UPDATE AND REVISION OF WHO AIR QUALITY GUIDELINES FOR EUROPE

Introduction

Clean air is considered to be a basic requirement for human health and well-being. Therefore, the World Health Organization has been concerned with air pollution and its impact on human health for 40 years. The first WHO conference on public health aspects of air pollution in Europe was held in Milan in 1957, and was followed by several activities of the Regional Office for Europe in this field, all aiming at international cooperation and harmonization of environmental policies in the European Region. These activities culminated in the development of the WHO Air Quality Guidelines for Europe.

The first edition of the WHO Air Quality Guidelines for Europe was published in 1987. This publication comprised health risk evaluations for 27 pollutants. It was the aim of the Guidelines as stated in the first edition to provide a basis for protecting public health from adverse effects of environmental pollutants and eliminating or reducing to a minimum exposure to those pollutants that are known or likely to be hazardous to human health or well-being. 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 for vegetation protection for nitrogen- and sulphur oxides and ozone have been established.

The Guidelines are intended to provide background information and guidance to national or international authorities in making risk assessment and risk management decisions. In providing pollutant levels below which exposure, for lifetime or for a given period of time, does not constitute a significant public health risk, the guidelines form a basis for setting (inter)national standards or limit values for air pollutants.

In general, the guidelines address single pollutants, whereas in real-life exposure to mixtures of chemicals occur, with additive, synergistic or antagonistic effects. Although the WHO Air Quality Guidelines are considered to be protective to human health they are by no means a "green light" for pollution and it should be stressed that attempts should be made to keep air pollution levels as low as practically achievable.

The Guidelines do not differentiate between indoor and outdoor air exposure because, although the site of exposure is determining the type and concentration of air pollutants, it does not directly affect the exposure-response relationship.

It should be emphasized, however, that the Guidelines are health based or based on environmental effects and are not standard per se. In setting legally binding standards also other considerations such as prevailing exposure levels, technical feasibility, source control measures, abatement strategies, as well as social, economic and cultural conditions must be taken into consideration. Consequently (inter)national standards may be above or below the health-based WHO Air Quality Guidelines.

Update and revision

Since the publication of the first edition of the WHO Air Quality Guidelines new scientific data in the field of air pollution toxicology and epidemiology have emerged and new developments in risk assessment methodology have taken place. These developments have necessitated updating and/or revision of the existing Guidelines. The Bilthoven Division of the European Centre for Environment and Health has undertaken the process of amending, updating and extending the existing Guidelines. This process was carried out in close cooperation with the International Programme of Chemical Safety (IPCS) and the European Commission (DG XI).

In January 1993 a Planning Meeting was convened where the priorities and the framework of the process were established. In setting priorities for the compounds to be reviewed the following criteria were applied:

- the compound (or mixture) posed a widespread problem in terms of exposure sources,
- the potential for personal exposure was large,
- new data on health or environmental impact have emerged,
- monitoring became feasible,
- a positive trend in ambient air concentrations was evident.

To carry out the evaluation process the following working groups were established:

Methodology and Format, September 1993

This working group provided advice on the format of the second edition and on the methods to be used in the risk assessment process. Guidance was given on the use of the threshold concept, the application of uncertainty factors, and the quantitative risk assessment of carcinogens.

In principle quantitative lifetime cancer risk estimates should be provided for compounds classified by IARC as Class 1 or 2A. For compounds classified as 2B or 3, in general, a threshold approach should be applied. However, in case sufficient information on the mechanism of action (in particular with respect to the presence or absence of a genotoxic potential) exists a deviation of these general principles was considered to be acceptable.

Ecotoxic Effects, September 1994

The working group evaluated the effects of ozone, nitrogen containing compounds and sulphur dioxide on vegetation. The principles applied were those as developed by the Working Group on Effects under the Convention on Transboundary Air Pollution of the UNECE, and the evaluations were carried out in cooperation with this working group. Critical levels for various vegetation categories have been established for ozone, SO_2, nitrogen oxides and ammonia, in addition critical loads representing quantitative estimates of deposition have been derived for nitrogen and sulphur oxides.

" Classical" Air Pollutants, October 1994

This working group evaluated the health risk of exposure to carbon monoxide (CO), ozone (O_3), nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and particulate matter (PM_{10}; particles with a diameter < 10 µm). The effects of these pollutants were considered separately and in combination. Due to emerging new European data on the effects of air pollution on health (APHEA study) a second working group on " Classical" Air Pollutants was convened in June 1996 in Brussels in close cooperation with EC-DG XI.

For CO, NO_2, SO_2 and O_3 threshold levels were established. For PM_{10}, however, available epidemiological data did not facilitate the establishment of a level below which no effects would be expected. Therefore, no specific guideline value was established, but, instead, exposure-effect information was provided, giving guidance to risk managers about the major health impact for short and long term exposure to various levels of this pollutant (see Table 2 and 3).

Inorganic Air Pollutants, October 1994

This working group evaluated the health effects of arsenic, cadmium, chromium, fluoride, lead, manganese, mercury, nickel and platinum. Threshold levels were established for lead, manganese and mercury. Quantitative risk estimates for lifetime cancer risk were derived for arsenic, chromium (Cr VI) and nickel. For platinum the derivation of a guideline value was not deemed necessary because ambient air concentrations are at least three orders below levels exerting sensitisation reactions in a sensitive part of the population. For cadmium a guideline value was derived based on environmental considerations. For fluoride it was concluded that levels that would protect livestock and plants would also sufficiently protect human health. No guideline value, however, could be derived for fluoride on this basis due to a lack of data.

Certain Indoor Air Pollutants, March 1995

This working group evaluated radon, man-made vitreous fibres (MMVF) and environmental tobacco smoke (ETS). Quantitative risk estimates were established for radon and for some MMVF, the refractory ceramic fibres (RCF). No guideline value was recommended for the other MMVF. For ETS no guideline value was established, because it has been found to be carcinogenic and to cause other serious health effects (cardiovascular effects) at typical environmental exposure levels.

PCBs, Dioxins and Furans, May 1995

In evaluating PCBs, PCDDs and PCDFs it was recognized that the direct health risk via inhalation is negligible in comparison with the total (oral) exposure to these compounds. Although emission into air is the major source of accumulation of these compounds in the food chain, no reliable information was available to calculate indirect human exposure from contaminated food via deposition from ambient air. For these reasons no guideline values were established.

Volatile Organic Pollutants, October 1995

This working group evaluated benzene, 1,3-butadiene, dichloromethane, formaldehyde, PAHs, styrene, tetrachloroethylene, toluene and trichloroethylene. Threshold levels were established for dichloromethane, formaldehyde, styrene, tetrachloroethylene and toluene. Quantitative risk estimates were derived for benzene, PAHs and trichloroethylene. No guideline was established for 1,3-butadiene, because cancer risk estimates in various species varied widely and no conclusion could be made which species to be used for human risk estimates.

The *Final Consultation on the Update and revision of the WHO Air Quality Guidelines for Europe* was convened from 28-31 October 1996. It was the aim of this Consultation to critically evaluate the recommendations of the various working groups with a view on possibly newly emerged information and consistency and transparency in the derivation of the guidelines. The Consultation approved nearly all recommended guidelines (amended only three of them) and provided a couple of amendments or extensions to the main body of the text of the final chapters of the second edition of the WHO Air Quality Guideline for Europe. For the final results of the WHO Air Quality Guidelines see Table 1.

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Table 1. REVISED WHO AIR QUALITY GUIDELINES FOR EUROPE

Substance	guideline value	averaging time
Classical Air Pollutants		
carbon monoxide	100 mg/m^3	15 min
	60 mg/m^3	30 min
	30 mg/m^3	1 hour
	10 mg/m^3	8 hour
ozone	120 µg/m^3	8 hour
nitrogen dioxide	200 µg/m^3	1 hour
	40 µg/m^3	annual
sulphur dioxide	500 µg/m^3	10 min
	125 µg/m^3	24 hour
	50 µg/m^3	annual
particulate matter	exposure-response [a)]	
Indoor Air		
MMVF (RCF)	1×10^{-6} (fibre/litre)$^{-1}$	UR / lifetime
radon	$3\text{-}6 \times 10^{-5}$/Bq/m^3	UR / lifetime
ETS	no guideline [a)]	
Organic Pollutants		
benzene	6×10^{-6} (µg/m^3)$^{-1}$	UR / lifetime
1,3 butadiene	no guideline [a)]	
dichloromethane	3 mg/m^3	24 hour
formaldehyde	0.1 mg/m^3	30 min
PAH (BaP)	8.7×10^{-5} (ng/m^3)$^{-1}$	UR / lifetime
styrene	0.26 mg/m^3	1 week
tetrachloroethylene	0.25 mg/m^3	annual

toluene	0.26 mg/m^3	1 week
trichloroethylene	4.3 x 10^{-7} (µg/m^3)$^{-1}$	UR / lifetime
PCBs, PCDDs, PCDFs	no guideline [a)]	
Inorganic Pollutants		
arsenic	1.5 x 10^{-3} (µg/m^3)$^{-1}$	UR / lifetime
cadmium	5 ng/m^3	annual
chromium (Cr VI)	4 x 10^{-2} (µg/m^3)$^{-1}$	UR / lifetime
fluoride	no guideline [a)]	
lead	0.5 µg/m^3	annual
manganese	0.15 µg/m^3	annual
mercury	1.0 µg/m^3	annual
nickel	3.8 x 10^{-4} (µg/m^3)$^{-1}$	UR / lifetime
platinum	no guideline [a)]	
Ecotoxic Effects		
SO2 critical level	10 - 30 µg/m^3 [b)]	annual
critical load	250 - 1500 eq/ha/yr [c)]	
NOx critical level	30 µg/m^3	annual
critical load	5 - 35 kgN/ha/yr [c)]	
ozone critical level	0.2 - 10 ppm.h [b, d)]	5 days - 6 months

a) see text
b) depending on type of vegetation
c) depending on the type of soil and ecosystem
d) AOT: Accumulated exposure Over a Threshold of 40 ppb.

UR is the excess risk of dying from cancer following lifetime exposure. This means for instance that for benzene 6 persons in a population of 1 million will die when they are exposure for their lifetime to a concentration of 1 µg/m^3, for PAHs the unit risk tells you that 87 persons in a population of 1 million will die from cancer following lifetime exposure to 1 ng/m^3.

Table 2. Summary of Relative Risk estimates for bronchodilator use, cough and LRS reporting, PEF changes and respiratory hospital admissions and daily mortality, associated with a 10 μg/m^3 increase in the concentration of PM10 or PM2.5 (results of meta-analysis of available studies)

Endpoint	**Relative Risk for PM2.5 (95% C.I.)**	**Relative risk for PM10 (95% C.I.)**
Bronchodilator use		1.0305 (1.0201-1.0410)
Cough		1.0356 (1.0197-1.0518)
LRS		1.0324 (1.0185-1.0464)
PEF change (relative to mean)		-.13% (-.17% - -.09%)
Respiratory hospital admissions		1.0080 (1.0048-1.0112)
Mortality	1.015 (1.011-1.019)	1.0074 (1.0062-1.0086)

Table 3. Summary of Relative Risk estimates for effects of long-term exposure to PM on morbidity and mortality, associated with a 10 μg/m^3 increase in the concentration of PM10 or PM2.5

Endpoint	**Relative Risk for PM2.5 (95% C.I.)**	**Relative Risk for PM10 (95% C.I.)**
Mortality (1)	1.14 (1.04, 1.24)	1.10 (1.03, 1.18)
Mortality (2)	1.07 (1.04, 1.11)	n.a.
Bronchitis (3)	1.34 (0.94, 1.99)	1.29 (0.96, 1.83)
% change in FEV_1, children (4)	-1.9% (-3.1%, -0.6%)	-1.2% (-2.7%, -0,1%)
% change in FEV_1, adults (5)		-1.0% (n.a.)

(1) **Dockery, D.W. et al.** An association between air pollution and mortality in six U.S. cities. *New England Journal of Medicine* 329: 1753-1759 (1993).

(2) **Pope, C.A. III. et al.** Particulate air pollution as a predictor of mortality in a prospective study of U.S. adults. *American Journal of Respiratory and Critical Care Medicine* 151: 669-674 (1995)

(3) **Dockery, D.W. et al.** Health effects of acid aerosols on North American children: respiratory symptoms. *Environmental Health Perspectives*, 104: 500-505 (1996)

(4) **Raizenne, M. et al.** Health effects of acid aerosols on North American children: pulmonary function. *Environmental Health Perspectives*, 104: 506-514 (1996)

(5) **Ackermann-Liebrich, U. et al.** Lung function and long-term exposure to air pollutants in Switzerland. *American Journal of Respiratory and Critical Care Medicine*, 155: 122-129 (1997)