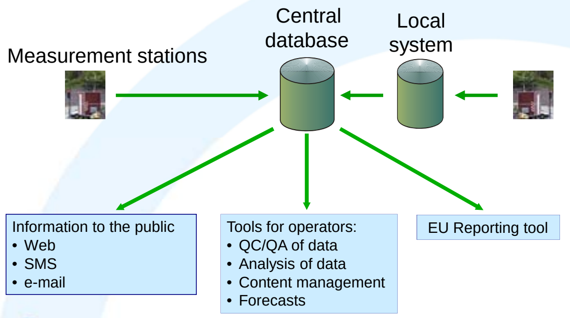
Pollution level
- Little
- Some
- A lot
- Very much

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

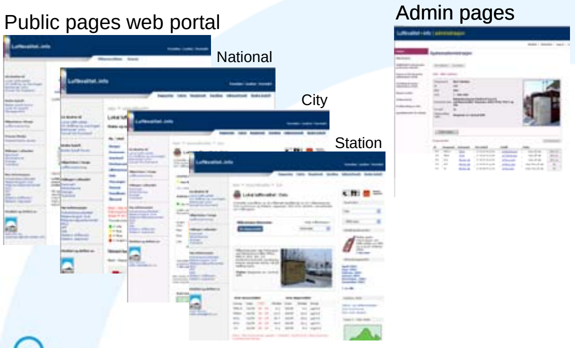
Technical
- Professional databases
- Powerful processing
- Automatic QA/QC
- Efficient data exchange



Integrated system



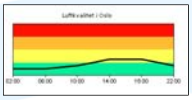
Organising the web portal



Administrative pages

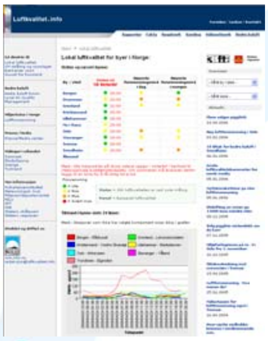
- Contents management
  - Add stations
  - Add/remove parameters at station
  - Edit information
  - Update forecasts
- Data quality control
  - Data validation
  - Data discrmination, flagging

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

Albania May 2010 Leif Marsteen 13

Station page

Contents:

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

Albania May 2010 Leif Marsteen 14

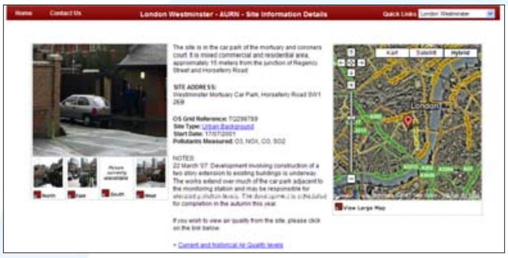
More examples, Cyprus

Access to details through map

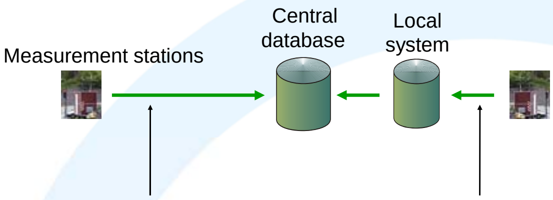
Albania May 2010 Leif Marsteen 15

Google Map as added information

UK Automatic Urban and Rural Network (AURN)



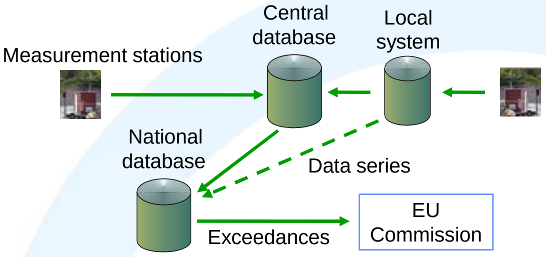
Data collection and validation



Centralised data collection:
Data validation tools available in admin pages

Local data collection:
Data validation is done locally

National data base



Stores data from stations that shall report data to the EU Commission

Possible services to client

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

Albania May 2010 Leif Marsteen 19

Summary

- Information to the public is required
- Via Web, SMS, WAP
- Forecasts
- On-line data
- Historical data
- Data reporting to the Commission

Standardisation Unit June 2009 Leif Marsteen 20

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/

Albania May 2010 Leif Marsteen 21

Thank you

Albania May 2010 Leif Marsteen 22

Air quality management planning (AQMP)

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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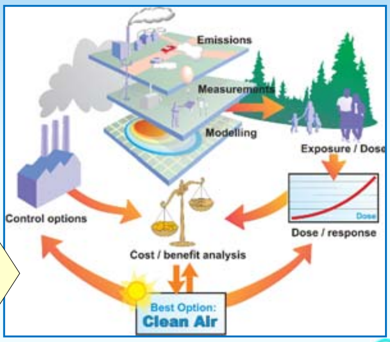
AQ Management Planning

Identify actions to improve air quality

Identify most cost-effective options



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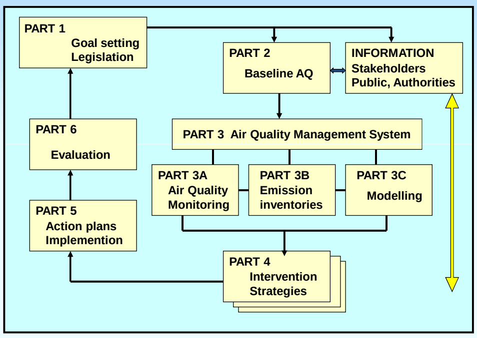
AQMP A dynamic process



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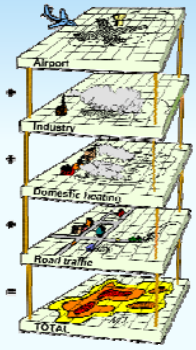
Dispersion modelling



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

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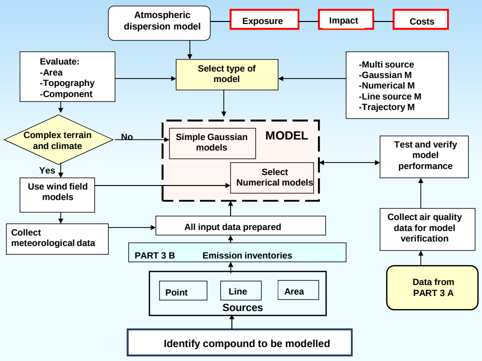
PART 3 C: Models
Atmospheric dispersion models



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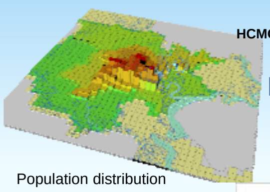
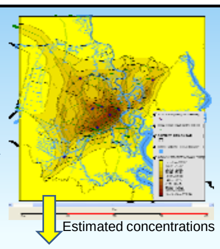
Model results

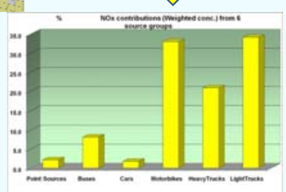


Population distribution



Estimated concentrations

Relative contributions of sources to the exposure in HCMC



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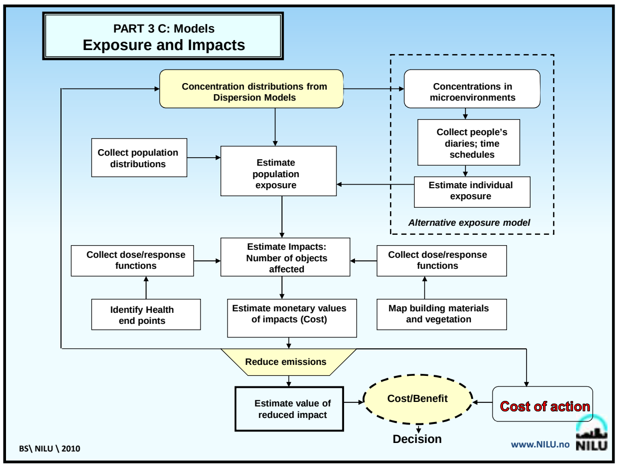
PART 3 C: Models
Exposure and Impacts
Concentration distributions from Dispersion Models
Concentrations in microenvironments
Collect people's diaries; time schedules
Collect population distributions
Estimate population exposure
Estimate individual exposure
Alternative exposure model
Collect dose/response functions
Estimate Impacts: Number of objects affected
Collect dose/response functions
Identify Health end points
Estimate monetary values of impacts (Cost)
Map building materials and vegetation
Reduce emissions
Estimate value of reduced impact
Cost/Benefit
Cost of action
Decision
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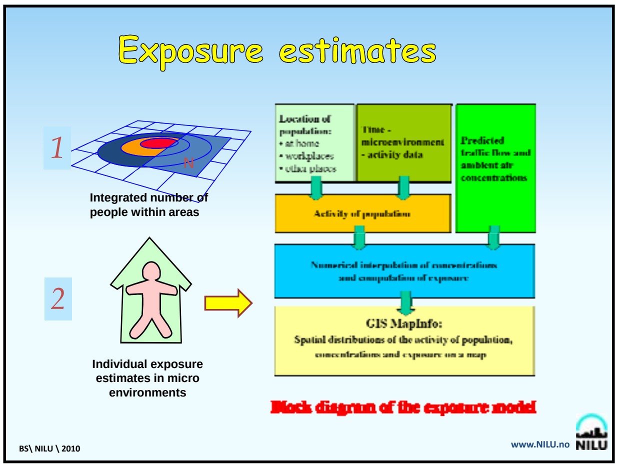
Exposure estimates
1
Integrated number of people within areas
2
Individual exposure estimates in micro environments
Location of population:
• at home
• workplaces
Time - microenvironment - activity data
Predicted traffic flow and ambient air concentrations
Activity of population
Numerical interpolation of concentrations and computation of exposure
GIS MapInfo:
Spatial distributions of the activity of population, concentrations and exposure on a map
Block diagram of the exposure model
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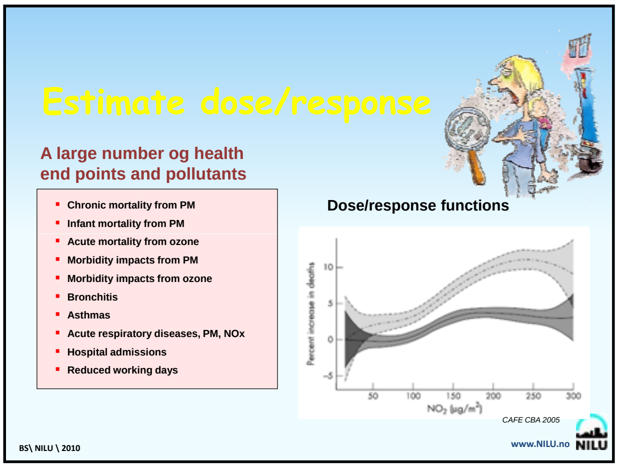
Estimate dose/response
A large number og health end points and pollutants
Chronic mortality from PM
Infant mortality from PM
Acute mortality from ozone
Morbidity impacts from PM
Morbidity impacts from ozone
Bronchitis
Asthmas
Acute respiratory diseases, PM, NOx
Hospital admissions
Reduced working days
Dose/response functions
Percent increase in deaths
10
5
0
-5
50
100
150
200
250
300
NO2 (µg/m3)
CAFE CBA 2005
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Exposure response relationships for PM

Meta-analyses; time series morbidity study in China

Health end point	Diseases	% per µg/m³ 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/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)

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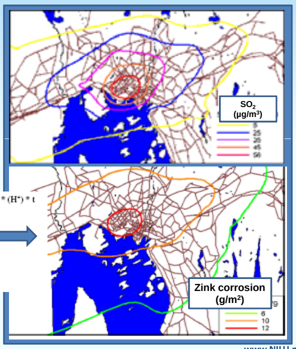
Environmental load

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/m² dag
SO_2 = svoveldioksid i µg/m³
O_3 = ozon i µg/ m³
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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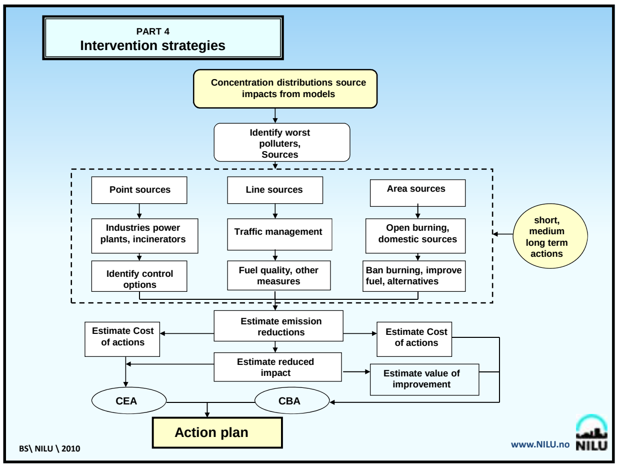
PART 4
Intervention strategies
Concentration distributions source impacts from models
Identify worst polluters, Sources
Point sources
Line sources
Area sources
Industries power plants, incinerators
Traffic management
Open burning, domestic sources
Identify control options
Fuel quality, other measures
Ban burning, improve fuel, alternatives
short, medium long term actions
Estimate Cost of actions
Estimate emission reductions
Estimate Cost of actions
Estimate reduced impact
Estimate value of improvement
CEA
CBA
Action plan
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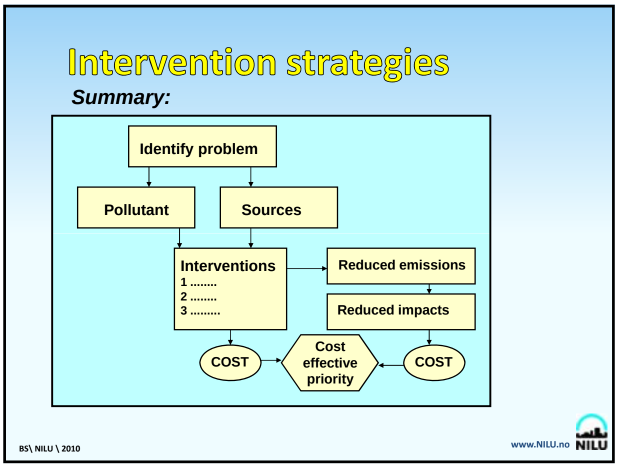
Intervention strategies
Summary:
Identify problem
Pollutant
Sources
Interventions
1 ....
2 ....
3 ....
Reduced emissions
Reduced impacts
COST
Cost effective priority
COST
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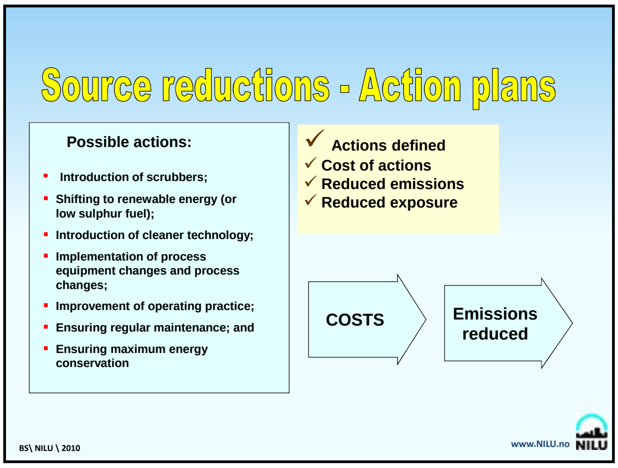
Source reductions - Action plans
Possible actions:
Introduction of scrubbers;
Shifting to renewable energy (or low sulphur fuel);
Introduction of cleaner technology;
Implementation of process equipment changes and process changes;
Improvement of operating practice;
Ensuring regular maintenance; and
Ensuring 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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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

Cost of Reduced Impacts

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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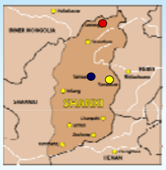
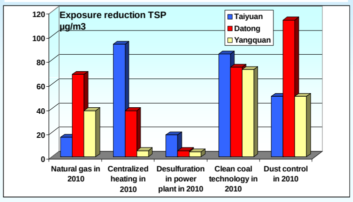
Reduced emissions ⇒ Reduced exposure



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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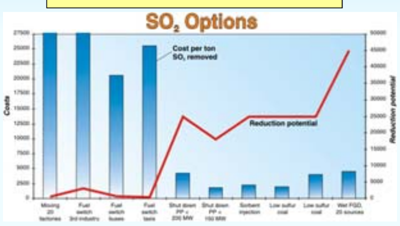
Cost effective SO2 options

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

Cost effective SO_2 options



interventions

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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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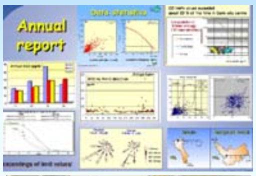
Evaluation and follow-up



- ✓ 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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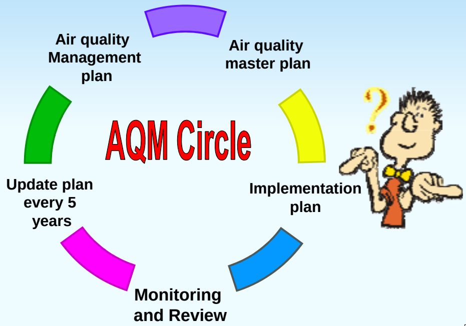
AQMP – update for sustainability



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Inform the public

To:
Stakeholders
Authorities
Decision makers

in order to:
Increase awareness
Better participation
NGO support
Understanding

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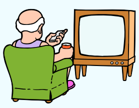
Disseminating air quality information



- Newspaper articles
- Booklets/Pamphlets /brochures/leaflets
- Posters on air pollution in central places such as schools and hospitals
- Radio, national and local
- TV
- Public meetings
- Bill boards

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Web solutions for dissemination of ambient air quality

Public pages

Admin pages

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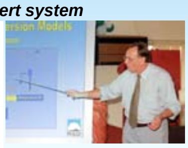
Capacity building and training

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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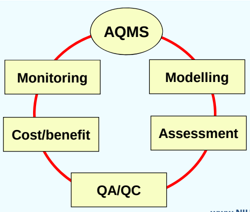
Training needs assessment

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;

Developing experts require training on:



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