

D R A F T

Chapter 5:
Drinking Water Guidelines and Standards

By

Sombo Yamamura

World Health Organization, Geneva, Switzerland

In collaboration with

**Jamie Bartram, Mihaly Csanady, Hend Galal Gorchev,
and Alex Redekopp**

Chapter Summary	2
5.1 Introduction	3
5.2 History of drinking water quality guidelines	6
5.3 Purpose of the GDWQ	7
5.4 Drinking Water Quality Guideline on Arsenic	8
5.5 National standards on Arsenic	12
5.6 Surveillance	14
5.7 Basic management aspects	15

Box 5-1: Provisional guideline value

Box 5-2: Arsenic health effects data in China (Province of Taiwan)

Box 5-3 :Risk assessment by Multistage model

Box 5-4: USEPA Proposed Revision to Arsenic Drinking Water Standard

Box 5-5: Application of national arsenic drinking water guidelines / standards in Hungary

References

Acronyms used in this chapter

Chapter summary

The primary aim of the WHO Guidelines for Drinking-water Quality (GDWQ) is the protection of public health. The Guidelines are intended to be used as a basis for the development of national standards that, if properly implemented, will ensure the safety of drinking water supplies through the elimination, or reduction to a minimum concentration, of constituents in drinking water that are known to be hazardous to health. The guideline values recommended are not mandatory limits. They are intended to be used in the development of risk management strategies which may include national or regional standards in the context of local or national environmental, social, economic and cultural conditions.

The main reason for not promoting the adoption of international standards for drinking water quality is the advantage provided by the use of a risk-benefit approach (qualitative or quantitative) to the establishment of national standards or regulations. This approach should lead to standards and regulations that can be readily implemented and enforced and which ensure the use of available national financial, technical and institutional resources for maximum public health benefit.

WHO has had a public position on arsenic in drinking water since 1958. The last edition of WHO GDWQ (1993) established 0.01 mg/L as a provisional guideline value for arsenic in drinking water with a view to reducing the concentration of arsenic in drinking-water, because lower levels preferred for health protection are not reliably measurable.

In a number of countries, the WHO provisional guidelines of 0.01 mg/L has been adopted as the standard. However, many countries have kept 0.05 mg/L, established in an earlier edition of the guidelines, as the national standard or as an interim target before tackling populations exposed to lower but still significant concentrations in the 0.01-0.05 range.

In developing national drinking water standards based on the guideline values, it will be necessary to take account of a variety of geographical, socio-economic, dietary and other conditions affecting potential exposure.

5.1 Introduction

The primary aim of the Guidelines for Drinking Water Quality is the protection of public health. In 1984 and 1985, WHO published the first edition in three volumes. The development of these Guidelines was organized and carried out jointly by WHO HQ and WHO EURO. In 1988, WHO (HQ & EURO) decided to initiate the revision of the Guidelines. The revised Guidelines have again been published in three volumes. They have been widely used as a basis for setting national standards to ensure the safety of public water supplies.

The guideline values recommended are not mandatory limits. Such limits should be set by national authorities, using a risk-benefit approach and taking into consideration local environmental, social, economic and cultural conditions.

Volume 1 Recommendations (published in 1993)

This volume sets out guideline values for a large number of water contaminants relevant to the quality of drinking-water. The book also provides an explanation of how the guideline values should be applied, the criteria used in selecting the various chemical, physical, microbiological, and radiological contaminants considered, a description of the approaches used to derive the guideline values, and brief summary statements supporting the values recommended or explaining why no health-based guideline value is necessary at present.

Addendum to Volume 1 (published in 1998) : **Recommendations**

The addendum is part of WHO's ongoing effort to ensure that recommendations about the safety of chemical substances found in drinking-water are in line with the latest scientific data. This addendum to volume one of *Guidelines for Drinking-water Quality* summarizes new findings that have become available since the second edition was published in 1993, and that call for a reconsideration of selected guideline values issued at that time. For some of the substances under review, previously established guideline values have been revised in the light of new evidence. For others, new findings confirm the continuing validity of previous recommendations. Evaluations of chemical substances published in this addendum supersede evaluations of the same substances previously published in the second edition of *Guidelines for Drinking-water Quality*. Updated or new evaluations are provided for seven inorganic substances (aluminium, boron, copper, nickel, nitrate, nitrite, and uranium), four organic substances (edetic acid, microcystin-LR, benzo[*a*]pyrene, and fluoranthene), ten pesticides (bentazone, carbofuran, cyanazine, 1,2-dibromoethane, 2,4-dichlorophenoxyacetic acid, 1,2-dichloropropane, diquat, glyphosate, pentachlorophenol, and terbuthylazine), and a disinfectant by-product (chloroform).

Addendum to Volume 2 (published in 1998): **Health Criteria and Other Supporting Information**

This companion volume reviews and interprets the extensive toxicological, epidemiological, and clinical evidence that formed the basis for the new or updated evaluations issued in the addendum to Volume 1 of the *Guidelines*. Covering the same 22 chemical substances, the volume communicates the scientific rationale for each individual recommendation. Well over 1,000 references to the recent literature are included. Evaluations of chemical substances published in this addendum supersede evaluations of the same substances previously published in the second edition of *Guidelines for Drinking-water Quality*.

Volume 2- Health criteria and other supporting information (published in 1996), reviews and interprets the extensive toxicological, epidemiological, and clinical evidence that shaped the determination of guideline values for drinking-water quality. Organized to parallel and extend the coverage of volume 1, which presented the recommended guideline values and brief summary statements supporting these values, this second work communicates the scientific rationale for individual recommendations based on a critical review of data linking health hazards to specific exposure levels. In so doing, it aims to establish an authoritative basis for national water-quality standards that are consistent with the goal of providing wholesome, safe drinking-water in a

sufficient quantity. Well over 3000 references to the literature are included.

The book has 17 chapters presented in three parts. The first, on microbiological aspects, addresses the common and widespread health risks associated with the direct or indirect contamination of drinking-water with human or animal excreta, particularly faeces. The second and most extensive part, which contains almost 800 pages, provides evaluations, supported by toxicological monographs, for each of 36 inorganic constituents and physical parameters, 27 industrial chemicals, 36 pesticides, four disinfectants, and some 23 disinfectant by-products. The final part explains application of the reference level of dose for radiological contaminants in drinking-water. The volume concludes with a list of the hundreds of experts who collaborated in the evaluations, a convenient tabular presentation of the guideline values, and a comprehensive index.

Volume 3 - Surveillance and control of community supplies (published in 1997), is a comprehensive guide to all practical procedures and technical measures required to ensure the safety of drinking-water supplies in small communities and periurban areas of developing countries. Now in its second edition, the book has been vastly expanded in line with broadened appreciation for the many factors that influence water quality and determine its impact on health. Revisions and additions also reflect considerable new knowledge about the specific technical and social interventions that have the greatest chance of success in situations where resources are scarce and logistic problems are formidable.

Since quality controls may be especially difficult to implement in small communities, the book concentrates on the most essential requirements, emphasizing the crucial need to ensure microbiological safety. Details range from advice on how to design simple pictorial reporting forms for sanitary inspections, to guidance on setting priorities for remedial action, from a comparison of different methods for the analysis of coliform bacteria, to drawings of measures for protecting water sources. Throughout, numerous checklists, charts, diagrams, and model forms are used to enhance the volume's practical value.

The book has eight chapters organized to reflect the key stages in the development of surveillance. Chapter one explains how the basic principles of surveillance and control apply to small-community supplies and alerts readers to several unique problems that need to be overcome. Planning and implementation are discussed in the second chapter, which gives particular attention to the distinct yet complementary responsibilities of the water supply agency and the public health protection agency. Subsequent chapters offer advice on the nature, scope, and timing of sanitary inspections, describe the most appropriate methods for sampling water and assessing its hygienic quality, and explain how the resulting data can be used to improve the quality, coverage, quantity, cost, and continuity of the water supply.

The most extensive chapter describes and illustrates numerous technical interventions for preventing or correcting hazards associated with water from different sources, procedures for water treatment, and methods used to treat and store water in households. Additional strategies for improvement are covered in the remaining

chapters, which outline methods of hygiene education in communities and discuss the important role of legislation and regulation.

Further practical guidance is provided in a series of annexes, which give examples of sanitary inspection and hazard scoring forms for 11 different types of water supply, list responsibilities for different categories of surveillance staff, and provide illustrated step-by-step instructions for several sampling methods and analytical tests for use in laboratories and the field.

5.2 History of drinking water quality standards / guidelines

The origin of WHO Guidelines for Drinking-Water Quality (GDWQ) goes back to the 1950s. At that time the requirements for safe and potable water supplies became particularly pertinent with the great increase in travel, especially global air travel. It became apparent that the traveler must be provided with potable drinking-water. In 1953, WHO distributed a questionnaire to all member states to assess the status of water treatment plants and their production of acceptable water quality. The replies to the questionnaire clearly indicated the magnitude of the problem and the need for WHO to establish drinking water standards. (WHO 1958)

Following a series of expert consultations culminating in a meeting in 1956 in Geneva the **International Standards for Drinking-Water** were published in 1958. In this instance the term "standards" was used to be applied to the suggested criteria of water quality (WHO 1958).

In addition to being cited in the International Sanitary Regulations for deciding what constitutes pure and acceptable water supply at ports and airports, the 1958 International Standards became to be widely used as a reference in the development of local national standards and as a basis for improved water treatment practices.

Some countries adopted the International Standards as the official and legal standards of water quality while other countries developed national standards based in part or in whole on the International Standards. Increasing knowledge of the nature and effect of various contaminants, and improved techniques for identifying and determining their concentrations, have led to a demand for further revision of the recommendations. Accordingly the International Standards for Drinking-Water were revised in 1963 and 1971. (WHO 1958, 1963, 1971)

The International Standards had been in existence for over a decade until they were superseded by the **WHO Guidelines for Drinking-Water Quality (GDWQ)** in 1984. While it was recognized that it might not be possible by a number of member states to attain all of the recommended guideline levels, it was anticipated that member states would develop water quality standards as close as possible to these guidelines in the endeavour to protect public health.

The change from Standards to Guidelines meant that the guidelines were intended for use by member states as a basis for the development of national standards which, if properly implemented, would ensure the safety of drinking-water supplies both in the urban and

rural settings. The philosophy and content of the WHO Guidelines constituted a drastic departure from the previous International Standards. The revised guidelines were published in three volumes including criteria monographs prepared for each substance or contaminant listed in the guidelines.(WHO 1984, 1985).

The second edition of the GDWQ Volume 1 was published in 1993 followed by Volume 2 in 1996 and Volume 3 in 1997. The work involved numerous institutions, over 200 experts from nearly 40 different developing and developed countries and 18 meetings of the various coordination and review groups. The International Programme on Chemical Safety (IPCS) provided major input to the health risk assessments of chemicals in drinking-water.

In establishing WHO guideline values for chemicals in drinking-water, guideline values were calculated using a tolerable daily intake (TDI) for chemicals showing a threshold for toxic effects. For carcinogens, for which there is convincing evidence to suggest a non-genotoxic mechanism, guideline values were calculated using a TDI approach. In the case of compounds considered to be genotoxic and carcinogenic, the International Agency for Research on Cancer (IARC) classification for carcinogenic compounds was taken into consideration and guideline values were established using a mathematical model, usually the linearized multistage extrapolation model. The guideline values are presented as the concentration in drinking-water associated with an estimated excess lifetime cancer risk of 10^{-5} (one additional cancer case per 100 000 of the population ingesting drinking-water containing the substance at the guideline value for 70 years). In cases in which the concentration associated with a 10^{-5} excess lifetime cancer risk was not practical, because of inadequate analytical methodology, a provisional guideline value was set at a practicable level and the estimated associated cancer risk was presented (WHO 1993).

A continuing process of updating guideline values was established with a number of chemical substances and microbiological agents subject to periodic evaluation. Addenda containing these evaluations were issued in 1998 for Volumes 1 and 2 and will be issued as necessary until the third edition of the GDWQ is published approximately 10 years after the second edition (WHO 1998).

5.3 Purpose of the GDWQ

In GDWQ, it is often emphasized that the guideline values recommended are not mandatory limits. In order to define such limits, it is necessary to consider the guideline values in the context of local or national environmental, social, economic, and cultural conditions. The main reason for not promoting the adoption of international standards for drinking-water quality is the advantage provided by the use of a risk-benefit approach (qualitative and quantitative) to the establishment of national standards and regulations.

This approach should lead to standards and regulations that can be readily implemented and enforced. For example, the adoption of drinking-water standards that are too stringent could limit the availability of water supplies that meet those standards a significant consideration in regions of water shortage. However, considerations of policy and convenience must never be allowed to endanger public health. The judgement of safety

or what is an acceptable level of risk 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 resulting from the adoption of any of the guideline values given here as standards justifies the cost is for each country to decide (WHO 1993).

5.4 Drinking Water Quality Guideline on Arsenic

WHO has had a public position on arsenic in drinking water since 1958. The first version of International Standards for Drinking-Water in 1958 included arsenic in the category of toxic substances which, if present in drinking-water supplies at concentrations above certain levels, may give rise to actual danger to health. It established 0.20 mg/L as an allowable concentration (WHO 1958). The updated standards in 1963 kept arsenic in the same category and established a stricter concentration of 0.05 mg/L, although no specific reason for this reduction was disclosed (WHO 1963).

An update in 1971, kept arsenic in the toxic substances category and reaffirmed the value of 0.05 mg/L. Its explanatory notes referred to the fact that figures higher than that quoted are found in a number of Latin American countries and levels up to 0.2 mg/L were not known to have caused difficulties in drinking water. It also referred to some epidemiological studies which have suggested that arsenic is carcinogenic but mentioned that no real proof of its carcinogenicity to man had been established. It concluded that it would seem wise to keep the level of arsenic in drinking-water as low as possible (WHO 1971).

The WHO Guidelines for Drinking-water Quality in 1984 were intended as a basis for the development of national standards in the context of national environmental, social, economic and cultural conditions. It introduced new categories in the drinking-water guidelines. The categories of toxic and specific substances in the preceding publications were abolished and arsenic was categorized among the inorganic constituents of significance to health. It recommended 0.05 mg/L as a guideline value with the explanation that, based on available human health data, a concentration of 0.05 mg of arsenic per litre in drinking water is not associated with any adverse health effects. Supporting evidence in the relevant criteria monograph included the case in Chile and China (Province of Taiwan). (WHO 1984)

The last edition of WHO GDWQ (1993) established 0.01 mg/L as a provisional guideline value for arsenic in drinking water. The fact that inorganic arsenic compounds are classified by IARC in Group 1 (carcinogenic to humans) on the basis of sufficient evidence for carcinogenicity in humans and limited evidence for carcinogenicity in animals was taken into consideration. Based on the increased incidence of skin cancer observed in the population in China (Province of Taiwan), the lifetime risk of skin cancer was estimated using a multistage model.

There are at least two reasons why 0.01 mg/L was selected as a provisional guideline value. These are: (1) On the basis of observations in a population ingesting arsenic-contaminated drinking-water, the concentration associated with an excess life-time skin cancer risk of 10^{-5} was calculated to be 0.00017mg/L. However, this value may overestimate the actual

risk of skin cancer owing to the possible dose-dependent variations in metabolism that could not be taken into consideration. (2) This value is below the practical quantification limit of 0.01mg/L. The estimated excess lifetime skin cancer risk associated with exposure to this concentration is 6×10^{-4} (WHO 1993).

IPCS Environmental Health Criteria on Arsenic was published in 1981 and provided the first consensus on international health risk assessments regarding arsenic in drinking water. The updated version is now under preparation and is to be completed in 2000.

BOX 5-1: Provisional guideline value

Inorganic arsenic compounds are classified by IARC in Group 1 (carcinogenic to humans) on the basis of sufficient evidence for carcinogenicity in humans and limited evidence for carcinogenicity in animals (IARC 1987). No adequate data on the carcinogenicity of organic arsenicals were available. The guideline value has been derived on the basis of estimated lifetime cancer risk.

Data on the association between internal cancers and ingestion of arsenic in drinking-water are limited and insufficient for quantitative assessment of an exposure-response relationship (USEPA 1988). However, based on the increased incidence of skin cancer observed in the population in China (Province of Taiwan), the US Environmental Protection Agency has used a multistage model that is both linear and quadratic in dose to estimate the lifetime skin cancer risk associated with the ingestion of arsenic in drinking-water. With this model and data on males (USEPA 1988), the concentrations of arsenic in drinking-water associated with estimated excess lifetime skin cancer risks of 10^{-4} , 10^{-5} , and 10^{-6} are 0.0017, 0.00017 and 0.000017 mg/L, respectively.

It should be noted, however, that these values may overestimate the actual risk of skin cancer because of possible simultaneous exposure to other compounds in the water and possible dose-dependent variations in metabolism that could not be taken into consideration. In addition, the concentration of arsenic in drinking-water at an estimated skin cancer risk of 10^{-5} is below the practical quantification limit of 0.01mg/L.

A value of 0.013mg/litre may be derived (assuming a 20% allocation to drinking-water) on the basis of the provisional maximum tolerable daily intake (PMTDI) of inorganic arsenic of 0.002 mg/kg of body weight set by the joint FAO/WHO Expert Committee on Food Additives (JECFA) in 1983 and confirmed as a provisional tolerable weekly intake (PTWI) of 0.015mg/kg of body weight in 1988 (FAO/WHO 1989). JECFA noted, however, that the margin between the PTWI and intakes reported to have toxic effects in epidemiological studies was narrow.

With a view to reducing the concentration of arsenic in drinking-water, a provisional guideline value of 0.01 mg/litre is recommended. The estimated excess lifetime risk of skin cancer associated with exposure to this concentration is 6×10^{-4} .

WHO Guidelines for drinking-water quality, volume 2, 1996

BOX 5-2: Arsenic health effects data in China (Province of Taiwan)

In a large study conducted in China (Province of Taiwan), a population of 40 421 was divided into three groups based on the arsenic content of their well-water (high, >0.60 mg/litre; medium, 0.30-0.59 mg/litre; and low, <0.29 mg/litre) (Tseng 1977). There was a clear dose-response relationship between exposure to arsenic and the frequency of dermal legions, ? blackfoot disease? (a peripheral vascular disorder), and skin cancer.

However, several methodological weaknesses (e.g. investigators were not ? blinded?) complicate the interpretation of the results. In addition, the possibility that other compounds present in the water supply might have been responsible for blackfoot disease was not considered. It has been suggested, for example, that humic acid in artesian well-water is the cause of the disease, not arsenic (Lu 1990).

In a study in which cancer mortality was examined in relation to the arsenic content of contaminated drinking-water in the same villages of China (Province of Taiwan) and at the same three levels, there were significant dose-response relationships for age-adjusted rates for cancers of the bladder, kidney, skin, and lung in both sexes and cancers of the prostate and liver in males (Wu 1989).

A study in which the ecological correlations between the arsenic level of well-water and mortality from various malignant neoplasms in China (Province of Taiwan) were examined demonstrated a significant association with the arsenic level in well-water for cancers of the liver, nasal cavity, lung, skin, bladder, and kidney in both males and females and for prostate cancer in males (Chen 1990).

In an investigation of the association between cancer incidence and the ingestion of arsenic-contaminated water in a limited area of China (Province of Taiwan), standardized mortality ratios (SMRs) for cancers of the bladder, kidney, skin, lung, liver, and colon were significantly elevated in the area of arsenic contamination. The SMRs for all but colon cancer also correlated well with the prevalence rate for blackfoot disease (Chen 1985).

In a case-control study of 204 subjects who died of cancer (69 of bladder, 76 of lung, and 59 of liver cancer) and 368 community controls matched for age and sex, the odds ratios of developing these cancers for those who had used artesian well-water for 40 or more years were 3.90, 3.39, and 2.67, respectively. Dose-response relationships were observed for all three cancer types by duration of exposure, and the odds ratios were not changed significantly when several other risk factors were taken into consideration in logistic regression analysis (Chen 1986). A technical Panel on Arsenic established by the US Environmental Protection Agency concluded that, although these studies demonstrated a qualitative relationship between the ingestion of arsenic-contaminated water and internal cancers, the data were not sufficient to enable the dose-response relationship to be assessed (USEPA 1988).

WHO Guidelines for drinking-water quality, volume 2, 1996

Box 5-3 :Risk assessment by Multistage model

Clear evidence of health effects are usually available at high level of exposure. Extrapolation from high to lower levels of exposure becomes critical for regulatory setting. Numerous mathematical models have been developed for estimating the effects of exposure levels well below levels for which cancer data are available. This is based on two fundamental assumptions: (a) There is no threshold dose for the carcinogenic effect; and (b) carcinogenic effects of chemicals are directly proportional to dose at low-dose levels, i.e., the dose response is linear at low doses.

Multistage model is one of the mathematical models, which is most frequently used in the regulatory process. It was also applied in the 1988 risk assessment for arsenic in drinking water done by USEPA using the data of an epidemiological study by Tseng et al. in 1968. This model is based on the concept that a tumour develops from a single cell in an organ as a result of a number of biological events or stages (e.g. mutation) that occur in a prescribed order. According to this model, the probability of developing tumours, $P(d)$, is

$$P(d) = 1 - \exp[-(a + q_1d + q_2d^2 + \dots + q_md^m)]$$

Where the parameter m is the number of stages, a is the background tumour rate and the q_i s are the values that maximize the likelihood of observing the experimental results. In practice the a , the q_i s and the m are estimated from the data. Some of the q_i s may be zero but none can be negative. When the unknown values of the multistage model parameters are replaced by their maximum likelihood estimates (MLEs), the resulting model estimates what the risk is most likely to be in the experimental situation. At low doses the dose-response relationship is thus approximately linear. This model will fit almost any observed data set as long as the dose-response curve is not markedly concave downward at low responses.

Although the mathematical models are useful as one tool in the regulatory process, they are oversimplifications of complex systems. It is important to note that quantitative risk estimates may give an impression of accuracy which in fact they do not have. In general, the risk assessment values for carcinogens are at best, "order of magnitude" estimates.

It should be emphasized that the guideline values for carcinogenic substances have been computed from hypothetical mathematical models that cannot be verified experimentally and that the values should be interpreted differently than TDI-based values because of the lack of precision of the models. At best, these values must be regarded as rough estimates of cancer risk. However, the models used are conservative and probably err on the side of caution. Moderate short-term exposure to levels exceeding the guideline value for carcinogens does not significantly affect the risk.

References:

Swedish National Chemicals Inspectorate. 1995. An Introduction to Health Risk Assessment of Chemicals, Marie Haag Grönlund

National Research Council. 1999. Arsenic in Drinking Water, Subcommittee on

Arsenic in Drinking Water, Committee on toxicology, Board on Environmental Studies and Toxicology, Commission on Life Sciences, National Academy Press

WHO, 1993

5.5 National standards on Arsenic

In a number of countries, the WHO provisional guidelines of 0.01 mg/L has been adopted as the standard. However, many countries have retained the earlier WHO guideline of 0.05 mg/L as the national standard or as an interim target.

A number of European countries have adopted the WHO provisional guideline of 0.01 mg/L as their standard. In the United States of America, the Safe Drinking Water Act (SDWA) directs the U.S. Environmental Protection Agency (EPA) to establish national standards for public drinking-water supplies. EPA's interim maximum contaminant level (MCL) for arsenic in drinking water is 0.05 mg/L. Under the 1996 SDWA amendments, EPA has proposed a new standard (an MCL) for arsenic in drinking water in June 2000 and will finalize it by January 2001. New standard value currently proposed is 0.005 mg/L (see BOX 5-4).

Countries where the national standard for arsenic in drinking water remains at 0.05 mg/L include Bangladesh, China and India. The Table 5-1 shows the currently accepted national standards for arsenic in drinking water in some selected countries.

Table 5-1 The currently accepted national standards for arsenic in drinking water

Standard	Countries
Countries whose standard is lower than 0.01 mg/L	Australia (0.007 mg/L, 1996)
Countries whose standard is 0.01 mg/L	European Union (1998), Japan (1993), Jordan (1991), Laos (1999), Laos, Mongolia (1998), Namibia, Syria(1994)
Countries whose standard is lower than 0.05 mg/l but higher than 0.01 mg/l	Canada (1999) 0.025 mg/l
Countries considering to lower the standard from 0.05 mg/L	United States (1986*) , Mexico(1994)
Countries whose standard is 0.05 mg/l	Bahrain, Bangladesh (unknown), Bolivia (1997), China (unknown), Egypt(1995), India (unknown), Indonesia (1990), Oman, Philippines (1978), Saudi Arabia, Sri Lanka (1983), Viet Nam(1989), Zimbabwe

() shows the year standard was established

* new standard value 0.005 mg/L is being proposed

In developing national drinking water standards based on the guideline values, it will be necessary to take account of a variety of geographical, socio-economic, dietary and other

conditions affecting potential exposure. This may lead to national standards that differ appreciably from the guideline values.

BOX 5-4 USEPA Proposed Revision to Arsenic Drinking Water Standard

The current standard of 50 ppb (0.05 mg/L) was set by EPA in 1975, based on a Public Health Service standard originally established in 1942. A March 1999, report by the National Academy of Sciences concluded that the current standard does not achieve EPA's goal of protecting public health and should be lowered as soon as possible. Under the Safe Drinking Water Act Amendments of 1996, EPA is required to promulgate a final rule by January 1, 2001.

EPA is proposing to change the arsenic standard in drinking water to 5 ppb (0.005 mg/L) to more adequately protect public health. The proposed arsenic standard is intended to protect consumers against the effects of long-term, chronic exposure to arsenic in drinking water. The new standard will apply to all 54,000 community water systems, serving approximately 254 million people.

EPA is taking comment on other proposed levels for arsenic [namely, 0.003 mg/L, 0.010 mg/L, and 0.020 mg/L]. EPA is for the first time proposing a drinking water standard (5 ppb) that is higher than the technically feasible level (3 ppb). The Safe Drinking Water Act (SDWA) requires EPA to determine the health goal, then to set the standard as close to the goal as technically feasible.

EPA is also proposing a public health goal of zero for arsenic. The health goal is the level below which no known or anticipated health effects would occur. EPA sets public health goals at zero for all known carcinogens for which there is no dose considered safe.

While many systems may not have detected arsenic in their drinking water above 5 ppb, there may be "hot spots" with systems higher than the predicted occurrence for an area. More water systems in western states that depend on underground sources of drinking water have naturally-occurring levels of arsenic at levels greater than 10 ppb (0.01 mg/L) than in other parts of the U.S.. Parts of the Midwest and New England have some systems whose current arsenic levels range from 2-10 ppb.

For systems that require corrective action to meet a standard of 5 ppb, annual household costs will average \$28 for Americans served by large systems and \$85 for those served by small systems (those serving fewer than 10,000 people). Over 98 percent of the cost to water systems comes from adding treatment equipment, chemicals, and oversight of the new treatment.

USEPA, 2000

Box 5-5: Application of national arsenic drinking water guidelines / standards in Hungary

Hungary has made a great effort to decrease the arsenic (As) in drinking water concentrations in 80 waterworks systems (supplying about 400,000 people) to below the 50 µg/L guideline. WHO and the EU however, decreased this guideline (1993 and 1998, respectively) to 10 µg/L. To comply with this new guideline or standard will be a very costly proposition.

Hungarian authorities have examined this issue very carefully and have suggested that the data for the development of this new guideline/standard be reviewed. For example, based on Hungarian experience which is supported by many referenced publications, no significantly elevated frequency of skin cancer was detected below a threshold value of 200µg/capita of daily exposure.

According to another toxicological approach (JECFA, cited by WHO), the daily exposure from food and drinking water together must not exceed 140 µg/capita or, if it is possible, 100 µg/capita. If the food contains less arsenic (e.g. in Hungary 20 µg/day capita), drinking water can contain more arsenic without increasing the risk. Based on these considerations, the proposed limit of arsenic in drinking water was set by Hungarian authorities at 30 µg/L. From the toxicological approach this would appear to be acceptable, but not from legal point of view, in terms of the new EU regulations.

In Hungary, more than 1.2 million people consume drinking water with an arsenic concentration in the range 10-30 µg/L. To decrease this concentration below 10 µg/L within the foreseeable future appears to be very difficult without the development of appropriate and economically viable water treatment technologies which can be utilised at the municipal level.

5.6 Surveillance

WHO Guidelines Vol. 3 focuses on the surveillance of drinking-water quality in small-community supplies keeping in mind the special needs of developing countries. In such countries a stepwise approach to initiating a sustainable water quality surveillance programme may be called for. It is anticipated that this approach will ultimately lead to the implementation of a programme that will be a step towards the achievement of guideline values.

Surveillance is an investigative activity undertaken to identify and evaluate factors associated with drinking-water which could pose a risk to health. Surveillance contributes to the protection of public health by promoting improvement of the quality, quantity, coverage, cost, and continuity of water supplies. Its principal objective is to identify public health risks so that action may be taken promptly to prevent public health problems. Surveillance requires a systematic programme of surveys that combine analysis, sanitary inspection, and institutional and community aspects.

In most countries the agency responsible for the surveillance of drinking-water supply supplies (urban and rural) is the ministry of health. In some countries, the ministry of

environment or the ministry of local government may have that responsibility. The surveillance agency should preferably be an established national institution designated by appropriate legislation and should be able to operate at central, provincial and local levels.

Water-quality surveillance requires an appropriate institutional framework and adequate resources (financial, infrastructure & human) to function effectively. Surveillance activities need to be adapted to local conditions and to the availability of local financial resources, personnel, infrastructure and political commitment.

The objective of water quality surveillance is not simply to collect and collate information, but also to contribute to the protection of public health by promoting the improvement of water supply with respect to quality, coverage, cost and continuity.

5.7 Basic management aspects

The Guidelines for drinking-water quality cover a large number of possible contaminants in order to meet the varied needs of countries. However, it is very unlikely that all of the contaminants mentioned will occur in a water supply. Care should therefore be taken in selecting substances for which national standards will be developed. Scarce resources should not be wasted on developing standards for, and monitoring, substances of minor importance.

In countries where economic and human resources are limited, short- and medium-term targets should be set in establishing national drinking-water standards, water-quality surveillance, and quality-control programmes so that the most significant risks to human health are controlled first.

The most common and widespread health risk associated with drinking-water is microbial contamination, the consequences of which are so serious that its control must always be of paramount importance. It is therefore necessary to ensure that priority is given to water supplies presenting the greatest public health risk.

When a guideline value is exceeded, this should be a signal: (1) to investigate the cause with a view to taking remedial action; and (2) to consult with, and seek advice from, the authority responsible for public health.

References

- WHO, 1958. International Standards for Drinking-water,
- WHO, 1963. International Standards for Drinking-water , Second edition,
- WHO, 1971. International Standards for Drinking-water, Third edition,
- WHO, 1984. Guidelines for Drinking-water Quality, volume 1
- WHO, 1984. Guidelines for Drinking-water Quality, volume 2
- WHO, 1985. Guidelines for Drinking-water Quality, volume 3
- WHO, 1993. Guidelines for drinking-water quality, second edition, volume 1,
- WHO, 1996. Guidelines for drinking-water quality, second edition, volume 2,
- WHO, 1997. Guidelines for drinking-water quality, second edition, Volume 3
- WHO, 1998. Guidelines for drinking-water quality, second edition, Addendum to Volume 1,
- WHO, 1998. Guidelines for drinking-water quality, second edition, Addendum to Volume 2
- International Agency for Research on Cancer. *Overall evaluations of carcinogenicity; an updating of IARC Monographs volumes 1-42*. Lyon, 1987: 100-106. (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Suppl. 7).
- Risk Assessment Forum. *Special report on ingested inorganic arsenic. Skin cancer; nutritional essentiality*. Washington, DC, US Environmental Protection Agency, 1988 (EPA-625/3-87/013).
- Joint FAO/WHO Expert Committee on Food Additives. *Toxicological evaluation of certain food additives and contaminants*. Cambridge, Cambridge University Press, 1989:155-162 (WHO Food Additives series, No.24)
- Tseng WP. Effects of dose-response relationship of skin cancer and blackfoot disease with arsenic. *Environmental health perspectives*, 1977, 19:109-119.
- USEPA, Proposed Revision to Arsenic Drinking Water Standard, Technical Fact Sheet: Proposed Rule for Arsenic in Drinking Water and Clarifications to Compliance and New Source Contaminants Monitoring, http://www.epa.gov/safewater/ars/prop_techfs.html,_May 2000
- Lu FJ. Blackfoot disease: arsenic or humic acid? *Lancet*, 1990, 336(8707):115-116
- Wu MM et al. Dose-response relation between arsenic concentration in well water and mortality from cancers and cardiovascular diseases. *American journal of epidemiology*, 1989, 130:1123-1132.
- Chen CJ, Wang CJ. Ecological correlation between arsenic level in well water and age adjusted mortality from malignant neoplasms. *Cancer research*, 1990, 50:5470-5474.
- Chen CJ et al. Malignant neoplasms among residents of a blackfoot disease-endemic area in Taiwan: high-arsenic artesian well water and cancers. *Cancer research*, 1985, 45:5895-5899.

Chen CJ et al. A retrospective study on malignant neoplasms of bladder, lung and liver in blackfoot disease endemic area of Taiwan, *British journal of cancer*, 1986, 53:399-405

WHO Guidelines for Drinking Water Quality Training Pack, March 2000
http://www.who.int/water_sanitation_health/Training_mat/GDWQtraining.htm

Acronyms used in this chapter

EU: European Union

GDWQ: WHO guidelines for Drinking-water Quality

IARC: International Agency for research on Cancer

IPCS: International Programme on Chemical safety

JECFA: Joint FAO/WHO Expert Committee on Food Additives

MCL: maximum contaminant level

MLE maximum likelihood estimates

PMTDI: provisional maximum tolerable daily intake

PTWI: provisional tolerable weekly intake

SDWA: Safe Drinking Water Act

SMR: standardized mortality ratios

TDI: tolerable daily intake

USEPA: United States of America, Environmental Protection Agency

WHO EURO: The World Health Organization Regional Office for Europe

WHO HQ: WHO Head Quarters (in Geneva)

WHO: World Health Organization