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DANIDA

EIMP Phasing-out Phase, 2003-2004

A National Air Quality Monitoring Programme for EEAA, Egypt

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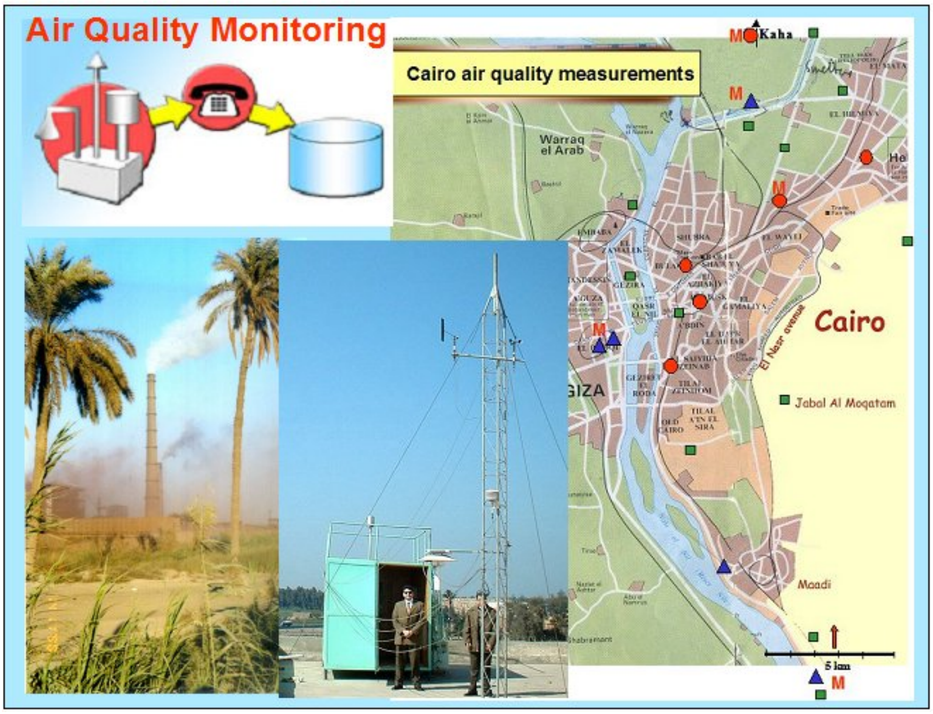

EIMP Environmental Information and Monitoring Programme

NILU Norwegian Institute for Air Research

List of Abbreviations:

AQG(L)		Air Quality Guideline (or limit value)
AQMS	:	Air Quality Management System
ASU	:	Ain Shams University
AWS	:	Automatic Weather Station
BTX	:	Benzene Toluene and Xylene
CAIP	:	Cairo Air Improvement Programme
CEHM	:	Centre for Environmental Hazard Mitigation
CO	:	Carbon Monoxide
Danida	:	Danish International Development Assistance
DAS		Data Acquisition System
DKK	:	Danish Currency Unit
DQO	:	Data Quality Objective
EEA	:	European Environmental Agency
EEIS	:	Egyptian Environmental Information System
EIA	:	Environmental Impact Assessment
EIMP	:	Environmental Information and Monitoring Programme
EPA	:	Environmetal Protction Ahency
ESPS	:	Environmental Sector Programme Support
EU	:	European Union
GD	:	General Directorate (EEAA)
GIS	:	Geographical Information System
GOE	:	Government of Egypt
IGSR	:	Institute for Graduate Studies and Research (Alexandria)
NILU	:	Norwegian Institute for Air Research
NIS	:	National Institute for Standardisation
NO_2	:	Nitrogen dioxide
PM_{10}	:	Particles with diameter less than 10 micrometer
RDE	:	Royal Danish Embassy
SOP		Standard Operations Procedures
SO_2	:	Sulphur dioxide
QA / QC	:	Quality Assurance / Quality Control
TA	:	Technical Assistance
ToR	:	Terms of Reference
TSP	:	Total Suspended Particulate Matter
VOC	:	Volatile Organic Compounds
WHO	:	World Health Organisation

Table of Contents

1 Introduction

The EIMP project was launched in 1996 with the Egyptian Environmental Affairs Agency (EEAA) as the implementing agency for an environmental information and monitoring programme covering institutional support, coastal waters, air pollution, point sources emissions and the development of reference laboratories for improvement of the quality of monitoring data.

The EIMP project is funded by Danida and headed by COWI. NILU was as sub-consultant to COWI responsible for the design, installations, training and operations of the national air quality monitoring system for Egypt, to be operated by experts in EEAA and at selected monitoring institutions. The design and installations of the monitoring network were completed covering 42 sites all over Egypt in July 1999 while operations and training by expatriate experts continued till the end of 2000.

The EIMP Phasing-out Phase has been formulated to consolidate EIMP achievements, while gradually integrating the EIMP activities and staff into the existing EEAA administrative and organisational structure. The Phasing-out Phase started in 2003.

EEAA has expressed a need for a comprehensive assessment of the overall requirements for establishing a complete national air quality-monitoring network for Egypt. This request has been addressed and included as part of the Phasing Out Phase of the EIMP programme.

This report presents a proposal for a future National Air Quality Monitoring Network for Egypt to be operated by EEAA. The proposal combines the two existing networks developed by the Danida funded EIMP and the USAID funded CAIP programme. Input and comments given by the EIMP and the CAIP staff at EEAA as well as from the experts at the monitoring institutions at CEHM and IGSR have been included in this report.

2 The Objectives

The development objective of the Air Component of the EIMP programme has been to establish detailed knowledge of the ambient air quality in Egypt for the relevant authorities to act to improve the air pollution situation in Egypt. This has been achieved through the establishment of a high quality environmental monitoring programme.

The objectives of the future national air quality network for Egypt presented in this report have been formulated in co-operation with representatives from EEAA. The information collected so far from the EIMP programme and from the CAIP programme was used to formulate this programme. Also comments and suggestions given by the EIMP staff at EEAA as well as from the experts at the monitoring institutions at CEHM and IGSR has been used as input to the proposed monitoring programme.

An overall objective of the air quality measurement programme is to obtain a better understanding of the urban and residential air pollution as a prerequisite for finding effective solutions to air quality problems and for sustainable development in the urban environment.

Further it will be important to identify areas where the Air Quality Limit values are exceeded and to identify possible actions to reduce the pollution load and to improve the general environmental conditions of the country.

The main purpose of the air quality measurements will be to identify the possible exposure to the public and to people in general. Information will be collected on ambient air pollution levels in areas where people live and work. The measurements will cover areas of impact from various sources of pollution.

To enable evaluation and assessments of air quality and to enable trend analyses a network of **fixed stations** is needed. There are international rules for estimating the minimum number of sampling points for fixed measurements to assess the compliance with limit values for the protection of human health.

3 General design criteria

The first priority for location of monitoring stations in an urban or residential area will be to identify an area where you would expect the highest concentrations. In many urban areas of Europe as well as in Egypt this may be in a busy street canyon. In some regions it may be downwind from a major industrial source or in areas of extensive waste and agricultural burning.

The following considerations are sited from the European Air Quality Daughter Directives and relates to fixed measurement points directed at the **protection of human health** (Macro scale siting):
Sampling should be sited to

1. Provide data on the areas within polluted areas or urban agglomerations where the highest concentrations occur to which the population is likely to be directly or indirectly exposed for a period which is significant in relation to the averaging period of the limit value(s);
2. Provide data on levels in other areas within the agglomerations, which are representative of the exposure of the general population.
3. Avoid measuring very small microenvironments in their immediate vicinity. As a guideline, a sampling point should be sited to be representative of air quality in a surrounding area of no less than 200 m^2 at traffic-orientated sites and of several square kilometres at urban-background sites.

The information shall be available in such a form that it is suitable to:

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

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

3.1 Air pollutants to be measured

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

Local and regional authorities are using the selected set of environmental indicators as a basis for the design of monitoring and surveillance programmes and for reporting the state of the environment.

Air quality indicators should:

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

Measurement techniques should be reasonably accurate and within an acceptable cost. The effect of indicators on health impact, building deterioration, vegetation damage, etc., should be adequately documented and linked to public awareness. Selected indicators should respond to mitigation actions to prevent manmade negative impacts on the environment.

The most commonly selected air quality indicators for urban air pollution are:

- ➢ Nitrogen dioxide (NO_2),
- ➢ Sulphur dioxide (SO_2),
- ➢ Carbon monoxide (CO),
- ➢ Particles with aerodynamic diameter less than 10 μm (or 2,5 μm), PM_{10} ($PM_{2,5}$),
- ➢ Ozone.

Most of these indicators have been identified in the air quality limit values as presented in the Law no. 4 for Egypt. Based on impact to public health some selected air quality guideline (AQG) values for most of these indicators have also been presented by the World Health Organisation (WHO, 1987 and 1995).

Air quality limit values have been presented as the Egypt's Air Quality Standards and Limit Values as stated in Law number 4 of 1994 (EEAA, 1994). Revisions of these standards have been discussed several times during the EIMP programme. In the discussions of high PM_{10} concentrations frequently measured in Egypt, the natural background levels originating from wind generated dusts in the desert areas was evaluated in a Memo dated 31 May 2003 (Sivertsen and Dreiem, 2004, Appendix F2). See also Appendix A, which presents the proposed new limit values as well as the limit values and targets for Europe

In the European EUROAIRNET programme priority indicators have been selected for different types of impact to the environment. A summary of the first priority pollutants as given by the European Environmental Agency (EEA) is presented in the Table below.

Table 1: Priority pollutants included in the urban air quality monitoring programmes.

No.	**ISO-Code**[9]	**Formula**	**Name of pollutant**	**Units of measurement**	**Average over**
1.	01	SO_2	Sulphur dioxide	$\mu g/m^3$	1 h
2.	03	NO_2	Nitrogen dioxide	$\mu g/m^3$	1 h
3.	24	PM10	Suspended particulates (< 10 µm)	$\mu g/m^3$	24 h
4.	39	PM2.5	Suspended particulates (< 2.5 µm)	$\mu g/m^3$	24 h
5.	15?	PM1	Suspended particulates (< 1 µm)	$\mu g/m^3$	24 h
6.	22	SPM	Suspended particulates (total)	$\mu g/m^3$	24 h
7.	19	Pb	Lead	$\mu g/m^3$	24 h
8.	08	O_3	Ozone	$\mu g/m^3$	1 h
9.	V4	C_6H_6	Benzene	$\mu g/m^3$	24 h
10.	04	CO	Carbon monoxide	mg/m^3	1 h

Also the US EPA and other national and international authorities have identified indicators similar to the ones presented above. To provide international inter comparisons it is important to include at least the first priority pollutants in the database.

3.2 Site characterisation

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

Data should represent measurements collected at different stations representing different microenvironments, characterised by:

SC:	**Street canyon,**	**RS:**	**Roadside**
I:	**Industrial**	**UB:**	**Urban Background**
R:	**Residential**	**B:**	**Regional Background**

Descriptions of each site should follow the Meta database for the measurement programme, which also includes specifications of parameters, samplers and monitors. Meteorological data should be measured at open sites so that the wind and dispersion conditions are representative for a larger area. Simple statistics on prevailing wind directions has to be prepared and presented as such, and these data will also provide a basis for the air quality assessment.

Another system of classification is to divide the measurement stations into 3 types of areas; urban, suburban and rural. In each of the areas there may be 3 types of stations; traffic, industrial and background. The background stations are divided into; near-city background, regional and remote background stations.

Descriptions of the areas are given in the Table below:

Table 2: Area type classification and descriptions.

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

3.3 The air quality monitoring system

A modern air quality monitoring system should include:

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

The measurements consist of monitors and samplers of different kinds developed for collecting information about the indicators selected. Instruments used in the EIMP/EEAA programme as well as in the CAIP developed system will be presented later.

The key features of a modern air quality monitoring and assessment system will normally include an integrated approach that combines monitoring, surveillance, information and planning and enables the user in a user friendly way to not only access data quickly, but also to use the data directly in the assessment and in the planning of actions.

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

3.4 Instruments and samplers

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

Table 3: Different types of instruments, their abilities and price.

Instrument type	**Type of data collected**	**Data availability**	**Typical averaging time**	**Typical price (US $)**
Passive sampler	Manual, in situ	After lab analyses	1-30 days	20
Sequential sampler	Manual /semi-automatic , in situ	After lab analyses	24 h	5 000
Monitors	Automatic Continuous, in situ	Directly, on-line	1h	>20 000
Remote monitoring	Automatic/Continuous, path integrated (space)	Directly, on-line	<1 min	>150 000

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.

Meteorological data from the surface boundary layer is needed, and is normally collected along 10 m towers. In some cases data may be available for the whole atmospheric boundary layer. Automatic weather stations are currently being used in most field studies. Meteorological “surface data” are normally collected together with the air quality data and transferred to a central computer together with air pollution data. The Automatic Weather Stations (AWS) requires sensors for the most important parameters such as:

1. Wind speeds,
2. Wind directions,
3. Relative humidity,
4. Temperatures or vertical temperature gradients,
5. Net radiation,
6. Wind fluctuations or turbulence,
7. Atmospheric pressure and
8. Precipitation.

3.5 Data quality objectives

Procedures for Quality Assessment (QA) and Quality Control (QC) are developed to ensure that the data emerging from the monitoring programme will at least satisfy the data quality objectives (DQOs) defined by the responsible authorities.

Complete QA/QC procedures are rather complex, and they should be documented. A very important element in the quality control procedures is the calibration procedures and the trace ability of the calibration standards used in the network and at each station. Institutions responsible for the QA/QC procedures and their follow-up may be national, regional or local

The accuracy of the air quality data and their spatial and temporal representativeness is obviously very important for the quality of the assessments produced from the data. Data Quality Objectives (DQOs) are set, so that when they are fulfilled, one can use the data confidently for the purposes for which DQOs have been set.

The objectives that guide the quantification of DQOs, are set to enable comparison of air quality internationally. The data shall enable detection of the trend in air quality in the country as well as in each area where stations are located, over a reasonable time period (3-5 years, dependent upon the magnitude of the trend). The data shall also enable the assessments of exposure.

DQOs have been set for the following Data Quality Indicators:

- Accuracy
- Precision
- Area of representativeness
- Data time coverage

A summary of the European data quality objectives set so far is presented in the following table:

Monitoring objective	Data Quality Objectives				
	Accuracy	Precision	Data completeness		Representative-ness (spatial)
			Temporal	Spatial	
Mapping/comparability	≤ 10%	≤2 ppb	≥90%	1)	1), 2)
Trend detection	3)		≥90%	1)	1), 2)

1) The DQOs are set for station-by-station comparison (for same station class) and for trend detection at any one station.
In the case of comparisons of e.g. cities or larger entities, or trend assessment for larger areas, the requirements to spatial coverage and representativity would be strict, and to quantify those requires more analysis.
2) To be eligible for comparison with a station of the same class in another location (city, country), specified representativeness criteria should be complied with.

To detect a trend with certain accuracy, the combined accuracy and precision of the measurement must be considerably better than the expected trend (expressed as relative change.

3.6 Data retrieval

For every site there is a need for a data acquisition system (DAS) to receive the measurement values collected by one or several gas or dust analysers, meteorological sensors or other parameters. These parameters must be stored, every minute, every 5 min. or every hour locally and then transmitted to a central computer via modem and telephone lines. The local storage time must be several days or up to some months in case of problems with modem, transmission lines or the central computer.

3.6.1Data retrieval via telephone lines

The data retrieval from monitoring stations, which are equipped with modems and telephone lines, may be performed by the Computer centre using the following procedures:

- The Computer centre data base system asks for data automatically once a day (normally during night hours, at 02:00 hrs).
- The Computer centre operator initiates download (manually) which requires that the modem is functioning.

3.6.2Monitoring stations without telephone lines

If telephone lines are not available at a monitoring station, data have to be collected manually on any form of electronic storage media. Calibration values should always follow the diskettes or memory stick, as there is no procedure for retrieving this information automatically.

The data from diskettes, CDs or memory sticks should be imported to the Central data base system directly and checked. Reports should be printed daily or as a minimum on a weekly basis.

3.6.3Sampling stations

Data from manually operated sampling stations will have to be collected regularly dependent on the sampling schedule specified by the measurement programme. Air samples are collected mostly on filters; dry or impregnated. These filters are prepared in the chemical laboratory at the monitoring institution and will have to be brought back for analyses.

These data are manually imported into the database after quality controls and verification of the results.

3.7 Quality Assurance and QA/QC procedures

It is important for the operations of a monitoring network to include a comprehensive QA/QC programme to assure that the monitors are actually providing concentrations within the required level of uncertainty, and that malfunctions and errors are detected and corrected.

3.7.1The quality organisation

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** are normally running the 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.

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.

3.7.2 Documentation

It will be necessary to develop and implement a complete QA/QC system for the operational level of the air quality monitoring programme. Complete documentation will have to be established, which explains in detail how to perform and record all operations necessary to run, maintain and calibrate the instrumentation both in the laboratory and in the field. The procedures are supposed to be used by the operators in their daily work.

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 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
- Emission inventory maintenance
- Running models
- Quality System audits
- Training
- Document handling and document version control

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.

The operation of the central data retrieval system and database system will be documented in specific standard operational procedures, SOPs. The QA/QC procedures for the data retrieval system will include SOPs on:

- Operation of the data retrieval system
- Instrument status checking
- Data evaluation

The SOP on operation of the data retrieval system will cover activities such as defining, changing and removing sites in the data retrieval system, specifying data retrieval schedules and solving data communication problems. These operations will be performed when needed.

The SOP on instrument status checking will cover remote checking of instrument status and performance as well as alarm handling. These operations will be performed regularly, e.g. once a day.

The SOP on data evaluation will cover the technical data evaluation process. This is the first level of data evaluation and is based on technical knowledge about the data. It includes data inspection, identifying and marking invalid data, converting raw data to scientific units and making the final data ready for statistical evaluation. These operations will be performed regularly, e.g. once a month.

The exact content of these SOPs will depend on the selected system. The operation of the data base system will also be documented in specific SOPs. The QA/QC procedures for the data base system will include a SOP on Data base maintenance

The SOP on data base maintenance will cover typical data base maintenance activities such as data base backup, data base tuning and space allocation. These operations will be performed regularly. The period will be defined after gaining experience with the installed system, number of stations, etc.

3.8 Reference laboratory

The Reference Laboratory for air quality, as it has been established in Egypt at NIS, will be responsible for administration and maintenance of the Quality System.

This includes preparing new procedures, updating the quality documentation, informing the network operators on changes and updates in the Quality System.

The Reference Laboratory will also maintain the reference calibration standards. The reference standards will represent the highest level of calibration in the measurement network. The Reference laboratory will provide trace ability to the reference standards to all measurement instruments in the monitoring network.

The activities to ensure trace ability for calibrations at Reference Laboratory Air are at present organised in the following way:

1. The Reference Laboratory performs calibrations, audits etc., and
2. EEAA purchases the reference gases and the calibration services from Switzerland necessary to establish trace ability in the calibration and other activities.

This arrangement is not always optimal and the Reference laboratory personnel have stated that the arrangement may result in negative effects. In the future programme it may be necessary to discuss more optimal solutions.

Finally, the Reference Laboratory will perform audits in the measurement network to assess the actual quality of the measurements.

3.8.1Audits

Audits from NIS have been undertaken routinely as part of the EEAA/EIMP programme. These audits are working, but the system will have to be followed up by EEAA and the reports presented in the bi-annual seminars will represent a basis for improvements and upgrading.

Audits as part of the Quality System will have to focus on operational matters like maintenance, calibration, action criteria, data evaluation, record keeping, training and audits follow-up. The calibration laboratory at the Monitoring institution (CEHM) will ensure that the measurement instruments are in good working order and calibrated with trace ability to the Reference laboratory.

As part of the audits it will also be important to include inspections of the intake systems, and check that cleaning and maintenance has been properly followed up by the Monitoring Institutions.

3.9 Data storage and database

Databases have been established at the Monitoring Institutions (CEHM and IGSR) and at EEAA. These databases occasionally need upgrading, and updated computers and hardware systems may also be needed.

To meet the future requirements of fast and on-line access to air quality data and assessments we have indicated that that EEAA should start preparing the tools for performing an air quality management planning system. The tools for such assessment and abatement strategy planning procedures are available.

At least a measurement database has to be established to store, retrieve and organise the measurements in a fast and organised formate. It should be possible to carry out various analyses on data stored in the database, such as statistical calculations and quality assurance tests. Data will also have to be viewed graphically and printed.

The databases contain information that enables an evaluation of the actual state of the environment and it includes data for establishing trend analyses, warnings and the undertaking of countermeasures in case of episodic high pollution.

The data in the measurement database are normally organised in data series (measurement time series). The data series are identified by a set of properties that describe the values. The necessary properties to identify data series in the measurement database are given in the table below:

Information	**Properties describing the data series**	**Properties describing each value**
Where are the measurements taken	Station, Measurement position	Description, map, UTM
What is measured	Medium, Component (Indicator), Unit	Formula, unit
How is this measured	Instrument, Sampling method, Analysis	
When is this measured		From-time, To-time
What was the result		Value
Quality status of the measurements		Quality status flag, Exception flag

One available database system that meets the requirements of modern air quality assessment is the AirQUIS system, which was developed by the Norwegian Institute for Air Research (NILU) (www.NILU.no) to handle a number of air pollution tasks and challenges. It is based on a Geographical Information System (GIS), it is operated on an Oracle database and it supports direct data and information transfer, data presentation tools as well as statistical and numerical modelling capabilities for now casting and forecasting. It also supports Internet based data dissemination tools. Such system is presently being tested in EEAA.

The AirQUIS system consists of several databases, which serve as main storage platforms for:

- On-line collected ambient air quality data,
- Calculated fields of emissions, concentrations and exposure,
- Historical data with trends, background information (land use, population)
- National and international regulations and air quality limits
- Information on the support and decision-making processes

The system offers several options for graphical presentation. Time series data can be present updated e.g. every hour included one or several indicators.

4 Existing EEAA air quality measurement programmes

The proposal for a future National Air Quality Monitoring Network presented in this report has been based on the results and content of two air quality monitoring programmes developed in Egypt during the last 8 years. These programmes are:

- EIMP-air (Environmental Information and Monitoring Programme) supported by Danida
- CAIP (Cairo Air Improvement Programme) supported by USAID

EEAA has expressed a need for a comprehensive assessment of the overall requirements for establishing a complete national air quality monitoring network. Once a plan has been elaborated EEAA will seek funding from relevant sources, including international donors, but there is not necessarily any commitment from Danida's side to support further development of Egypt's air quality monitoring network. The regularly occurring air pollution “episodes” in Cairo has further accentuated this need during the autumn season.

In the EIMP Phasing-out Phase proposal it was stated that this report would include:

- Assessment of current EIMP and CAIP air quality monitoring networks.
- Establishment of EEAA objectives for a complete national air quality monitoring network.

The existing networks are briefly presented and assessed in this chapter.

4.1 The EIMP air quality monitoring programme

The Environmental Information and Monitoring Programme, EIMP, was established for Egyptian Environmental Affairs Agency (EEAA) in co-operation with Danida in order to have a view of the present environment. As part of the EIMP programme a national air pollution-monitoring programme consisting of a total 42 measurement sites has been developed and established.

The design of the EIMP Air Quality Monitoring network included:

- Data collectors; sensors and monitors
- Data transfer systems and data quality assurance/control procedures
- Data bases and
- Data distribution systems.

4.1.1 The sites

The design, development, construction and installation of the EIMP measurement programme started in 1997 and were completed in July 1999. The Centre of Environmental Hazard Mitigation (CEHM) at Cairo University and the Institute of Graduate Studies and Research (IGSR) at Alexandria University are operating on behalf of EEAA, a total of:

- 14 sites located in Greater Cairo area,
- 8 sites in Alexandria area,
- 7 sites in Delta,
- 3 sites in Canal area and
- 10 sites in Upper Egypt and Sinai

The total programme include more than one hundred instruments in field at any time, consisting of:

- 46 automatic monitors for SO_2, NOx, PM_{10}, O3, and CO,
- 26 AirMetrics and Hivol PM_{10} samplers
- 14 sequential samplers for SO_2 and NO_2
- 5 High volume samplers for TSP
- 18 dust fall collectors
- 8 Automatic Weather stations
- A number of passive samplers (flexible)

The sites selected represent different area types, bearing in mind that the EIMP programme is mainly designed to monitor the impact in areas where people live.

The area characteristics where instruments are already operating are:

- Industrial areas (represented by 12 sites),
- Urban city centres (9 sites),
- Streets and road sides (3 sites),
- Residential areas (15 sites),
- Regional and background areas (3 sites).

The field operations require that trained monitoring experts are visiting the stations every week. Other experts are responsible for the databases and quality assurance of the programme, while a third set of experts should take care of maintenance, repair and calibrations. All these instruments are being operated by a team of trained experts at CEHM at Cairo University (for Cairo, Canal area and Upper Egypt) and IGSR at Alexandria University (for Alexandria and the Delta region).

A map showing the sites in Egypt is presented in Figure 1.

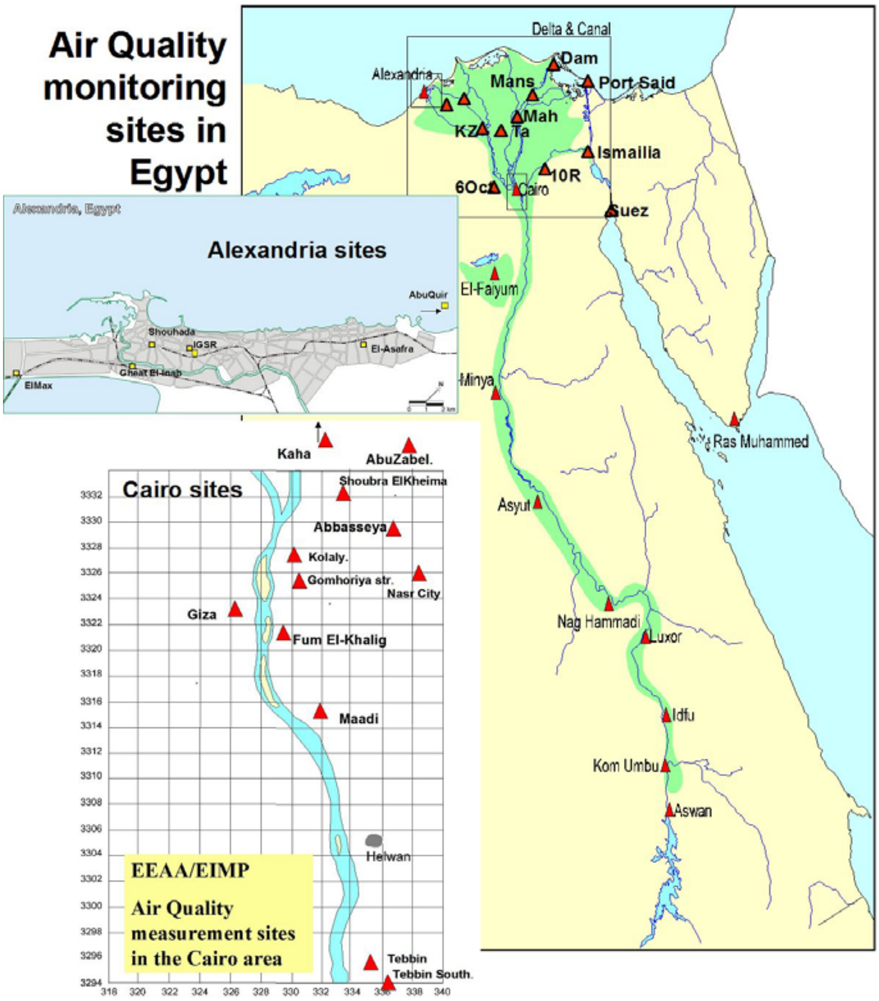

Figure 1: The EEAA/EIMP air quality monitoring sites in Egypt as operated in 2004.

4.1.2 Indicators and compound

The indicators and compounds selected for the EIMP air quality monitoring programme are in accordance with international recognised priority pollutants, and are linked to international guidelines and standards. The guidelines, as given by for instance the World Health Organisation (WHO, 1987), US-EPA or the European Union have been the basis for the selection of basic priority pollutants.

These represent the main air pollution indicators, and include usually:

- Sulphur dioxide (SO_2),
- Nitrogen dioxide (NO_2) and/or NOx (nitrogen oxides),
- Total suspended particulate matter (TSP), or better PM10 (suspended particles with diameter less than 10 micrometer),
- Ozone (O3)
- Carbon monoxide (CO).

The indicators selected also meet the requirements of the Law number 4 for the Environment, Egypt 1994 (EEAA, 1994). Not all parameters are being measured by the EIMP/EEAA programme at all sites. This will be dependent upon site specifications and typical dominating sources in the specific area. In some sites in Egypt hydrocarbons (NMHC or VOC) and dust fall are also being measured.

Black smoke (BS) or soot has been analysed by the EIMP programme since May 1999. Volatile Organic Compounds (VOC) has also been measured as part of the EIMP programme. For these pollutants no Air Quality Limit values are available.

Dust fall (DF) measurements are already part of the programme, as dust is assumed to be a major air pollution problem in Egypt. No Air Quality Limit values are given for dust fall. However, western countries normally state that whenever dust fall values are less than 10 g/m^2 per 30 days, the area may be considered clean.

Several reports have been prepared based on the measurements, and a selection of different publications can be found in the list of References. The following typical reporting procedures are being followed:

- Daily report with a statement of the last 24-hour air quality (at EEAA)
- Monthly reports summarising the air pollution at all sites in Egypt (at EEAA)
- Quarterly reports (data presentations from CEHM and IGSR)
- Annual reports (summary from CEHM and IGSR as basis for report in Arabic language produced at EEAA)

In addition a number of newsletters, papers and memos have been produced during the course of the project.

4.1.3 Summary of the air quality in Egypt

Suspended dust (measured as PM_{10} and TSP) is the major air pollution problem in Egypt. Annual average concentrations of PM_{10} range between 100 and 200 µg/m^3 in urban and residential areas and between 200 and 500 µg/m^3 near industrial areas. Daily average concentrations of more than 6 times the Air Quality Limit value for Egypt are being recorded occasionally (2 to 3 % of the time) in the urban areas of Cairo. The natural background concentration of PM_{10} in Egypt has been evaluated to represent levels close to or around the Air Quality Limit value of 70 µg/m^3 as a daily average.

The concentration levels of SO_2 have also been observed to exceed the Air Quality Limit values in industrial areas and during some occasions in the big cities. Both the long term (annual averages) and the short-term (1-hour average) Air Quality Limit levels have been exceeded.

Eight-hour average CO concentrations in streets and along roads in Cairo have frequently exceeded the Air Quality Limit value. In the streets of Cairo, with high traffic density, the 8-hour average CO concentration, especially during daytime hours, was exceeded in 5 to 33 % of the time during the last 4 years.

High concentrations of surface ozone have been observed as a result of regionally produced secondary pollutants in the Cairo region. Also the background measurements of tropospheric ozone at Ras Mohamed, at the southern tip of Sinai, show high concentrations especially in the summer season. On an annual basis the

8-hour average limit value (120 µg/m^3) was exceeded in the urban area of Cairo in about 5 to 10 % of the time in 2000.

NO_2 is not a big problem in Egypt based on a rather high air quality limit value of 400 µg/m^3 as a one-hour average limit value. The 24-hour average limit value of 150 µg/m^3, however, was exceeded during one to five days in the streets of Cairo.

4.2 Assessment of the CAIP programme

Meetings with the experts operating the CAIP air pollution monitoring programme have been held to evaluate the quality of the measurements as well as giving input to planning of one total national monitoring programme for Egypt.

The original CAIP programme was measuring PM_{10} /$PM_{2,5}$ in the greater Cairo area at 36 sites. This has been reduced to 20 sites. A map in Figure 2 indicate the positions of the following sites:

Table 4: Sites operated by the CAIP programme for measurements of PM_{10} and $PM_{2.5}$.

ID	Site	code	start	Type	Northing	Easting	PM2,5	PM10
1	ElQualalySquare	EQS	1June	Traffic	3326603	330594	X	X
3	KobryElKobba	MET	1June	Mixed	3328951	335190	X	X
7	TebbinSouth	TBS	17July	Industrial	3292317	336948	XC	XC
10	OldMaadi	EEA	1June	Residential	3315847	331076	X	X
11	Giza	AGL	10June	Traffic	3323063	327125	X	X
13	6thOctoberCity	OCT	1-nov	Residential	3313591	298716		X
16	Mokotam	ATI	1-nov	Residential	3321420	335413		X
18	ShobraKheima	MYC	1-nov	Residential	3332591	332797		X
19	ElSahel	TTI	1-nov	Industrial	3332027	332511	XC	XC
21	Matarya	DRC	1June	Mixed	3333406	337635	X	X
22	ElWaily	AMP	1-nov	Mixed	3330857	333996		X
25	Imbaba	HTI	1-nov	Residential	3329039	328829		X
26	Kaha	KFC	1June	Background	3350606	326517	X	X
29	Basateen	LRC	1June	Mixed	3318364	331495	X	X
31	TahrirSquare	AUC	1-nov	Mixed	3324855	329990	X	X
32	Zamalek	BIS	1-nov	Residential	3326590	328661	X	X
33	Helwan	HFS	1-nov	Residential	3302944	338983		X
34	ElMassara	SBH	1June	Mixed	3309097	335395	X	X
35	Heliopolis	OLS	1-nov	Residential	3331676	339733		X
37	AbuZabal	ABZ	1June	Industrial	3350930	342637		X

Sampling is undertaken using AirMetrics samplers every six day. The analyses have been undertaken at the Institute for Geological Surveys. Monthly reports are being prepared, but are delayed by about 5 months. The analyses take 2 months to finalise. This “problem” are being looked into and would be solved if analyses was to be undertaken at EEAA.

The CAIP programme also operates 4 meteorological stations (simple Met1 instruments). The meteorological stations are located at:
Kaha, Aby Zabal, Maadi and Tabbin South.

Software supplied by these instrument do NOT allow hourly data for longer periods to be imported into a database

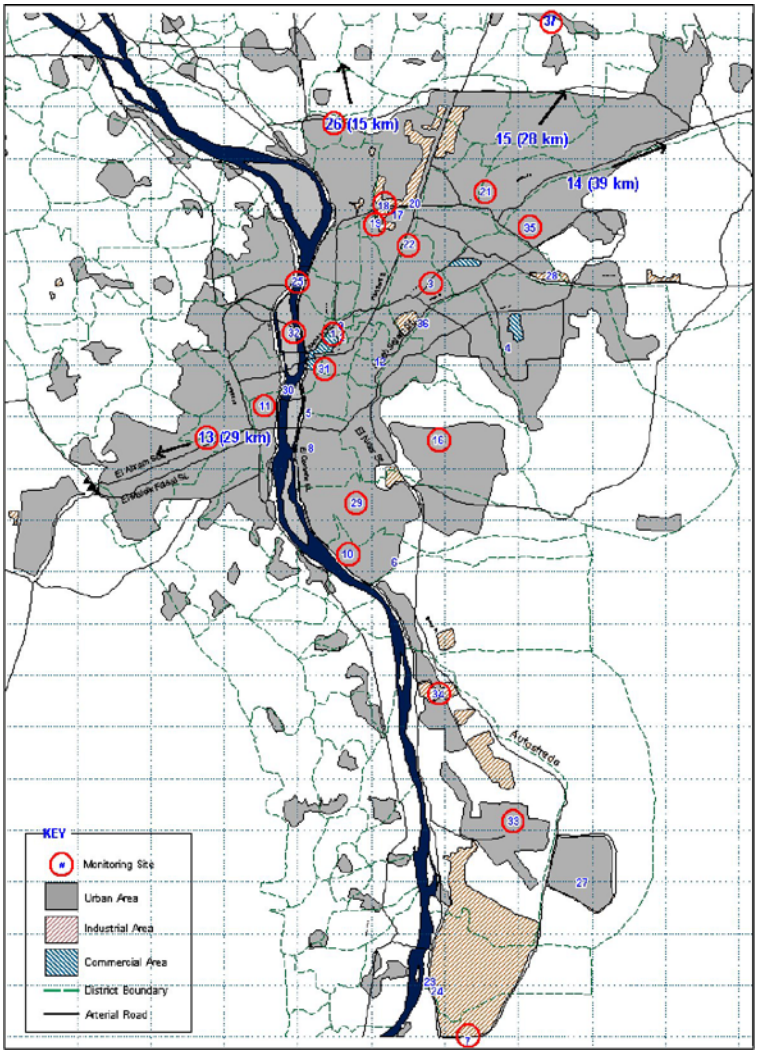

Figure 2: Measurements of PM_{10} and $PM_{2.5}$ operated by the CAIP programme.

The Shoubra site together with Abu Zabal is considered very important. Also Tabbin South is considered an important measurement area due to the high exposure of suspended dust to the population here. The Kaha site should according to the objectives represent a "background" area. However, there are so much activities, open air burning etc. in that area that the concentrations of PM_{10} are on the same level as in the city of Cairo.

From the CAIP network we have selected five high priority sites, which will have to be part of the future network. Table 5 shows that the typical average PM_{10} concentrations at these sites range between 200 and 250 $\mu g/m^3$.

Three of these sites are coinciding with measurements undertaken as part of the EIMP programme. Imbaba and ElWaily, however, are new areas, which will be included in the future. At these sites it may also be necessary to measure $PM_{2.5}$.

Table 5: Five selected highly polluted sites for PM_{10} measurements in the future.

TOP 5 PM_{10}

Site_No	Site_Code	Easting	Northing	Average
37	Abu Zabal	342637	3350930	249,6
18	Shobra Kheima/MYC	332797	3332591	218,3
25	Imbaba	328829	3329039	215,5
22	El Waily	337635	3330857	213,8
1	El Qualaly Square	330594	3326603	203,2

A comparison of PM_{10} concentrations measured by the CAIP programme and by the EIMP programme has been undertaken as shown in Figure 3.

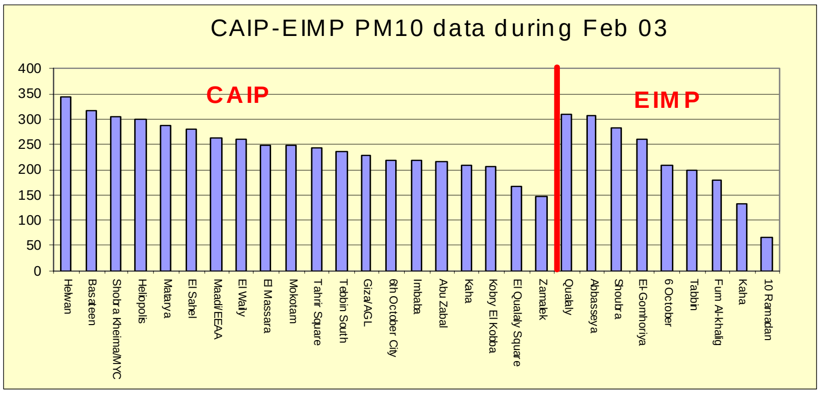

Figure 3: An example of comparisons between PM_{10} concentrations measured by CAIP and EIMP. Different types of samplers were used in EIMP. None of the sites are the same.

These types of comparisons have been run for several months. The general conclusion is that the levels of PM_{10} measured by CAIP are similar to those measured by the EIMP programme.

In the proposal for future air quality measurements in Egypt we have included PM_{10} and at some sites $PM_{2.5}$ measurements taking into account that the quality of the measurements seem to be comparable. The future common handling and analyses of filters will have to be decided by EEAA.

5 Proposed future air quality monitoring programme for Egypt

5.1 Priorities for Egypt

A list of priorities will have to be prepared for keeping up an air quality network for EEAA that will meet the most urgent needs and at the same time meet the international requirements for quality and standard.

Such a list will include discussions on:

- Indicators (or compounds)
- Measurement methods
- Sites and areas to monitor
- Data retrieval system
- Data dissemination and data storage

The most important **indicators** for air pollution in Egypt, when related to international guidelines and standards are particulate matter (PM). The network of continuous on-line monitors as well as the manually operated AirMetrics network will have to be considered as one total system.

The second priority pollutants will be NO_2, ozone, SO_2 and CO (in that sequence). Other indicators such as BTX could be introduced in the future, while PAH and other organic compounds may be measured intermittently and not on a continuous basis. Some of the points of view as well as conclusions are presented in the following.

5.2 Indicators and instruments

The most important air pollution indicator in Egypt is at present PM measured as PM_{10}. A basic network of monitors will have to be established for on-line transmission of data and information.

In addition to the on-line network of PM_{10} monitors, a number of sites should report PM_{10} and $PM_{2.5}$ based on the AirMetrics network established by CAIP and EIMP. These data are manually collected and analysed and reported after some weeks.

The second important indicators for characterising air quality in Egypt are probably ozone and NO_2. The available data have reported that the limit values have been exceeded several times in many areas.

SO_2 concentrations will have to be measured in all major industrial areas. In some of the industrial areas we have recorded that national and international limit values have been exceeded frequently. Also at least one site in central Cairo and Alexandria will have to report SO_2 originating from diesel-operated vehicles.

At a selected number of street and roadside stations also CO will have to be monitored. Exceeding of limit values has mainly been reported for the 8-hour average concentrations. VOC should be measured in areas where hydrocarbon emissions are expected based on a manually operated sampling programme. One on-line BTEX station could in addition be established in the city centre of Cairo.

Additional compounds influencing on the composition and nuisance of atmospheric pollutants have been discussed. In some areas, especially south of Alexandria, H_2S may be a major problem to the population. Ammonium chloride has been shown to be the third largest component of PM_{10} concentrations measured at Kaha, Zamalek and downwind from the Kaliobeya area. The reason may be the large emissions of ammonia from hundreds of chicken farms combined with the use of fertilisers in agricultural activities.

There is still also a need for analyses of lead near some of the industrial activities in Egypt. There will have to be a schedule and sampling programme prepared for this purpose based on the high volume PM_{10} filter samplers and some of the AirMetrics filters collected.

5.3 Sites and areas

The sites where air pollution will have to be measured and reported in the future have been discussed. We have preferred to divide the measurement sites into 3 classes of sites. A set of first priority sites has been selected to obtain on-line data as a basis for daily reporting of air quality. The sites should be the following:

- ElQuolaly, Cairo city centre highly impacted by traffic
- FumAlKhalig, Cairo, traffic and general urban
- Abbasseya, Cairo, urban background/ residential
- Gomhoreya Street, Cairo, street canyon site
- Kaha, upwind from prevailing winds at Cairo
- ElShouhada, central Alexandria traffic and general activities
- KafrZayat, most polluted industrial site in Delta

In the future it may be necessary to install an on-line site in Heliopolis. We will propose that the shelter and instruments to this site will be moved from Assyut.

Instruments presently operated at the Giza Campus site will be moved to a new site to be established at Giza Square. This site should measure NO_2, SO_2 and PM_{10}. Only ozone will be measured at Giza Campus to evaluate the regional formation of ozone in the greater Cairo area.

To keep up and operate an on-line air quality monitoring programme in Upper Egypt is very expensive and it is also labour demanding. It is therefore suggested that most of the measurement programme for Upper Egypt would be based on sampling systems, which will be collected and analysed in a central laboratory

However, on-line monitoring of SO_2 should be performed at the site in KomOmbo. This monitor will be taken from Aswan. In Aswan we will continue the on-line measurements of ozone.

Several changes, improvements and additions have been prepared and effectuated during the Phasing-out Phase of the EIMP programme as presented in the next chapter. New monitoring sites, improvements at existing sites as well as new procedures for field calibrations have been introduced.

5.4 New sites already decided

A new location was selected for monitoring in Suez in May 2003 (Sivertsen and Dreiem 2003a, Appendix B.8). Lack of permissions from the local police resulted in a change of position. The new site has been operated since the summer of 2004.

Danida had approved two new sites for installations in Beni Suef. A site visit and site studies were undertaken on 21 October 2003. A proposal for installations included a rough cost estimated is presented in Mission report 03 (Sivertsen and Dreiem 2003b,Appendix B4).

The air quality network will consist of two main stations in the city of Beni Suef. The main stations will mainly contain automatic monitoring equipment located at permanent measurement sites. Two permanent sites have been selected.

Meteorological measurement will be undertaken along a 10 m mast at the station located at the roof of the Governerate building. In the most polluted areas also PM_{10} measurements will be undertaken with simple AirMetrics samplers. A few passive-sampling sites has also been identified.

5.5 Instrument lifetime and upgrading

The normal lifetime of air quality monitors that are being used in the EIMP programme is between 5 and 10 years. This implies that many of the monitors that have been installed since the end of 1997 till 1999 already are reaching the end of their normal lifetime.

To keep up the quality in the monitoring system, as well as assure sustainability we have proposed that old instruments are gradually replaced with new instruments. The procedures in other countries demand that instruments are taken off field when expensive parts indicate that the lifetime of the instrument has been reached. The instrument is then collected for storage in the laboratory for 5 years, and used for spare parts while a new instrument is being installed in field.

We will also propose to move gas monitors around in the system to assure that the most interesting and most impacted areas receive the attention needed. For the PM_{10} monitors, however, an urgent need for upgrading the instrument park has been demonstrated and reported in a memo presented to EEAA on 5 October 2004. The background is that the on-line continuous measurements of PM_{10} (as an indicator for suspended particles in air) are considered the first priority in the air-monitoring programme for Egypt.

There will also soon be a lack of gas monitors. Only about 33 out of a total of 53 monitors installed as a part of the EIMP programme were operating in October 2004, as seen from Table 6.

Table 6: Operating monitors in the EIMP programme as of October 2004.

Parameter	**Working monitor**	**N**	**Not working**	**N**	**Tot**
PM_{10}	Quo, Tab, Abb, Fum, Kah	5	IGSR, KaZ, Ass, Mah	4	9
NOx	Gom, Tab, Fum, CaU, Sho, Suez, KaZ	7	Quo, Mad, Kah, Ass, Man, IGSR?	6	13
SO_2	Quo, Gom, Abb, Tab, Mad, Fum, Suez?, IGSR, Sho, KaZ	10	Sho, CaU, Ass, Asw, Mans? Mah?	6	16
O_3	Abb, Asw, Ras, IGres	4	Kah, CaU?	2	6
CO	Gom, Fum, IGS	3			3
met	Ab, Tab, Asw, Mans?	4	Kah, IGres	2	6
	Total avail. monitors	**33**		**20**	**53**

There were several reasons for monitoring being out of operations; they were taken in for calibrations, for repair, they had missing spare parts, unknown errors in the instrument, and some instruments are already taken out of operations forever for the reason that crucial parts cannot be obtained from the instrument provider.

5.6 Proposed future air quality measurement programme

Based on the discussion with EEAA experts and the teams at CEHM, IGSR as well as the personnel working with the PM sampling programme developed during CAIP, we have presented a first proposal for an updated measurement programme for air quality in Egypt. This proposal is presented in the following 3 Tables.

5.7 The highest priority stations for on-line transmission of data

A total of nine high priority stations will be operating on-line transferring data on a daily basis to the central computer at CEHM and at EEAA. These stations will have to get first priority in the future system. QA/QC as well as calibrations and instruments will have to be available at all times.

When considering the present status of the monitoring system as presented in Table 1 we will have to reorganise and move some of the monitors already located at different sites. A complete plan for this upgrading will have to be developed.

Table 7 presents the eight priority sites as well as the monitors and indicators included.

Table 7: First priority on-line monitoring system for Egypt..

ID	**Station Name**	**Area Type**	**On-line data**					
			Monitors					
			SO_2	NO_x	PM_{10}	O_3	CO	Met
Kol	El-Kolaly	Urban Center	1	1	1			
Gom	El-Gomhoryia	Street Canyon	1	1			1	
Abb	Abbassyia	Urb. /Res.	1		1	1		1
FKa	Fum El-Khalig	Roadside/Urb.	1	1	1		1	
GiS	Giza square	Urb/road	1	1	1			
Kah	Kaha	Regional back		1	1	1		1
Sh	El Shouhada	Traffic	1	1	1		1	
KZa	Kafr El-Zayat	Industrial/Res.	1	1	1			1
Hel	Heliopolis	Urban	1	1	1			

At Quolaly we also propose to measure BTEX continuously. We see that there is a need for 8 PM_{10} monitors only in this part of the monitoring programme. Presently there are only 5 such instruments operating in Egypt as seen from Table 6.

In the future it may be possible to establish an automatic data retrieval system collecting the data every hour into a central database. The AirQUIS database has been tested at EEAA, and discussions have proven that automatic transfer is possible and may be developed.

5.8 Second priority network

A second set of air quality measurement stations will combine monitors and samplers. Among these stations are also four selected sites for ground level ozone measurements; Ras Mohamed, Aswan, Alexandria IGSR Regional and the Cairo University campus area (at Giza). Together with the two priority sites Kaha and Abbasseya included above, the ozone programme will represent different purposes, and may give a good picture of the background ozone level in Egypt as well as regionally formed ozone.

There is also a new site proposed in the Governerate of Sharqiya to monitor the plumes generated from burning of agricultural waste in eastern Delta. The site proposed is located between Bilbeis and Minyet ElQamh, in the small village of Nishwa.

The new sites, which are now being established in Beni Suef are combined monitoring and sampling sites, which are also included in the total programme for EEAA

There will thus be a total of 24 sites equipped with monitors of some kind. Whenever monitors break down totally, the first priority programme will have to be secured. Monitors from sites such as ElMahalla and ElMaadi may be used in a case of lack of monitors in the first priority programme.

There will thus be a total of 13 PM_{10} monitoring sites, which all should be given high priority. However, again in cases of instrument break down it would be advisable to have priority in the first group of sites. We have also indicated in a memo dated 5 October 2004 the need for purchasing more PM monitors. The cost for this upgrading has also been presented.

Table 8: Air quality measurement sites with combined monitoring and sampling.

ID	Station Name	Area Type	Instrumentation								
			Monitors				Samplers				Other
			SO_2	NO_2	PM_{10}	O3	BS	NO	PM	TSP	
Mad	El-Maadi	Resid	1	1					AM		
Tab	Tabbin	Industrial	1	1	1						Met
Sho	Shoubra	Industrial	1					SS	AM	S	Metmin
Suz	Suez	Urban	1	1					AM	S	DF
Kom	KomOmbo	Industrial	1				1		M		DF
IGS	IGSR	Urb/Road		1					AM		PS
IGR	IGSR Reg	Backgr.				1					Met
GiC	Giza Camps	Resident				1			AM		
BSG	B Suef, Gov	Urb bckg	1	1	1	1					Met
BSC	B Suef ,prk	Urb/road	1	1	1						CO
Asw	Aswan	Urb./Res.				1			AM		DF, PS
RaM	Ras Moham	Backgr				1			AM		PS
Mah	ElMahalla	Indus/res	1		1				AM		
Man	ElMansura	Indus/res	1	1					AM		
Nis	Nishwa	Backgr	1		1						

5.9 Sampling sites

The last part of the total air quality measurement programme for EEAA and Egypt consists of 32 sampling sites of various composition and importance. The main core of this programme is based on sequential samplers for SO_2, NO_2 and soot (black smoke, BS) and AirMetrics type PM_{10} and $PM_{2,5}$ samplers. The most important part of these measurements will be to present a complete picture of the PM exposure in Egypt

Additional passive sampling has been included in this programme to measure time-integrated concentrations of SO_2 and NO_2. In the proposal presented in Table 9 we have also included 10 sites presently covered by the CAIP installed sampling programme.

The meteorological stations have been located at sites where monitors and shelters are already available. The sites have been chosen to give a general wind pattern for the greater Cairo area as well as for Alexandria and the Delta. Important information missing in the existing programme is a stability parameter. This will have to be secured in the future network.

Table 9: Air quality sampling sites covering urban, residential and industrial areas with a possibility for air pollution impact in Egypt..

ID	**Station Name**	**Area**							
		Type	**Samplers**						**Other**
			SO_2	**BS**	**NO_2**	**PM_{10}**	**TSP**	**DF**	
NAC	Nasr City	Residential	SS	SS	SS	S			$PM_{2,5}$
TaS	Tabbin South	Industrial	SS	SS		AM	S	NC	VOC
AZa	Abu Zabel	Ind./Res.				AM		NC	PS
6oc	6 October	Res./Ind.	SS	SS	SS	AM			
10R	10 Ramadan	Residential	SS	SS		AM			
PSa	Port Said	Residential				AM			PS
Ism	Ismailia	Urb. /Res.				AM			PS
Fay	El Fayum	Urban				AM		NC	PS
BSN	BeniSuef,New	Resident				AM			PS
Min	El-Minya	Res./Ind.				AM		NC	PS
Ass	Assyut	Res./Urb.				AM		NC	PS
NgH	Nag Hammad	Ind./Res.				AM		NC	PS
Lux	Luxor	Urb./Res.	SS	SS		AM		NC	
Edf	Edfu	Ind./Res.				AM		NC	PS
ElT	ElTahr	Industrial				AM			PS
Max	El-Max	Industrial	SS	SS	SS	S		NC	VOC
Awd	El Awaid	Residential	SS	SS		S		NC	PS
GEI	Gheat El-Inab	Residential	SS	SS	SS	S			
Dam	Damanhur	Industr/Res				AM			PS
Tan	Tanta	Urban	SS	SS		S			PS
Dam	Damiatta	Residential	SS	SS		S			PS,VOC
KDw	Kafr El Dawar	Residential	SS	SS		AM			PS
Mok	Mokatam hill	Residential				AM			
Sah	ElSahel	Industrial				AM			
Mat	Matarya	Mixed				AM			$PM_{2,5}$
Wai	ElWaily	Mixed/Ind.				AM			
Emb	Embaba	Residential				AM			
Bas	Basateen	Ind/res				AM			$PM_{2,5}$
Thr	Tahrir Square	urban				AM			$PM_{2,5}$
Zam	Zamalek	Residentia				AM			$PM_{2,5}$
Hwn	Helwan	Residential				AM	S		DF
Mas	El Massara	Ind/res				AM			

SS = Sequential sampler S = sampler (high vol) NC = NILU dust fall collector
AM = AirMetrics PM sampler PS = Passive sampler Met = Weather station
VOC= Volatile organic compounds sampler

Realising that suspended particulate matter is the main air pollution problem in Egypt it will be important to collect all data in the same database. This will give a better and total picture of the air pollution situation of Egypt.

There will according to the proposal presented here be more than 50 sites in Egypt covering the particulate matter problem. It will also be required to select a number of filters each month for the analyses of elements such as lead (Pb) and cadmium (Cd).

The measurement programme as it has been proposed for Cairo is presented in Figure 4. In the area presented by the map in Figure 4 a total of 23 stations will be operated. From these there will be 6 on-line monitoring sites (first priority). Five sites will have monitors and samplers from which the monitor data will be transmitted on-line. Another 12 sites will have only samplers.

Figure 4: Different types of monitoring and sampling stations proposed for the Cairo area.

6 Air pollution management and planning

One of the main challenges in Egypt is to have timely and appropriate access to relevant and good quality environmental data. A number of air pollution episodes with very high air pollution impact to the population of Cairo have demonstrated the needs for information and actions. The aim is to enable actions whenever environmental requirements and limits are violated and to perform long term planning to reduce the air pollution load in Egypt.

A system that meets the requirements of modern air quality data presentation and data assessment is urgently needed at EEAA. The main objective of such a modern environmental surveillance platform is to manage and secure data quality controls and at the same time enable direct data and information transfer to the decision makers and to the public.

Air quality assessment and management has been part of the EIMP Phase out programme during the last two years. The limitations at EEAA are clearly revealed when management and impact assessment has to be performed. Presently there is a total lack of systems, models and expertise that can perform air quality planning based on models related to the good quality data that are collected by the EIMP/EEAA monitoring programme.

6.1 An integrated database and air quality management system

The best approach to meet the needs identified by EEAA will be to start preparing the tools for performing an air quality management planning system. Tools are needed for statistical treatment and presentation of collected air quality and meteorological data and also for the preparation of an emission inventory for Cairo. Based on these tools it may be possible to develop a master plan, which include an evaluation and presentation of the best possible reduction measures classified by cost/effectiveness.

The tools for such air quality assessment studies including optimal abatement strategy planning are available. A central part of this system is the dispersion models. The models will have to cover different parts of the data processes in the system such as an air emission calculation model, a meteorological model for winds and turbulence, an air dispersion model and population exposure models.

For the development at EEAA this establishment will require a fair amount of training. However, experts connected to the air pollution forecasts at EEAA to day, have some training in operating air pollution dispersion models.

6.2 The AirQUIS air quality assessment and planning tool

One such system that meets the requirements of modern air quality assessment is the AirQUIS system, which was developed by the Norwegian Institute for Air Research (NILU) (www.NILU.no) to handle a number of air pollution tasks and challenges. It is based on a Geographical Information System (GIS).

This system is presently being tested and operated by the EIMP experts at EEAA. The system has been provided to EEAA free of charge from NILU for 3 months. After that period, no later than 17 January 2005, EEAA will have to make a decision whether to purchase the total system, which include databases, GIS systems, statistical and numerical models and a GIS based data presentation tool.

In a meeting on 10 May 2003 NILU was asked to present a proposal for developing a complete integrated database and planning system for EEAA including a cost estimate for the different modules including:

- The measurement database
- The emission inventory system
- The atmospheric dispersion models and
- The exposure and planning tools.

The total AirQUIS system is shown in Figure 5.

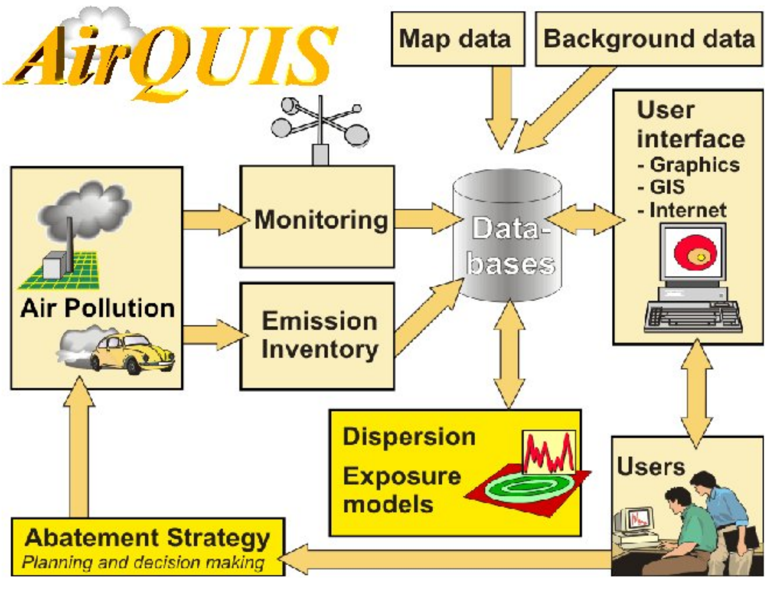

Figure 5: A Simple layout illustrating the content of the AirQUIS system.

To meet these requests a project proposal for the development of such an integrated system was presented to EEAA on 13 May 2003. NILU agreed in thid proposal to reduce the prices compared to the normal list prices A cost estimate was presented based on the AirQUIS reduced prices given to EEAA.

6.2.1 The measurement database

The most important and urgent module to be installed at EEAA is the air quality measurement database including the statistical models and the presentation tools.

This module will include:

- Data base structure
- Import/export of data
- Graphical presentation tools
- Database for storing measured data
- Data statistics and presentation tools
- Report generator
- User interface including integrated GIS

This part of AirQUIS is presently being tested at EEAA on one server provided by NILU. The system may in the future operate on up to eight PC clients. If such client installations are desired to make the system more available to the EEAA staff, the associated time costs and licenses should be discussed before a final agreement can be made.

An evaluation was performed of the presently operated System Manager, which was installed as part of the EIMP programme. It was concluded that an interface could be developed to read and import automatically the data available at the monitoring institutions. Data quality control is performed at different levels in the data collection process and the import to AirQUIS will identify and flag and assure good quality data. Statistics and data graphics are used to check the validity and representativity of the data.

6.2.2 Emission inventories

The emission module is a flexible system containing a user friendly map oriented inter phase to treat the main sources for emission to air such as industry, traffic, energy (consumption of fossil fuels) and emissions related to other mobile sources such as airport and harbour activities.

The industry emission module allows the user to select sources related to specific activities or areas. The time variation of emissions can be entered specific for each source or for groups of sources. Based on emission factors, emissions can be calculated from consumption data. The system may use emission factors based on US EPA42 or the European Corinair database.

Specific designed templates based on Microsoft Excel working tools will be provided for the collection of emission data. The traffic module is the most complex part of the emission module, includes road types, vehicle type distribution, traffic time variation and emission factors dependent on parameters such as vehicle type, traffic speed and road type.

6.2.3 Air Quality models

The models included in a total air quality management system will cover different parts of the data processes in the system such as an air emission calculation model, a meteorological model for winds and turbulence, an air dispersion model and population exposure models.

For the needs identified by EEAA and especially for Cairo the different models needed are divided into the following categories:

- Wind field models
- Numerical models for local and regional scale dispersion (EPISODE)
- Puff trajectory type models for impact for large point sources (INPUF)
- Line source models for emissions from streets and roads (ROADAIR & CONTILENK)
- Exposure models for estimating the impact to the population
- Accidental release models

The NILU source oriented dispersion models calculates spatial distribution of hourly concentrations of SO2, NOX, NO2 and suspended particles. All model results are displayed using the integrated GIS Module.

For most of the purposes a local scale numerical model combined with puff trajectory type models will meet most of the objectives. These models may be able to handle instationarity in the atmospheric conditions typical for the meteorological conditions over Cairo. The models would perfectly enable estimates of air pollution episodes, and if forecasted meteorological conditions are available, the system can also predict the air quality 24 or 48 hours in advance.

6.2.4 Exposure and planning

The exposures estimates are used as a basis for estimating the impact of air pollution on people, vegetation and materials. Based on concentration calculations and population distribution, exposure estimates for human health can be performed. The exposure estimates can be related to air quality limit values or other air quality indicators used for the component considered. Exposure estimates may also be linked to other inventories and spatial distributions such as different materials, cultural heritage and plants.

The impact assessment can again be capitalised and weighed against the cost of cleaning and options to reduce the air pollution loads. In this way we can identify the optimal abatement strategies related to cost/benefits.

7 Training needs assessment

When choosing AirQUIS NILU will offer standard packages for installation and training NILU also offers various support such as customisation of AirQUIS based on the specifications and needs specified by the customer.

As part of the installation, some basic training will be mandatory to enable the local users to operate the system at EEAA.

7.1 Installation, interfaces and hand-on-training

In addition to installation of the necessary software, 'on site' training of project personnel is needed as well as any necessary software customising to comply with given formats on input data. Also, an automatic functionality for on line transfer of measured data from the data acquisition system must be customised for communication with the measurement database.

Local experts will have to participate in the installation and will thus receive hand-on training in the installation procedures and give input to the necessary interfaces with existing data.

7.2 AirQUIS training seminar

A training seminar will be offered to give the local EEAA experts instruction in the use of the system. The training sessions will deal with both data system handling in addition to relevant theory and practical use of the system.

For other international projects a two-week training seminar has been offered at NILU. Several users in Europe and Asia have been attending these seminars. For EEAA we will propose that this seminar will be held at EEAA to reduce the costs and give more local experts the chance to participate. A maximum of 5 people should attend this seminar.

7.3 Training for emission inventorying and modelling

For the future use of the modules including the emission inventory system and the dispersion models a group of experts will be appointed to perform, organising and structuring the emission data. Also, support may be given in importing these data into the AirQUIS emission database and reporting the contents of the resulting point source, area source and line sources emission inventory. Specific designed templates based on Microsoft Excel working tools will be presented, and hand-on training in using these will be provided.

The models that can be used for impact assessment and long term planning will be the third modules in the system. Training will also be needed for experts to operate the modelling system. The dispersion models can also in the future be linked to dynamical meteorological forecast models to improve the air quality forecasts for Cairo. It is strongly recommended that EEAA is planning in this direction, and that a proposal for this long-term development is followed up by EEAA.

7.4 Air Quality Management Training

The organisation to be established for air quality management must be trained in operating all parts of the integrated monitoring and management system. The main objectives of the training part of the project are capacity building and institutional strengthening. General institutional strengthening through air quality lectures and seminars should be given to the selected experts in EEAA.

The seminars and workshops will give general presentations of the background and the use of an integrated AQMS, while on-the-job training in practical operation of all elements of the system will be given to the actual operators on all levels from central software to modellers and management officers.

7.5 Maintenance and service agreement

Maintenance and service agreements may be established with NILU. This will assure the operation of the system in the future. Customers with Maintenance Agreement will receive new upgraded versions of AirQUIS free of charge.

NILU do also provide User Support Agreement for AirQUIS. The User Support is normally operated through the “Help desk” and is performed on-line through Internet, E-Mail and telephone communications.

Normally NILU will charge 15 % of the AirQUIS costs for maintenance and 17 % for support for each module. Upgrading is then free of charge.

8 A rough cost estimate

At the end of Mission 05 during the Phasing-out Phase of the EIMP programme the air quality task manager was asked to provide a rough estimate of the costs for upgrading the air quality monitoring and assessment programme for Egypt.

The cost estimate below has been based on a careful upgrading of the existing EIMP programme. We have concentrated the efforts on achieving a well-operated on-line monitoring system.

There are a number of high volume samplers in the programme to day, which are not working due to missing spare parts. Most of this problem may be solved in the near future. PM_{10} sampling will also be undertaken using AirMetrics instruments. We assume that there will be a sufficient number of these instruments already at EEAA as part of the former CAIP developed sampling programme.

As can be seen from the table 10 presented below a total of 8 PM_{10} monitors and 6 gas monitors as well as 2 meteorological stations will have to be purchased to update the national air quality monitoring programme for EEAA, Egypt. In addition we will have to procure one BTEX monitor.

There will according to this proposal be more than 50 sites in Egypt covering the particulate matter problem. Some of the old high volume samplers will have to be repaired and a constant need for spare parts have to be identified and purchased. It will also be required to select a number of filters each month for the analyses of elements such as lead (Pb) and cadmium (Cd). This, however, may be some of the future operational costs, which is not included here.

8.1The monitoring programme

A complete list of monitoring stations proposed for EEAA in Egypt is presented in Table 10: In addition to this list there will be a number of manually operated samplers as presented in Table 9.

Table 10: An overview of monitoring sites proposed fro EEAA in Egypt. Available monitors have been indicated.

ID	Site Name	Area Type	On-line data					
			Monitors					
			SO_2	NO_x	PM_{10}	O_3	CO	Met
Kol	El-Kolaly	Urban Center	a	a	a			
Gom	El-Gomhoryia	Street Canyon	a	a			a	
Abb	Abbassyia	Urb. /Res.	a		a	a		a
FKa	Fum El-Khalig	Roadside/Urb.	a	a	a?		a	
Kah	Kaha	Regional back		a	n	n		a?
Sh	El Shouhada	Traffic	a	a	n		m?	
KZa	Kafr El-Zayat	Industrial/Res.	a	a	n			m
Hel	Heliopolis	Urban	m	n	n			
Mad	El-Maadi	Resid	a	a				
GiS	Giza square	Urb/road	a	n	n			
Tab	Tabbin	Industrial	a	a	a			a
Sho	Shoubra	Industrial	a					a
Suz	Suez	Urban	a	a				
BSG	B Suef, Gov	Urb bckg	a	a	a	a		a
BSC	B Suef ,prk	Urb/road	a	a	a		a	
Kom	KomOmbo	Industrial	m					
IGS	IGSR	Urb/Road		a				
IGR	IGSR Reg	Backgr.				a		n
GiC	Giza Camps	Resident				a?		a
Asw	Aswan	Urb./Res.				a		a
RaM	Ras Moham	Backgr				a		
Mah	ElMahalla	Indus/res	a		?			
Man	ElMansura	Indus/res	a	a				
Nis	Nishwa	Backgr	n		n			
Number of instruments available			18	13	5	5	3	7
Number of instruments needed			**1**	**2**	**8**	**2**	**1**	**2**
Total number of monitors in system			14	15	13	7	4	9

a = available at site , n = not available, m = to be moved from other site
? = Inadequately operating

Including the meteorological stations there will be a total of 62 automatic monitoring instruments operated in Egypt.

To operate the system in a more flexible and real-time way the on-line data retrieval system will have to be modernised and simplified, and a new database and assessment system will have to be installed at EEAA.

The costs for instrumentation, some spare parts for repairing instrument out of operation, shelters and infra structures are estimated and presented in Table 11 below.

Table 11: A rough cost estimates for instruments and infrastructures necessary to upgrade, repair and install the total system as presented in this report.

Ambient monitors and various equipment	**Estimated price (1000 EL)**	**Number instruments**	**Total 1000 EL**
SO_2 Pulsed UV fluorescence	90	1	**90**
NO/NO_x Chemiluminescence	95	2	**190**
CO Gas filter correlation/infrared abs.	95	1	**95**
BTEX	180	1	**180**
Ozone UV photometry	70	2	**140**
Air Intake	30	4	**120**
Spare parts to set air monitors in operation	20	12	**240**
PM 10 monitor (ESM Andesen)	147	8	**1176**
Automatic Weather station (AWS)	85	2	**170**
Met. Mast	55	2	**110**
Dataloggers	40	3	**120**
Shelter	20	3	**60**
Rack+aircon+power+telephone	15	3	**45**
Moving and installations	5	3	**15**
Total for new monitors and 3 sites needed			**2751**

A number of calibration gases are also needed.

8.2 The database, air quality assessment and planning tool

Updating the air pollution database has been offered previously to EEAA at a special price of **130 000 EL**.

This Air Quality Measurement Module, which is a minimum required for operating the air quality measurement programme includes the basic Kernel and the GIS system, the measurement module, additional software, statistical programmes, graphical presentation tools, hardware, computers (server), installations and some basic training.

The total AirQUIS package will enable EEAA to start collecting input data for modelling and air quality assessment and planning. This will require emission inventories and dispersion models, which will be part of the deliveries. The estimated total cost of for the necessary tools to enable EEAA to start air quality management and planning has been presented in previous plans and proposals and amounts to a total of **400 000 EL.**

This will include installation training and the following modules:

- Geographical Information System (GIS)
- Measurement database based on Oracle
- Statistical and Graphical Presentation Tools
- Emission Inventory modules and templates
- Atmospheric Dispersion models
- The exposure and planning tools
- Graphics and web based data dissemination systems.

The total cost for upgrading the EEAA national air quality monitoring system will thus be about **3.1 million Egyptian Pounds.**

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Appendix A

New proposed Limit Values for Egypt

A summary of the new proposed air quality limit values for Egypt as proposed by the Chemonic Criteria Document is presented in the following table.

Compound	Limit value ($\mu g/m^3$)	Average	Exceeding, comments	Impact
SO_2	350	1 hour	Not to be exceeded more than 175 times per calendar year	Health
	150	24- hour	Not to be exceeded more than 3 times per calendar year	Health
	60	year		Ecosystem
	500	hourly	Alert threshold measured over 3 hrs	
NO_2	400	1 hour	Not to be exceeded more than 18 times per calendar year	Health
	150	24 hours	Not to be exceeded more than 3 times per calendar year	Health
	400	hourly	Alert threshold measured over 3 hrs	
PM_{10}	150	24 hour	Not to be exceeded more than 35 times per calendar year	Health
	70	Calendar year	Median value	Health
$PM_{2,5}$	65	24 hour	Not to be exceeded more than 7 times per calendar year	Health
	15	Calendar year	Indicative annual average value	Health
Ozone	200	1 hour	Not to be exceeded more than 7 times per calendar year	Health
	120	8-hours	8-h moving average, Not to be exceeded more than 4 days per calendars year	Health
	65	24 hour	Arithmetic mean	Ecosystem
	360	1 hour	Alert threshold	
Lead	0,5	Calendar year	Arithmetic mean of 24 h average measurements	Health
	1,5	Quarter year	Arithmetic mean of 24 h average measurements every 3 month	Health
CO	30	1 hour	Not to be exceeded more than 24 times per calendar year	Health
	10	8.hour	8-h moving average, Not to be exceeded more than 3 times per calendar year	Health

Appendix B

Air pollution limits and target values for Europe

Air pollution limit values and targets in Europe

Health-protection limit values and guidelines

EU Directives

Compound	Limit/target value			Target year
PM10 Stage 1	Annual average:	40 µg/m^3		2005
	Daily average:	50 µg/m^3	May be exceeded up to 35 days a year	2005
PM10 Stage 2	Annual average:	20 µg/m^3	Indicative	2010
	Daily average:	50 µg/m^3	Indicative; may be exceeded up to 7 days a year	2010
NO_2	Annual average	40 µg/m^3		2010
	Hourly average:	200 µg/m^3	May be exceeded up to 18 hours per year	2010
Ozone	8-hour average:	120 µg/m^3 (Target value)	May be exceeded up to 25 days per year [1)]	2010
SO_2	Daily average:	125 µg/m^3	May be exceeded up to 3 days per year	2005
	Hourly average:	350 µg/m^3	May be exceeded up to 24 hours per year	2005
CO	8-hour average:	10 mg/m^3		2005
Pb	Annual average:	0.5 µg/m^3		2005 [2)]
Benzene	Annual average:	5 µg/m^3		2010

1) As an average over the 3 preceding years.
2) 2010 in the immediate vicinity of specific industrial sources, notified to EC before 19 July 2001.

WHO Guidelines

PM10	No lower threshold for effects. Guideline is given in terms of dose-response functions as a basis for risk estimates.		
NO_2	Guideline levels are the same as in the EU Directive, but allowable exceedances are not given.		
Ozone	Guideline level is the same as in the EU Directive , but allowable exceedances are not given.		
SO_2	Annual average.	50 µg/m^3	
	Daily average.	125 µg/m^3	(as in EU Directive, but allowable exceedances are not given.)
	10 minutes average:	500 µg/m^3	
CO	8 hours:	10 mg/m^3	(in addition, guidelines are given for 1-hour, 30 minutes and 15 minutes averages).
Pb	Same as in EU Directive		
Benzene	No safe level of exposure is recommended		

Appendix C

Reference methods for air pollution measurements in Europe

The measurement reference methods are presented in Annex IX of the EU Council Directive 1999/30/EC. A brief summary of these reference methods is presented in the following.

1.1 I.Reference method for the analysis of sulphur dioxide:

Ambient air - determination of sulphur dioxide - ultraviolet fluorescence method. ISO/FDIS 10498. A Member State may use any other method, which it can demonstrate, gives results equivalent to the above method.

1.2 II.Reference method for the analysis of nitrogen dioxide and oxides of nitrogen:

Ambient air - determination of the mass concentrations of nitrogen oxides - chemiluminescence method. ISO 7996: 1985: A Member State may use any other method, which it can demonstrate, gives results equivalent to the above method.

1.3 III.Reference method for the sampling and measurement of PM10

Member States will preferably use the reference method of the directive (sampling method according to CEN 12341 followed by gravimetric mass determination) or whatever method the Member State can demonstrate to produce equivalent results or to show a consistent relationship to the reference method. If a method other than the reference method is used, the report should also contain a demonstration of the equivalence or of the consistent relationship between the method and the reference method

The reference method for the sampling and measurement of PM10 will be that described in EN 12341 "Air Quality - Field Test Procedure to Demonstrate Reference Equivalence of Sampling Methods for the PM10 fraction of particulate matter".

The measurement principle is based on the collection on a filter of the PM_{10} fraction of ambient particulate matter and the gravimetric mass determination. One accepted method for PM_{10} sampling is using the German “Kleinfilter gerat”, another is the Anderson high volume sampler with hood.

Every PM_{10} sampler obtained for air quality monitoring should be equivalent to those approved according to CEN standard EN12341. This standard formulates criteria of the equivalence. Other certifications, including USEPA approvals, do not necessarily constitute compliance with CEN standard EN12341.

If monitors are to be used for PERSONAL measurements the new Eberline beta gauge monitor could be applied, even if this is still not a completely accepted method.

1.4 IV.Reference method for the sampling and analyses of lead:

For sampling of lead use the reference method specified for sampling of PM_{10} .A Member State may use any other method, which it can demonstrate, gives results equivalent to the above method.

For the analysis of lead, use ISO 9855: 1993 “Ambient air - Determination of the particulate lead content of aerosols collected in filters”. Analyses to be performed with atomic absorption spectroscopy method.

1.5 V.Provisional reference method for the sampling and measurement of *$PM_{2,5}$*

The Commission will produce guidelines, in consultation with the committee referred to in Article 12 of Directive 96/62/EEC, for an appropriate provisional reference method for the sampling and assessment of $PM_{2.5}$ by 19 July 2001.

The dual head sampler $PM_{10}/PM_{2.5}$ has not been accepted a reference method.

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ABSTRACT
A national air quality network for Egypt has been designed and proposed on request from the Egypt Environmental Affairs Agency (EEAA). In discussions with representatives from the Danida developed EIMP programme as well as with the US Aid supported CAIP programme it has been decided that EEAA in the future would like to develop a modern air quality management programme to be operated on a GIS based air quality database that could also be used for planning purposes. A total of 50 sites have been proposed. The most important indicator is PM_{10}, and 9 of the sites have been identified as first priority on-line measurement sites with automatic monitoring equipment and daily transmission of data into a central database. A total of 24 sites are equipped with monitors, and ten sites have been appointed second priority sites equipped with a combination of monitors and manually operated samplers.

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