World Health Organization
Regional Office for Europe
Copenhagen

Air Quality Guidelines for Europe

WHO Regional Publications, European Series No. 23

World Health Organization
Regional Office for Europe
Copenhagen

Air quality guidelines for Europe

WHO Regional Publications, European Series No. 23

ISBN 92 890 1114 9
ISSN 0378-2255

PRINTED IN DENMARK

Foreword

Following the successful introduction of WHO guidelines for drinking-water quality, the Government of the Netherlands approached the WHO Regional Office for Europe in 1983 to suggest that air quality guidelines should be developed, using the same general philosophy and approach. We realized from the outset that this would be a difficult task and that, for example, sampling procedures were very much more complicated than in the case of water supplies. As was also the case for the drinking-water programme, we agreed that it would be inappropriate to try to formulate "standards", these being for governments and regulating agencies to decide on in the context of prevailing exposure levels and environmental, social, economic and cultural conditions. The approach has been to develop guideline values that in the opinion of the experts are appropriate for the safeguarding of public health and will guide national and local authorities in their risk management decisions. It is important that the numerical values are taken in the context of the descriptive sections of the guidelines: in many cases only an order of magnitude can be given, based on available data, but this is more useful to public health officials and regulators than no figure at all. In some cases, it has not been found useful to give a guideline value, but instead to provide a risk estimate.

Great efforts have been made during recent years in many countries of the European Region to reduce air pollution, and the intense smogs that were frequently experienced in London and other large cities up until 30 years ago no longer occur. Progress has, however, been uneven and in particular the burning of low-quality soft coals has caused increasing problems in some parts of Europe, especially when associated with atmospheric inversions.

In addition to the major pollutants such as sulfur dioxide and particulates, there is now increasing interest in the emission of small concentrations of potentially toxic inorganic and organic micropollutants.

The vast majority of Europeans spend over 75% of their lives indoors and the guidelines appropriately include consideration of indoor air quality, though not of occupational exposure. Although this publication is primarily intended to cover public health considerations, it was, I think, a useful decision to include some ecotoxicological dimensions. Most certainly, those involved in environmental management and public health practices increasingly need to view the effects of pollution on man within the context of the health of the entire biosphere. This is particularly important in the case of air pollution, which transcends national frontiers and can have marked effects at great distances from the source.

It is hoped that the guidelines will have a wide application in environmental decision-making throughout the Region as well as in other parts of the world. They were developed to a very demanding time scale and all those concerned in their preparation are aware that the publication does not represent any final judgement on the subject. In future editions new parameters will have to be addressed and the effect of combined exposures may have to be taken into account.

The farsightedness of the initiative by the Government of the Netherlands and the encouragement received from their representatives during the preparation of the guidelines are warmly acknowledged. The work involved great dedication and enthusiasm on the part of the 150 experts who participated in the various meetings and who were often under very great pressure to meet apparently impossible deadlines. It is appropriate that the unstinting efforts of the Editorial Consultation Group that met in Copenhagen in March 1986 should be specially recognized.

That the final product was delivered on time is a great tribute to all concerned and I would like to thank the secretaries and other members of the Regional Office staff for their great contribution and to mention in particular Dr Reiner Türck, project coordinator, and Dr Dinko Kello, project consultant, without whose combined qualities of scientific excellence, power of persuasion, tenacity and organizational ability, the work could not have been completed within an acceptable time frame.

J.I. Waddington
Director
Environmental Health Service

Preface

The World Health Organization has been concerned with air pollution and, in particular, its dangers to human health for 30 years. In 1957, a WHO conference was held in Milan dealing with the public health aspects of air pollution in Europe. In the same year a special report on air pollution by the WHO Expert Committee on Environmental Sanitation was published.

Since then, many activities have been undertaken covering different areas of the subject, such as measurement techniques, the compilation of air quality data from different urban areas in the world and the effects of air pollution on health. A *Manual on urban air quality management* published in 1976, a *Glossary on air pollution* published in 1980, and a *Manual on industrial air pollutants* published on behalf of WHO by Elsevier in 1983, have been part of the work of the Regional Office for Europe in this field.

With regard to air quality criteria and guides, the report of a WHO Expert Committee was published in 1972. Furthermore, the Environmental Health Criteria Programme, which started under the joint sponsorship of WHO and UNEP and now comes under the trilateral responsibility of WHO, UNEP and ILO, within the framework of the International Programme on Chemical Safety, has so far resulted in some 60 environmental health criteria documents, a significant number of which deal with air pollutants.

When the industrialized countries of the European Region began to establish environmental policies, it soon became apparent that a yardstick was needed for the evaluation of air quality. Air quality standards or objectives for major urban air pollutants were accordingly developed in many European countries. In this context, it was gradually recognized that international cooperation would be needed in certain areas, one of them being the joint assessment by scientists from various countries of the adverse effects of air pollutants. This perception may be demonstrated by a statement in the WHO Global Medium-term Programme for the Promotion of Environmental Health, 1983:

> With respect to environmental hazards assessment and control, much can be accomplished through international cooperation. The collection and assessment of information on human exposures to pollutants and on their effects on health is a very time-consuming and expensive effort, and very few countries, even in the industrialized world, have the necessary resources and expertise to do this alone. The pooling of resources to conduct these assessments can provide the governments with the necessary information which they need to take action.

It is obvious why the WHO Regional Office for Europe therefore felt fully justified in embarking on its project of establishing air quality guidelines for the Region. The recent successful development of guidelines for drinking-water quality was regarded as a further incentive.

From the very beginning of the project, it was clear that some basic principles would have to be followed.

- The guidelines should describe the latest state of scientific knowledge. They would have to be developed together in a short time period in order to guarantee this objective.

- The information provided would have to be condensed, describing only the essential factors leading to the final conclusions. To create a one-volume book on 28 pollutants or groups of pollutants, all encyclopaedic types of information would have to be ignored.

- The description of scientific findings would have to be of a kind that would be understandable to a broad and rather heterogeneous readership. The flow of the arguments would have to be clear.

- The rationale for the guideline recommendations should also contain a description of uncertainties in the evaluation process due to missing, inadequate or equivocal data. Any illusion should be avoided that it is possible to condense a very complex situation in reality down to a simple figure without making assumptions. In particular, questions of safety or protection factors, combined effects and high-risk groups would have to be discussed in this context.

- Another important goal would be to create a basic common structure for the description of pollutants and the rationale for guidelines, without deleting too much of the "handwriting" of specific authors and working groups.

- Finally, it was a prerequisite that the draft guidelines would have to undergo several intensive reviews, giving everybody involved the chance to look at the whole document at various stages of development.

It can easily be understood that the achievement of these goals required a high spirit of cooperation among all the experts involved in this publication. It is for the reader to decide how successfully their task has been accomplished.

The term "guidelines" should be understood literally, meaning that the main objective is to provide guidance to those interested in air pollution problems as well as to those directly involved in air quality management.

The guidelines consider various toxic (carcinogenic and noncarcinogenic) substances, and for a few substances also their ecological effects. No differentiation is made in terms of guidelines for outdoor or indoor pollution. The guidelines address concentration and exposure times regardless

of whether the exposure is inside or outside buildings. However, typical occupational exposures are not the main focus of attention as these guidelines relate to the general population.

For those compounds that were not reported to induce carcinogenic effects and on which data regarding carcinogenic effects were lacking or insufficient, a threshold assumption was made and guideline values were proposed. For carcinogenic substances, the guidelines provide an estimate of lifetime cancer risk arising from exposure to those substances.

The guidelines are intended to provide background information and guidance to governments in making risk management decisions, particularly in setting standards. It should be strongly emphasized that the guideline values are not to be regarded as standards in themselves. It is obvious that there is a variety of ways to control air pollution and to protect our health and environment: it is advisable to use all the tools available. Air quality guidelines alone may not be very effective in the fight against pollution, but they should prove extremely useful in the framework of an overall environmental policy.

R. Türck
Project Coordinator
Air Quality Guidelines

CONTENTS

PART III. INORGANIC SUBSTANCES

PART IV. EFFECTS OF INORGANIC SUBSTANCES ON VEGETATION

1

Introduction

Human beings need a continuous supply of food, air and water to exist. The requirements for air and water are relatively constant (10–20 m^3 and 1–2 litres per day respectively). Air and water are also used in industrial processes of energy conversion, in manufacturing, and for the removal of waste products, some of which may be injurious to human health. In a comprehensive set of guidelines for drinking-water developed by WHO *(1)*, guideline values were recommended for specified contaminants, a consistent process of assessment being used.

The WHO Regional Office for Europe has subsequently developed the present air quality guidelines for the European Region. The task of developing such guidelines is more difficult than that of drawing up drinking-water guidelines, since for air, unlike water, there is no centrally supplied and controlled source. The development of consistent rules for assessing 28 chemical air contaminants also posed a challenge.

These air quality guidelines should be seen as a contribution to the target on air pollution contained in WHO's regional strategy for health for all. This target states that "by 1995, all people of the Region should be effectively protected against recognized health risks from air pollution" *(2)*. Accordingly, "the achievement of this target will require the introduction of effective legislative, administrative and technical measures for the surveillance and control of both outdoor and indoor air pollution, in order to comply with criteria to safeguard human health" *(2)*.

Various chemicals are emitted into the air from both natural and man-made (anthropogenic) sources. The quantities may range from hundreds to millions of tonnes annually. Natural air pollution stems from various biotic and abiotic sources (e.g. plants, radiological decomposition, forest fires, volcanoes and other geothermal sources, emissions from land and water), leading to a natural background concentration that varies according to local sources or specific weather conditions. Anthropogenic air pollution has existed at least since people learned to use fire, but it has increased rapidly since industrialization began. The increase in air pollution as a consequence of the expanding use of fossil energy sources and the growth in the manufacture and use of chemicals has been accompanied by mounting public awareness of and concern about its detrimental effects on

health and the environment. Moreover, knowledge of the nature, quantity, physicochemical behaviour and effects of air pollutants has greatly increased in recent years. Nevertheless, more needs to be known. Certain aspects of the health effects of air pollutants require further assessment; these include newer scientific areas such as developmental toxicity. The proposed guideline values will undoubtedly be changed as future studies lead to new information.

The impact of air pollution is broad. In man, the pulmonary deposition and absorption of inhaled chemicals can have direct consequences for health. However, public health can also be indirectly affected by the deposition of air pollutants in plants, animals and the other environmental media, resulting in chemicals entering the food chain or being present in drinking-water and thereby constituting additional sources of human exposure. Furthermore, the direct effects of air pollutants on plants, animals and soil can influence the structure and function of ecosystems, including their self-regulation ability, thereby affecting the quality of life.

Although in recent decades major efforts have been made to reduce air pollution, the situation in the European Region is still not satisfactory. While air pollution has decreased and peak concentrations have been reduced in many larger cities and urban areas, the overall pollution in terms of the amounts of pollutants released into the atmosphere has often been only slightly reduced or has remained unchanged, and concentrations have even increased in some areas and for some pollutants *(2–5)*.

Many countries of the European Region encounter rather similar air pollution problems, partly because pollution sources are comparable, and in any case air pollution does not respect national frontiers. The subject of the transboundary medium- and long-range transport of air pollution has received increasing attention in Europe in recent years. International efforts to combat its consequences are under way, for instance within the framework of the Convention on Long-range Transboundary Air Pollution established by the United Nations Economic Commission for Europe *(6)*.

The task of reducing levels of exposure to air pollutants is a complex one. It begins with an analysis to determine which chemicals are present in the air, at what levels, and whether these levels of exposure are hazardous to human health and the environment. It must then be decided whether an unacceptable risk is present. When a problem is identified, mitigation strategies are developed and implemented so as to prevent excessive risk to public health in the most efficient way.

Analyses of air pollution problems are exceedingly complicated. Some are national in scope (e.g. definition of actual levels of exposure of the population, determination of acceptable risk, identification of the most efficient control strategies), while others are of a more basic character and are applicable in all countries (e.g. analysis of the relationships between chemical exposure levels, doses and their effects). The latter form the basis of the present guidelines.

The most direct and important source of air pollution affecting the health of many people is tobacco smoke. Even those who do not smoke may inhale the smoke produced by others ("passive smoking"). Indoor pollution

in general and occupational exposure in particular also contribute substantially to overall human exposure: indoor concentrations of nitrogen dioxide, carbon monoxide, respirable particulates, formaldehyde and radon are often higher than outdoor concentrations *(7)*.

Outdoor air pollution can originate from a single point source which may affect only a relatively small area. More often, outdoor air pollution is caused by a mixture of pollutants from a variety of diffuse sources, such as traffic and heating, and from point sources. Finally, in addition to those emitted by local sources, pollutants transported over medium and long distances contribute further to the overall level of air pollution.

The relative contribution of emission sources to human exposure to air pollution may vary according to regional and lifestyle factors. Although indoor air pollution will be of higher relevance than outdoor pollution as far as certain air pollutants are concerned, this does not diminish the importance of outdoor pollution. In terms of the amounts of substances released, the latter is far more important and may have deleterious effects on animals, plants and materials as well as adverse effects on human health.

Nature of the Guidelines

The primary aim of the air quality guidelines[a] is to provide a basis for protecting public health from adverse effects of air pollution and for eliminating, or reducing to a minimum, those contaminants of air that are known or likely to be hazardous to human health and wellbeing.

The guidelines are intended to provide background information and guidance to governments in making risk management decisions, particularly in setting standards, but their use is not restricted to this. They also provide information for all who deal with air pollution. The guidelines may be used in planning processes and various kinds of management decision at community or regional level. When guideline values are indicated, this does not necessarily mean that they must take the form of general countrywide standards, monitored by a comprehensive network of control stations. In the case of some agents, guideline values may be of use mainly for carrying out local control measures around point sources.

It should be emphasized that when air quality guideline values are given, these values are not standards in themselves. Before standards are adopted, the guideline values must be considered in the context of prevailing exposure levels and environmental, social, economic and cultural conditions *(1)*. In certain circumstances there may be valid reason to pursue policies which will result in pollutant concentrations above or below the guideline values.

Ambient air pollutants can cause several significant effects which require attention: irritation, odour annoyance, acute and long-term toxic effects (including carcinogenic effects). Air quality guidelines either indicate levels combined with exposure times at which no adverse effect is expected concerning noncarcinogenic endpoints, or they provide an estimate of lifetime

[a] Guidelines in the present context are not restricted to suggested numerical values, but also include any kind of recommendation or guidance in the relevant field.

cancer risk arising from those substances which are proven human carcinogens or carcinogens with at least limited evidence of human carcinogenicity (see p. 12).

The guidelines represent the current best scientific judgement, but there is a need for periodic revision, since much remains to be determined regarding the toxicity of air pollutants for humans.

It is believed that inhalation of an air pollutant in concentrations and for exposure times below a guideline value will not have adverse effects on health and, in the case of odorous compounds, will not create a nuisance of indirect health significance (see definition of health, *Constitution of the World Health Organization*). Compliance with recommendations regarding guideline values does not guarantee the absolute exclusion of effects at levels below such values. For example, highly sensitive groups especially impaired by concurrent disease or other physiological limitations may be affected at or near concentrations referred to in the guideline values. Health effects at or below guideline values can also result from combined exposure to various chemicals or from exposure to the same chemical by multiple routes.

It is important to note that guidelines have been established for single chemicals. Chemicals, in mixture, can have additive, synergistic or antagonistic effects; however, knowledge of these interactions is still rudimentary. With a few exceptions, such as the combined effect of sulfur dioxide and particulates, there is insufficient information at present to establish guidelines for mixtures. An adequate margin of safety should exist between the guideline values and concentrations at which toxic effects will occur.

Risk estimates for carcinogens do not indicate a safe level; they are presented so that the carcinogenic potencies of different carcinogens can be compared and an assessment of overall risk made.

Although health effects were the major consideration in establishing the guidelines, ecologically based guidelines for preventing adverse effects on terrestrial vegetation were also considered and guideline values were recommended for a few substances. These ecological guidelines for vegetation have been established because, in the long term, only a healthy total environment can guarantee human health and wellbeing (see p. 17). Ecological effects on species other than plants have not been discussed, since they are outside the scope of this book.

The guidelines do not differentiate between indoor and outdoor exposure (with the exception of exposure to mercury) because, although the sites influence the type and concentration of chemicals, they do not directly affect the basic exposure–effect relationship. Occupational exposure has been considered in the evaluation process, but it was not a main focus of attention as these guidelines relate to the general population. However, it should be noted that occupational exposure may add to the effects of environmental exposure.

The guidelines do not apply to very high short-term concentrations which may result from accidents or natural disasters.

The health effects of tobacco smoking have not been assessed here, the carcinogenic effects of smoking having recently been evaluated by IARC (*8* and see Annex 1). Neither have the effects of air pollutants on climate

been considered, since too many uncertainties remain to allow an evaluation of the possible adverse health and environmental effects. However, possible changes of climate have to be investigated very seriously by the appropriate bodies because their overall consequences, for example the "greenhouse effect", may go beyond direct adverse effects on human health or ecosystems.

Procedures used in Establishing the Guidelines

The first step in the process of establishing air quality guidelines was the selection of pollutants. Air pollutants of special environmental and health significance to countries of the European Region were identified and selected on the basis of the following criteria suggested by a WHO Scientific Group *(9)*:

(*a*) severity and frequency of observed or suspected adverse effects on human health, where irreversible effects are of special concern;

(*b*) ubiquity and abundance of the agent in man's environment, with emphasis on air pollutants;

(*c*) environmental transformations or metabolic alterations, as these alterations may lead to the production of chemicals with greater toxic potential;

(*d*) persistence in the environment, particularly if the pollutant would resist environmental degradation and accumulate in humans, the environment or food chains; and

(*e*) population exposed (size of exposed population and special groups at risk).

Other factors affecting the selection were the timetable of the project and the fact that only those substances could be considered for which sufficient documentation was available (such as the WHO *Environmental health criteria* documents). On the basis of these criteria, the following 28 pollutants were selected for evaluation.

Organic air pollutants

Acrylonitrile
Benzene
Carbon disulfide
1,2-Dichloroethane
Dichloromethane
Formaldehyde
Polynuclear aromatic hydrocarbons (carcinogenic fraction)
Styrene
Tetrachloroethylene
Toluene
Trichloroethylene
Vinyl chloride

Inorganic air pollutants

Arsenic
Asbestos
Cadmium
Carbon monoxide
Chromium
Hydrogen sulfide
Lead
Manganese
Mercury
Nickel
Nitrogen oxides
Ozone/photochemical oxidants
Particulate matter
Radon
Sulfur oxides
Vanadium

After a planning meeting in early 1984 that offered suggestions on content, format, workplan and timetables for the air quality guidelines project, a series of nine meetings involving more than 130 experts took place to evaluate various air pollutants (see Annex 2).

Before the meeting of each working group, scientific background documents were prepared as a basis for discussion and for establishing the guidelines. After each meeting, a text on the individual pollutant or pollutant group was drafted on the basis of the amended background documents, incorporating the working group's conclusions and recommendations. The drafts were then circulated to all participants of the meetings for their comments and corrections. An editorial consultation group of scientists was then convened to review the documents for clarity of presentation, adequacy of description of the rationale supporting each guideline and consistency in the application of criteria. Certain sections in which inconsistencies were noted were again submitted for review, whereupon the final draft was prepared and submitted for extramural review; it was sent to the governments of Member States of the Region, and to organizations and individuals engaged in air quality research or management. The process concluded with a review in a final meeting, at which the recommendations and conclusions of all the working groups were submitted for final appraisal.

References

1. *Guidelines for drinking-water quality. Vol. 1. Recommendations.* Geneva, World Health Organization, 1984.
2. *Targets for health for all.* Copenhagen, WHO Regional Office for Europe, 1985.
3. **United Nations Economic Commission for Europe.** *Airborne sulphur pollution: effects and control.* New York, United Nations, 1984 (Air Pollution Series, No. 1).
4. **International Register of Potentially Toxic Chemicals.** *List of environmentally dangerous chemical substances and processes of global significance: scientific monographs.* Geneva, United Nations Environment Programme, 1984 (UNEP Report No. 2).
5. *Pilot compendium of environmental data.* Paris, Organisation for Economic Co-operation and Development, 1984.
6. **United Nations Economic Commission for Europe.** Convention on Long-range Transboundary Air Pollution. *International digest of health legislation,* **30**(4): 965 (1979).
7. *Estimating human exposure to air pollutants. GEMS: Global Environmental Monitoring System.* Geneva, World Health Organization, 1982 (WHO Offset Publication, No. 69).
8. *Tobacco smoking.* Lyon, International Agency for Research on Cancer, 1986 (IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans, Vol. 38).
9. Background and purpose of the WHO environmental health criteria programme. *In: Mercury.* Geneva, World Health Organization, 1976 (Environmental Health Criteria, No. 1).