DEPARTMENT OF ENVIRONMENTAL AFFAIRS AND TOURISM

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AN INTRODUCTION TO AIR QUALITY MANAGEMENT

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ACRONYMS

APPA	Atmospheric Pollution Prevention Act (No. 45 of 1965)
AQA	National Environmental Management: Air Quality Act (No. 39 of 2004)
AQM	Air Quality Management
AQMP	Air Quality Management Plan
AQMS	Air Quality Management System
CFC	Chlorofluorocarbons

GLOSSARY OF TERMS

Ambient air
Considered to be the air in the environment excluding indoor air.

Ambient air quality standard
Considered to be the level of an air pollutant that is adopted by a regulatory authority and is legally enforceable. Unlike a guideline value, a number of elements in addition to the effect-based level and the averaging time must be specified in the formulation of a standard. These elements include:

- measurement strategy;
- data handling procedures; and
- measurement statistics used to derive the value to be compared with the standard.

The numerical value of a standard may also include the permitted number of exceedences per averaging period.

Anthropogenic sources
Pollution sources that are related to human activities.

Baseline air quality assessment
A compilation of existing or current data and knowledge on air quality in a particular area. It forms an essential input into the subsequent formulation of the Air Quality Management Plan. It comprises an assessment of the current ambient air quality status; an assessment of current organisational structures for air quality management; and an assessment of current air quality initiatives to reduce air pollution.

Best Available Technology (BAT)
Emission standards that require the control of emission sources to the best degree technologically possible, without economic consideration.

Best Available Technology Not Entailing Excessive Cost (BATNEEC) Emission standards that require that the technology should be the best available at preventing pollution, but not at a cost which far outweighs the benefits of the control.

Best Environmental Practice (BEP) and Best Practicable Environmental Option (BPEO)
Emission standards that require that the needs of the environment are placed before the profits of the polluter.

Biogenic sources
Emission of a range of pollutants from soils and vegetation.

Continuous sampling
Ambient air quality sampling conducted by drawing air into sampling equipment with real time analysis of concentrations via reference methods. Measurement and recording is done in a continuous manner.

Dispersion modelling
The use of a computer-based model that simulates the dispersion or movement of pollutants in the atmosphere based on a set of equations that are determined by the meteorological conditions of the atmosphere. The output is a set of predicted values of a pollutant for a defined location and time period.

Emission
Pollution discharged into the atmosphere from a range of stationary and mobile sources. These include smokestacks, vents and surface areas of commercial or industrial facilities; residential sources; motor vehicles and other transport related sources.

Emission control technology
Technology that aims to reduce emissions into the atmosphere.

Emissions inventory
A data base that provides information on ***what*** pollutants are being emitted, ***where*** they are being emitted, ***when*** they are being emitted, in ***what quantities*** they are being emitted, and by whom they are emitted.

Emission reduction strategies
An intervention designed to reduce emissions into the atmosphere.

Environment
The surroundings within which humans exist and that are made up of (i) the land, water and atmosphere of the earth; (ii) micro-organisms, plant and animal life; (iii) any part or combination of (i) and (ii) and the interrelationships among and between them; and (iv) the physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and well-being (definition from the National Environmental Management Act - NEMA).

Exceedence
A situation in which a measured ambient air quality concentration (or emission rate) of a particular pollutant exceeds the ambient air quality guideline or standard (or emission limit) for that pollutant. Exceedances are normally expressed as a total number per time period and give an indication of the severity of the air pollution problem.

Guideline
A recommendation on the ambient concentration of a pollutant required for the protection of human health (or receptors in the environment) from the adverse effects of the pollutant. It is not restricted to a numerical value but might also be expressed e.g. for example as exposure-response information or as a unit risk estimate.

Guideline value
A numerical value expressed either as a concentration in ambient air or as a deposition level, that is linked to an averaging time. In the case of human health, the guideline value provides a concentration below which no adverse effects and, in the case of odorous compounds, no nuisance or indirect health impact, are expected, although it does not guarantee the absolute exclusion of effects at concentrations below the given value.

Monitoring
Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant concentrations in various media or in humans, plants, and animals.

Montreal Protocol
The **Montreal Protocol on Substances That Deplete the Ozone Layer** is an international treaty designed to protect the ozone layer by phasing out the production

of a number of substances believed to be responsible for ozone depletion. The treaty was opened for signature on September 16, 1987 and entered into force on January 1, 1989. Since then, it has undergone five revisions, in 1990 (London), 1992 (Copenhagen), 1995 (Vienna), 1997 (Montreal), and 1999 (Beijing).

Natural sources
Pollution sources that are related to natural processes as opposed to those which are due to human activities.

Passive Sampling
Air quality monitoring by means of exposure of the sampler to ambient air and adsorption of the pollution into the sampling medium. Sampling is over longer time periods and subsequent analysis is required to determine concentrations.

Threshold Limit Values (TLV)
The maximum permissible concentration of a pollutant, generally expressed in parts per million in air for some defined period of time (often 8 hours, but sometimes for 40 hours per week over an assumed working lifetime). These values, which may differ from country to country, are often backed up by regulation and therefore may be legally enforceable.

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1. INTRODUCTION

The approach to air quality management in South Africa was informed by the Air Pollution Prevention Act (APPA, Act 45 of 1965). APPA was regarded as ineffective for a number of reasons. Some of the most important reasons are that:

- APPA had limited powers to protect the right to air quality that is not harmful to health and well-being;
- It applied a best practicable means approach to controlling air pollution, but this was not sufficiently effective;
- It did not effectively provide for integrated planning between social, economic and environmental factors;
- It had an industrial focus and allowed the development of areas of poor air quality, so-called air pollution 'hotspots';
- APPA did not set air quality standards to protect public health; and
- APPA it did not provide incentives for reducing emissions and improving air quality.

The National Environmental Management: Air Quality Act (AQA, Act 39 of 2004) has replaced APPA. This new legislation addresses the shortcomings of APPA by promoting the improvement of air quality and environmental protection through the holistic approach of air quality management systems. Unlike APPA, with a focus on emissions limits, a holistic approach to managing air quality entails a process of setting air quality objectives based on air quality standards and the nature of the receiving environment, implementing interventions to ensure the objectives are met and a process of measurement and management of pollution activities to ensure air quality continually meets the requirements of the air quality objectives.

This booklet aims to provide the reader with an introduction to air quality management systems (AQMS) in the context of APPA and the AQA. AQMS provide the theoretical framework for managing air quality. This booklet also reviews some more traditional air quality management strategies and evaluates the advantages and disadvantages of these. With air quality management a priority of AQA, this booklet provides an introduction to developing an air quality management plan (AQMP). An AQMP applies the theory of the AQMS in an operational manner.

2. AIR QUALITY MANAGEMENT SYSTEMS

Air quality *per se* cannot be managed. Rather the activities that impact on air quality can be managed to effect an improvement. The common and accepted approach in recent times to achieve such improvements, and the approach that is promoted by the AQA, is the air quality management system (AQMS) approach.

The AQMS approach can be applied at a range of scales depending on the nature and the magnitude of the air quality issue that needs to be addressed. For example, AQMS can be instituted for a single industrial plant that needs to reduce emissions to effect an improvement in air quality at a local scale, or for an urban centre, or a region or global initiatives such as the Montreal Protocol which implemented the phasing out of CFCs to address the globally important issue of stratospheric ozone depletion.

The AQMS strategy is a structured approach that is driven by defined air quality objectives. These objectives are mostly associated with achieving compliance with ambient air quality standards or guidelines. Measuring progress towards reaching the objectives over a given time period is dependant on the implementation of a number of associated tasks, illustrated in Figure 1.

An initial and fundamental component of the AQMS strategy is the development of a *comprehensive emission inventory* that details the natural and anthropogenic emissions from the various sources in the region of interest. The emission inventory preferably includes information on the source (position, release height, etc) and the emission (what pollutants are emitted, at what rate, when the emission occurs, etc).

Emissions information can, in turn be related to ambient concentrations of pollutants using local meteorological information and *air quality modelling*. An ideal model would accurately predict the air quality at a particular location at any time for any set of emissions and meteorological conditions. The modelling enables the air quality manager to identify zones of maximum impact, to estimate the magnitude of the deviation from the air quality objectives, and importantly to design an optimum *air quality and meteorological monitoring* initiative. The air quality management strategy is thus inherently dependent on air quality modelling, which is sometimes regarded as a drawback of this approach.

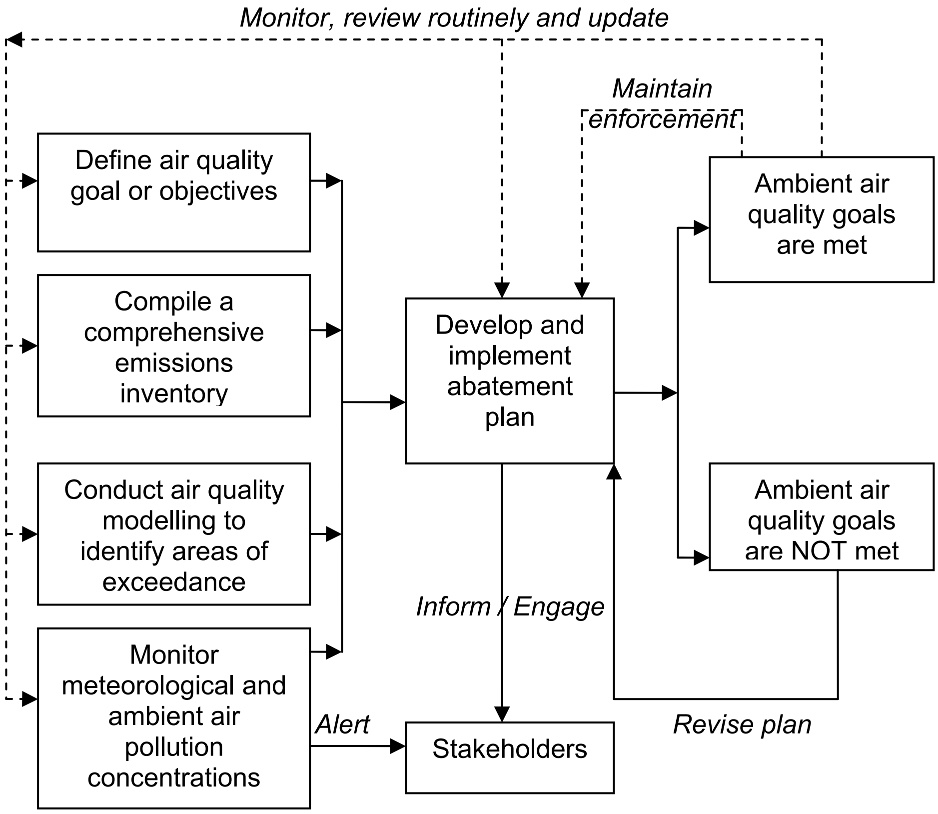

Figure 1: Air Quality management System (AQMS) framework (adapted from Elsom, 2004)

An *enforcement procedure* which allows the implementation of a planned emission abatement programme is developed. Credible emission control tactics are set down which are later evaluated to determine whether they will allow the air quality objectives to be met. Ongoing ambient air quality monitoring provides information on the status of ambient air quality and provides a means to evaluate the performance of the planned abatement programme. The programme should be revised if it is not effective; otherwise the programme is maintained and routinely reviewed against the set objectives of the AQMS strategy.

3. TRADITIONAL AIR QUALITY MANAGEMENT STRATEGIES

3.1 Emission Standards

Emission standards existed as an air quality management strategy before air quality management systems. This strategy was first applied as air pollution control efforts were directed at controlling the smoke from inefficient combustion of coal and as a method most often used to limit visible emissions. Later, emission standards were developed to control emissions for specific groups of emitters (such as oil refineries) and required that all members of these groups release no more than these permitted emission levels. These standards could be local, regional or national in application.

Emission standards can be based on air quality standards and will then be supplementary to an air quality management system. In some instances emission standards are independent of air quality standards and then serve as a different type of strategy from that of an air quality management system.

There are four main categories of emission standards. These are:

- *Numerical standards* which give the maximum amount of a substance that can be released.
- *Fuel standards* that control the type of fuel used.
- *Equipment standards* that specify the equipment for process or storage of chemicals.
- *Prohibitive standards* that prevent the use of certain chemicals or processes in specific areas.

3.2 Emission Taxes

Employing emission taxes as an air quality management strategy shifts the pollution control function from the authority to the polluter. With this approach the polluter stands to gain by not installing pollution control technology. The cost of damage is so passed on to the public and the polluter gains an advantage over competitors who install pollution control equipment. There is no economic incentive to reduce emissions and legal and public opinion are the only influential forces.

Under an emission tax strategy, major polluters could find it economical to install pollution control equipment rather than pay the taxes. In its purest form there would be no legal or moral sanction against an emitter who elected to pay the tax and not control emissions.

An example of a pollution tax is a charge per unit of pollutant released. Other examples of taxes include sales taxes, tax remissions, property taxes, subsidies, import restraints and domestic production restraints. Emission taxes can also be proposed in combination with air quality management systems approach to act as an incentive for polluters to reduce emissions to lower levels than those required to meet air quality standards. In this case the two approaches work in parallel. Alternatively, the tax rate may steadily increase until some predetermined ambient air quality level is reached.

3.4 Cost-Benefit Strategies

Cost-benefit strategies for air quality management involve quantifying the damages from various pollutants and the cost of controlling those pollutants and, in turn, selecting pollution-control alternatives that lead to a minimum of pollution damage and pollution control costs. This AQM approach requires an assessment of the damage various levels of exposure to all pollutants and then evaluating each emission in terms of the cost to abate it with the benefits of the abatement. Choices can then be made between pollution control options by implementing those which will produce benefits greater than or equal to the costs and rejecting those which will produce benefits less than the control costs. Cost-benefit strategies lead to more stringent air quality requirements for urban air than for rural air where the number of people exposed is smaller.

3.5 Non-Degradation Strategy

Up until the 1960s, the atmosphere was seen to have natural processes for removing pollutants and this cleansing power of the atmosphere led it to be viewed as a resource. The popular air quality management viewpoint at the time was that pollution sources should be located in remote areas away from large population centres.

An alternative view arose in the 1970s when remote areas with clean air were recognised as a valuable resource. Air quality management emphasis then shifted to controlling polluting industries at source as an attempt to prevent deterioration of air quality in pristine areas.

3.6 Emission Density Strategy

Land use zoning in cities strives to locate polluting industries away from residential and commercial areas. In general this has been done without any explicit air pollution regulations, but rather for implicit reasons based on emission density.

4. COMPARISON OF STRATEGIES

A qualitative comparison of the four main strategies used to manage air quality is made in Table 1.

Table 1: Relative comparison of AQM Strategies (from Stern, 1977)

	AQMS	**Emission standard**	**Emission taxes**	**Cost-benefit analysis**
Cost effectiveness	Good	Terrible	Fair	Excellent
Simplicity	Poor	Excellent	Excellent	Terrible
Enforceability	Fair	Excellent	Excellent	Unknown
Flexibility	Fair	Poor	Unnecessary	Unknown
Evolutionary ability	Fair	Fair	Good	Good

Under APPA, industry in South Africa operated under the principle of Best Practicable Means. Industries were categorised as either scheduled or non-scheduled, depending on the nature of the industrial process. The emission limits were based upon threshold limit values (TLVs) so that under normal operating conditions, the ground level concentration of pollutants at any point around the plant should not exceed TLV/50, unless the pollutant is carcinogenic or accumulative, in which the ratio of TLV/100 applies. The AQA introduces the concept of ambient air quality standards and promotes an AQMS strategy, similar to that of the United States and the United Kingdom.

The US Clean Air Act Amendments of 1970 gave the Environmental Protection Agency (EPA) the authority to establish and enforce ambient air quality standards and to set emission standards for new factories and extremely hazardous industrial pollutants. In addition, emissions from existing stationary sources are regulated through the installation of emission control devices to meet ambient air quality standards.

The Best Practicable Means to control emissions was applied in the UK up until the National Air Quality Strategy was published in 1997 and revised in 2000. This strategy set ambient air quality limits aimed at protecting human health, vegetation, and the natural environment, and requires holistic air quality management planning, with local government taking an increasing important role in air quality management.

5. DEVELOPING AN AIR QUALITY MANAGEMENT PLAN

Air quality management plans (AQMP) should be established with specific air quality goals in mind. In the context of AQA, the development of an AQMP for a specific area, be this a Priority Area or a district or local municipality, is the responsibility of the designated Air Quality Office (AQO – See Section 14 of AQA). Air quality management plans can also be developed for sectors or individual polluters. AQMP goals should provide focus for the development and implementation phases of the plan. Examples of AQMP goal could be:

> *The goal of the AQMP for City X is to ensure that ambient air quality standards are maintained throughout the city*, or

> *The goal of the AQMP for Company X is to manage air polluting activities on site to ensure that exceedances of SO_2 in the ambient environment are limited to 2 per annum.*

An AQMP is developed in a systematic way. With reference to Figure 1, the first step is establishing the ***goals or objectives*** for the AQMP over set time frames. Air quality goals and objectives are specific to areas where air quality needs to be managed and can differ between geographical areas. For example, in Richards Bay fluoride is emitted from a number of sources that are unique to this area. The air quality goals may therefore include objectives to manage fluoride. By contrast, in the Rustenburg area the AQMP may look to establish air quality goals for hexavalent chrome and not fluoride as this is a common pollutant in this area. Establishing air quality goals is done through identifying all the issues and perceived air pollution problems in the area of interest. A documented list of all of the identified issues should be the first milestone of the development of the AQMP. Prioritising the issues assists in setting the AQMP goal or objectives. The AQA promotes a philosophy of continual improvement. It may therefore be necessary to revisit the objectives of the AQMP on an ongoing basis, hence the setting of new air quality objectives.

Most air pollution concerns relate to the nature of pollutants, their sources or the zones of impact. The next steps in the development of an AQMP are the identification of pollutants and their sources and compiling an ***emissions inventory***, the ***identification of the areas of exceedence*** using air quality monitoring and modelling.

An emissions inventory is a data base that includes information on what pollutants are being emitted, where they are being emitted, when they are being emitted, in what quantities they are being emitted, and by whom they are emitted. Emissions may arise from a number of anthropogenic and natural sources. These may be from:

- Industry (small and large);
- Business;
- Motor vehicles (primary emissions and dust entrainment);
- Biomass fuel burning in non-electrified residential areas;
- Agricultural activities;
- Wind blown dust from open areas;
- Biomass burning;
- Tyre burning;
- Dust from construction and mining sites; and
- Biogenic emissions.

Identifying areas where ambient air quality standards are exceeded or have the greatest impact is generally done by using ambient air quality monitoring or air quality modelling. Each method has distinct advantages and disadvantages (Table 2), but generally a combination of the two approaches provides the best results.

An ***abatement plan*** can be developed once the nature of the air pollution has been determined, i.e. the sources and the pollutants are known and the magnitude of the problem is known. The abatement plan should be specific about what sources need to be reduced and about the degree of reduction required to achieve the AQMP's objectives or goals. When the abatement plan is implemented, the AQMP must continually review progress towards meeting its objectives and goals. If the objectives are not met, the abatement plan should be revised and the revisions should be implemented. This process of revision must be ongoing until the objectives of the AQMP are met. At this stage it is necessary to continually review to ensure compliance.

Table 2: Advantages and disadvantages of air quality monitoring and air quality modelling.

Air quality monitoring	Air quality modelling
Concentrations can be very precise.	Concentrations are estimated.
Concentrations represent the immediate monitoring area, monitoring is not spatially continuous.	Concentrations are estimations over a larger spatial area, modelling results are spatially continuous.
Monitoring is aimed at specific pollutants, one monitor per pollutant.	Modelling can be carried out for a range simultaneously.
Monitoring can provide results with a high temporal resolution.	Modelling provides estimated concentrations over longer averaging periods.
Monitoring is capital and labour intensive.	Modelling does not require major capital expenditure.
Concentrations can be temporally continuous.	Concentrations are mostly for episode or scenario purposes.
Limitations in understanding source and receptor relationships.	Good at evaluation sources and receptor relationships.
Used to calibrate models.	Used to design and optimise monitoring networks.
Used for current and historic state of air.	Used for scenario assessment, current, future or historic.

Details on the development of an air quality management plan are contained in Series 5: Book1 – *The Implementation Manual for Air Quality Management in Priority Areas.* This book includes discussion on all aspects of and AQMP, including air quality monitoring, establishing an emissions inventory and prioritising abatement options.

REFERENCES

Boubel, R.W., Fox, D.L., Turner, D.B. and Stern, A.C., 1994: *Fundamentals of Air Pollution*, Third Edition, Academic Press, San Diego.

Elsom, D. M., Developing an appropriate scientific decision making framework for effective air quality management, in Air pollution XII, C. A. Brebbia (ed.), Wit Press, Southampton, ISBN 1-85212-722-1.

Stern, A.C. (ed.), 1977: *Air Pollution*, Volume V: Air Quality Management, Third Edition, Academic Press, New York.