

7. Priority Setting in Air Quality Management

7.1 Introduction

This chapter is intended to give guidance on how to set priorities in rational air quality management. Actual priorities will differ for each country; therefore, each country sets priorities in air quality management according to its policy objectives, needs and capabilities. Priority setting in air quality management refers to prioritizing the health risks of air pollution, with corresponding prioritization of the pollutants, and concentrating on the most important sources of the pollutants. Conceptually, prioritizing health risks is straightforward (WHO 1999a; WHO 1999d). High priority health risks will be given to those compounds for which “high” toxicity and “high” exposure of the population are entailed.

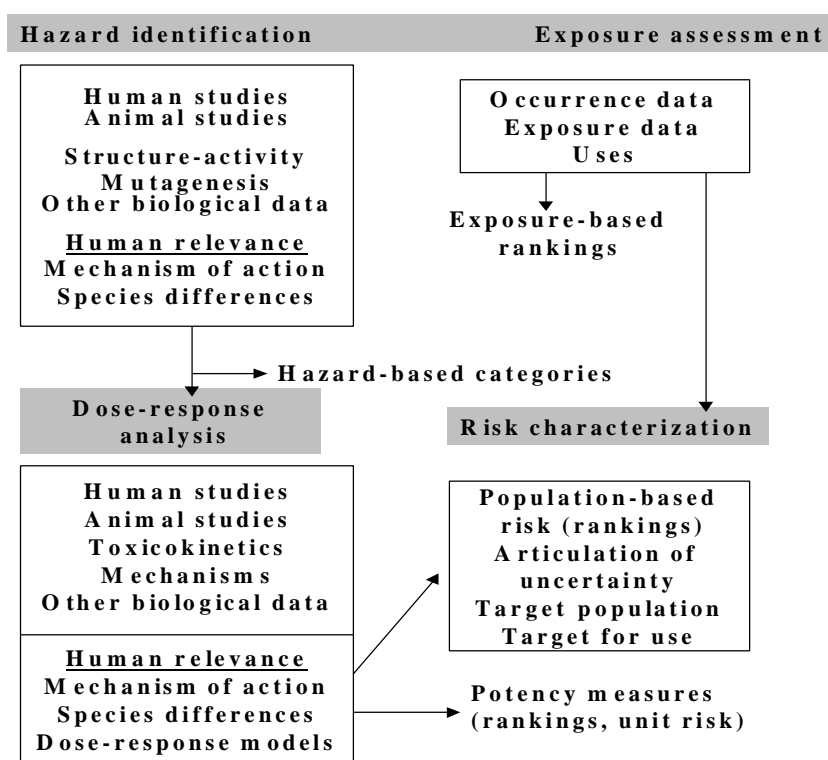


Figure 7.1 Basic elements of the estimation and prioritization of health risks

Conversely, low priority health risks involve agents of “low” toxicity and “low” exposure. “Medium” priority risks include compounds for which toxicity is “low” and exposure is “high,” or vice versa. Basic elements of the estimation and prioritization of health risks is illustrated in Figure 7.1 (Sexton 1993; Younes et al 1998).

For effective air quality management, goals, policies, strategies and tactics need to be defined. These are discussed in Chapter 6.

A framework for a political, regulatory and administrative approach is required to guarantee a consistent and transparent derivation of air quality standards and to ensure a basis for decisions on risk-reducing measures and abatement strategies. In such a framework the following considerations need to be included:

- legal aspects.
- the potential of air pollution to cause adverse effects on health, taking into account populations at risk.
- exposure-response relationships of pollutants and pollutant mixtures and the actual exposure responsible for related health and/or environmental risks.
- the acceptability of risk.
- cost-benefit analysis.
- stakeholder contribution in setting standards.

7.2 Legal aspects

A legislative framework usually provides the basis for policies that set air quality standards at the municipal, regional, national or supranational level. The setting of standards strongly depends on the risk management strategy adopted which, in turn, is influenced by country-specific socio-political considerations and/or international agreements. Legislation and air quality standards vary from country to country, but in general the following issues may be taken into consideration:

- Identification and selection of the adverse effects on public health and the environment to be avoided.
- Identification of the population to be protected from the adverse health effects.
- Identification of the pollutants to be considered.
- The numerical value of the standards for the various pollutants or the decision-making process.
- Existing background concentrations of air pollutants.
- Applicable monitoring methodology and its quality assurance.
- Enforcement procedures to implement air quality standards within a defined time frame, to achieve compliance.
- Emission control measures and emission standards.
- Environmental impact assessment procedures.
- Identification of responsible enforcement authorities.
- Resource commitment.

Air quality standards may be based solely on scientific and technical data. However, other aspects such as technological feasibility, costs of compliance, prevailing exposure levels, social, economic and cultural conditions, are also usually considered in setting standards or in designing appropriate emission abatement measures. These are discussed in Section 2.4. As a consequence, air quality standards differ widely from country to country (WHO 1998b).

Air quality standards can set the reference point for emission control and abatement policies at national, regional or municipal levels. The latter two levels are only effective if long-distance transport of air pollution does not influence exposure. In the case of exposure to pollutants from long-range transboundary transport, however, adequate measures can only be achieved through appropriate international agreements.

Air quality standards strongly influence the implementation of air pollution control policies. In many countries, there is an obligation to develop action plans at the municipal, regional or national level to abate air pollution (clean air implementation plans) if standards are exceeded. Such plans have to address all relevant sources. Air quality standards also play a role in environmental impact assessments and in the provision of public information on the state of the environment.

7.3 Adverse effects on health

In setting air quality standards on the basis of air quality guidelines, it is necessary to define from which effects the population is to be protected. Health effects range from death and acute illness, through chronic and lingering diseases, to temporary physiological or psychological changes.

The distinction between adverse and non-adverse effects poses considerable difficulties. WHO has given a definition of adverse effects as “any effect resulting in functional impairment and/or pathological lesions that may affect the performance of the whole organism, or which contribute to a reduced ability to respond to an additional challenge” (WHO 1987). A more recent definition was given in the framework of the International Programme for Chemical Safety in its Environmental Health Criteria Series (WHO 1994c): “An adverse effect is any change in morphology, physiology, growth, development or life span of an organism which results in impairment of functional capacity, or impairment of capacity to compensate for additional stress, or increase in susceptibility to the harmful effects of other environmental influences.” Even this elaborate definition incorporates significant subjectivity and uncertainty in defining an adverse effect of air pollutants on health.

More serious effects are generally accepted as adverse. But when the health effects are either temporary and reversible, or involve biochemical or functional changes with uncertain clinical significance, a judgement is required on whether these less serious effects should be considered when deriving the standards. Judgements as to whether the health effects are adverse may differ between countries, because of factors including different cultural backgrounds and different levels of health status. The use of biomarkers or other indicators of exposure may provide a basis for setting air quality standards. Changes in such indicators, while not necessarily being adverse effects in themselves, may be harbingers of adverse effects on health. An example is blood lead content as an indicator of likely impairment of neuro-behavioural development.

7.4 Population at risk

The population at risk is that part of the population that is exposed to enhanced concentrations of air pollution. Each population has sensitive groups or sub-populations that are at higher risk for developing health effects following exposure to air pollutants. Sensitive groups include individuals impaired by concurrent diseases or other physiological limitations, and those with specific characteristics, which makes them more vulnerable to air pollutants (e.g. infants, elderly people). Other groups may be judged to be at higher risk due to enhanced exposure (outdoor workers, athletes, children). The sensitive groups in a population may vary across countries due to differences in medical care, nutritional status, lifestyle, and/or prevailing genetic factors, or due to the existence of endemic diseases or the prevalence of debilitating diseases

7.5 Exposure-response relationships

Chapter 3 provides exposure-response relationships for a number of pollutants, including graphs for particulate matter and O₃. The percent change of various health endpoints, such as daily mortality and hospital admissions, are derived for a 10 µg/m³ increase in PM₁₀ and PM_{2.5} concentrations. Assuming linearity, the relationships apply from 0 and 200 µg/m³. For carcinogenic compounds quantitative assessment of the unit risks provides an approximate estimate of responses at different concentrations. In setting standards, the definition of acceptable risk is related to risk perception and economic and social circumstances.

In developing standards, regulators should consider the degree of uncertainty in the exposure-response relationships provided in the air quality guidelines. Differences in the population structure (age, health status) climate (temperature and humidity), and geography (altitude, environment) can influence the prevalence, frequency and severity of health effects. Consequently, modified exposure-response relationships should be applied when setting standards (see Section 2.4).

7.6 Exposure characterization

When setting standards it is not enough to simply consider the pollutant concentrations in ambient air. Personal exposure of the population should also be considered. As discussed in Section 4.2.3, the total exposure of people to pollutants also depends on the time people spend in the polluted environments, i.e. outdoor, indoor, workplace, in-vehicle etc. Exposure also depends on the various routes of intake of the pollutants into the human body, for example air, water, food and tobacco smoking. Multiple exposures may vary across these routes which should be considered in the standard setting procedure. In deriving air quality standards, the size of the population at risk (i.e. exposed to enhanced air pollutant concentrations) is also an important factor to consider. Models of exposure estimates should be used in addition to ambient and indoor concentration monitoring.

7.7 Risk assessment

The development of air quality standards should be based on health and ecological risk models. Increasingly, these models are used to inform policy makers on some of the possible consequences of air pollutants at levels corresponding to various options for standards. Using this information, the policy maker can better assess the effects of air pollution.

Regulatory risk assessment in air pollution management includes a consideration of hazard identification, exposure-response relationships, exposure assessment and quantitative risk characterization. The first step, hazard identification, and to some extent exposure-response relationships, have already been provided in the *Guidelines for Air Quality*. Exposure assessment may predict changes in exposure associated with reductions in emissions from a specific source or group of sources. When using ambient air concentrations in the assessment of exposure, the issues discussed in Section 7.4 have to be taken into consideration. The final step in regulatory risk assessment, risk characterization, refers to the quantitative estimation of the health effects in the population at risk. Examples for such estimates were given by Hong 1995; Ostro 1996; Schwela 1996a; Schwela 1996b; Schwela 1998; Murray and Lopez 1996.

Regulatory risk assessments are likely to result in different risk estimates across countries and economic regions, owing to differences in exposure patterns, and in the size and characteristics of sensitive groups. Differences in the legislation and availability of information may also lead to differing results. There are many uncertainties at each step of a regulatory risk assessment. Therefore, the methods used to conduct the risk assessments should be clearly described and the limitations associated with the analysis discussed. A sensitivity and uncertainty analysis should be performed to characterize the major uncertainties of the risk estimates.

7.8 Acceptability of risk

In the absence of thresholds for the onset of health effects - as in the cases of fine and ultra-fine particulate matter and carcinogenic compounds - the selection of an air quality standard requires that the regulator determine an acceptable risk for the population. This also applies in cases where thresholds are present, but it would not be feasible to adopt air quality guidelines as standards because of economic or technical constraints. The acceptability of the risks and, therefore, the standards selected, depends on the expected incidence and severity of the potential effects, the size of the population at risk, the perception of related risks and the degree of scientific uncertainty that the effects will occur at a specific level of air pollution. For example, if a suspected but uncertain health effect is severe, and the size of the population at risk is large, a more cautious approach would be appropriate than if the effect were less severe, or if the population were smaller.

The acceptability of risk may vary among countries because of differences in social norms, the degree of adversity and risk perception in the general population, and because of the influences of various

stakeholders. Risk acceptability is also influenced by how the risks associated with air pollution compare with risks from other pollution sources or human activities.

7.9 Cost-benefit analysis

In the derivation of air quality standards from air quality guidelines two different approaches for decision making can be applied. Decisions can be based purely on health, cultural and environmental consequences with little weight to economic efficiency. This approach would have the objective of reducing the risk of adverse effects to a socially acceptable level. The second approach would be based on a formal cost-effectiveness or cost-benefit analysis (CBA), with the objective of identifying the control action that achieves greatest net economic benefit, or is the most economically efficient. The development of air quality standards should account for both extremes, and encompass a process that involves stakeholders and assures social equity to all involved. It should also provide sufficient information to guarantee that the stakeholders understand the scientific and economic consequences. Cost benefit analysis is discussed in Section 2.4.7.

The steps in a cost-benefit analysis include:

- Identification and cost analysis of control action (emission abatement strategies and tactics).
- Assessment of air quality and population exposure, with and without the control action.
- Identification of benefit categories (health effects, material damage, damage to ecosystems).
- Comparison of health and environmental effects, with and without control action.
- Comparison of the estimated costs of control action and benefits.
- Sensitivity and uncertainty analysis.

Cost analysis of control action. To determine the financial burden of control action, cost assessment should include all costs of investment, operation and maintenance. This is usually not a problem for direct abatement measures at the source, which can be monetarized. It may be more difficult to determine the costs of indirect measures, such as alternative traffic plans or change in behaviour of individuals. Even when secondary air pollutants are not monitored they should be included in the CBA.

Assessment of air quality. An assessment of air quality includes information about expected air quality, both with and without control measures. Typically, the assessment is based on air quality monitoring data and dispersion modelling. The types of data requested in a CBA include pollutant concentrations (evaluated for relevant averaging times), site classification, emission data (with sufficient temporal and spatial resolution), and meteorological and topographical data relevant to the dispersion of emissions. The air quality guidelines are based on a set of health and environmental effect endpoints determined by consensus and scientific judgement. Other effects that were not included in the air quality guidelines may occur in a special local situation and may be considered in an analysis of costs and benefits.

Identification of benefit categories. Relevant benefit categories defined in existing CBAs include: mortality and morbidity due to long- and short-term exposures, climate and visibility effects, non-human biological effects, soiling and material damage (USEPA 1987a,b); total premature mortality and mortality due to respiratory and cardiovascular diseases, hospital admissions, upper and lower respiratory symptoms, symptom exacerbation among asthmatics and reduced activity days (EC DG XII 1995; GVF 1996). The quantification of benefit categories included in a CBA is a difficult task. Some indicators of diseases can be quantified, such as the use of medication, number of hospital admissions, outpatient visits or days of labour lost. Other effects, such as premature death of the elderly or excess mortality present more difficult problems. Well-being, the quality of life or the value of ecosystems may be difficult or even impossible to monetarize. The values assigned to benefit categories might differ substantially among countries due to different cultural or social attitudes. It is better, however, to include the relevant benefit categories, even if the economic assessment is uncertain or ambiguous.

Comparison of health and environmental effects. A comparison of the health and environmental benefits with and without control action, and information on exposure-response relationships, should be combined with information on air quality assessment. The combined information is applied to the population at risk. To assess the influence of air pollution, knowledge is needed of the prevalence of different health effects in the population at risk and the percent increase of health effects with one unit of pollutant concentration.

Comparison of costs and benefits. The CBA should provide a benefit-cost ratio based on monetarized costs and benefits, and be accompanied by a description of the non-monetarized items that also should be considered. Monetary valuation of control actions, and of the effects on health and the environment, may be different in concept and vary substantially from country to country. There may be differences in assessing costs, and the relative value of benefit categories can vary. The costs of environmental policy action may also vary according to the scale and level of decision making, e.g. with respect to transfer costs (taxes, subsidies aimed at redistribution of costs). Benefits may also be transferable between groups of the population. Furthermore, action taken to reduce one pollutant may increase or decrease the concentration of other pollutants. These additional effects should be considered, as well as pollutant interactions, which may lead to double counting of costs or benefits, or to disregarding some costly but necessary action. Due to different levels of knowledge about the costs of control action and the costs of health effects there is a tendency to overestimate the cost of control action and underestimate the benefits. Thus, CBAs in two areas with otherwise similar conditions may differ significantly.

Sensitivity and uncertainty analysis. In a CBA, sensitivity analysis provides valuable insight into the properties and assumptions underlying the results of the CBA. Sensitivity methods include comparison with other CBA studies, recalculation of the whole chain of CBA using other assumptions, or ranges around a central value. Sensitivity analysis has to be carefully designed and requires considerable resources.

In conclusion, CBA is a highly interdisciplinary task. Appropriately applied, CBA is a legitimate and useful way to provide information for risk managers making decisions that will affect public health and the environment. CBAs should be peer-reviewed and not be used as the sole and overriding determinant of these decisions.

7.10 Review of standard setting

The setting of standards should involve stakeholders (industry, local authorities, non-governmental organisations and the general public) that assures, as far as possible, social equity or fairness to all the parties involved. It should also provide sufficient information to guarantee that stakeholders understand the scientific and economic consequences. The earlier stakeholders are involved the more likely is their acceptance. Transparency in moving from air quality guidelines to air quality standards helps to increase public acceptance of necessary measures. Raising public awareness of air pollution-induced health and environmental effects (changing of risk perception) serves to obtain public support for necessary control action. Information to the public about the air quality during episodes, as well as the risks entailed, lead to a better understanding of the issue (risk communication).

Air quality standards should be regularly reviewed and revised as new scientific evidence on the effects on public health and the environment emerges.

7.11 Enforcement of air quality standards: Clean air implementation plans

The aim of enforcement is to attain compliance with the standards. The instruments used to achieve this goal are Clean Air Implementation Plans (CAIPs). The outline of such a plan should be defined in regulatory policies and strategies. Clean air implementation plans were formulated in several developed countries during the 1970s and 1980s. Air pollution was characterized by many sources and many different types of air pollutants. Consequently it was extremely difficult to assess the public health risks

associated with a single source or group of sources. As a consequence, on the basis of the polluters pay principle (Chapter 6), sophisticated tools were developed to assess the sources (e.g. air pollutant concentrations, health and environmental effects, control measures) and to make a causal link between emissions, air pollution and the necessary and efficient control measures. A typical clean air implementation plan (CAIP) includes:

- Description of area.
- Emissions inventory.
- Air pollutant concentrations inventory - monitored and simulated.
- Comparison of emissions and air quality standards or guidelines.
- Inventory of effects on public health and the environment.
- Causal analysis of effects and attribution to individual sources.
- Control measures and their costs.
- Transportation and land-use planning.
- Enforcement procedures.
- Resource commitment.
- Projections for the future.

Costs of public health and environmental effects have not been included in published clean air implementation plans. However, the CAIP has been a very efficient instrument of air pollution abatement in developed countries (Schwela and Köth-Jahr 1994, WHO 1997a). In the cities of developing countries, or countries in transition, much simplified CAIPs would have to be developed. The main sources of emissions in many cities of the developing world are old vehicles and some industrial sources such as power plants, brick kilns, cement factories and a few others. Their relative contribution to air pollution could be determined by use of rapid emission inventories. The emission factors used in such inventories are published (WHO 1993a 1993b), and a PC programme is available (WHO 1995; WHO 1997b; WHO 1998) that enables emissions and ambient air concentrations to be estimated, and the impact of possible control measures to be evaluated. Projections for the future can also be evaluated by the programme. By using the experience obtained in developed countries, the control action to be taken is very often obvious. As a consequence less monitoring could be sufficient, and dispersion models could help simulate spatial distributions of concentrations when little useful monitoring data are available. 0