Guidelines for Drinking-water Quality

FIRST ADDENDUM TO THIRD EDITION

Volume 1
Recommendations

World Health Organization

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Contents

Preface

Access to safe drinking-water is essential to health, a basic human right and a component of effective policy for health protection.

The importance of water, sanitation and hygiene for health and development has been reflected in the outcomes of a series of international policy forums. These have included health-oriented conferences such as the International Conference on Primary Health Care, held in Alma-Ata, Kazakhstan (former Soviet Union), in 1978. They have also included water-oriented conferences such as the 1977 World Water Conference in Mar del Plata, Argentina, which launched the water supply and sanitation decade of 1981–1990, as well as the Millennium Development Goals adopted by the General Assembly of the United Nations (UN) in 2000 and the outcome of the Johannesburg World Summit for Sustainable Development in 2002. Most recently, the UN General Assembly declared the period from 2005 to 2015 as the International Decade for Action, "Water for Life."

Access to safe drinking-water is important as a health and development issue at national, regional and local levels. In some regions, it has been shown that investments in water supply and sanitation can yield a net economic benefit, since the reductions in adverse health effects and health care costs outweigh the costs of undertaking the interventions. This is true for major water supply infrastructure investments through to water treatment in the home. Experience has also shown that interventions in improving access to safe water favour the poor in particular, whether in rural or urban areas, and can be an effective part of poverty alleviation strategies.

In 1983–1984 and in 1993–1997, the World Health Organization (WHO) published the first and second editions of the *Guidelines for Drinking-water Quality* in three volumes as successors to previous WHO International Standards. In 1995, the decision was made to pursue the further development of the Guidelines through a process of rolling revision. This led to the publication of addenda to the second edition of the Guidelines, on chemical and microbial aspects, in 1998, 1999 and 2002; the publication of a text on *Toxic Cyanobacteria in Water*; and the preparation of expert reviews on key issues preparatory to the development of a third edition of the Guidelines.

In 2000, a detailed plan of work was agreed upon for development of the third edition of the Guidelines. As with previous editions, this work was shared between WHO Headquarters and the WHO Regional Office for Europe (EURO). Leading the process of the development of the third edition were the Programme on Water, Sanitation and Health within Headquarters and the European Centre for Environment and Health, Rome, within EURO. Within WHO Headquarters, the Programme on Chemical Safety provided inputs on some chemical hazards, and the Programme on Radiological Safety contributed to the section dealing with radiological aspects. All six WHO Regional Offices participated in the process.

The revised Volume 1 of the Guidelines, published in 2004, is accompanied by a series of publications providing information on the assessment and management of risks associated with microbial hazards and by internationally peer-reviewed risk assessments for specific chemicals. These replace the corresponding parts of the previous Volume 2. Volume 3 provides guidance on good practice in surveillance, monitoring and assessment of drinking-water quality in community supplies. The Guidelines are also accompanied by other publications explaining the scientific basis of their development and providing guidance on good practice in implementation.

Volume 1 of the *Guidelines for Drinking-water Quality* explains requirements to ensure drinking-water safety, including minimum procedures and specific guideline values, and how those requirements are intended to be used. It also describes the approaches used in deriving the guidelines, including guideline values. It includes fact sheets on significant microbial and chemical hazards. The development of the third edition of the *Guidelines for Drinking-water Quality* includes a substantive revision of approaches to ensuring microbial safety. This takes account of important developments in microbial risk assessment and its linkages to risk management. The development of this orientation and content was led over an extended period by Dr Arie Havelaar (RIVM, Netherlands) and Dr Jamie Bartram (WHO).

The contents of this addendum to Volume 1 of the Guidelines amend and supersede the corresponding sections of Volume 1 of the Guidelines.

The third edition of these Guidelines, including these amendments, supersedes previous editions (1983–1984, 1993–1997 and addenda in 1998, 1999 and 2002) and previous International Standards (1958, 1963 and 1971). The Guidelines are recognized as representing the position of the UN system on issues of drinking-water quality and health by "UN-Water," the body that coordinates among the 24 UN agencies and programmes concerned with water issues.

The *Guidelines for Drinking-water Quality* are kept up to date through a process of rolling revision, which leads to periodic release of documents that may add to or supersede information in this volume.

The Guidelines are addressed primarily to water and health regulators, policymakers and their advisors, to assist in the development of national standards. The Guidelines and associated documents are also used by many others as a source of information on water quality and health and on effective management approaches.

Acknowledgements

The preparation of the third edition of the *Guidelines for Drinking-water Quality* (GDWQ) and supporting documentation covered a period of eight years and involved the participation of over 490 experts from 90 developing and developed countries. The contributions of all who participated in the preparation and finalization of the third edition and of this addendum, including those individuals listed in Annex 2 of the third edition and in Changes to Annex 2 in this addendum, are gratefully acknowledged.

The work of the following working group coordinators was crucial in the development of this addendum to the third edition:

Dr I. Chorus, Federal Environment Agency, Germany (*Resource and source protection*)
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The draft text was discussed at the Working Group Meeting for the first addendum to the third edition of the GDWQ, held on 17–21 May 2004. The final version of the

document takes into consideration comments from both peer reviewers and the public. The input of those who provided comments and of participants in the meeting is gratefully acknowledged.

The WHO coordinator was Dr J. Bartram, Coordinator, Programme on Water, Sanitation and Health, WHO Headquarters. Ms C. Vickers provided a liaison with the Programme on Chemical Safety, WHO Headquarters. Mr Robert Bos, Programme on Water, Sanitation and Health, WHO Headquarters, provided input on pesticides added to drinking-water for public health purposes.

Ms Penny Ward provided invaluable administrative support at the Working Group Meeting and throughout the review and publication process. Ms Marla Sheffer of Ottawa, Canada, was responsible for the scientific editing of the document.

Many individuals from various countries contributed to the development of the GDWQ. The efforts of all who contributed to the preparation of this document and in particular those who provided peer or public domain review comment are greatly appreciated.

Acronyms and abbreviations used in text

AAS	atomic absorption spectrometry
ADI	acceptable daily intake
AES	atomic emission spectrometry
BDCM	bromodichloromethane
BMD	benchmark dose
$BMDL_{10}$	lower-bound confidence limit on the benchmark dose associated with a 10% increase in response over background
CAS	Chemical Abstracts Service
CICAD	Concise International Chemical Assessment Document
CSAF	chemical-specific adjustment factor
DBCM	dibromochloromethane
DBP	disinfection by-product
DCA	dichloroacetic acid
DNA	deoxyribonucleic acid
ECD	electron capture detector
FAAS	flame atomic absorption spectrometry
FAO	Food and Agriculture Organization of the United Nations
FID	flame ionization detector
GAC	granular activated carbon
GC	gas chromatography
HAA	haloacetic acid
IARC	International Agency for Research on Cancer
ICP	inductively coupled plasma
JECFA	Joint FAO/WHO Expert Committee on Food Additives
JMPR	Joint FAO/WHO Meeting on Pesticide Residues
LOAEL	lowest-observed-adverse-effect level
MS	mass spectrometry
MTBE	methyl *tertiary*-butyl ether
NOAEL	no-observed-adverse-effect level
NOEL	no-observed-effect level

NTP	National Toxicology Program (USA)
PAC	powdered activated carbon
PBPK	physiologically based pharmacokinetic
PTWI	provisional tolerable weekly intake
RDL	reference dose level
TDI	tolerable daily intake
THM	trihalomethane
TOX	organohalogen
TPH	total petroleum hydrocarbons
USA	United States of America
WHO	World Health Organization
WHOPES	World Health Organization Pesticide Evaluation Scheme
WSP	water safety plan

Changes to Table of contents

Page iii

➢ Replace section "1.16" with section "1.1"

Page v

➢ Delete section 4.4.4

➢ In chapter 6 heading, replace "guidelines" with "Guidelines"

Page vi

➢ Insert the following new sections below section 7.5:

7.6 Identifying local actions in response to microbial water quality problems and emergencies
- 7.6.1 Boil water and water avoidance advisories
- 7.6.2 Actions following an incident

Page vii

➢ Insert the following new sections below section 8.5.6:

8.6 Identifying local actions in response to chemical water quality problems and emergencies
- 8.6.1 Trigger for action
- 8.6.2 Investigating the situation
- 8.6.3 Talking to the right people
- 8.6.4 Informing the public
- 8.6.5 Evaluating the significance to public health and individuals
- 8.6.6 Determining appropriate action
- 8.6.7 Consumer acceptability
- 8.6.8 Ensuring remedial action, preventing recurrence and updating the water safety plan

8.6.9 Mixtures
8.6.10 Water avoidance advisories

Page viii

➢ Delete section 9.6.2

Page xi

➢ Insert the following below section 12.54:

12.54(a) 1,4-Dioxane

➢ In section 12.66, replace "ibromoacetonitrile" with "dibromoacetonitrile"

➢ Insert the following below section 12.84:

12.84(a) Methyl *tertiary*-butyl ether

Page xii

➢ Insert the following below section 12.99:

12.99(a) Petroleum products

Page xiii

➢ Delete "Annex 3 Default assumptions"

Changes to Preface

Page xv

➢ In the second paragraph, replace "Millennium Declaration goals" with "Millennium Development Goals"

Page xvii

➢ In the second last bullet item, amend the second sentence as follows:

These include fluoride, arsenic and nitrate.

Changes to Acronyms and abbreviations used in text

Page xx

➢ Insert below DBP:

DCA	dichloroacetic acid

Page xxii

➢ Insert below MS:

MTBE	methyl *tertiary*-butyl ether

Page xxiii

➢ Insert below TID:

TPH	total petroleum hydrocarbons

Changes to Chapter 1: Introduction

Page 2

➢ In Section 1.1, fourth paragraph, delete the sentence:

Neither the minimum safe practices nor the numeric guideline values are mandatory limits.

➢ Amend the subsequent sentence to read as follows:

In order to define mandatory limits, it is preferable to consider the guidelines in the context of local or national environmental, social, economic and cultural conditions.

Page 18

➢ In section 1.3 heading, replace "guidelines" with "Guidelines"

Page 20

➢ Replace "*Arsenic in Drinking-water: Assessing and managing health risks*" with: "*Arsenic in Drinking-water: Assessing and Managing Health Risks*"

Changes to Chapter 2: The Guidelines: a framework for safe drinking-water

Pages 30–31

➢ Delete paragraph 5 in section 2.2.2 (from "The exceedance of a guideline value" to "is considered in more detail in section 6.2.")

Page 34

➢ Add the following text at the end of section 2.3.2:

In order to account for the variations in exposure from different sources in different parts of the world, default values, generally between 10% and 80%, are used to make an allocation of the tolerable daily intake (TDI) to drinking-water in setting guideline values for many chemicals. Where relevant exposure data are available, authorities are encouraged to develop context-specific guideline values that are tailored to local circumstances and conditions. For example, in areas where the intake of a particular contaminant in drinking-water is known to be much greater than that from other sources (e.g., air and food), it may be appropriate to allocate a greater proportion of the TDI to drinking-water to derive a guideline value more suited to the local conditions.

Volatile substances in water may be released to the atmosphere in showering and through a range of other household activities. Under such circumstances, inhalation may become a significant route of exposure. Some substances may also be absorbed through the skin during bathing, but this is not usually a major source of uptake. In some parts of the world, houses have a low rate of ventilation, and authorities may wish to take inhalation exposure into account in adapting the guidelines to local conditions, although other uncertainty factors used in the quantitative assessments may render this unnecessary. For those substances that are particularly volatile, such as chloroform, the correction factor would be approximately equivalent to a doubling of exposure. Where such exposure is shown to be important for a particular substance (i.e., high volatility, low ventilation rates and high rates of showering/bathing), it may be appropriate to adjust the guideline value accordingly (e.g., halve the guideline value to account for an approximate doubling of exposure).

➢ In the second paragraph of section 2.4, first bullet point, replace "microbiologically" with "microbially" (twice)

Page 35

➢ In the third paragraph under section 2.4.2, amend the second sentence as follows: These include fluoride, arsenic and nitrate.

Page 36

➢ In the paragraph beginning "Additional information on the hazards and risks," replace "www.epa.gov/waterscience" with "http://www.epa.gov/waterscience"

Changes to Chapter 4: Water safety plans

Page 49

➢ Insert the following after "A WSP has three key components" (first line of first paragraph):

(Figure 4.1)

Page 50

➢ In the fourth box of Figure 4.1, replace "existing proposed" with "existing or proposed"

➢ Revise the text following the bottom five arrows on Figure 4.1 as follows:

See section 4.3
See section 4.4
See section 4.4, Piped distribution
See section 4.5, Community + household
See section 4.6

Page 59

➢ In the first sentence of the paragraph beginning "Retention of water in reservoirs," add a comma after "disinfection" and correct the spelling of "opportunities"

Page 62

➢ Replace "*Safe, Piped Water*" (second line before Hazard identification heading) with "*Safe Piped Water*"

Page 64

➢ Replace "*Safe, Piped Water*" (second line before section 4.1.6) with "*Safe Piped Water*"

Page 69

➢ Insert a new bullet point immediately below the bullet point beginning "*Chlorine residual monitoring*" in section 4.2.2:

— *Oxidation–reduction potential* (ORP, or redox potential) measurement can also be used in the operational monitoring of disinfection efficacy. It is possible to define a minimum level of ORP necessary to ensure effective disinfection. This value has to be determined on a case-by-case basis; universal values cannot be recommended. Further research and evaluation of ORP as an operational monitoring technique are highly desirable.

➢ Replace "*Safe, Piped Water*" (last line on page) with "*Safe Piped Water*"

Page 70

➢ In Table 4.4, insert the following entry in the column headed "Operational parameter" below the entry "Disinfectant residual":

Oxidation–reduction potential (ORP)

➢ Add a checkmark (✓) in the column headed "Disinfection" next to the new entry

Page 72

➢ Add the following text at the end of the first paragraph on the page (beginning "For microbial verification"):

Trihalomethanes (THMs) and haloacetic acids (HAAs) are the most common DBPs and occur at among the highest concentrations in drinking-water. Under many circumstances, they can serve as a suitable measure that will reflect the concentration of a wide range of related chlorinated DBPs.

Page 79

➢ Delete the following text from the top of the page (middle of the second paragraph of section 4.4.3) to the end of section 4.4.3:

During an emergency in which there is evidence of faecal contamination of the drinking-water supply . . . In an emergency situation, the public health authorities should be consulted about appropriate action.

➢ Replace the above deleted text with the following:

Response plans for emergencies and unforeseen events involving microorganisms or chemicals should also include the basis for issuing boil water and water avoidance advisories. The objective of the advisory should be taken in the public interest, and

the advisory will typically be managed by public health authorities. A decision to close a drinking-water supply carries an obligation to provide an alternative safe supply and is very rarely justifiable because of the adverse effects, especially to health, of restricting access to water. Specific actions in the event of a guideline exceedance or an emergency are discussed in section 7.6 (microbial hazards) and section 8.6 (chemical hazards). "Practice" emergencies are an important part of the maintenance of readiness for emergencies. They help to determine the potential actions that can be taken in different circumstances for a specific water supply. Actions in the case of emergencies are considered further in sections 6.2, 7.6 and 8.6.

➢ Delete section 4.4.4.

Page 82

➢ In line 5, replace "see sections 4.4.2, 4.4.3 and 4.4.4" with "see sections 4.4.2 and 4.4.3"

Changes to Chapter 6: Application of the Guidelines in specific circumstances

Page 107

➢ Add the following sentence at the end of the third paragraph under section 6.2.3 (beginning "Drinking-water should be disinfected in emergency situations"):

Local actions that should be considered in response to microbial water quality problems and emergencies are further discussed in section 7.6.

Page 108

➢ Add the following sentence at the end of the first paragraph under section 6.2.5 (beginning "Many chemicals in drinking-water are of concern"):

Local actions that can be considered in the event of a short-term guideline exceedance or emergency are discussed in section 8.6.

Page 111

➢ Replace the second sentence in the fifth paragraph of section 6.4 (beginning "In applying the Guidelines to desalinated water supply systems") with the following:

These differences include the factors described below.

Changes to Chapter 7: Microbial aspects

Page 128

➢ Insert the following text at the end of the third paragraph (beginning "It is rarely possible or appropriate") under the heading Exposure assessment in section 7.2.2:

(see also the supporting document *Water Treatment and Pathogen Control*; section 1.3).

Page 131

➢ Insert the following text at the end of the second paragraph in section 7.2.3 (beginning "Performance targets are most frequently applied"):

(see also the supporting document *Water Treatment and Pathogen Control*; section 1.3).

Page 144

➢ Insert the following sections below Table 7.8:

7.6 Identifying local actions in response to microbial water quality problems and emergencies

During an emergency in which there is evidence of faecal contamination of the drinking-water supply, it may be necessary either to modify the treatment of existing sources or to temporarily use alternative sources of drinking-water. It may be necessary to increase disinfection at source, following treatment or during distribution.

If microbial quality cannot be maintained, it may be necessary to advise consumers to boil the water during the emergency (see section 7.6.1). Initiating superchlorination and undertaking immediate corrective measures may be preferable where the speed of response is sufficient to prevent significant quantities of contaminated water reaching consumers.

During outbreaks of potentially waterborne disease or when faecal contamination of a drinking-water supply is detected, the concentration of free chlorine should be

increased to greater than 0.5 mg/litre throughout the system as a minimum immediate response. It is most important that decisions are taken in consultation with public health authorities and, where appropriate, civil authorities (see also section 8.6).

7.6.1 Boil water and water avoidance advisories

Water suppliers in conjunction with public health authorities should develop protocols for boil water orders and water avoidance advisories. Protocols should be prepared prior to the occurrence of incidents and incorporated within management plans. Decisions to issue advisories are often made within a short period of time, and developing responses during an event can complicate decision-making, compromise communication and undermine public confidence.

In addition to the information discussed in section 4.4.3, the protocols should deal with:

— criteria for issuing and rescinding advisories;
— information to be provided to the general public and specific groups; and
— activities impacted by the advisory.

Protocols should identify mechanisms for the communication of boil water and water avoidance advisories. The mechanisms may vary, depending on the nature of the supply and the size of the community affected, and could include:

— media releases through television, radio and newspapers;
— telephone, e-mail and fax contact of specific facilities, community groups and local authorities;
— posting of notices in conspicuous locations;
— personal delivery; and
— mail delivery.

The methods chosen should provide a reasonable surety that all of those impacted by the advisory, including residents, workers and travellers, are notified as soon as possible.

Boil water advisories should indicate that the water can be made safe by bringing it to a rolling boil. After boiling, the water should be allowed to cool down on its own without the addition of ice. This procedure is effective at all altitudes and with turbid water.

The types of event that should lead to consideration of boil water advisories include:

— substantial deterioration in source water quality;
— major failures associated with treatment processes or the integrity of distribution systems;
— inadequate disinfection;
— detection of pathogens or faecal indicators in drinking-water; and

— epidemiological evidence suggesting that drinking-water is responsible for an outbreak of illness.

Boil water advisories are a serious measure that can have substantial adverse consequences. Advice to boil water can have negative public health consequences through scalding and increased anxiety, even after the advice is rescinded. In addition, not all consumers will follow the advice issued, even at the outset; if boil water advisories are issued frequently or are left in place for long periods, compliance will decrease. Hence, advisories should be issued only after careful consideration of all available information by the public health authority and the incident response team and conclusion that there is an ongoing risk to public health that outweighs any risk from the advice to boil water. For example, where microbial contamination is detected in samples of drinking-water, factors that should be considered in evaluating the need for an advisory include:

— reliability and accuracy of results;
— vulnerability of source water to contamination;
— evidence of deterioration in source water quality;
— source water monitoring results;
— results from operational monitoring of treatment and disinfection processes;
— disinfectant residuals; and
— physical integrity of the distribution system.

The available information should be reviewed to determine the likely source of the contamination and the likelihood of recurrence or persistence.

When issued, a boil water advisory should be clear and easily understood by recipients, or it may be ignored. Advisories should normally include a description of the problem, potential health risks and symptoms, activities that are impacted, investigative actions and corrective measures that have been initiated, as well as the expected time to resolve the problem. If the advisory is related to an outbreak of illness, specific information should be provided on the nature of the outbreak, the illness and the public health response.

Boil water advisories should identify both affected and unaffected uses of drinking-water supplies. Generally, the advisory will indicate that unboiled water should not be used for drinking, preparing cold drinks, making ice, preparing or washing food or brushing teeth. Unless heavily contaminated, unboiled water will generally be safe for bathing (providing swallowing of water is avoided) and washing clothes. A boil water advisory could include specific advice for vulnerable groups, such as pregnant women and those who might be immunocompromised.

Specific advice should also be provided to facilities such as dental clinics, dialysis centres, doctors' offices, hospitals and other health care facilities, child care facilities, schools, food suppliers and manufacturers, hotels, restaurants and operators of public swimming pools and spas.

Provision of alternative supplies of drinking-water, such as bottled water or bulk water, should be considered when temporary boil water or water avoidance advisories are in place. The protocols should identify sources of alternative supplies and mechanisms for delivery.

Protocols should include criteria for rescinding boil water and water avoidance advisories. Depending on the reason for issuing the advisory, the criteria could include one or more of the following:

- —evidence that source water quality has returned to normal;
- —correction of failures associated with treatment processes or distribution systems;
- —correction of faults in disinfection processes and restoration of normal disinfectant residuals;
- —where detection of microbial contamination in drinking-water initiated the advisory, evidence that this contamination has been removed or inactivated;
- —evidence that sufficient mains flushing or water displacement has removed potentially contaminated water and biofilms; and/or
- —epidemiological evidence indicating that an outbreak has concluded.

When boil water and water avoidance advisories are rescinded, information should be provided through similar channels and to the same groups that received the original advice. In addition, operators/managers or occupants of large buildings and buildings with storage tanks should be advised of the need to ensure that storages and extensive internal distribution systems are thoroughly flushed before normal uses are restored.

Water avoidance advisories, which share many features with boil water advisories but are less common, are applied when the parameter of concern, primarily chemical contaminants, is not susceptible to boiling (see section 8.6).

7.6.2 Actions following an incident

It is important that any incident be properly investigated and remedial action instigated to prevent its recurrence. The WSP will require revision to take into account the experience gained, and the findings may also be of importance in informing actions regarding other water supplies to prevent a similar event from occurring elsewhere. Where appropriate, epidemiological investigations by the health authority will also help to inform actions for the future.

Changes to Chapter 8: Chemical aspects

Page 150

➢ Replace "(see Annex 3)" on lines 1 and 3 with "(see below)"

Pages 151–152

➢ Replace the subsection "Allocation of intake" in section 8.2.2 with the following:

Allocation of intake

Drinking-water is not usually the sole source of human exposure to the substances for which guideline values have been set. In many cases, the intake of chemical contaminants from drinking-water is small in comparison with that from other sources, such as food, air and consumer products. Some consideration is therefore needed as to the proportion of the TDI that may be allowed from different sources in developing guidelines and risk management strategies. This approach ensures that total daily intake from all sources (including drinking-water containing concentrations of the substance at or near the guideline value) does not exceed the TDI.

Wherever possible, data concerning the proportion of total intake normally ingested in drinking-water (based on mean levels in food, air and drinking-water) or intakes estimated on the basis of consideration of physical and chemical properties were used in the derivation of the guideline values. In developing guideline values that can be applied throughout the world, it is difficult to obtain such data, which are highly variable for many chemicals. Where appropriate information is not available, values are applied that reflect the likely contribution from water for various chemicals. The values generally vary from 10% for substances for which exposure from food is probably the major source to 80% for substances for which exposure is primarily through drinking-water. Although the values chosen are, in most cases, sufficient to account for additional routes of intake (i.e., inhalation and dermal absorption) of contaminants in water, under certain circumstances, authorities may wish to take inhalation and dermal exposure into account in adapting the guidelines to local conditions (see section 2.3.2).

Where locally relevant exposure data are available, authorities are encouraged to develop context-specific guideline values that are tailored to local circumstances and conditions. For example, in areas where the intake of a particular contaminant in drinking-water is known to be much greater than that from other sources (e.g., air and food), it may be appropriate to allocate a greater proportion of the TDI to drinking-water to derive a guideline value more suited to the local conditions.

Page 152

➢ Insert the following new subsection in section 8.2.2, immediately above the subsection "Significant figures":

Default assumptions

There is variation in both the volume of water consumed by, and the body weight of, consumers. It is, therefore, necessary to apply some assumptions in order to determine a guideline value. The default assumption for consumption by an adult is 2 litres of water per day, while the default assumption for body weight is 60 kg. It is recognized that water intake can vary significantly in different parts of the world, particularly where consumers are involved in manual labour in hot climates. In the case of a few parameters, such as fluoride, local adjustment may be needed in setting local standards. For most other substances, the drinking-water intake range is very small (perhaps a factor of 2–4) compared with the much larger range in the toxicological uncertainty factors. In some cases, the guideline value is based on children, where they are considered to be particularly vulnerable to a particular substance. In this event, a default intake of 1 litre is assumed for a body weight of 10 kg; where the most vulnerable group is considered to be bottle-fed infants, an intake of 0.75 litre is assumed for a body weight of 5 kg.

Pages 152–154

➢ Replace section 8.2.3 with the following:

8.2.3 Alternative approaches

Alternative approaches being considered in the derivation of TDIs for threshold effects include the benchmark dose (BMD) and chemical-specific adjustment factors (CSAFs). The BMD is the lower confidence limit of the dose that produces a small increase in the level of adverse effects (e.g., 5% or 10%), to which uncertainty factors can be applied to develop a tolerable intake. The BMD has a number of advantages over the NOAEL, including the fact that it is derived on the basis of data from the entire dose–response curve for the critical effect rather than from the single dose group at the NOAEL (IPCS, 1994). CSAFs, which were previously called "data-derived uncertainty factors," are derived from quantitative toxicokinetic and toxicodynamic data and replace the default values for extrapolation between species and between

routes of exposure. As such, they reduce reliance on empirical mathematical modelling (IPCS, 2001).

Page 154

➢ Replace section 8.2.4 with the following:

8.2.4 Non-threshold chemicals

In the case of compounds considered to be genotoxic carcinogens, guideline values were normally determined using a mathematical model. Although several models exist, the linearized multistage model was generally adopted. Other models were considered more appropriate in a few cases. These models compute an estimate of risk at a particular level of exposure, along with upper and lower bounds of confidence on the calculation, which may include zero at the lower bound. Guideline values are conservatively presented as the concentrations in drinking-water associated with an estimated upper-bound excess lifetime cancer risk of 10^{-5} (or one additional cancer per 100 000 of the population ingesting drinking-water containing the substance at the guideline value for 70 years). This value does not equate to the number of cases of cancer that will be caused by exposure to the substance at this level. It is the maximum potential risk, taking into account large uncertainties. It is highly probable that the actual level of risk is less than this, but risks at low levels of exposure cannot be experimentally verified. Member States may consider that a different level of risk is more appropriate to their circumstances, and values relating to risks of 10^{-4} or 10^{-6} may be determined by respectively multiplying or dividing the guideline value by 10.

The mathematical models used for deriving guideline values for non-threshold chemicals cannot be verified experimentally, and they do not usually take into account a number of biologically important considerations, such as pharmacokinetics, DNA repair or protection by the immune system. They also assume the validity of a linear extrapolation of very high dose exposures in test animals to very low dose exposures in humans. As a consequence, the models used are conservative (i.e., err on the side of caution). The guideline values derived using these models should be interpreted differently from TDI-derived values because of the lack of precision of the models. Moderate short-term exposure to levels exceeding the guideline value for non-threshold chemicals does not significantly affect the risk.

Page 160

➢ In Table 8.7, add the following entry to column 1, immediately below "Dichloromethane":

1,4-Dioxane

➢ Insert "+++" under the column heading "GC/MS" for the above new entry

Page 166

➢ Insert the following text immediately following the first paragraph under section 8.4 (beginning "As noted above, where a health-based guideline value"):

Collection, treatment, storage and distribution of drinking-water involve deliberate additions of numerous chemicals to improve the safety and quality of the finished drinking-water for consumers (direct additives). In addition, water is in constant contact with pipes, valves, taps and tank surfaces, all of which have the potential to impart additional chemicals to the water (indirect additives). The chemicals used in water treatment or from materials in contact with drinking-water are discussed in more detail in section 8.5.4.

Page 180

➢ Insert the following new subsection at the end of section 8.4.12:

Removing DBPs prior to distribution

It is technically feasible to remove DBPs prior to distribution; however, this is the least attractive option for controlling DBP concentrations. Feasible processes include air stripping to remove volatile DBPs such as THMs or adsorption onto activated carbon. These processes would need to be followed by a further disinfection step to guard against microbial contamination and to ensure a residual concentration of disinfectant within distribution.

Page 187

➢ In Table 8.20, insert the following below "Dichloroethane, 1,1-":

Dichloroethene, 1,1-	Occurs in drinking-water at concentrations well below those at which toxic effects may occur

➢ In Table 8.20, insert the following below "Hexachlorobenzene":

Methyl *tertiary*-butyl ether (MTBE)	Any guideline that would be derived would be significantly higher than concentrations at which MTBE would be detected by odour

➢ In Table 8.20, insert the following below "Monochlorobenzene":

Petroleum products	Taste and odour will in most cases be detectable at concentrations below those concentrations of concern for health, particularly with short-term exposure

Page 188

➢ In Table 8.21, replace the "Mercury" entry as follows:

Mercury	0.006	For inorganic mercury

➢ In Table 8.21, delete the "Dichloroethene, 1,1-" entry

➢ In Table 8.21, insert the following below "Dichloromethane":

Dioxane, 1,4-	50[b]

➢ In Table 8.21, revise the "Trichloroethene" entry as follows:

Trichloroethene	20 (P)

Pages 188–189

➢ Replace the first and second paragraphs under section 8.5.4 (beginning "Chemicals are used in water treatment and may give rise" and ending "and to control the formation of DBPs") with the following:

Chemicals used in water treatment and chemicals arising from materials in contact with water may give rise to contaminants in the final water.

Some substances are deliberately added to water in the course of treatment (direct additives), some of which may be inadvertently retained in the finished water (e.g., salts, coagulant polymer residues or monomers). Chloramine and chlorine disinfectant residuals, for example, are deliberate additives, and their presence confers a benefit. Others, such as DBPs, are generated during chemical interactions between disinfectant chemicals and substances normally in water (see Table 8.25). Chlorination by-products and other DBPs may also occur in swimming pools, from which exposure by inhalation and skin absorption will be of greater importance (WHO, 2000).

Other chemicals, such as lead or copper from pipes or brass taps and chemicals leaching from coatings, may be taken up from contact with surfaces during treatment or distribution (indirect additives).

Some chemicals used in water treatment (e.g., fluoride) or in materials in contact with drinking-water (e.g., styrene) have other principal sources and are therefore discussed in detail in other sections of this chapter.

Many of these additives, both direct and indirect, are components of processes for producing safe drinking-water. The approach to monitoring and management is preferably through control of the material or chemical. It is important to optimize treatment processes and to ensure that such processes remain optimized in order to control residuals of chemicals used in treatment and to control the formation of DBPs. Inadvertent contamination caused by poor quality materials is best controlled by applying specifications governing the composition of the products themselves rather than by setting limits on the quality of finished water, whereas contamination due to

the inappropriate use of additives can be addressed by guidance on use. Similarly, regulations on the quality of pipe can avoid possible contamination of water by leachable materials. Control of contamination from *in situ* applied coatings requires suitable codes of practice on their application in addition to controls on the composition of materials.

Numerous national and third-party evaluation and approval systems for additives exist throughout the world; however, many countries do not have or operate such systems. Governments and other organizations should consider establishing or adapting additive management systems and setting product quality standards and guidance on use that would apply to determining acceptable water contact products. Ideally, harmonized standards between countries or reciprocal recognition would reduce costs and increase access to such standards (see also section 1.2.9).

Page 189

➢ In Table 8.22, add the following entry immediately below "Cypermethrin":

Deltamethrin	Unlikely to occur in drinking-water

Page 190

➢ Insert the following new subsections at the end of section 8.5.4:

Indicator substances for monitoring chlorination by-products

Although guidelines have been established for a number of chlorination by-products, data from drinking-water supplies indicate that THMs and HAAs are adequate as indicators of the majority of chlorination by-products. The most appropriate means of controlling chlorination by-products is to remove the organic precursors, which are largely of natural origin. Measurement of THMs and, if appropriate, HAAs (e.g., where water is chlorinated at a low pH) can be used to optimize treatment efficiency and to establish the boundaries of other operational parameters that can be used to monitor treatment performance. In these circumstances, monitoring frequencies of other chlorination by-products can be reduced. Although total organohalogen (TOX) does not correlate well with either THMs or HAAs, it does correlate with total chlorination by-products and may be another potential indicator.

In all circumstances, disinfection efficiency should not be compromised in trying to meet guidelines for DBPs, including chlorination by-products, or in trying to reduce concentrations of these substances.

Contaminants from storage and generation of hypochlorite solutions

Sodium hypochlorite solutions slowly decompose – more rapidly at warmer temperatures – to produce chlorate and chlorite ions. As the solution ages and the available chlorine concentration decreases, it is necessary to dose more product to achieve the

desired residual chlorine concentration, with a consequent increase in the amounts of chlorate and chlorite added to the treated water. The decomposition of solid calcium hypochlorite is much slower, and consequently contamination is less likely to be significant. However, if calcium hypochlorite solutions are prepared and stored before use, then decomposition to form chlorate and chlorite would also occur.

Sodium hypochlorite is manufactured by electrolysing sodium chloride, which naturally contains small concentrations of sodium bromide. This results in the presence of bromate in the sodium hypochlorite solution. This will contribute bromate to the treated water. The quality and acceptability of sodium hypochlorite will partly be a function of the bromate residue concentration. Industrial-grade product may not be acceptable for drinking-water applications. The sodium bromide present in sodium chloride will also be oxidized to form bromate in systems using on-site electrochemical generation of hypochlorite.

Contaminants from use of ozone and chlorine dioxide

The use of ozone can lead to elevated bromate concentrations through oxidation of bromide present in the water. As a general rule, the higher the water bromide concentration, the more bromate is produced.

Chlorine dioxide solutions can contain chlorate as a result of reactions that compete with the desired reaction for generation of chlorine dioxide. Chlorite ion is an inevitable decomposition product from the use of chlorine dioxide; typically, 60–70% of the applied dose is converted to chlorite in the treated water.

Page 192

➢ Insert the following paragraph immediately following the paragraph beginning "As for the other groups of chemicals discussed in this chapter" in section 8.5.5:

In addition to the use of larvicides approved for drinking-water application to control disease vector insects, other control measures should also be considered. For example, the stocking of fish of appropriate varieties (e.g., larvae-eating mosquitofish) in water bodies may adequately control infestations and breeding of mosquitoes in those bodies. Other mosquito breeding areas where water collects should be managed by draining, especially after rainfall.

Page 193

➢ In Table 8.26, insert the following below "Bromochloroacetonitrile":

Chloral hydrate (trichloroacetaldehyde)	Occurs in drinking-water at concentrations well below those at which toxic effects may occur

➢ In Table 8.26, insert the following below "Dichlorophenol, 2,4-":

Formaldehyde	Occurs in drinking-water at concentrations well below those at which toxic effects may occur

Page 194

➢ In Table 8.27, delete the "Chloral hydrate (trichloroacetaldehyde)" entry

➢ In Table 8.27, revise the "Chloroform" entry as follows:

Chloroform	300

➢ In Table 8.27, revise the "Dichloroacetate" entry as follows:

Dichloroacetate	50[b] (T,D)

➢ In Table 8.27, delete the "Formaldehyde" entry

➢ In Table 8.27, revise the "Nickel" entry as follows:

Nickel	70

Page 195

➢ In Table 8.28, insert the following below "DDT and metabolites":

Permethrin	300

➢ In Table 8.28, revise footnote a as follows:

[a] Only pyriproxyfen is recommended by WHO for addition to water for public health purposes. Permethrin is not recommended by WHO for this purpose, as part of its policy to exclude the use of any pyrethroids for larviciding of mosquito vectors of human disease. This policy is based on concern over the possible accelerated development of vector resistance to synthetic pyrethroids, which, in their application to insecticide-treated mosquito nets, are crucial in the current global anti-malaria strategy.

Page 196

➢ Insert the following text at the end of chapter 8:

8.6 Identifying local actions in response to chemical water quality problems and emergencies

It is difficult to give comprehensive guidance concerning emergencies in which chemicals cause massive contamination of the drinking-water supply, caused either by accident or by deliberate action. Most of the guideline values recommended in these Guidelines (see section 8.5 and annex 4) relate to a level of exposure that is regarded

as tolerable throughout life. Acute toxic effects are considered for a limited number of chemicals. The length of time for which exposure to a chemical far in excess of the guideline value would have adverse effects on health will depend upon factors that vary from contaminant to contaminant. In an emergency situation, the public health authorities should be consulted about appropriate action.

The exceedance of a guideline value may not result in a significant or increased risk to health. Therefore, deviations above the guideline values in either the short or long term may not 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 upon the specific substance involved. However, exceedance should be a signal:

- as a minimum, to investigate the cause with a view to taking remedial action as necessary; and
- to consult the authority responsible for public health for advice on suitable action, taking into account the intake of the substance from sources other than drinking-water, the toxicity of the substance, the likelihood and nature of any adverse effects and the practicality of remedial measures.

If a guideline value is to be exceeded by a significant amount or for more than a few days, it may be necessary to act rapidly so as to ensure that health protective action is taken and to inform consumers of the situation so that they can act appropriately.

The primary aim with regard to chemical contaminants when a guideline is exceeded or in an emergency is to prevent exposure of the population to toxic concentrations of pollutants. However, in applying the Guidelines under such circumstances, an important consideration is that, unless there are appropriate alternative supplies of drinking-water available, maintenance of adequate quantities of water is a high priority. In the case of an incident in which chemical contaminants are spilt into a source water and enter a drinking-water supply or enter a supply through treatment or during distribution, the primary aim is to minimize the risk of adverse effects without unnecessarily disrupting the use of the water supply.

This section of the Guidelines can be used to assist evaluation of the risks associated with a particular situation and – especially if a guideline value exists or an authoritative risk assessment is available from an alternative source – support appropriate decision-making on short- and medium-term actions. The approaches proposed provide a basis for discussion between various authorities and for judging the urgency of taking further action.

Normally, a specific review of the situation will be required and should call on suitable expertise. It is important to take local circumstances into account, including the availability of alternative water supplies and exposure to the contaminant from other sources, such as food. It is also important to consider what water treatment is applied and/or available and whether this will reduce the concentration of the substance.

Where the nature of contamination is unknown, expert opinion should be sought as quickly as possible to identify the contaminants and to determine what actions can be taken to:

— prevent the contaminants from entering the supply; and/or
— minimize the exposure of the population and so minimize any potential for adverse effects.

A WSP should include planning for response to both predictable events and undefined "emergencies." Such planning facilitates rapid and appropriate response to events when they occur (see section 4.4).

Consideration of emergency planning and planning for response to incidents in which a guideline value is exceeded, covering both microbial and chemical contaminants, is discussed in section 4.4. Broader discussion of actions in emergency situations can be found in section 6.2 and, for microbial contamination, section 7.6.

8.6.1 Trigger for action

Triggers for action may include:

— detection of a spill by, or reporting of a spill to, the drinking-water supplier;
— an alarm raised by the observation of items, such as chemical drums, adjacent to a vulnerable part of the drinking-water supply;
— the detection of a substance in the water;
— a sudden change to water treatment; or
— consumer complaints (e.g., an unusual odour, taste or discoloration).

8.6.2 Investigating the situation

Each incident is unique, and it is therefore important to determine associated facts, including what the contaminant is; what the likely concentration is, and by how much the guideline has been exceeded, if at all; and the potential duration of the incident. These are important in determining the actions to be taken.

8.6.3 Talking to the right people

In any emergency, it is important that there be good communication between the various authorities, particularly the water supplier and health authorities. It will usually be the health authorities that make the final decisions, but knowledge of the water supply and the nature of the supply is vital in making the most appropriate decisions. In addition, timely and clear communication with consumers is a vital part of successfully handling drinking-water problems and emergencies.

Liaison with key authorities is discussed in section 4.4. It is particularly important to inform the public health authority of any exceedance or likely exceedance of a guideline value or other conditions likely to affect human health and to ensure that

the public health authority is involved in decision-making. In the event of actions that require all consumers to be informed or where the provision of temporary supplies of drinking-water is appropriate, civil authorities should also be involved. Planning for these actions is an important part of the development of WSPs. Involving the public health authorities at an early stage enables them to obtain specialist information and to make the appropriate staff available.

8.6.4 Informing the public

Consumers may be aware of a potential problem with the safety of their drinking-water because of media coverage, their own senses or informal networks. Lack of confidence in the drinking-water or the authorities may drive consumers to alternative, potentially less safe sources. Not only do consumers have a right to information on the safety of their drinking-water, but they have an important role to play in assisting the authorities in an incident by their own actions and by carrying out the necessary measures at the household level. Trust and goodwill from consumers are extremely important in both the short and long term.

The health authorities should be involved whenever a decision to inform the public of health-based concerns or advice to adopt health protection measures such as boiling of water may be required. Such guidance needs to be both timely and clear.

8.6.5 Evaluating the significance to public health and individuals

In assessing the significance of an exceedance of a guideline value, account should be taken of:

- information underpinning the guideline value derivation;
- local exposure to the substance of concern through other routes (e.g., food);
- any sensitive subpopulations; and
- locally relevant protective measures to prevent the chemical from entering the source water or supply in the case of a spill.

Information underpinning guideline value derivation

The derivation of guideline values for chemical contaminants is described in section 8.2.

Most guideline values are derived by calculating a TDI or using an existing TDI or ADI. A proportion of the TDI or ADI is then allocated to drinking-water to make allowance for exposure from other sources, particularly food. This allocation is often 10%, but it may be as low as 1% or as high as 80%. In many circumstances, a review of likely local sources of exposure may identify that sources other than drinking-water are less significant than assumed and that a larger proportion of total exposure can be safely allocated to drinking-water. The summary statements in chapter 12 and background documents on all chemicals addressed in these Guidelines

(http://www.who.int/water_sanitation_health/dwq/chemicals/en/#V) provide further information on likely sources of the chemicals concerned, including their allocation factors. When rapid decision-making is required for such chemicals, it is possible to allow 100% of the TDI to come from drinking-water for a short period (e.g., a few days) while undertaking a more substantive review. In the event that there is significant exposure from other sources or exposure is likely to be for more than a few days, then it is possible to allocate more than the allocation used in the guideline value derivation, but no more than 100%.

In some cases, the guideline value is derived from epidemiological or clinical studies in humans. In most cases (e.g., benzene, barium), these relate to long-term exposure, and short-term exposure to concentrations higher than the guideline value are unlikely to be of significant concern; however, it is important to seek expert advice. In other cases of guidelines derived from epidemiological studies, the associated health effects are acute in nature (e.g., nitrate/nitrite, copper):

- The guideline value (50 mg/litre) for nitrate is based on the occurrence of methaemoglobinaemia, or blue-baby syndrome, in bottle-fed infants. This outcome is complicated by the presence of microbial contamination, which can increase the risk to this group significantly. Methaemoglobinaemia has rarely been associated with nitrate in the absence of faecal contamination of the drinking-water. As a short-term measure, water should not be used for bottle-fed infants when nitrate levels are above 100 mg/litre; however, it may be used if medical authorities are increasingly vigilant when the nitrate concentration is between 50 and 100 mg/litre, provided that the water is known and is confirmed to be microbially safe. The guideline value for nitrate relates to a specific and vulnerable subgroup (i.e., bottle-fed infants), and therefore the guideline will be more than adequately protective for older children and adults.
- The guideline value for copper is also based on short-term exposure but is intended to protect against direct gastric irritation, which is a concentration-dependent phenomenon. The guideline value may be exceeded, but there will be an increasing risk of consumers suffering from gastrointestinal irritation as the concentration increases above the guideline value. The occurrence of such irritation can be assessed in exposed populations.

In some cases, the guideline value is derived from a cancer risk estimate derived from studies in laboratory animals. In these cases, short-term (a few months to a year) exposure to concentrations up to 10 times the guideline value would result in only a small increase in estimated risk of cancer. Because the estimate of risk varies over a wide range, there may be no, or a very small, increase in risk. In such a circumstance, accepting a 10-fold increase in the guideline value for a short period would have no discernible impact on the risk over a lifetime. However, care would be needed to determine whether other toxicological end-points more relevant for short-term exposure, such as neurotoxicity, would become significant.

Assessing locally relevant sources of the substance of concern through other routes of exposure

The most useful sources of information regarding local exposure to substances through food and, to a lesser extent, air and other environmental routes are usually government departments dealing with food and environmental pollution. Other sources may include universities. In the absence of specific data, the Guidelines background documents consider the sources of exposure and give a generic assessment that can be used to make a local evaluation as to the potential use of a chemical and whether this would be likely to enter the food-chain. Further information is available in *Chemical Safety of Drinking-water: Assessing Priorities for Risk Management* (see section 1.3).

Sensitive subpopulations

In some cases, there may be a specific subpopulation that is at greater risk from a substance than the rest of the population. These usually relate to high exposure (e.g., bottle-fed infants) or a particular sensitivity (e.g., fetal haemoglobin and nitrate/nitrite). However, some genetic subpopulations may show greater sensitivity to particular toxicity (e.g., glucose-6-phosphate dehydrogenase-deficient groups and oxidative stress on red blood cells). If the potential exposure from drinking-water in an incident is greater than the TDI or exposure is likely to be extended beyond a few days, then this would require consideration in conjunction with health authorities. In such circumstances, it may be possible to target action to avoid exposure at the specific group concerned, such as supplying bottled water for bottle-fed infants.

Specific mitigation measures affecting risk assessment

Such measures relate to actions taken locally or on a household basis that can impact on the presence of a particular contaminant. For example, the presence of a substance that is volatile or heat labile will be affected by heating the water for cooking or the preparation of beverages. Where such measures are routinely undertaken by the exposed population, the risk assessment may be modified accordingly. Alternatively, such steps can be used on a household basis to reduce exposure and allow the continued use of the supply without interruption.

8.6.6 Determining appropriate action

Determining appropriate action means that various risks will need to be balanced. The interruption of water supply to consumers is a serious step and can lead to risks associated with contamination of drinking-water stored in the household with pathogens and limiting use for purposes of hygiene and health protection. Issuing a "do not drink" notice may allow the use of the supply for hygiene purposes such as showering or bathing, but creates pressure on consumers and authorities to provide a safe alternative for drinking and cooking. In some cases, this option will be expensive and could divert resources from other more important issues. Appropriate action

will always be decided on a case-by-case basis in conjunction with other authorities, including the health protection and civil authorities, who may be required to participate in informing consumers, delivering alternative supplies or supervising the collection of water from bowsers and tankers. Responding to a potential risk to health from a chemical contaminant should not lead to an increase in overall health risk from disruption of supply, microbial contaminants or other chemical contaminants.

8.6.7 Consumer acceptability

Even though, in an emergency, supplying water that contains a substance present at higher concentrations than would normally be desirable may not result in an undue risk to health, the water may not be acceptable to consumers. A number of substances that can contaminate drinking-water supplies as a consequence of spills can give rise to severe problems with taste and/or odour. Under these circumstances, drinking-water may become so unpalatable as to render the water undrinkable or to cause consumers to turn to alternative drinking-water sources that may present a greater risk to health. In addition, water that is clearly contaminated may cause some consumers to feel unwell due to a perception of poor water quality. Consumer acceptability may be the most important factor in determining the advice given to consumers about whether or not the water should be used for drinking or cooking.

8.6.8 Ensuring remedial action, preventing recurrence and updating the water safety plan

The recording of an incident, the decisions taken and the reasons for them are essential parts of handling an incident. The WSP, as discussed in chapter 4, should be updated in the light of experience. This would include making sure that problem areas identified during an incident are corrected. Where possible, it would also mean that the cause of the incident is dealt with to prevent its recurrence. For example, if the incident has arisen as a consequence of a spill from industry, the source of the spill can be advised as to how to prevent another spill and the information passed on to other similar industrial establishments.

8.6.9 Mixtures

A spill may contain more than one contaminant of potential health concern (see section 8.2.9). Under these circumstances, it will be important to determine whether the substances present interact. Where the substances have a similar mechanism/mode of action, it is appropriate to consider them as additive. This may be particularly true of some pesticides, such as atrazine and simazine. In these circumstances, appropriate action must take local circumstances into consideration. Specialist advice should generally be sought.

8.6.10 Water avoidance advisories

Water avoidance advisories share many features with boil water advisories (see section 7.6.1), but are less common. Like boil water advisories, they are a serious measure that should be instituted only when there is evidence that an advisory is necessary to reduce a substantial public health risk. In cases where alternative sources of water are recommended, particular consideration should be given to the potential for microbial hazards in those alternative sources. Water avoidance advisories are applied when the parameter of concern is not susceptible to boiling or when risks from dermal contact or inhalation of the contaminant are also significant. Water avoidance advisories may also be issued when an unknown agent or chemical substance is detected in the distribution system. It is important that the water avoidance advisories include the information that boiling is ineffective and/or insufficient to reduce the risk.

As with the case of boil water advisories, water suppliers in conjunction with public health authorities should develop protocols for water avoidance advisories. Protocols should be prepared before any incident occurs and incorporated within WSPs. Decisions to issue advisories are often made within a short period of time, and developing responses during an event can complicate decision-making, compromise communication and undermine public confidence.

In addition to the information discussed in section 4.4.3, the protocols should provide information to the general public and specific groups on the following:

— criteria for issuing and rescinding advisories;
— activities impacted by the advisory; and
— alternative sources of safe water for drinking and other domestic uses.

Protocols should identify mechanisms for the communication of water avoidance advisories. The mechanisms may vary, depending on the nature of the supply and the size of the community affected, and could include:

— media releases through television, radio and newspapers;
— telephone, e-mail and fax contact of specific facilities, community groups and local authorities;
— posting of notices in conspicuous locations;
— personal delivery; and
— mail delivery.

The methods chosen should provide a reasonable assurance that all of those impacted by the advisory, including residents, workers and travellers, are notified as soon as possible.

The issuing of a water avoidance advisory may be necessary, for example, following contamination – e.g., chemical, radiological or microbial – as a result of accidental, natural or malicious origin that leads to:

- —a significant exceedance of a guideline value, which may pose a threat to health from short-term exposure;
- —concentrations of a chemical with no guideline value that may pose a threat to health from short-term exposure; and
- —significant odour or taste that has no identified source or that will give rise to significant public anxiety.

When issued, water avoidance advisories should provide information on the same issues included in boil water advisories (see section 7.6.1), although recommendations relating to affected uses and users will vary, depending on the nature of the problem. For example, for elevated concentrations of contaminants that are of concern only from a drinking or cooking perspective, the public could be advised to avoid using the water for drinking, food preparation, preparing cold drinks, making ice and hygienic uses such as tooth brushing. Where the advisory applies to elevated levels of chemicals that can cause skin or eye irritation or gastrointestinal upsets, the public could be advised not to use the water for drinking, cooking, tooth brushing or bathing/showering. Alternatively, specific water avoidance advice might be issued where the contamination might affect subgroups of the population – for example, pregnant women or bottle-fed infants.

As for boil water advisories, specific advice may need to be issued for dentists, doctors, hospitals and other health care facilities, child care facilities, schools, food suppliers and manufacturers, hotels, restaurants and operators of public swimming pools.

Water avoidance advisories do not equate to cessation of supply; water will generally be suitable for flushing toilets and other uses, such as clothes washing. However, suitable alternative supplies of drinking-water, such as bottled water and/or carted or tankered water, will be required for drinking and other domestic uses.

Criteria for rescinding water avoidance advisories will generally be based on evidence that the source of elevated concentrations of hazardous contaminants has been removed, that distribution systems have been appropriately flushed and that the water is safe for drinking and other uses. In buildings, the flushing would extend to storages and internal plumbing systems.

Changes to Chapter 9: Radiological aspects

Page 198

➢ Replace the partial paragraph above section 9.1, beginning "The additional risk to health from exposure," with the following:

The additional risk to health from exposure to an annual dose of 0.1 mSv associated with the intake of radionuclides from drinking-water is considered to be low for the following reasons:

- The nominal probability coefficient for radiation-induced stochastic health effects, which include fatal cancer, non-fatal cancer and severe hereditary effects for the whole population, is 7.3×10^{-2}/Sv (ICRP, 1991). Multiplying this by an RDL equal to 0.1 mSv annual exposure via drinking-water gives an estimated upper-bound lifetime risk of stochastic health effects of approximately 10^{-4}, which can be considered small in comparison with many other health risks. This reference risk estimation for radionuclides is quite reliable due to the extensive scientific databases that have included human population exposure data. As with chemical carcinogen risk extrapolations, the lower-bound risk is zero.
- Background radiation exposures vary widely across the Earth, but the average is about 2.4 mSv/year, with the highest local levels being up to 10 times higher without any detected increased health risks from population studies; 0.1 mSv therefore represents a small addition to background levels.

Page 200

➢ Add the following at the end of the second paragraph (beginning "There are large local variations") of section 9.1:

(UNSCEAR, 2000).

Page 206

➢ Replace the second sentence of the second paragraph (beginning "Underground rock containing") in section 9.5.1 with the following:

Radon is readily released from surface water; consequently, groundwater has potentially much higher concentrations of radon than surface water.

Pages 206–207

➢ Replace the third paragraph (beginning "For assessing the dose from radon ingestion") of section 9.5.1 with the following:

In assessing the dose from radon ingestion, it is important that water processing technology that can remove radon be considered before consumption is taken into account. Moreover, the use of radon-containing groundwater supplies not treated for radon removal (usually by aeration) for general domestic purposes will increase the levels of radon in the indoor air, thus increasing the dose from indoor inhalation. This dose depends markedly on the forms of domestic usage and housing construction (NCRP, 1989), because most of the indoor air radon usually enters from the foundation of the house in contact with the ground rather than from the water. The amount and form of water intake, other domestic usage of water and the construction of houses vary widely throughout the world.

Page 207

➢ Replace the second sentence of the first paragraph of section 9.5.3 (beginning "Controls should be implemented") with the following:

Any new, especially public, drinking-water supply using groundwater should be tested prior to being used for general consumption.

Page 208

➢ Delete section 9.6.2 (Measuring potassium-40)

Page 209

➢ Replace the first two paragraphs under section 9.6.4 ("Sampling") with the following:

New groundwater sources for public supplies should be sampled at least once to determine their suitability for drinking-water supply before design and construction to characterize the radiological quality of the water supply and to assess any seasonal variation in radionuclide concentrations. This should include analysis for radon and radon daughters.

Once measurements indicate the normal range of the supply, then the sampling frequency can be reduced to, for example, every 5 years. However, if sources of potential radionuclide contamination exist nearby (e.g., mining activity or nuclear reactors), then sampling should be more frequent. Less significant surface and underground drinking-water sources may be sampled less frequently.

Changes to Chapter 12: Chemical fact sheets

Page 306

➢ In section 12.8, under "Occurrence," replace "rangey" with "range"

Page 309

➢ In section 12.10, replace the last sentence under "Toxicological review" with the following:

IARC has concluded that atrazine is not classifiable as to its carcinogenicity in humans (Group 3).

Page 310

➢ In section 12.11, add the following row at the bottom of the table:

Additional comments	The guideline value for barium is based on an epidemiological study in which no adverse effects were observed, although the study population was relatively small and the power of the study was limited. As a consequence, an uncertainty factor of 10 was applied to the level of barium in the drinking-water of the study population. However, the level at which effects would be seen may be significantly greater than this concentration, so the guideline value for barium may be highly conservative and the margin of safety is likely to be high.

Page 315

➢ In section 12.15, in the table under "Provisional guideline value," delete "and uncertainties in the toxicological data"

➢ In section 12.15, in the table under "Occurrence," add the following text at the end:

; can also be formed in the electrolytic generation of chlorine and hypochlorite from brine with a high level of bromide contamination

Pages 321–322

➢ Replace section 12.20 with the following:

12.20 Chloral hydrate (trichloroacetaldehyde)

Chloral hydrate can be formed as a by-product of the chlorination of water containing organic precursor material, such as fulvic and humic acids. It has been found in drinking-water at concentrations of up to 100 µg/litre, but concentrations are usually below 10 µg/litre. Concentrations are generally higher in surface water than in groundwater, and concentrations appear to increase during distribution.

Chloral hydrate is used as an intermediate in the production of insecticides, herbicides and hypnotic drugs. It has also been widely used as a sedative or hypnotic drug in humans at oral doses of up to about 750–1000 mg/day. Although intake from clinical use is considerably higher than intake from drinking-water, clinical exposure is of shorter-term duration.

No epidemiological or carcinogenic studies were found in humans that associated exposure to chloral hydrate with cancer, despite the fact that chloral hydrate has been used for many decades (and still is used) as a sedative and hypnotic drug in adults and children (specifically for dental procedures). IARC classified chloral hydrate as not classifiable as to its carcinogenicity to humans (Group 3), based on inadequate evidence in humans and limited evidence in experimental animals. There is equivocal evidence of genotoxicity for chloral hydrate.

A health-based value of 0.1 mg/litre (rounded figure) can be calculated on the basis of a TDI of 0.0045 mg/kg of body weight per day derived based on an increased incidence of liver histopathology observed in B6C3F1 mice in a 2-year drinking-water study, allocating 80% of the TDI to drinking-water (because most exposure to chloral hydrate is from drinking-water) and assuming a 60-kg adult consuming 2 litres of water per day. However, because chloral hydrate usually occurs in drinking-water at concentrations well below those at which toxic effects are observed, it is not considered necessary to derive a guideline value.

Chloral hydrate levels in drinking-water can be controlled by changes to disinfection practice (e.g., enhanced coagulation and softening to remove organic precursor compounds, moving the point of disinfection to reduce the reaction between chlorine and precursor compounds and using chloramines for residual disinfection instead of chlorine) and by GAC treatment.

History of guideline development

The 1958, 1963 and 1971 WHO *International Standards for Drinking-water* and the first edition of the *Guidelines for Drinking-water Quality*, published in 1984, did not refer to chloral hydrate. The 1993 Guidelines established a provisional health-based guideline value of 0.01 mg/litre for chloral hydrate in drinking-water. The guideline value was designated as provisional because of the limitations of the available data-

base, necessitating the use of an uncertainty factor of 10 000. This guideline value was brought forward to the third edition of the Guidelines.

Assessment date

The risk assessment was conducted in 2004.

Principal references

IPCS (2000) *Chloral hydrate.* Geneva, World Health Organization, International Programme on Chemical Safety (Concise International Chemical Assessment Document 25).

IPCS (2000) *Disinfectants and disinfectant by-products.* Geneva, World Health Organization, International Programme on Chemical Safety (Environmental Health Criteria 216).

WHO (2005) *Chloral hydrate in drinking-water. Background document for development of WHO Guidelines for drinking-water quality.* Geneva, World Health Organization (WHO/SDE/WSH/05.08/49).

Page 326

➢ In section 12.24, in the table under "Occurrence," add the following text at the end: Chlorate can also form in hypochlorite solutions on storage.

Pages 349–350

➢ Replace section 12.41 with the following:

12.41 Dichloroacetic acid

Chlorinated acetic acids, including dichloroacetic acid (DCA), are formed from organic material during water chlorination. DCA has been used as a therapeutic agent to treat lactic acidosis, diabetes and familial hyperlipidaemia in humans.

Provisional guideline value	0.05 mg/litre The guideline value is designated as provisional because the data on treatment are insufficient to ensure that the health-based value of 0.04 mg/litre is technically achievable in a wide range of circumstances. Difficulties in meeting a guideline value must never be a reason to compromise adequate disinfection.
Occurrence	Found in groundwater and surface water distribution systems at concentrations up to about 100 µg/litre, with mean concentrations below 20 µg/litre

Basis of guideline derivation	Using the tumour prevalence data from male mice, the combined data for carcinomas and adenomas in male B6C3F1 mice exposed to doses of 0, 8, 84, 168, 315 or 429 mg/kg of body weight per day for up to 2 years were plotted using the US EPA's Benchmark Dose software version 1.3.1. The slope factor of 0.0075 (mg/kg of body weight per day)$^{-1}$ was derived from the $BMDL_{10}$ using a linear multistage model of the dose–response data.
Limit of detection	<0.1–0.4 µg/litre by GC with ECD; practical quantification level 1 µg/litre
Treatment achievability	Concentrations may be reduced by installing or optimizing coagulation to remove precursors and/or by controlling the pH during chlorination.
Additional comments	The concentration associated with a 10^{-5} upper-bound excess lifetime cancer risk is 40 µg/litre. However, it may not be possible to adequately disinfect potable water and maintain DCA levels below 40 µg/litre, so the provisional guideline value of 50 µg/litre is retained.

Toxicological review

IARC reclassified DCA as Group 2B (possibly carcinogenic to humans) in 2002, based on the absence of data on human carcinogenicity and sufficient evidence of its carcinogenicity in experimental animals. This classification was based primarily on findings of liver tumours in rats and mice. Genotoxicity data are considered to be inconclusive, particularly at lower doses. Glycogen deposition, peroxisome proliferation, changes in signal transduction pathways and DNA hypomethylation have all been observed following DCA exposure and have been hypothesized to be involved in its carcinogenicity. However, the available data are not sufficient to establish a cancer mode of action with reasonable certainty, especially at the very low exposure levels expected to apply to humans ingesting chlorinated drinking-water. Recent data suggest that there may be more than one mechanism leading to tumours, since altered hepatic foci from treated mice were found to have three different types of cellular characteristics.

History of guideline development

The 1958, 1963 and 1971 WHO *International Standards for Drinking-water* and the first edition of the *Guidelines for Drinking-water Quality*, published in 1984, did not refer to DCA. In the 1993 Guidelines, a provisional guideline value of 0.05 mg/litre was derived for DCA; the guideline value was designated as provisional because the data were insufficient to ensure that the value was technically achievable. This guideline value was brought forward to the third edition.

Assessment date

The risk assessment was conducted in 2004.

Principal reference

WHO (2005) *Dichloroacetic acid in drinking-water. Background document for development of WHO Guidelines for drinking-water quality*. Geneva, World Health Organization (WHO/SDE/WSH/05.08/121).

Pages 354–355

➢ Replace section 12.45 with the following:

12.45 1,1-Dichloroethene

1,1-Dichloroethene, or vinylidene chloride, is used mainly as a monomer in the production of polyvinylidene chloride co-polymers and as an intermediate in the synthesis of other organic chemicals. It is an occasional contaminant of drinking-water, usually being found together with other chlorinated hydrocarbons. There are no data on levels in food, but levels in air are generally less than 40 ng/m^3 except at some manufacturing sites. 1,1-Dichloroethene is detected in finished drinking-water taken from groundwater sources at median concentrations of 0.28–1.2 µg/litre and in public drinking-water supplies at concentrations ranging from ≤0.2 to 0.5 µg/litre.

1,1-Dichloroethene is a central nervous system depressant and may cause liver and kidney toxicity in occupationally exposed humans. It causes liver and kidney damage in laboratory animals. IARC has placed 1,1-dichloroethene in Group 3. It was found to be genotoxic in a number of test systems *in vitro* but was not active in the dominant lethal and micronucleus assays *in vivo*. It induced kidney tumours in mice in one inhalation study but was reported not to be carcinogenic in a number of other studies, including several in which it was given in drinking-water.

A health-based value of 140 µg/litre (rounded value) can be derived from a TDI of 0.046 mg/kg of body weight, derived using the BMD approach from a study in which the critical effect was minimal hepatocellular mid-zonal fatty change in female rats. However, this value is significantly higher than the concentrations of 1,1-dichloroethene normally found in drinking-water. It is therefore considered unnecessary to set a formal guideline value for 1,1-dichloroethene in drinking-water.

History of guideline development

The 1958, 1963 and 1971 WHO *International Standards for Drinking-water* did not refer to 1,1-dichloroethene. In the first edition of the *Guidelines for Drinking-water Quality*, published in 1984, a health-based guideline value of 0.0003 mg/litre was recommended for 1,1-dichloroethene, while noting that the mathematical model appropriate to chemical carcinogens that was used in its derivation involved considerable uncertainty. A health-based guideline value of 0.03 mg/litre for 1,1-dichloroethene was recommended in the 1993 Guidelines. This value was brought forward to the third edition of the Guidelines.

Assessment date

The risk assessment was conducted in 2004.

Principal references

IPCS (2003) *1,1-Dichloroethene (vinylidene chloride).* Geneva, World Health Organization, International Programme on Chemical Safety (Concise International Chemical Assessment Document 51).

WHO (2005) *1,1-Dichloroethene in drinking-water. Background document for development of WHO Guidelines for drinking-water quality.* Geneva, World Health Organization (WHO/SDE/WSH/05.08/20).

Page 366

➢ Insert the following new section above section 12.55:

12.54(a) 1,4-Dioxane

1,4-Dioxane is used as a stabilizer in chlorinated solvents and as a solvent for resins, oils and waxes, for agricultural and biochemical intermediates and for adhesives, sealants, cosmetics, pharmaceuticals, rubber chemicals and surface coatings.

Guideline value	0.05 mg/litre (derived using TDI approach as well as linear multistage modelling)
Occurrence	Has been measured in surface water at concentrations up to 40 µg/litre and in groundwater at concentrations up to 80 µg/litre
TDI	16 µg/kg of body weight, based on a NOAEL of 16 mg/kg of body weight per day for hepatocellular tumours observed in a long-term drinking-water study in rats, using an uncertainty factor of 1000 (100 for inter- and intraspecies variation and 10 for non-genotoxic carcinogenicity)
Guideline derivation • allocation to water • weight • consumption	 10% of TDI 60-kg adult 2 litres/day
Basis of guideline derivation based on carcinogenicity	Linear multistage model applied to data for hepatic tumours from drinking-water studies in rats
Limit of detection	0.1–50 µg/litre by GC/MS
Treatment achievability	Not removed using conventional water treatment processes; effectively removed by biological activated carbon treatment
Additional comments	Similar guideline values were derived using the TDI approach (assuming 1,4-dioxane is not genotoxic in humans at low doses) and linear multistage modelling (because the compound clearly induces multiple tumours in various organs).

Toxicological review

1,4-Dioxane caused hepatic and nasal cavity tumours in rodents in most long-term oral studies conducted. Tumours in peritoneum, skin and mammary gland were also observed in rats given a high dose. Lung tumours were specifically detected after intraperitoneal injection. Although cohort studies of workers did not reveal any elevation in the incidence of death by cancer, a significant increase in the incidence of liver cancer was found in a comparative mortality study. However, the evidence is inadequate for human carcinogenicity assessment because of small samples or lack of exposure data. A possibly weak genotoxic potential of 1,4-dioxane has been suggested. IARC has classified 1,4-dioxane as Group 2B (possibly carcinogenic to humans).

History of guideline development

1,4-Dioxane was not referred to in the 1958, 1963 and 1971 WHO *International Standards for Drinking-water*, the first edition of the *Guidelines for Drinking-water Quality*, published in 1984, the second edition of the Guidelines, published in 1993, or the third edition, published in 2004.

Assessment date

The risk assessment was conducted in 2004.

Principal reference

WHO (2005) *1,4-Dioxane in drinking-water. Background document for development of WHO Guidelines for drinking-water quality*. Geneva, World Health Organization (WHO/SDE/WSH/05.08/120).

Pages 377–378

➢ Replace section 12.64 with the following:

12.64 Formaldehyde

Formaldehyde occurs in industrial effluents and is emitted into air from plastic materials and resin glues. Formaldehyde in drinking-water results primarily from the oxidation of natural organic matter during ozonation and chlorination. Concentrations of up to 30 µg/litre have been found in ozonated drinking-water. Formaldehyde can also be found in drinking-water as a result of release from polyacetal plastic fittings. Formaldehyde's physicochemical properties suggest that it is unlikely to volatilize from water, so exposure by inhalation during showering is expected to be low.

Rats and mice exposed to formaldehyde by inhalation exhibited an increased incidence of carcinomas of the nasal cavity at doses that caused irritation of the nasal epithelium. Ingestion of formaldehyde in drinking-water for 2 years caused stomach irritation in rats. Papillomas of the stomach associated with severe tissue irritation were observed in one study. IARC has classified formaldehyde in Group 2A (proba-

bly carcinogenic to humans). The weight of evidence indicates that formaldehyde is not carcinogenic by the oral route.

Owing to formaldehyde's high reactivity, effects in the tissue of first contact following ingestion are more likely to be related to the concentration of the formaldehyde consumed than to its total intake. A tolerable concentration of 2.6 mg/litre for ingested formaldehyde has been established based on a NOEL of 260 mg/litre for histopathological effects in the oral and gastric mucosa of rats administered formaldehyde in their drinking-water for 2 years, using an uncertainty factor of 100 (10 for interspecies variation and 10 for intraspecies variation). In view of the significant difference between the expected concentrations of formaldehyde in drinking-water and the tolerable concentration, it is not considered necessary to set a formal guideline value for formaldehyde.

History of guideline development

The 1958, 1963 and 1971 WHO *International Standards for Drinking-water* and the first edition of the *Guidelines for Drinking-water Quality*, published in 1984, did not refer to formaldehyde. The second edition of the Guidelines established a health-based guideline value of 0.9 mg/litre for formaldehyde in drinking-water. This value was brought forward to the third edition.

Assessment date

The risk assessment was conducted in 2004.

Principal references

IPCS (2002) *Formaldehyde.* Geneva, World Health Organization, International Programme on Chemical Safety (Concise International Chemical Assessment Document 40).

WHO (2005) *Formaldehyde in drinking-water. Background document for development of WHO Guidelines for drinking-water quality*. Geneva, World Health Organization (WHO/SDE/WSH/05.08/48).

Pages 402–403

➢ Replace section 12.82 with the following:

12.82 Mercury

Mercury is used in the electrolytic production of chlorine, in electrical appliances, in dental amalgams and as a raw material for various mercury compounds. Methylation of inorganic mercury has been shown to occur in fresh water and in seawater, although almost all mercury in uncontaminated drinking-water is thought to be in the form of Hg^{2+}. Thus, it is unlikely that there is any direct risk of the intake of organic mercury compounds, especially of alkylmercurials, as a result of the ingestion of drinking-water. However, there is a possibility that methylmercury will be converted into inor-

ganic mercury. Food is the main source of mercury in non-occupationally exposed populations; the mean dietary intake of mercury in various countries ranges from 2 to 20 µg/day per person.

Guideline value	0.006 mg/litre for inorganic mercury
Occurrence	Mercury is present in the inorganic form in surface water and groundwater at concentrations usually below 0.5 µg/litre, although local mineral deposits may produce higher levels in groundwater.
TDI	2 µg/kg of body weight for inorganic mercury based on a NOAEL of 0.23 mg/kg of body weight per day for kidney effects in a 26-week study in rats and applying an uncertainty factor of 100 (for inter- and intraspecies variation) after adjusting for 5 days/week dosing
Limit of detection	0.05 µg/litre by cold vapour AAS; 0.6 µg/litre by ICP; 5 µg/litre by FAAS
Treatment achievability	It should be possible to achieve a concentration below 1 µg/litre by treatment of raw waters that are not grossly contaminated with mercury using methods that include coagulation/sedimentation/filtration, PAC and ion exchange.
Guideline derivation • allocation to water • weight • consumption	 10% of TDI 60-kg adult 2 litres/day
Additional comments	• A similar TDI may be obtained by applying an uncertainty factor of 1000 (an additional uncertainty factor of 10 for adjustment from a LOAEL to a NOAEL) to the LOAEL for renal effects of 1.9 mg/kg of body weight per day in a 2-year NTP study in rats. • The new guideline value applies to inorganic mercury, which is the form found in drinking-water, whereas the previous guideline value applied to total (inorganic and organic) mercury.

Toxicological review

The toxic effects of inorganic mercury compounds are seen mainly in the kidney in both humans and laboratory animals following short- and long-term exposure. In rats, effects include increased absolute and relative kidney weights, tubular necrosis, proteinuria and hypoalbuminaemia. In humans, acute oral poisoning results primarily in haemorrhagic gastritis and colitis; the ultimate damage is to the kidney. The overall weight of evidence is that mercury(II) chloride has the potential to increase the incidence of some benign tumours at sites where tissue damage is apparent and that it possesses weak genotoxic activity but does not cause point mutations.

History of guideline development

The 1958 and 1963 WHO *International Standards for Drinking-water* did not mention mercury. Mercury was first mentioned in the 1971 International Standards, which gave the tentative upper concentration limit for mercury as 0.001 mg/litre (total mercury), based on health concerns. It was noted that this figure was related to levels

found in natural water. In the first edition of the *Guidelines for Drinking-water Quality*, published in 1984, the guideline value of 0.001 mg/litre was retained for total mercury. The 1993 Guidelines also retained the guideline value of 0.001 mg/litre for total mercury, based on the PTWI for methylmercury established by JECFA in 1972 and reaffirmed by JECFA in 1988. This value was brought forward to the third edition.

Assessment date

The risk assessment was conducted in 2004.

Principal references

IPCS (2003) *Elemental mercury and inorganic mercury compounds: human health aspects*. Geneva, World Health Organization, International Programme on Chemical Safety (Concise International Chemical Assessment Document 50).

WHO (2005) *Mercury in drinking-water. Background document for development of WHO Guidelines for drinking-water quality*. Geneva, World Health Organization (WHO/SDE/WSH/05.08/10).

Page 405

➢ Insert the following new section above section 12.85:

12.84(a) Methyl tertiary-butyl ether (MTBE)

The major use of MTBE is as a gasoline additive. Surface water can be contaminated by gasoline spills; however, due to the high volatility of MTBE, most is lost to evaporation. Spills and leaking storage tanks can cause more serious problems in groundwater, where MTBE is more persistent. MTBE has been detected in groundwater and drinking-water at concentrations in the ng/litre to µg/litre range.

No human cancer studies have been published for either the general population or occupationally exposed cohorts. There have been a number of human studies of neurological and clinical effects of exposure to MTBE by inhalation, with mixed results. In general, no objective changes could be seen at levels of MTBE normally found, even in such microenvironments as gasoline filling stations.

The weight of evidence suggests that MTBE is not genotoxic. A large number of studies using *in vitro* and *in vivo* mammalian and non-mammalian systems have been conducted to assess the mutagenicity of MTBE, almost all of which have produced negative results. These results suggest that the mechanism of action of MTBE is more likely to be non-genotoxic than genotoxic, although no one mechanism appears to explain all of the observed effects.

It has been concluded that MTBE should be considered a rodent carcinogen but that it is not genotoxic, and the carcinogenic response is evident only at high levels of exposure that also induce other adverse effects. The available data are therefore considered inconclusive and prohibit their use for human carcinogenic risk assessment. A health-based guideline value has not been derived for MTBE, due to the fact that

any guideline value that would be derived would be significantly higher than the concentration at which it would be detected by odour (15 µg/litre is the lowest level eliciting a response in a study using taste- and odour-sensitive participants).

History of guideline development

MTBE was not evaluated in WHO *International Standards for Drinking-water* or in the first, second or third editions of the *Guidelines for Drinking-water Quality*.

Assessment date

The risk assessment was conducted in 2004.

Principal references

IPCS (1998) *Methyl tertiary-butyl ether*. Geneva, World Health Organization, International Programme on Chemical Safety (Environmental Health Criteria 206).

WHO (2005) *Methyl tertiary-butyl ether (MTBE) in drinking-water. Background document for development of WHO Guidelines for drinking-water quality*. Geneva, World Health Organization (WHO/SDE/WSH/05.08/122).

Pages 415–417

➢ Replace section 12.93 with the following:

12.93 Nickel

Nickel is used mainly in the production of stainless steel and nickel alloys. Food is the dominant source of nickel exposure in the non-smoking, non-occupationally exposed population; water is generally a minor contributor to the total daily oral intake. However, where there is heavy pollution, where there are areas in which nickel that naturally occurs in groundwater is mobilized or where there is use of certain types of kettles, of non-resistant material in wells or of water that has come into contact with nickel- or chromium-plated taps, the nickel contribution from water may be significant.

Guideline value	0.07 mg/litre
Occurrence	The concentration of nickel in drinking-water is normally less than 0.02 mg/litre, although nickel released from taps and fittings may contribute up to 1 mg/litre. In special cases of release from natural or industrial nickel deposits in the ground, the nickel concentrations in drinking-water may be higher.
TDI	12 µg/kg of body weight, derived from a LOAEL established after oral provocation of fasted patients with an empty stomach
Limit of detection	0.1 µg/litre by ICP-MS; 0.5 µg/litre by FAAS; 10 µg/litre by ICP-AES

Treatment achievability	20 µg/litre should be achievable by conventional treatment, e.g., coagulation. Where naturally occurring nickel is mobilized in groundwater, removal is by ion exchange or adsorption. Where nickel leaches from alloys in contact with drinking-water or from chromium- or nickel-plated taps, control is by appropriate control of materials in contact with the drinking-water and flushing taps before using the water.
Guideline derivation	
• allocation to water	20% of TDI
• weight	60-kg adult
• consumption	2 litres/day
Additional comments	• Although the guideline value is close to the acute LOAEL, the LOAEL is based on total exposure from drinking-water, and absorption from drinking-water on an empty stomach is 10- to 40-fold higher than absorption from food. Deriving the total acceptable intake for oral challenge from studies using drinking-water on an empty stomach in fasted patients can, therefore, be considered a worst-case scenario. • A general toxicity value of 130 µg/litre could be determined from a well conducted two-generation study in rats. However, this general toxicity value may not be sufficiently protective of individuals sensitized to nickel, for whom a sufficiently high oral challenge has been shown to elicit an eczematous reaction.

Toxicological review

IARC concluded that inhaled nickel compounds are carcinogenic to humans (Group 1) and that metallic nickel is possibly carcinogenic (Group 2B). However, there is a lack of evidence of a carcinogenic risk from oral exposure to nickel. In a well conducted two-generation reproductive study in rats administered nickel by gavage, a clear NOEL was observed for adult rats and their offspring for all the end-points studied, including integrity and performance of male and female reproductive systems, growth and development of offspring and post-implantation/perinatal lethality. Allergic contact dermatitis is the most prevalent effect of nickel in the general population.

History of guideline development

The 1958, 1963 and 1971 WHO *International Standards for Drinking-water* did not refer to nickel. In the first edition of the *Guidelines for Drinking-water Quality*, published in 1984, it was concluded that the toxicological data available indicate that a guideline value for nickel in drinking-water was not required. A health-based guideline value of 0.02 mg/litre was derived in the second edition of the Guidelines, published in 1993, which should provide sufficient protection for individuals who are sensitive to nickel. This guideline value was maintained in the addendum to the second edition, published in 1998, because, on the basis of the available data, it was considered to provide sufficient protection for individuals who are sensitive to nickel. However, the guideline value was designated as provisional owing to uncertainties

about the effect level for perinatal mortality. This value was brought forward to the third edition.

Assessment date

The risk assessment was conducted in 2004.

Principal reference

WHO (2005) *Nickel in drinking-water. Background document for development of WHO Guidelines for drinking-water quality*. Geneva, World Health Organization (WHO/SDE/WSH/05.08/55).

Pages 425–426

➢ Replace section 12.99 with the following:

12.99 Permethrin

Permethrin (CAS No. 52645–53–1) is a contact insecticide effective against a broad range of pests in agriculture, forestry and public health. It has been used as a larvicide to control aquatic invertebrates in water mains. Permethrin is photodegraded both in water and on soil surfaces. In soil, permethrin is rapidly degraded by hydrolysis and microbial action under aerobic conditions. Exposure of the general population to permethrin is mainly via the diet.

Guideline value	0.3 mg/litre (when permethrin is used as a larvicide) This guideline value is applicable where permethrin is applied directly to water as a larvicide. In other situations, it is not considered necessary to derive a health-based guideline value (see Additional comments below).
Occurrence	Concentrations as high as 0.8 mg/litre have been recorded in surface water; in the United Kingdom, levels in drinking-water are below 0.1 µg/litre, but no data were located from elsewhere.
ADI	0.05 mg/kg of body weight, established for technical-grade permethrin with cis:trans ratios of 25:75 to 40:60 on the basis of a NOAEL of 100 mg/kg, equivalent to 5 mg/kg of body weight per day, in a 2-year study in rats, which was based on clinical signs and changes in body and organ weights and blood chemistry at 500 mg/kg, and a NOAEL of 5 mg/kg of body weight per day in a 1-year study in dogs, based on reduced body weight at 100 mg/kg of body weight per day, and applying an uncertainty factor of 100
Limit of detection	0.05 µg/litre by gas–liquid chromatography with an ECD or FID
Treatment achievability	Permethrin adsorbs to a wide range of materials and is readily removed by conventional treatment methods; neither cis- nor trans-permethrin reacts with chlorine under normal disinfection conditions.

Guideline derivation	
• allocation to water	20% (where permethrin is used as a larvicide in water)
• weight	60 kg
• consumption	2 litres/day
Additional comments	• A health-based value of 20 µg/litre (rounded value) can be derived by allocating 1% of the ADI to drinking-water, because there is significant exposure to permethrin from food. However, because permethrin usually occurs in drinking-water at concentrations well below those at which toxic effects are observed, it is not considered necessary to derive a health-based guideline value where permethrin is not added directly to water as a larvicide. • Adding permethrin directly to drinking-water for public health purposes is not recommended by WHO, as part of its policy to exclude the use of any pyrethroids for larviciding of mosquito vectors of human disease. This policy is based on concern over the possible accelerated development of vector resistance to synthetic pyrethroids, which, in their application to insecticide-treated mosquito nets, are crucial in the current global anti-malaria strategy.

Toxicological review

Technical-grade permethrin is of low acute toxicity. The *cis* isomer is considerably more toxic than the *trans* isomer. IARC has classified permethrin in Group 3 (not classifiable as to its carcinogenicity to humans), as there are no human data and only limited data from animal studies. Permethrin is not genotoxic. JMPR has concluded that technical-grade permethrin is not a reproductive or developmental toxin.

History of guideline development

The 1958 and 1963 WHO *International Standards for Drinking-water* did not refer to permethrin, but the 1971 International Standards suggested that pesticide residues that may occur in community water supplies make only a minimal contribution to the total daily intake of pesticides for the population served. Permethrin was not evaluated in the first edition of the *Guidelines for Drinking-water Quality*, published in 1984, but the second edition of the Guidelines (1993) established a health-based guideline value of 0.02 mg/litre for permethrin in drinking-water, based on an ADI established by JMPR in 1987 for 2:3 and 1:3 *cis*:*trans*-permethrin and recognizing the significant exposure to permethrin from the environment. It was noted that if permethrin is to be used as a larvicide for the control of mosquitoes and other insects of health significance in drinking-water sources, the share of the ADI allocated to drinking-water may be increased.

Assessment date

The risk assessment was conducted in 2004.

Principal references

FAO/WHO (2000) *Pesticide residues in food — 1999. Evaluations — 1999. Part II — Toxicology*. Geneva, World Health Organization, Joint FAO/WHO Meeting on Pesticide Residues (WHO/PCS/00.4).

WHO (2005) *Permethrin in drinking-water. Background document for development of WHO Guidelines for drinking-water quality*. Geneva, World Health Organization (WHO/SDE/WSH/05.08/111).

Page 426

➢ Insert the following new section above section 12.100:

12.99(a) Petroleum products

Petroleum products are used in large quantities, primarily as fuels. They are complex mixtures of chemicals derived from crude oil by distillation and fractionation. They consist primarily of a wide range of aliphatic and aromatic hydrocarbons, many of which are of extremely low solubility in water. Petroleum products are widely stored and handled and are often spilt. The primary concern for drinking-water is the potential for spills into source water, penetration of distribution systems and contamination of drinking-water treatment works.

Exposure to the constituents of petroleum products through drinking-water is frequently short term, as the result of an accidental spill or short-term incident. Such incidents may lead to high concentrations of total petroleum hydrocarbons (TPH). However, a number of the most soluble aromatic hydrocarbons will be detectable by taste and/or odour at concentrations below those concentrations of concern for health, particularly for short-term exposure. Substances such as the alkyl benzenes and the alkyl naphthalenes have taste and odour thresholds of a few micrograms per litre. In view of the above, it is not considered appropriate to set a formal health-based guideline value for petroleum products in drinking-water.

In the event of a spill, it may be necessary to carry out a context-specific assessment of the risk to health. The fact that petroleum products are complex mixtures of many individual hydrocarbons is a complicating factor in determining the potential risks to consumers. The traditional approach of evaluating individual chemicals in assessing the risks from drinking-water is, therefore, largely inappropriate. In order to overcome this difficulty, it is more practical to consider a series of hydrocarbon fractions and to determine appropriate tolerable concentrations for those fractions. The most widely accepted approach is that developed by the Total Petroleum Hydrocarbons Criteria Working Group in the USA, which divided TPH into a series of aliphatic and aromatic fractions based on the number of carbon atoms and the boiling point, to give equivalent carbon numbers.

This pragmatic approach provides a suitable basis for assessing the potential health risks associated with larger-scale contamination of drinking-water by petroleum

products. The allocation of 10% of each of the reference doses, equivalent to TDIs, for the various fractions to drinking-water provides a conservative assessment of the risks. Although the approach is based on the analysis of hydrocarbon fractions, most are of low solubility, and the most soluble fractions, consisting largely of lower molecular weight aromatic hydrocarbons, will be present in the greatest concentration.

History of guideline development

The 1958, 1963 and 1971 WHO *International Standards for Drinking-water* and the first, second and third editions of the *Guidelines for Drinking-water Quality* did not refer to petroleum products in general, although guideline values have been established for individual petroleum hydrocarbons (e.g., benzene, ethylbenzene, toluene, xylenes) and individual polycyclic aromatic hydrocarbon contaminants of petroleum products (e.g., benzo(*a*)pyrene).

Assessment date

The risk assessment was conducted in 2004.

Principal reference

WHO (2005) *Petroleum products in drinking-water. Background document for development of WHO Guidelines for drinking-water quality*. Geneva, World Health Organization (WHO/SDE/WSH/05.08/123).

Pages 448–449

➢ Replace section 12.119 with the following:

12.119 Trichloroethene

Trichloroethene is used primarily in metal degreasing. It is emitted mainly to the atmosphere, but it may also be introduced into groundwater and, to a lesser extent, surface water in industrial effluents. Poor handling as well as improper disposal of trichloroethene in landfills have been the main causes of groundwater contamination. It is expected that exposure to trichloroethene from air will be greater than that from food or drinking-water, unless the drinking-water contains trichloroethene at levels above about 10 µg/litre.

Provisional guideline value	0.02 mg/litre The guideline value is designated as provisional because of deficiencies in the toxicological database.
Occurrence	Due to its high volatility, concentrations are normally low (<1 µg/litre) in surface water; concentrations may be higher (usually below 100 µg/litre) in groundwater systems where volatilization and biodegradation are limited.

TDI	1.46 µg/kg of body weight per day in a developmental toxicity study in rats, based on a $BMDL_{10}$ (the lower 95% confidence limit corresponding to a 10% increase in extra risk of fetal heart malformations over background) of 0.146 mg/kg of body weight per day and using an uncertainty factor of 100 for intra- and interspecies variation
Limit of detection	0.01–3.0 µg/litre by purge and trap capillary GC with photoionization detectors or with photoionization detectors and ECD in series; 0.5 µg/litre by purge and trap capillary GC with MS; 0.01 µg/litre by liquid–liquid extraction and GC with ECD; practical quantification limit considered to be achievable by most good laboratories is 5 µg/litre
Treatment achievability	0.002 mg/litre should be achievable by air stripping, possibly in combination with GAC adsorption
Guideline derivation • allocation to water • weight • consumption	 50% of TDI 60-kg adult 2 litres/day
Additional comments	• The guideline value is protective for both cancer and non-cancer end-points. • In countries with low rates of ventilation in houses and high rates of showering and bathing, authorities may wish to take the additional exposures through the dermal and inhalation routes into consideration in developing national standards from the provisional guideline value.

Toxicological review

Although trichloroethene appears to be weakly genotoxic in *in vitro* and *in vivo* assays, several of its metabolites are genotoxic, and some are established as known or likely human carcinogens. In view of the sufficient weight of evidence of carcinogenicity in two species of experimental animals with supporting human data, IARC classified trichloroethene as Group 2A (probably carcinogenic to humans). Developmental toxicity is considered to be the critical non-cancer effect, because of the low adverse effect level, the severity of the end-point (heart malformations) and the presence of evidence for similar effects (e.g., cardiac anomalies) from epidemiological studies.

History of guideline development

The 1958, 1963 and 1971 WHO *International Standards for Drinking-water* did not refer to trichloroethene. In the first edition of the *Guidelines for Drinking-water Quality*, published in 1984, a tentative guideline value of 0.03 mg/litre was recommended; the guideline was designated as tentative because, although carcinogenicity was observed in one species only, the compound occurs relatively frequently in drinking-water. The second edition of the Guidelines (1993) established a provisional health-based guideline value of 0.07 mg/litre for trichloroethene. The value was provisional because an uncertainty factor of 3000 was used in its derivation. This guideline value was brought forward to the third edition.

Assessment date

The risk assessment was conducted in 2004.

Principal reference

WHO (2005) *Trichloroethene in drinking-water. Background document for development of WHO Guidelines for drinking-water quality.* Geneva, World Health Organization (WHO/SDE/WSH/05.08/22).

Pages 451–454

➢ Replace section 12.121 with the following:

12.121 Trihalomethanes (bromoform, bromodichloromethane, dibromochloromethane, chloroform)

Trihalomethanes (THMs) are formed in drinking-water primarily as a result of chlorination of organic matter present naturally in raw water supplies. The rate and degree of THM formation increase as a function of the chlorine and humic acid concentration, temperature, pH and bromide ion concentration. Chloroform is the most common THM and the principal DBP in chlorinated drinking-water. In the presence of bromides, brominated THMs are formed preferentially and chloroform concentrations decrease proportionally. It is assumed that most THMs present in water are ultimately transferred to air as a result of their volatility. For chloroform, for example, individuals may be exposed during showering to elevated concentrations from chlorinated tap water. For the volatile THMs, approximately equal contributions to total exposure come from four areas: ingestion of drinking-water, inhalation of indoor air largely due to volatilization from drinking-water, inhalation and dermal exposure during showering or bathing, and ingestion of food, with all but food exposure arising primarily from drinking-water. Indoor air exposure to the volatile THMs is particularly important in countries with low rates of ventilation in houses and high rates of showering and bathing.

Guideline values	
Chloroform	0.3 mg/litre
Bromoform	0.1 mg/litre
Dibromochloromethane (DBCM)	0.1 mg/litre
Bromodichloromethane (BDCM)	0.06 mg/litre
Occurrence	THMs are not expected to be found in raw water (unless near a pollution source) but are usually present in finished or chlorinated water; concentrations are generally below 100 µg/litre. In most circumstances, chloroform is the dominant compound.

TDIs	
Chloroform	15 µg/kg of body weight, derived from the lower 95% confidence limit for the 5% incidence of hepatic cysts, generated by PBPK modelling, in beagle dogs that ingested chloroform in toothpaste for 7.5 years, using an uncertainty factor of 25 (10 for intraspecies differences in toxicokinetics and toxicodynamics and 2.5 for differences in interspecies toxicodynamics)
Bromoform	17.9 µg/kg of body weight, based on the absence of histopathological lesions in the liver in a well conducted and well documented 90-day study in rats, using an uncertainty factor of 1000 (100 for intra- and interspecies variation and 10 for possible carcinogenicity and short duration of exposure)
DBCM	21.4 µg/kg of body weight, based on the absence of histopathological effects in the liver in a well conducted and well documented 90-day study in rats, using an uncertainty factor of 1000 (100 for intra- and interspecies variation and 10 for the short duration of the study); an additional uncertainty factor for potential carcinogenicity was not applied because of the questions regarding mouse liver tumours from corn oil vehicles and inconclusive evidence of genotoxicity
Basis of guideline derivation for BDCM	Application of the linearized multistage model for the observed increases in incidence of kidney tumours in male mice observed in an NTP bioassay, as these tumours yield the most protective value
Limit of detection	0.1–0.2 µg/litre (method detection limits) by purge-and-trap and liquid–liquid extraction and direct aqueous injection in combination with a chromatographic system; 0.1 µg/litre by GC with ECD; 2.2 µg/litre by GC/MS
Treatment achievability	Concentrations of chloroform, bromoform, BDCM and DBCM in drinking-water are generally below 0.05 mg/litre. Concentrations can be reduced by changes to disinfection practice (e.g., reducing organic THM precursors) or using air stripping.
Guideline derivation	
• allocation to water	20% of TDI for bromoform and DBCM 75% of TDI for chloroform
• weight	60-kg adult
• consumption	2 litres/day
Additional comments on THMs	For authorities wishing to establish a total THM standard to account for additive toxicity, the following fractionation approach could be taken: $\frac{C_{bromoform}}{GV_{bromoform}} + \frac{C_{DBCM}}{GV_{DBCM}} + \frac{C_{BDCM}}{GV_{BDCM}} + \frac{C_{chloroform}}{GV_{chloroform}} \leq 1$ where C = concentration and GV = guideline value. It is emphasized that adequate disinfection should never be compromised in attempting to meet guidelines for THMs. Nevertheless, in view of the potential link between adverse reproductive outcomes and THMs, particularly brominated THMs, it is recommended that THM levels in drinking-water be kept as low as practicable.

Additional comments on chloroform	• In countries with low rates of ventilation in houses and high rates of showering and bathing, the guideline value could be lowered to account for the additional exposures from inhalation of indoor air largely due to volatilization from drinking-water and inhalation and dermal exposure during showering or bathing. • The guideline value is based on the same study as in the third edition; the increase in value is primarily a result of an increase in the allocation of exposure in drinking-water from 50% to 75% to account for the fact that chloroform is used less now than it was in 1993 when the original guideline was developed.
Additional comments on BDCM	• Although a health-based value of 21 µg/litre is derived, the previous guideline of 60 µg/litre has been retained for two reasons: 1) both calculations were based on the same study, the only differences being the model and model assumptions used to derive the guideline value; there is therefore no scientific basis on which to justify a change in the guideline value; and 2) BDCM concentrations below 50 µg/litre may be difficult to achieve using currently available technology without compromising the effectiveness of disinfection. • As with chloroform, countries with low rates of ventilation and high rates of showering and bathing may wish to lower the guideline value to account for dermal and inhalation exposures, although, as noted above, concentrations below 50 µg/litre may be difficult to achieve using currently available technology without compromising the effectiveness of disinfection.

Toxicological review

Chloroform

The weight of evidence for genotoxicity of chloroform is considered negative. IARC has classified chloroform as possibly carcinogenic to humans (Group 2B) based on limited evidence of carcinogenicity in humans but sufficient evidence of carcinogenicity in experimental animals. The weight of evidence for liver tumours in mice is consistent with a threshold mechanism of induction. Although it is plausible that kidney tumours in rats may similarly be associated with a threshold mechanism, there are some limitations of the database in this regard. The most universally observed toxic effect of chloroform is damage to the centrilobular region of the liver. The severity of these effects per unit dose administered depends on the species, vehicle and method by which the chloroform is administered.

Bromoform

In an NTP bioassay, bromoform induced a small increase in relatively rare tumours of the large intestine in rats of both sexes but did not induce tumours in mice. Data from a variety of assays on the genotoxicity of bromoform are equivocal. IARC has classified bromoform in Group 3 (not classifiable as to its carcinogenicity to humans).

Dibromochloromethane

In an NTP bioassay, DBCM induced hepatic tumours in female and possibly in male mice but not in rats. The genotoxicity of DBCM has been studied in a number of assays, but the available data are considered inconclusive. IARC has classified DBCM in Group 3 (not classifiable as to its carcinogenicity to humans).

Bromodichloromethane

IARC has classified BDCM in Group 2B (possibly carcinogenic to humans). BDCM gave both positive and negative results in a variety of *in vitro* and *in vivo* genotoxicity assays. In an NTP bioassay, BDCM induced renal adenomas and adenocarcinomas in both sexes of rats and male mice, rare tumours of the large intestine (adenomatous polyps and adenocarcinomas) in both sexes of rats and hepatocellular adenomas and adenocarcinomas in female mice. Exposure to BDCM has also been linked to a possible increase in reproductive effects (increased risk for spontaneous abortion or stillbirth).

History of guideline development

The 1958, 1963 and 1971 WHO *International Standards for Drinking-water* did not refer to THMs. In the first edition of the *Guidelines for Drinking-water Quality*, published in 1984, no guideline values for THMs other than chloroform were recommended after a detailed evaluation of the compounds. A health-based guideline value of 0.03 mg/litre was established for chloroform only, as few data existed for the remaining THMs and, for most water supplies, chloroform was the most commonly encountered member of the group. It was noted that the guideline value for chloroform was obtained using a linear multistage extrapolation of data obtained from male rats, a mathematical model that involves considerable uncertainty. It was also mentioned that although the available toxicological data were useful in establishing a guideline value for chloroform only, the concentrations of the other THMs should also be minimized. Limits ranging from 0.025 to 0.25 mg/litre, which represent a balance between the levels that can be achieved given certain circumstances and those that are desirable, have been set in several countries for the sum of bromoform, DBCM, BDCM and chloroform. In the second edition of the Guidelines, published in 1993, no guideline value was set for total THMs, but guideline values were established separately for all four THMs. Authorities wishing to establish a total THM standard to account for additive toxicity could use a fractionation approach in which the sum of the ratios of each of the four THMs to their respective guideline values is less than or equal to 1. The 1993 Guidelines established health-based guideline values of 0.1 mg/litre for both bromoform and DBCM, and guideline values of 0.06 mg/litre for BDCM and 0.2 mg/litre for chloroform, associated with an upper-bound excess lifetime cancer risk of 10^{-5}, were derived. The guideline value of 0.2 mg/litre for chloroform was retained in the addendum to the second edition of the Guidelines, published

in 1998, but was developed on the basis of a TDI for threshold effects. These guideline values were brought forward to the third edition.

Assessment date

The risk assessment was conducted in 2004.

Principal references

IPCS (2000) *Disinfectants and disinfectant by-products.* Geneva, World Health Organization, International Programme on Chemical Safety (Environmental Health Criteria 216).

IPCS (2004) *Chloroform.* Geneva, World Health Organization, International Programme on Chemical Safety (Concise International Chemical Assessment Document 58).

WHO (2005) *Trihalomethanes in drinking-water. Background document for development of WHO Guidelines for drinking-water quality.* Geneva, World Health Organization (WHO/SDE/WSH/05.08/64).

Changes to Annex 1: Bibliography

Page 463

➢ Delete the following references:

Farland & Dourson (1992)
Guth et al. (1991)
Hertzberg (1989)
Hertzberg & Miller (1985)

Page 464

➢ Delete the following reference:

ICRP (1992)

Page 465

➢ Delete the following reference:

Renwick (1993)

Page 466

➢ Insert the following reference below WHO (2003b):

WHO (in revision) *Guidelines for safe recreational water environments.* Vol. 2. *Swimming pools and similar recreational water environments.* Geneva, World Health Organization, Water, Sanitation and Health.

Changes to Annex 2: Contributors to the development of the Third Edition of the Guidelines for Drinking-water Quality

Page 467

➢ Amend the title of Annex 2 as follows:

Contributors to the development of the third edition of the *Guidelines on drinking-water quality* and addenda

➢ Insert the following below Mr R. Aertgeerts:

Dr F. Ahmed, (30), Bangladesh University of Engineering and Technology, Bangladesh

➢ For Dr A. Aitio, replace the parenthetical material as follows:

(26, 30)

Page 468

➢ Insert the following below American Chemistry Council:

Dr L.K. Andersen, (31: vii), The Danish Environmental Protection Agency, Copenhagen, Denmark

➢ Insert the following below Mr R. Bannerman:

Dr M. Baril, (31: ii), Institut de Recherche Robert-Sauvé en Santé et en Sécurité du Travail, Montreal, Canada

➢ For Dr J. Bartram, replace the parenthetical material as follows:

(1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 13, 14, 15, 16, 18, 19: xiii–lii, liv–lxviii, 21: i–v, 22, 23, 24, 25, 29, 30)

➢ Insert the following below Dr A. Basaran:

Dr H. Bates, (31: vii), Nickel Producers Environmental Research Association, Durham, NC, USA

➢ For Dr A. Bathija, replace the parenthetical material as follows:

(19: xxvi, 30)

➢ Insert the following below Mr U. Bayar:

Mr A. Beaudoin, (31: ii), Health Canada, Ottawa, Canada

➢ Insert the following below Dr R. Belmar:

Dr R. Benson, (31: viii), US Environmental Protection Agency, Denver, CO, USA

Page 469

➢ Replace right-hand page header in Annex 2 with the following:

ANNEX 2. CONTRIBUTORS TO THE THIRD EDITION AND ADDENDA

➢ Insert the following below Ms T. Boonyakarnkul:

Mr R. Bos, (30, 31: xiii), WHO, Geneva, Switzerland

➢ Insert the following below Mr R. Carr:

Mr R. Carrier, (31: ii, viii, ix, xi), Health Canada, Ottawa, Canada

➢ Insert the following below Professor W. Chee Woon:

Dr R.S. Chhabra, (31: ii), National Institute of Environmental Health Sciences, Research Triangle Park, NC, USA

Page 470

➢ Insert the following below Dr W.T. Chung:

Dr M. Cikrt, (31: ii), National Institute of Public Health, Prague, Czech Republic

➢ For Dr J. Cotruvo, replace the parenthetical material as follows:

(3, 5, 7, 9, 14, 18, 22, 23, 25, 30)

➢ For Dr C. Cunliffe, replace the parenthetical material as follows:

(8, 13, 19, 20, 21: iv, 22, 23, 25, 27, 30)

➢ Insert the following below Dr J.M. Delattre:

Dr A.M. de Roda Husman, (30), National Institute of Public Health and the Environment, Bilthoven, Netherlands

➢ Insert the following below Dr P. Dillon:

Dr B.A. Dmytrasz, (31: xii), Petroleum Products CONCAWE, Brussels, Belgium

Page 471

➢ For Dr J. Donohue, replace the parenthetical material as follows:

(7, 19: xxxvi, 31: iii)

➢ For Dr M. Ema, replace the parenthetical material as follows:

(19: xlii, xlix, 31: x)

➢ For Dr T. Endo, replace the parenthetical material as follows:

(5, 7, 14, 15, 19, 22, 30)

➢ For Dr J. Fawell, replace the parenthetical material as follows:

(4, 5, 7, 15, 17, 19: vi, xii–lxix, 20, 22, 29, 30, 31: iv–vii, xii)

Page 472

➢ Replace Mr B. Fields with Dr B. Fields

➢ Insert the following below Dr P. Gale:

Dr Luiz Augusto Galvao, (30), Regional Office for the Americas/Pan American Health Organization, Washington, DC, USA

➢ Insert the following below Dr T. Gerschel:

Dr A. Geyid, (30), Ethiopian Health and Nutrition Research Institute, Addis Ababa, Ethopia

➢ For Ms M. Giddings, replace the parenthetical material as follows:

(15, 19: xiii–lii, liv–lxviii, 20, 22, 29, 30, 31: ii, viii, ix, xi)

➢ Insert the following below Dr M.I. Gonzalez:

Mr B. Gordon, (30), WHO, Geneva, Switzerland

➢ For Ms F. Gore, replace the parenthetical material as follows:

(22, 30)

Page 473

➢ Insert the following below Professor W. Grabow:

Professor R.C. Grafström, (31: v), Institute of Environmental Medicine, Stockholm, Sweden

➢ For Dr. S. Grant-Trusdale, replace the text as follows:

Ms S. Grant-Trusdale, (19: xxxiv, 31: ix, xi), Health Canada, Ottawa, Canada

➢ Insert the following below Professor A. Grohmann:

Professor J. Gunnar, (31: xi), Institute of Environmental Medicine, Karolinska Institutet, Stockholm, Sweden

➢ Insert the following below Mr P. Hecq:

Mr H. Heijnen, (30), WHO, New Delhi, India

➢ Insert the following below Mr A. Hicking:

Dr R. Hilton, (31: vii), Inco Limited, Toronto, Canada

Page 474

➢ For Dr G. Howard, replace the parenthetical material as follows:

(2, 5, 7, 8, 12, 13, 15, 19, 20, 22, 23, 25, 30)

➢ For Mr J. Hueb, replace the parenthetical material as follows:

(20, 21: v, 23, 30)

➢ For Mr P. Jackson, replace the parenthetical material as follows:

(2, 5, 7, 15, 19: xiii–lii, liv–lxviii, 22, 25, 30, 31: i, xiv)

Page 475

➢ Insert the following below Dr T. Kuiper-Goodman:

Dr S. Kumar, (30), University of Malaya, Kuala Lumpur, Malaysia

➢ For Dr S. Kunikane, replace the parenthetical material as follows:

(7, 15, 17, 22, 30)

➢ Insert the following below Dr J. Langford:

Dr P.B. Larsen, (31: vii), The Danish Environmental Protection Agency, Copenhagen, Denmark

➢ For Dr J. Latorre, replace the entry as follows:

Dr J. Latorre Monterro, (25, 30), Universidad del Valle, Cali, Colombia

➢ For Dr P. Literathy, replace the parenthetical material as follows:

(2, 5, 29, 31: xii)

➢ For Dr Y. Magara, replace the parenthetical material as follows:

(1, 4, 5, 7, 14, 15, 19: xiii–lii, liv–lxviii, 21: iv, 22, 30, 31: x)

Page 476

➢ Insert the following below Dr I. Mäkeläinen:

Mr M. Malkawi, (30), WHO, Regional Office for the Eastern Mediterranean, Cairo, Egypt

Dr A.K. Mallett, (31: xii), Consultant, Woking, UK

➢ Insert the following below Dr D. McFadden:

Dr D. McGregor, (31: xi), Toxicity Evaluation Consultants, Aberdour, UK

Page 477

➢ For Dr T. Nishimura, replace the parenthetical material as follows:

(15, 19: xix, xlii, xlix, lvii, 31: x)

➢ Insert the following below Dr C. Nokes:

Dr N. Nwachuku, (30), US Environmental Protection Agency, Washington, DC, USA

➢ For Dr H. Ogawa, replace the parenthetical material as follows:

(23, 30)

➢ Insert the following below Dr Y. Ortega:

Dr M. Ouahdi, (22), Ministry of Health and Population, Alger, Algeria

Page 478

➢ For Mr F. Properzi, replace the parenthetical material as follows:

(22, 30)

Page 479

➢ Insert the following below Professor K.-P. Seiler:

Dr S. Semalulu, (31: viii, ix), Health Canada, Ottawa, Canada

➢ Insert the following below Mr T. Simons:

Ms J. Sims, (30), WHO, Geneva, Switzerland

Page 480

➢ Remove italics from the Professor H.V. Smith entry

➢ For Professor M. Sobsey, replace the parenthetical material as follows:

(7, 8, 12, 13, 20, 22, 25, 28, 30)

➢ Insert the following below Professor J.A. Sokal:

Dr R. Solecki, (30), Federal Institute for Risk Assessment, Thielallee, Berlin

➢ Insert the following below Dr G. Stanfield:

Dr U. Stenius, (31: viii), Institute of Environmental Medicine, Karolinska Institutet, Stockholm, Sweden

Page 481

➢ For Dr B.H. Thomas, replace the parenthetical material as follows:

(4, 31: xi)

➢ For Mr T. Thompson, replace the parenthetical material as follows:

(7, 12, 15, 17, 22, 23, 25, 27, 30)

➢ For Dr P. Toft, replace the parenthetical material as follows:

(1, 4, 7, 15, 19: xiii–lii, liv–lxviii, 22, 31: xiii)

➢ Insert the following below Mr V. Tovu:

Dr A. Tritscher, (30), WHO, Geneva, Switzerland

➢ Insert the following below Dr F.X.R. van Leeuwen:

Dr M. van Raaij, (30), National Institute for Public Health and the Environment, Bilthoven, Netherlands

➢ For Ms C. Vickers, replace the text as follows:

Ms C. Vickers, (15, 19: xiii–lii, liv–lxviii, 30), WHO, Geneva, Switzerland

Page 482

➢ Insert the following below Mr M. Waite:

Dr G. Wallace, (31: xi), The European Fuel Oxygenates Association, Brussels, Belgium

➢ Insert the following below Dr B. Wilkins:

Dr C. Willert, (31: vii), Jacques Whitford Limited, Markham, Canada

➢ For Dr D. Wong, replace the parenthetical material as follows:

(19: xxvii, xxxiii, lxviii, 31: iii)

➢ Insert the following below Dr Z. Yinfa:

Dr Abdul Sattar Yoosuf, (30), Regional Office for South-East Asia, New Delhi, India

Page 485

➢ In #23, amend the title of the document as follows:

"Safe Piped Water: Managing Microbial Water Quality in Piped Distribution Systems."

➢ Add the following text at the bottom of the page:

30. *Participant in Expert Consultation for the Rolling Revision of the Guidelines on Drinking-water Quality, Geneva, Switzerland, 17–21 May 2004*
31. *Contributors to the chemical background document on:*
    - *i. Bromate*
    - *ii. Chloral hydrate*
    - *iii Dichloroacetate*
    - *iv. 1,1-Dichloroethene*
    - *v. Formaldehyde*
    - *vi. Mercury*
    - *vii. Nickel*
    - *viii. Trichloroethene*
    - *ix. Trihalomethanes*
    - *x. 1,4-Dioxane*
    - *xi. MTBE*
    - *xii. Petroleum oils*
    - *xiii. Permethrin*
    - *xiv. Chlorite and chlorate*

Changes to Annex 3: Default assumptions

Pages 486–487

➢ Delete Annex 3

Changes to Annex 4: Chemical summary tables

Page 488

➢ In Table A4.1, add the following entry immediately below "Cypermethrin":

Deltamethrin	Unlikely to occur in drinking-water

Page 489

➢ Insert the following below "Bromochloroacetonitrile":

Chloral hydrate (trichloroacetaldehyde)	Occurs in drinking-water at concentrations well below those at which toxic effects may occur

➢ Insert the following below "Dichloroethane, 1,1-":

Dichloroethene, 1,1-	Occurs in drinking-water at concentrations well below those at which toxic effects may occur

➢ Insert the following below "Fluoranthene":

Formaldehyde	Occurs in drinking-water at concentrations well below those at which toxic effects may occur

Page 490

➢ Insert the following below "Methyl parathion":

Methyl *tertiary*-butyl ether (MTBE)	Any guideline that would be derived would be significantly higher than concentrations at which MTBE would be detected by odour

➢ Insert the following below "Permethrin":

Petroleum products	Taste and odour will in most cases be detectable at concentrations below those concentrations of concern for health, particularly with short-term exposure

Page 491

➢ In Table A4.3, delete "Chloral hydrate (trichloroacetaldehyde)" entry

➢ In Table A4.3, revise the "Chloroform" entry as follows:

Chloroform 0.3

➢ In Table A4.3, revise the "Dichloroacetate" entry as follows:

Dichloroacetate 0.05[b] (T, D)

Page 492

➢ In Table A4.3, delete the "Dichloroethene, 1,1-" entry

➢ In Table A4.3, insert the following below "Dimethoate":

Dioxane, 1,4- 0.05[b]

➢ In Table A4.3, delete the "Formaldehyde" entry

➢ In Table A4.3, replace the "Mercury" entry as follows:

Mercury 0.006 For inorganic mercury

➢ In Table A4.3, revise the "Nickel" entry as follows:

Nickel 0.07

➢ In Table A4.3, insert the following below "Pentachlorophenol":

Permethrin 0.3 Only when used as a larvicide for public health purposes

Page 493

➢ Revise the "Trichloroethene" entry as follows:

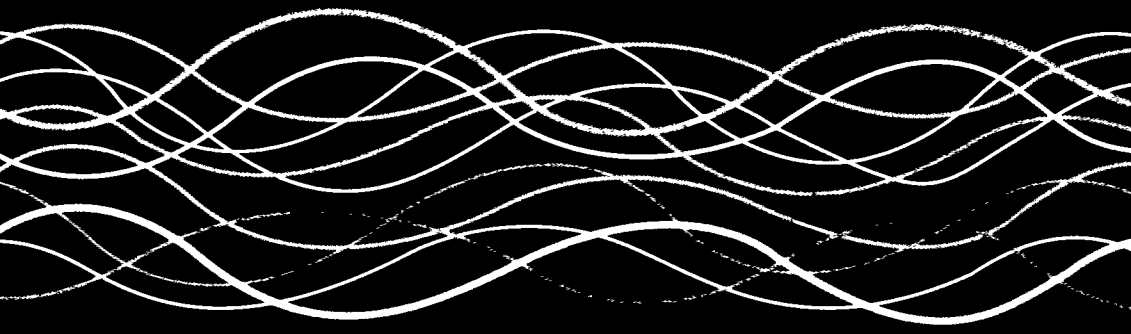
Trichloroethene 0.02 (P)

Changes to Index

Page 510

➢ Replace "*Safe, Piped Water: Managing Microbial Water Quality in Piped Distribution Systems*" with *Safe Piped Water: Managing Microbial Water Quality in Piped Distribution Systems*

Note: This index has not been updated to reflect any new entries or changes that result from the incorporation of the first addendum into the third edition of the *Guidelines for Drinking-water Quality.*



The first and second editions of the *Guidelines for Drinking-water Quality* were used by developing and developed countries worldwide as the basis of regulation and standard setting to ensure the safety of drinking-water. They recognized the priority that should be given to ensuring microbial safety and provided guideline values for a large number of chemical hazards.

The third edition of the Guidelines was comprehensively updated to take account of developments in risk assessment and risk management.

The first addendum updates the third edition. It includes more guidance on management of emergencies and unforeseen events and additions concerning chlorination by-products and developing standards for volatile substances.

New facts sheets are included for chloral hydrate (trichloroacetaldehyde), dichloroacetic acid, 1,1-dichloroethene, 1,4-dioxane, formaldehyde, mercury, methyl tertiary-butyl ether (MTBE), nickel, permethrin, petroleum products, trichloroethene and trihalomethanes.

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