GUIDELINES FOR DRINKING-WATER QUALITY

Vol. 1. Recommendations

WORLD HEALTH ORGANIZATION

GUIDELINES FOR DRINKING-WATER QUALITY

Volume 1

Recommendations

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PREFACE

The *Guidelines for drinking-water quality* are intended for use by countries as a basis for the development of standards, which, if properly implemented, will ensure the safety of drinking-water supplies. It must be emphasized that the levels recommended in the guidelines for water constituents and contaminants are not standards in themselves. In order to define standards, it is necessary to consider these recommendations in the context of prevailing environmental, social, economic, and cultural conditions.

Guideline values for various constituents of drinking-water are given in this volume. Volume 2 of the *Guidelines for drinking-water quality* contains the criteria monographs that were prepared for each substance or contaminant; the guideline values are based on these. Volume 3 is intended to serve a very different purpose: it contains recommendations and information concerning what needs to be done in small communities and in rural areas to safeguard the water supplies.

These guidelines are intended to supersede both the *European standards for drinking-water* (*1*) and the *International standards for drinking-water* (*2*) which have been in existence for over a decade. While it is appreciated that it may not be possible in some countries to provide potable water that attains all the levels recommended in this volume, it is hoped that each country will try to develop water quality standards as close as possible to these guideline values in an endeavour to protect public health.

The compilation of these *Guidelines for drinking-water quality* covered a period of three years and, during that period, additional scientific information became available; none of this, however, alters significantly the guideline values proposed. It is possible, however, that as further new information becomes available, some guideline values may require revision in due course.

Work done under the auspices of the International Programme on Chemical Safety (IPCS) will considerably influence future updating of these guidelines. IPCS is a cooperative venture of the United Nations Environment Programme (UNEP), the International Labour Organisation (ILO), and the World Health Organization (WHO) and has as two of its main objectives the evaluation of the effects of chemicals on human health and the quality of the environment and the development of guidelines on exposure limits (such as acceptable daily intakes and maximum permissible or desirable levels in air, water, food, and the working environment) for various classes of chemicals, including food additives, industrial chemicals, toxic substances of natural origin, plastics, packaging materials, and pesticides.

These guidelines have been developed by WHO to describe the quality of water that is suitable for drinking purposes under all circumstances. It is intended that these guidelines should be applied in developing national standards, not only for community piped-water supplies but also for all water used for drinking purposes, including that obtained from community standpipes and wells and drinking-water distributed by tankers or in bottles. The guidelines can also serve as a basis for developing standards for water supplies serving transient populations (e.g., in transportation terminals, on trains, boats or aircraft, in pilgrimage and refugee centres and recreational camps, and at rallies or fairs), as these have been implicated in a number of epidemics of waterborne diseases. The guidelines do not apply to bottled mineral waters, which should be regarded as beverages rather than drinking-water in the usual sense of the word.

The main reason for departing from the previous practice of prescribing international standards for drinking-water quality is the desirability of adopting a risk–benefit approach (qualitative or quantitative) to national standards and regulations. Standards and regulations achieve nothing unless they can be implemented and enforced, and this requires relatively expensive facilities and expertise. Furthermore, water is essential to sustain life and must be available even if the quality is not entirely satisfactory. Adoption of too-stringent drinking-water standards could limit the availability of water supplies that meet those standards—a significant consideration in regions of water shortage. Therefore, it is to be expected that the adoption of standards will be influenced by national priorities and economic factors. However, considerations of policy and convenience must never be allowed to endanger public health.

The probability and potential consequences of bacterial contamination are such that its control must always be of paramount importance. For example, drinking-water of high bacteriological quality, but subject to high salinity, may be rejected by the consumer as unpalatable, in favour of a water that is aesthetically more pleasing but may be bacteriologically unsound. There is also wide variation in different regions and countries in such factors as the amount of water consumed daily, and this will have a bearing on the potential intake of chemicals from drinking-water.

Land use in the watershed and the nature of the water source (e.g., surface-water, ground-water) will often dictate the need for standards to control the chemical and aesthetic variables included in these guidelines. Thus, in some localities, the risk posed by small amounts of carcinogenic industrial chemicals in the water may be of major importance; in others, agricultural practices or vector control programmes may lead to a potential danger from pesticide residues occurring in the water.

Although the main purpose of these guidelines is to provide a basis for the development of drinking-water standards, the information given may also be of assistance in developing alternative control procedures when the implementation of standards is not feasible. For example, adequate codes of practice for the installation and operation of water-treatment plants and water supply and storage systems, and for household plumbing, may promote safer drinking-water supplies by increasing the reliability of the service, avoiding the use of undesirable materials (e.g., lead pipes exposed to plumbo-corrosive water), and by simplifying repair and maintenance.

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The development of these guidelines was organized and carried out jointly by WHO headquarters and the WHO Regional Office for Europe. The coordinators were, respectively, Dr H. Galal-Gorchev and Mr W. M. Lewis. The preparation of the guidelines was made possible by the financial support afforded to WHO by the Danish International Development Agency (DANIDA) which is gratefully acknowledged. Appreciation is also extended to the United States Environmental Protection Agency who supported this effort by the secondment of Dr Galal-Gorchev for a period of two years.

The preparation of the new guidelines involved the active participation of nearly 30 WHO Member States, scores of scientists, and meetings of 10 task groups. The work of these institutions and scientists, whose names appear in Annex 1, was central to the successful completion of the guidelines and is much appreciated. The collaboration of the national focal points for the WHO Environmental Criteria Programme, various international organizations, and individual experts was most helpful and their continuing participation contributed effectively to the work.

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1. INTRODUCTION

1.1 Consumer perception of drinking-water quality

In assessing the quality of drinking-water, the consumer relies completely upon his senses. Water constituents may affect the appearance, smell, or the taste of the water and the consumer will evaluate the quality and the acceptability essentially on these criteria. Water that is highly turbid, highly coloured, or has an objectionable taste will be regarded as dangerous and will be rejected for drinking purposes. However, we can no longer rely entirely upon our senses in the matter of quality judgement. The absence of any adverse sensory effects does not guarantee the safety of water for drinking.

The primary aim of the *Guidelines for drinking-water quality* is the protection of public health and thus the elimination, or reduction to a minimum, of constituents of water that are known to be hazardous to the health and wellbeing of the community.

1.2 Priorities as regards water quality

The relative priorities assigned to the many substances for which guideline values are given later in this book will depend on local circumstances. Some guideline values, e.g., for colour and pH, are not related directly to health, but have been applied widely and successfully over many years to ensure the wholesomeness of water.

The microbiological quality of drinking-water is of the greatest importance, however, and must never be compromised in order to provide aesthetically pleasing and acceptable water.

1.3 Nature of guideline values

(*a*) A guideline value represents the level (a concentration or a number) of a constituent that ensures an aesthetically pleasing water and does not result in any significant risk to the health of the consumer.

(*b*) The quality of water defined by the *Guidelines for drinking-water quality* is such that it is suitable for human consumption and for all usual domestic purposes, including personal hygiene. However, water of a higher quality may be required for some special purposes, such as renal dialysis.

(*c*) When a guideline value is exceeded this should be a signal: (i) to investigate the cause, with a view to taking remedial action; (ii) to consult with authorities responsible for public health for advice.

(*d*) Although the guideline values describe a quality of water that is acceptable for lifelong consumption, the establishment of these guidelines should not be regarded as implying that the quality of drinking-water may be degraded to the recommended level. Indeed, a continuous effort should be made to maintain drinking-water quality at the highest possible level.

(*e*) The guideline values specified have been derived to safeguard health on the basis of lifelong consumption. Short-term exposures to higher levels of chemical constituents, such as might occur following accidental contamination, may be tolerated but need to be assessed case by case, taking into account, for example, the acute toxicity of the substance involved.

(*f*) Short-term deviations above the guideline values do not necessarily mean that the water is unsuitable for consumption. The amount by which, and the period for which, any guideline value can be exceeded without affecting public health depends on the specific substance involved.

It is recommended that, when a guideline value is exceeded, the surveillance agency (usually the authority responsible for public health) should be consulted for advice on suitable action, taking into account the intake of the substance from sources other than drinking-water (for chemical constituents), the likelihood of adverse effects, the practicability of remedial measures, and similar factors.

(*g*) In developing national drinking-water standards based on these guidelines, it will be necessary to take account of a variety of local geographical, socioeconomic, dietary, and industrial conditions. This may lead to national standards that differ appreciably from the guideline values.

(*h*) In the case of radioactive substances, the term guideline value is used in the sense of "reference level" as defined by the International Commission on Radiological Protection (ICRP).[a]

1.4 Derivation of guideline values for toxic chemicals

In arriving at the guideline values for various substances in water, the total intake from air, food, and water for each substance is taken into

[a] "Reference levels may be established for any of the quantities determined in the course of radiation protection programs, whether or not there are limits for these quantities. A reference level is not a limit and is used to determine a course of action when the value of a quantity exceeds or is predicted to exceed the reference level." *Annals of the ICRP*, 1(3):1–53 (1977) (ICRP Publication 26).

consideration, as far as possible from the information available; it is assumed that the daily *per capita* consumption of water is 2 litres.

For the majority of the substances for which guideline values are proposed, the toxic effect in man is predicted from studies with laboratory animals. The accuracy and reliability of a quantitative prediction of toxicity in man from animal experimentation depend upon a number of factors, e.g., choice of animal species, design of the experiment and, not least, extrapolation methods (*3*). However, for most of the organic compounds considered, the difference in chemical pathogenesis between animals and man is mainly quantitative, although qualitative differences also exist.

Data on the toxicity of chemicals are obtained from experiments in which the adverse effect occurs at considerably higher dosages than would be experienced in man. When extrapolating from such animal data to man, therefore, a safety factor must be introduced to provide for the unknown factors involved. The current doubts concerning both the biological and the mathematical reliability of methods of extrapolating from high doses to low doses necessitate the use of somewhat arbitrary safety factors, such as reduction by a factor of 100 or 1000.

These uncertainties arise from the nature of the toxic effects and the quality of the toxicological information. Other considerations are the size and type of the population to be protected, and thus under certain conditions safety factors (or uncertainty factors) as high as 1000 may be necessary.

However, assessment of the health risk to the population involves more than routine application of safety factors, and it must be emphasized that strictly speaking the extrapolation from animal experimentation applies only to the conditions of the particular experiment.

The existing methods of extrapolation from animal data to man deal with exposures to single substances, whereas in the human environment a large number of hazardous chemicals and other factors may interact. In the special case of substances possessing carcinogenic properties, this book illustrates the rationale of using a risk factor in arriving at the proposed guideline value. Owing to the considerable uncertainties in the available evidence, the proposed guideline values are in many cases deliberately cautious in character and therefore must not be interpreted as standards.

A judgement about safety—or what is an acceptable risk level in particular circumstances—is a matter in which society as a whole has a role to play. The final judgement as to whether the benefit from adopting any of these proposed guidelines does or does not justify the risk is for each country to decide. What must be re-emphasized is that the guideline values proposed are not strict standards that must be adhered to, but are subject to a wide range of flexibility and are provided essentially in an endeavour to protect public health and enable a judgement to be made regarding the provision of drinking-water of acceptable quality.

1.5 Operational procedure

In order to undertake the task of reviewing the relevant information and to develop recommendations for the values contained in these guidelines, a number of task groups were convened.[a] In arriving at their recommendations, the groups had the advantage of guidance from various WHO publications, such as the various volumes of *Environmental Health Criteria*, together with the reports of various WHO working groups on items of relevance. In addition, the groups re-examined the existing WHO drinking-water quality standards, and the various comments and observations that WHO had received over the years, before making their final decision.

In addition to a guideline value, a criteria monograph was prepared for each constituent and is the basis upon which recommendations have been prepared. The criteria monographs for each of the constituents and characteristics examined constitute Volume 2 of *Guidelines for drinking-water quality*, and contain the critical parts of the evidence used in deriving guideline values. They cover aspects such as general description; routes of exposure; metabolism; health effects; and basic literature references. Such information is of great importance in the interpretation of the guideline values.

In the subsequent chapters of the present volume, the recommended guideline values are summarized, together with a brief description of the rationale employed in establishing the values and essential information regarding monitoring and remedial measures.

1.6 Summary tables of guideline values

In presenting this summary of guideline values (Tables 1–5), it is not intended that individual values should be used directly from the tables. Guideline values must be used and interpreted in conjunction with the information contained in the appropriate section of Chapters 2–5 of this book.

[a] Task groups and other meetings:

Initial consultation	12–15 December 1978, Copenhagen, Denmark
Microbiology	17–21 December 1979, Medmenham, England
Organic contaminants (selection)	18–20 March 1980, Leidschendam, Netherlands
Biological contaminants	15–17 July 1980, Geneva, Switzerland
Inorganic contaminants	22–26 September 1980, Copenhagen, Denmark
Organic contaminants (quantification)	18–25 November 1980, Ottawa, Canada
Aesthetic and organoleptic aspects	2–5 February 1981, Copenhagen, Denmark
Application of the guidelines	1–5 June 1981, Alexandria, Egypt
Radioactive contamination	3–5 March 1982, Copenhagen, Denmark
Final meeting	22–26 March 1982, Geneva, Switzerland.

The lists of participants for each of the above meetings are given in Annex 1.

Table 1. Microbiological and biological quality

Organism	Unit	Guideline value	Remarks
I. Microbiological quality			
A. Piped water supplies			
A.1 Treated water entering the distribution system			
faecal coliforms	number/100 ml	0	turbidity < 1 NTU; for disinfection with chlorine, pH preferably < 8.0; free chlorine residual 0.2–0.5 mg/litre following 30 minutes (minimum) contact
coliform organisms	number/100 ml	0	
A.2 Untreated water entering the distribution system			
faecal coliforms	number/100 ml	0	
coliform organisms	number/100 ml	0	in 98% of samples examined throughout the year—in the case of large supplies when sufficient samples are examined
coliform organisms	number 100 ml	3	in an occasional sample, but not in consecutive samples
A.3 Water in the distribution system			
faecal coliforms	number/100 ml	0	
coliform organisms	number/100 ml	0	in 95% of samples examined throughout the year—in the case of large supplies when sufficient samples are examined
coliform organisms	number/100 ml	3	in an occasional sample, but not in consecutive samples
B. Unpiped water supplies			
faecal coliforms	number/100 ml	0	
coliform organisms	number/100 ml	10	should not occur repeatedly; if occurrence is frequent and if sanitary protection cannot be improved, an alternative source must be found if possible
C. Bottled drinking-water			
faecal coliforms	number/100 ml	0	source should be free from faecal contamination
coliform organisms	number/100 ml	0	
D. Emergency water supplies			
faecal coliforms	number/100 ml	0	advise public to boil water in case of failure to meet guideline values
coliform organisms	number/100 ml	0	
Enteroviruses	—	no guideline value set	
II. Biological quality			
protozoa (pathogenic)	—	no guideline value set	
helminths (pathogenic)	—	no guideline value set	
free-living organisms (algae, others)	—	no guideline value set	

Table 2. Inorganic constituents of health significance

Constituent	Unit	Guideline value	Remarks
arsenic	mg/l	0.05	
asbestos	—	no guideline value set	
barium	—	no guideline value set	
beryllium	—	no guideline value set	
cadmium	mg/l	0.005	
chromium	mg/l	0.05	
cyanide	mg/l	0.1	
fluoride	mg/l	1.5	natural or deliberately added; local or climatic conditions may necessitate adaptation
hardness	—	no health-related guideline value set	
lead	mg/l	0.05	
mercury	mg/l	0.001	
nickel	—	no guideline value set	
nitrate	mg/l (N)	10	
nitrite	—	no guideline value set	
selenium	mg/l	0.01	
silver	—	no guideline value set	
sodium	—	no guideline value set	

Table 3. Organic constituents of health significance

Constituent	Unit	Guideline value	Remarks
aldrin and dieldrin	μg/l	0.03	
benzene	μg/l	10[a]	
benzo[*a*]pyrene	μg/l	0.01[a]	
carbon tetrachloride	μg/l	3[a]	tentative guideline value[b]
chlordane	μg/l	0.3	
chlorobenzenes	μg/l	no health-related guideline value set	odour threshold concentration between 0.1 and 3 μg/l
chloroform	μg/l	30[a]	disinfection efficiency must not be compromised when controlling chloroform content
chlorophenols	μg/l	no health-related guideline value set	odour threshold concentration 0.1 μg/l
2,4-D	μg/l	100[c]	
DDT	μg/l	1	
1,2-dichloroethane	μg/l	10[a]	
1,1-dichloroethene[d]	μg/l	0.3[a]	
heptachlor and heptachlor epoxide	μg/l	0.1	
hexachlorobenzene	μg/l	0.01[a]	
gamma-HCH (lindane)	μg/l	3	
methoxychlor	μg/l	30	
pentachlorophenol	μg/l	10	
tetrachloroethene[d]	μg/l	10[a]	tentative guideline value[b]