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Air Quality Data Assessment and Interpretation

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Ho Chi Minh City, October – November 2006

Air Quality Data Assessment and Interpretation

1 Introduction

This paper is part of the NILU presentation prepared for two training seminars organised by the Stockholm Environment Institute (SEI). SEI was responsible for the overall coordination and management of the project. The training workshops, which were held in Bangkok in June 2006 and in Ho Chi Minh City in October-November 2006, were organised in collaboration with the Clean Air Network for Asia (CATNet). CATNet is part of the Clean Air Initiative for Asian Cities (CAI Asia), which has undertaken a series of activities to enhance the capacity of national and local governmental authorities in Asia

The seminar presented a summary of the air quality monitoring and management programme, which has been developed around the world and in Asia in particular. The NILU presentations were mainly based on the development and training performed by NILU and included background, monitoring system planning and development as well as data presentations and modelling.

This report presents air quality data assessment and interpretation as well as data reporting and data dissemination.

2 The monitoring programme

Before data can be presented and interpreted a brief presentation of the philosophy behind the monitoring programme should be presented.

Why do we measure what we measure and why do we measure where and what we measure. These elements have been discussed in another presentation at the seminar. (Sivertsen, 2006 a).

The air quality monitoring programme layout, parameters, QA/QC requirements etc. should be briefly reported. Also the air quality national and international limit values, standards or guideline values should be discussed as part of the reporting procedures. An example was presented based on reporting of data from Ho Chi Minh City (Sivertsen et al., 2005)

3 Interpretation of air quality data

Once the data have been collected, transferred into the database and subjected to quality assurance, they are ready for analysis and interpretation. Since the objectives of the monitoring program have been decided upon its commencement, the reasons for data collection, and thus the questions to be addressed by the program, have been identified.

Data analysis and data interpretation should be conducted with the intent of providing quantitative answers addressing the set objectives of the monitoring program. The process should be designed to provide useful information in an appropriate format for the end-user.

Examples of the general type of questions to be addressed in relation to air quality assessment include:

- What pollutants are present?
- At what concentrations?
- Do the concentration or emission levels exceed standards or targets?
- Where do they come from?
- What is the contribution of individual sources?
- What is population exposure to the pollutants?
- What harm do they do?
- To what extent would different mitigation measures help in controlling the pollution?

It is critical that at the beginning of the data analysis and interpretation the exact questions to be addressed are very clearly identified. A key tool in the process of data analysis and interpretation is statistics. The role of statistical methods in research is to enable the researcher to accurately utilize the gathered information and to be more specific in describing their findings.

A minimum level of data management could be the production of peak/average statistics of daily, monthly and annual summaries, involving simple statistics and graphical analyses that show both time and frequency distributions of monitoring data. The use of a Geographical Information System (GIS) should also be considered, particularly when the intention is to combine pollution data with those from epidemiological and other geo-coordinated social, economic or demographic sources.

In general, simple steps of data analysis and interpretation include:

1. Identify critical variables required to respond to your research question.
2. Sort, scale, and graph data in a spreadsheet.
3. Visually display data to emphasize relevant trends and patterns.
4. Differentiate between recognizable data patterns and outlying data.
5. Suggest explanations for recognizable data patterns and outlying data.
6. Present your findings in a clear, concise, and professional fashion.

4 Air quality data assessment

Annual average or seasonal average concentrations have been presented and compared to limit values in order to check the typical and average air pollution situation over the measurement area (city). Average diurnal concentration distributions of selected pollutants indicate time variations as a result of combined emission rates and atmospheric dispersion conditions.

An important element in the understanding of air pollution is the understanding of the meteorological dispersion conditions. The atmosphere's ability to transport and disperse pollutants emitted into the atmospheric surface boundary layer is often more decisive for the pollution levels than the emission rates itself.

Nighttime surface inversions combined with unstable convective daytime conditions bring about large diurnal variations in many of the air pollutants. These changes in weather conditions together with chemical reactions and variations in emission rates as traffic and human activities change from day to night has to be understood in order to evaluate the results of the measurement and modelling results.

Examples should be presented to explain what is going on in the area. The diurnal variation of NO_2 concentrations at urban background concentrations relative to variations very close to the source (the street or road) confirm the rapid dilution of pollutants as one move away from the street due to the convective and very unstable surface layer at daytime.

The relationship between NO_2 and ozone concentrations also illustrates the use of background ozone (and following reduction in ozone) as NO emissions and chemically transformed into NO_2.

Air pollution concentrations as functions of wind directions (an other meteorological parameters) may explain the importance of different source and the impact of emissions from source areas. High levels of PM_{10} concentrations measured at one of the selected sites are shown to be originating from the industrial complexes and power plants north of the site. Examples are presented base on data collected from Ho Chi Minh City (Sivertsen et al., 2004)

5 Annual reports

Annual reports should be summarising the air quality as monitored by the complete monitoring and sampling network designed for the area.

The report should reflect the status of the environment concerning air pollution and it should include information on:

- Average concentration levels
- Exceeding of standards
- Trend analyses; is it better or worse than before?
- Statistics on Air Quality Index values
- Air quality versus meteorology,
- Identify adverse meteorological conditions.
- Major source impact evaluations
- Discussions on source contributions
- Estimate of exposures if possible

In areas and in microenvironments where the air pollution frequently exceeded standard levels, more detailed analyses should be performed. Frequencies of exceeding the standards should be established.

In areas where levels are far below the limit values simple assessment may have been done without any fixed monitoring stations. Historical data based on screening studies using passive samplers may be used for verifications.

6 Information and dissemination of air quality information

Information dissemination and presentation solutions for air quality have been developed in several countries over the last decade. Relative large research program has been studying how air quality information should be presented. Presenting data that are both scientifically correct and capable of being understood, and used, by the wider public is a challenge. The dissemination channels likely to be used are in addition to Internet over the next years is WAP, e-mail and SMS, to be combined with subscription services for personalised information. Some countries already have had such solutions running for a few years.

There are in general four reasons for developing air quality dissemination and presentation solutions:

1. Give correct Air Quality status and forecasts
2. The needs for people's to use the information
3. Possible reduction of health impacts (for the sensitive part of population?)
4. To reduce the impact of air pollution episodes

Most solutions are today based on the needs indicated in 1 and 2 above. Still this is a great challenge. Even though the graphs and tables can be perfect, the presentation itself on an Internet page can affect the public's interpretation dramatically. Basic understanding of usability of relevant services is vital in order to gain useful knowledge in the field of data presentation and data distribution.

On-line presentation of environmental data includes different groups such as scientists, decision-makers and the general public. Hence the users will have very different backgrounds for understanding data presentations. The general public can misinterpret a scientifically correct presentation easily understood by experts. In order to address this problem, data should be presented in different ways depending on the target groups.

Solutions aimed for actually reducing health impacts is likely to be more integrated into air quality management strategies in the future. The research on such solutions clearly points out that that such solutions must give the end users useful information in advance so actions can be taken. This means that the end-user must know when and where likely high concentrations will come, sufficiently early in advance to take actions. If this is combined with personalised information and utilisation of channels like SMS/MMS and e-mail research shows great potential to help sensitive groups to avoid being exposed to unhealthy levels.

The final stage, where one uses information dissemination techniques also to actually influence the episode forecasted to be less sever that with no action, is likely to be an area of research for the future. The interest is then to combined the personalised advanced information dissemination solutions tailored for individuals and combined it

with legal regulations, car numbers, car types, reduced public transport cost, car specific data recording, road pricing, car type pricing, number of persons in car etc. etc.

7 References

Sivertsen, B. (2006) Air quality monitoring programme design. Presented at the Clean Air for Asia Training Programme. Bangkok May 2006 (NILU F 88/2006)

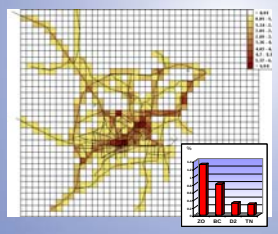
Sivertsen, B., Larssen, S., Laupsa, H. and Marsteen, L. (2006) Air Quality Management Project, Dhaka, Bangladesh, 2006. Final report. Kjeller (NILU OR 53/2006).

Sivertsen, B., Thanh, T.N., Le, K.V. and Vo, D.T. (2004) The air quality monitoring and management system for HCMC, Vietnam, Presented at the Better Air Quality Conference, Agra, India, December 2004.
URL: http://www.cleanairnet.org/baq2004/1527/article-59135.html

Sivertsen, B., Thanh, T.N., Le, K.V. and Vo, D.T. (2005) The air quality monitoring and management system for HCMC, Vietnam. Kjeller (NILU OR 1/2005).

Clean Air for Asia Training Programme

Data assessment and interpretation

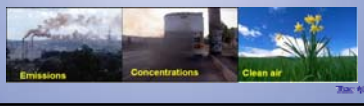


Bjarne Sivertsen
Norwegian Institute for Air Research (NILU)

Clean Air for Asia Training Programme

Reporting Air Quality

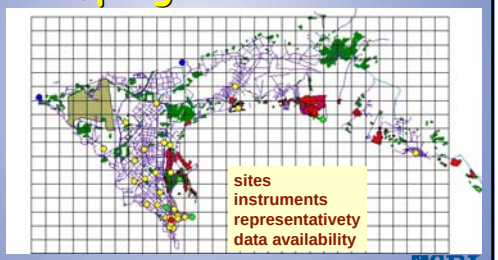
- Monitoring programme description
- Data reporting
- Data statistics
- Data assessment
- Explain cause/relationship
- Data dissemination
- Internet and public awareness



Clean Air for Asia Training Programme

Describe monitoring programme

Sampling sites



sites
instruments
representativety
data availability

Clean Air for Asia Training Programme

Sites

Positions – representativity - instruments - methods

Clean Air for Asia Training Programme

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)

Clean Air for Asia Training Programme

Air Quality Standards and Limit Values ($\mu g/m^3$)

	SO2		NO2			PM10		Ozone
	Year	Day	Year	Day	Hour	Year	Day	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

Clean Air for Asia Training Programme

WHO AQ Guideline values

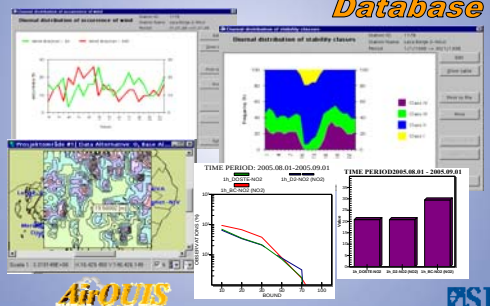
Pollutant	Averaging Time	WHO (µg/m³) 2005 update	Vietnam proposal TCVN-2005 (µg/m³)
SO_2	Annual avg.	-	50
	24 Hours.	20	-
	24 Hours	125 (interim)	125
	10 min	500	-
CO	8 Hours	10 000	10 000
	1 Hour	30 000	30 000
NO_2	Annual Avg.	40	40
	24 Hours	-	-
O_3	1 Hour	200	200
	8 Hours	100	80 *(24 h)*
	1 Hour	-	120
PM10	Annual Avg.	20	50
	24 Hours	50	150
PM2,5	Annual Avg.	10	-
	24 Hours	25	-
Pb	Annual	0.5	-

Vietnam proposed standards

Clean Air for Asia Training Programme

Data Presentations

Database



AirQUIS

Clean Air for Asia Training Programme

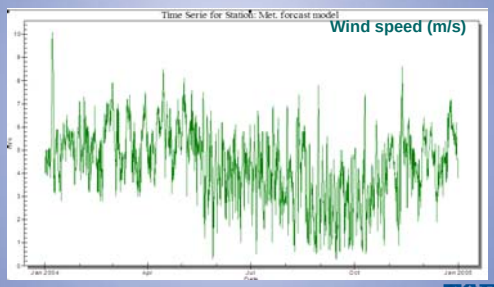
Data quality assured

- 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 !

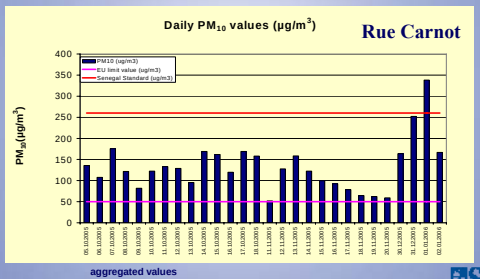
Clean Air for Asia Training Programme

Presenting time series



Clean Air for Asia Training Programme

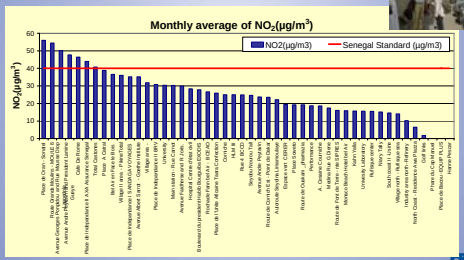
PM_{10} from screening study



aggregated values

Clean Air for Asia Training Programme

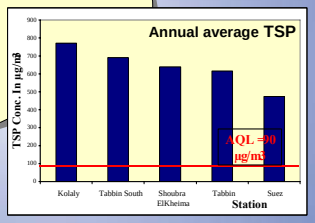
NO_2 measured at 48 sites in Dakar



Clean Air for Asia Training Programme

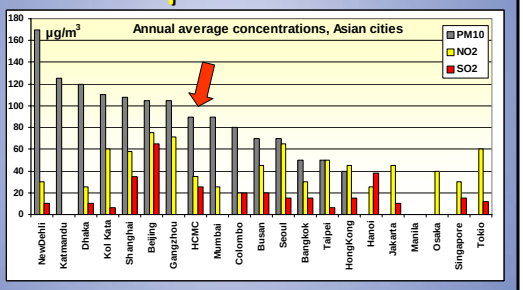
Annual average concentrations

Suspended dust is the main problem; generated by traffic, small industries open air waste burning and WIND !



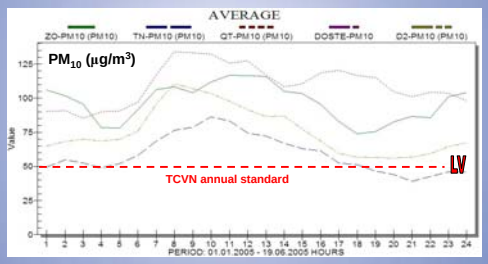
Clean Air for Asia Training Programme

HCMC compared to Asian cities



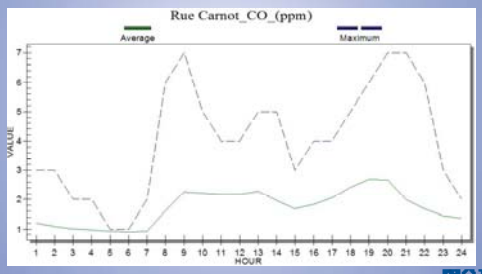
Clean Air for Asia Training Programme

Average diurnal variation PM_{10}



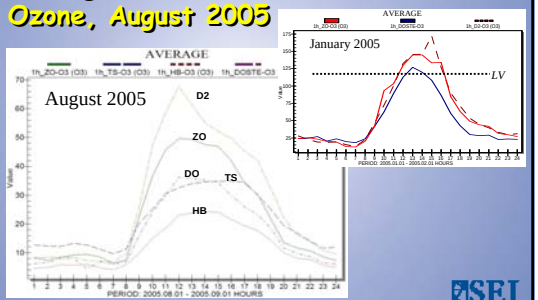
Clean Air for Asia Training Programme

Diurnal variation of CO



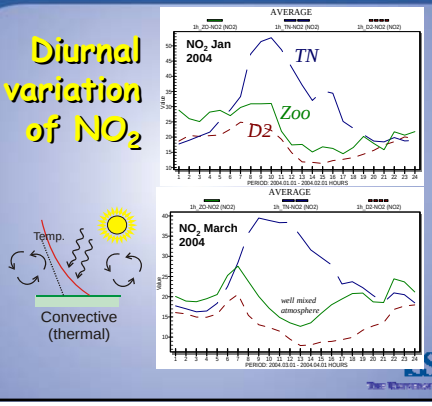
Clean Air for Asia Training Programme

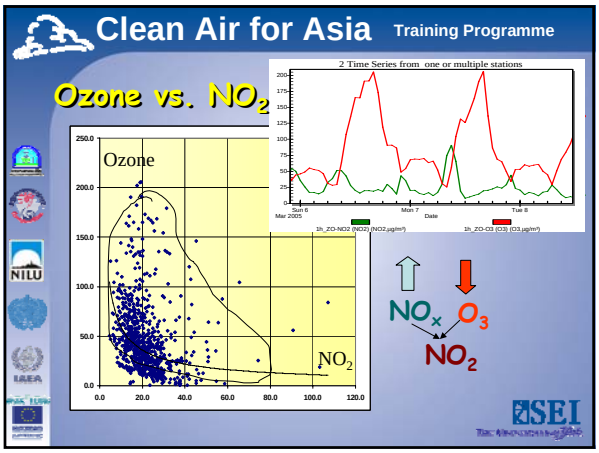
Average diurnal variation of Ozone, August 2005

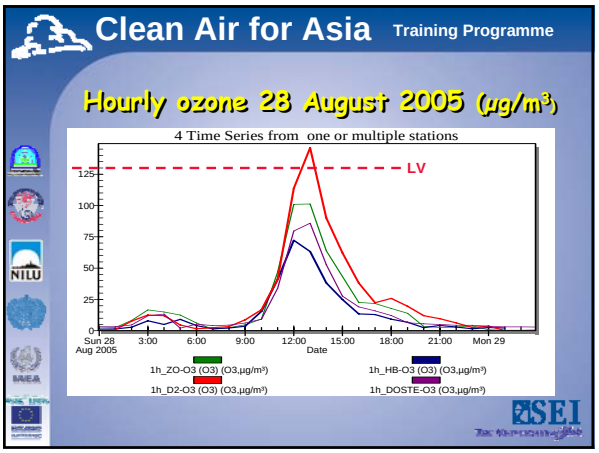


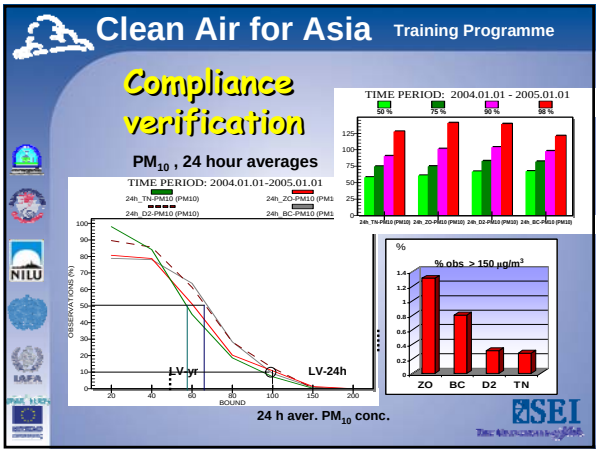
Clean Air for Asia Training Programme

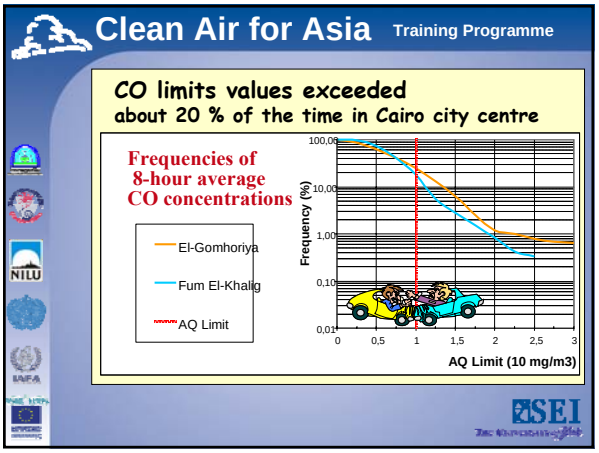
Diurnal variation of NO_2

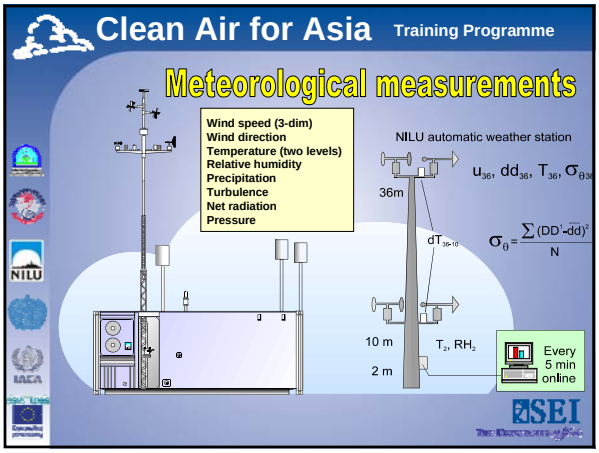


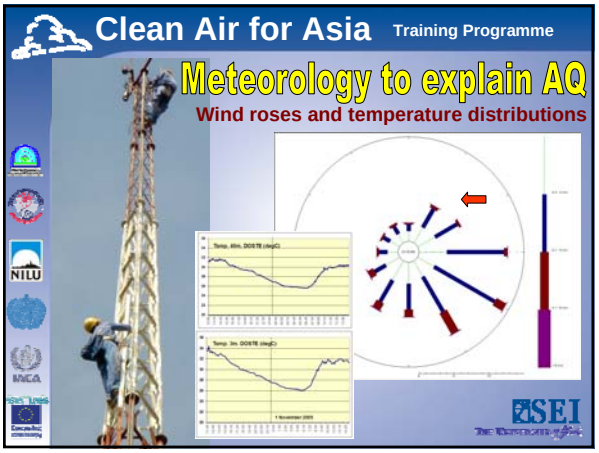

Clean Air for Asia
Training Programme
Ozone vs. NO2
Ozone
NO2
NOx
O3
NO2


Clean Air for Asia
Training Programme
Hourly ozone 28 August 2005 (µg/m³)
4 Time Series from one or multiple stations
LV
Sun 28 Aug 2005
Mon 29
Date
1h_ZO-O3 (O3) (O3,µg/m³)
1h_HB-O3 (O3) (O3,µg/m³)
1h_D2-O3 (O3) (O3,µg/m³)
1h_DOSTE-O3 (O3,µg/m³)


Clean Air for Asia
Training Programme
Compliance verification
PM10 , 24 hour averages
TIME PERIOD: 2004.01.01 - 2005.01.01
LV-yr
LV-24h
% obs. > 150 µg/m3
ZO
BC
D2
TN
24 h aver. PM10 conc.


Clean Air for Asia
Training Programme
CO limits values exceeded
about 20 % of the time in Cairo city centre
Frequencies of 8-hour average CO concentrations
El-Gomhoriya
Fum El-Khalig
AQ Limit
Frequency (%)
AQ Limit (10 mg/m3)


Clean Air for Asia
Training Programme
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
Every 5 min online


Clean Air for Asia
Training Programme
Meteorology to explain AQ
Wind roses and temperature distributions

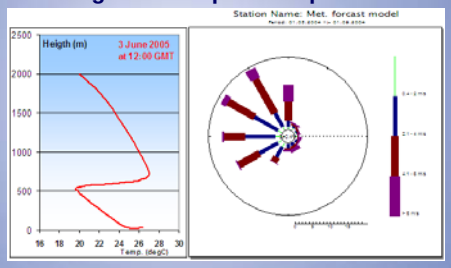
Clean Air for Asia Training Programme

Night time surface inversion

Clean Air for Asia Training Programme

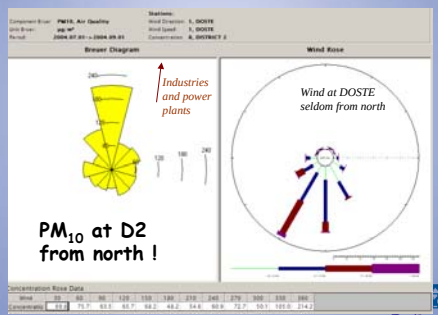
Temperature inversion

Blocking vertical spread of pollutants !



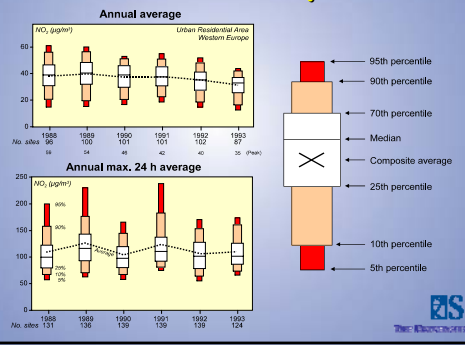
Clean Air for Asia Training Programme

Where does dust come from at D2 ?



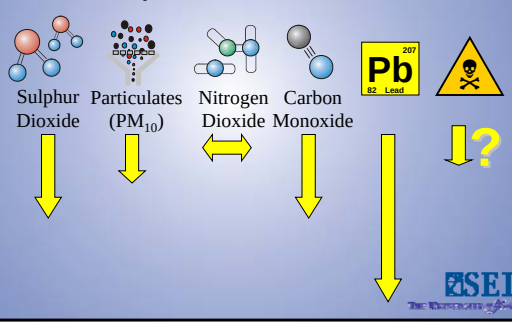
Clean Air for Asia Training Programme

Trend analysis



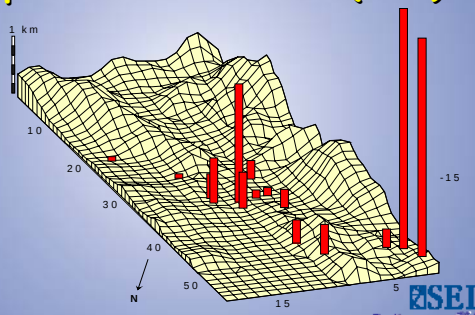
Clean Air for Asia Training Programme

Hopeful Trends

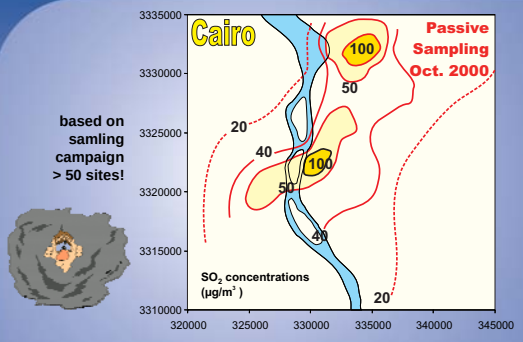


Clean Air for Asia — Training Programme

Spatial distributions (GIS)

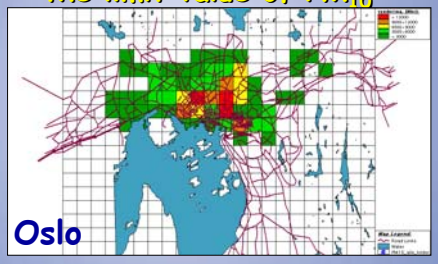


Clean Air for Asia — Training Programme



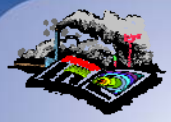
Clean Air for Asia — Training Programme

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



Clean Air for Asia — Training Programme

Reporting requirements



- ✓ Daily; AQI + graphs
- ✓ Weekly (printouts)
- ✓ Monthly or Quarterly data summary results
- ✓ Annual report (state of the environment AQ assessment)

Daily: Clean Air for Asia — Training Programme

Air Quality Index (AQI)

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

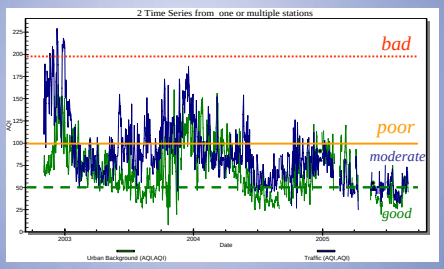
The daily index, AQI^d_j, is calculated as:

$$AQI^d_j = \text{Max}_i(C^d_{i,j} / S^d_i) * 100$$

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

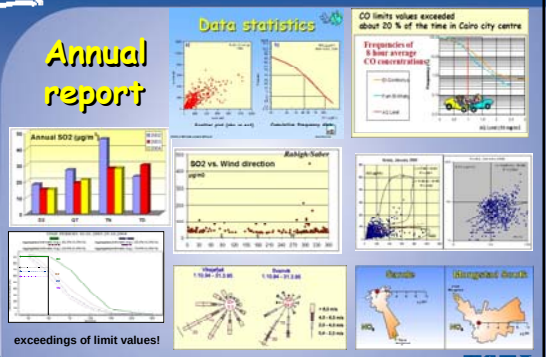
Clean Air for Asia Training Programme

Daily AQI values, 2002 - 2005



Clean Air for Asia Training Programme

Annual report



exceedings of limit values!

Clean Air for Asia Training Programme

Conclusions

simple – easy to understand – input for actions

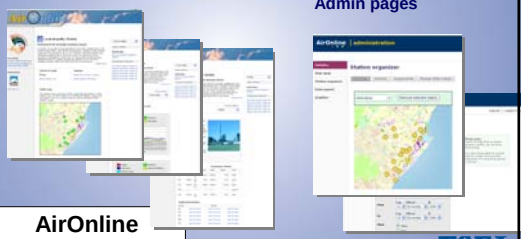
- ✓ The main problem is (PM?)
- ✓ PM exceeds all standards!
- ✓ High CO in streets with dense traffic
- ✓ NO_2 may exceed standards near streets and roads
- ✓ Ozone is a problem in suburban areas
- ✓ SO_2 has not been identified as a major problem
- ✓ PM + VOC in industrial areas

Clean Air for Asia Training Programme

Web solutions for dissemination of ambient air quality

Public pages

Admin pages



AirOnline

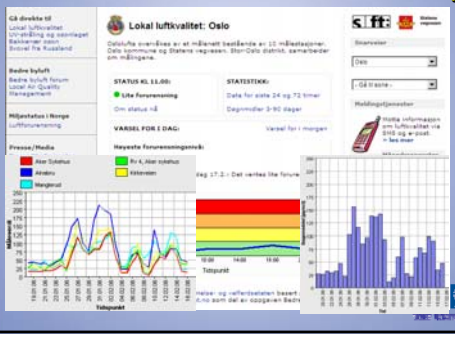
Clean Air for Asia Training Programme

Information about Measurement Station

- ✓ Measurement stations on "Map"
- ✓ Detail Information about the measurement stations

Clean Air for Asia Training Programme

Public solution in Norway



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Now in Norway

- **E-mail**
- **SMS**
- **WAP**
- MMS

Forecast

Health impact
Recommendation

- Forecasts
- Status

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Thank you !

Your AQ data
+ QA/QC included
+ the statistics
+ graphical tools
+ understanding

= your report to the users

Clean Air for Asia — Training Programme

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