

Guidelines for Drinking-water Quality

FIRST ADDENDUM TO THIRD EDITION

Volume 1

Recommendations



World Health
Organization

WHO Library Cataloguing-in-Publication Data

World Health Organization.

**Guidelines for drinking-water quality [electronic resource] :
incorporating first addendum. Vol. 1, Recommendations. – 3rd ed.**

Electronic version for the Web.

1.Potable water – standards. 2.Water – standards. 3.Water quality –
standards. 4.Guidelines. I. Title.

ISBN 92 4 154696 4

(NLM classification: WA 675)

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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 a national, regional and local level. 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.

This revised Volume 1 of the Guidelines 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.

This volume 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. The volume 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 this 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).

Since the second edition of WHO's *Guidelines for Drinking-water Quality*, there have been a number of events that have highlighted the importance and furthered understanding of various aspects of drinking-water quality and health. These are reflected in this third edition of the Guidelines.

These Guidelines supersede those in 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 amongst the 24 UN agencies and programmes concerned with water issues. This edition of the Guidelines further develops concepts, approaches and information in previous editions:

- Experience has shown that microbial hazards continue to be the primary concern in both developing and developed countries. Experience has also shown the value

of a systematic approach towards securing microbial safety. This edition includes significantly expanded guidance on ensuring microbial safety of drinking-water, building on principles – such as the multiple-barrier approach and the importance of source protection – considered in previous editions. The Guidelines are accompanied by documentation describing approaches towards fulfilling requirements for microbial safety and providing guidance to good practice in ensuring that safety is achieved.

- Information on many chemicals has been revised. This includes information on chemicals not considered previously; revisions to take account of new scientific information; and, in some cases, lesser coverage where new information suggests a lesser priority.
- Experience has also shown the necessity of recognizing the important roles of many different stakeholders in ensuring drinking-water safety. This edition includes discussion of the roles and responsibilities of key stakeholders in ensuring drinking-water safety.
- The need for different tools and approaches in supporting safe management of large piped supplies versus small community supplies remains relevant, and this edition describes the principal characteristics of the different approaches.
- There has been increasing recognition that only a few key chemicals cause large-scale health effects through drinking-water exposure. These include fluoride, arsenic and nitrate. Other chemicals, such as lead, selenium and uranium, may also be significant under certain conditions. Interest in chemical hazards in drinking-water was highlighted by recognition of the scale of arsenic exposure through drinking-water in Bangladesh and elsewhere. The revised Guidelines and associated publications provide guidance on identifying local priorities and on management of the chemicals associated with large-scale effects.
- WHO is frequently approached for guidance on the application of the *Guidelines for Drinking-water Quality* to situations other than community supplies or managed utilities. This revised edition includes information on application of the Guidelines to several specific circumstances and is accompanied by texts dealing with some of these in greater detail.

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. This version of the Guidelines integrates the third edition, which was published in 2004, with the first addendum to the third edition, published in 2005.

The Guidelines are addressed primarily to water and health regulators, policy-makers 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 current edition of the *Guidelines for Drinking-water Quality* 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 *Guidelines for Drinking-water Quality*, including those individuals listed in Annex 2, are gratefully acknowledged.

The work of the following Working Groups was crucial to the development of the third edition of the *Guidelines for Drinking-water Quality*:

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ACKNOWLEDGEMENTS

The WHO coordinators were:

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Ms Marla Sheffer of Ottawa, Canada, was responsible for the editing of the Guidelines. Mr Hiroki Hashizume provided support to the work of the Chemical Aspects Working Group. Ms Mary-Ann Lundby, Ms Grazia Motturi and Ms Penny Ward provided secretarial and administrative support throughout the process and to individual meetings.

The preparation of these Guidelines would not have been possible without the generous support of the following, which is gratefully acknowledged: the Ministry of Health of Italy; the Ministry of Health, Labour and Welfare of Japan; the National Health and Medical Research Council, Australia; the Swedish International Development Cooperation Agency, Sweden; and the United States Environmental Protection Agency.

Acronyms and abbreviations used in text

| | |
|-------|--|
| AAS | atomic absorption spectrometry |
| AD | Alzheimer disease |
| ADI | acceptable daily intake |
| AES | atomic emission spectrometry |
| AIDS | acquired immunodeficiency syndrome |
| AMPA | aminomethylphosphonic acid |
| BaP | benzo[<i>a</i>]pyrene |
| BDCM | bromodichloromethane |
| BMD | benchmark dose |
| bw | body weight |
| CAC | Codex Alimentarius Commission |
| CAS | Chemical Abstracts Service |
| CICAD | Concise International Chemical Assessment Document |
| CSAF | chemical-specific adjustment factor |
| Ct | product of disinfectant concentration and contact time |
| DAEC | diffusely adherent <i>E. coli</i> |
| DALY | disability-adjusted life-year |
| DBCM | dibromochloromethane |
| DBCP | 1,2-dibromo-3-chloropropane |
| DBP | disinfection by-product |
| DCA | dichloroacetic acid |
| DCB | dichlorobenzene |
| DCP | dichloropropane |
| DDT | dichlorodiphenyltrichloroethane |
| DEHA | di(2-ethylhexyl)adipate |
| DEHP | di(2-ethylhexyl)phthalate |
| DNA | deoxyribonucleic acid |

ACRONYMS AND ABBREVIATIONS USED IN TEXT

| | |
|-------|---|
| EAAS | electrothermal atomic absorption spectrometry |
| EAEC | enteroaggregative <i>E. coli</i> |
| EBCT | empty bed contact time |
| EC | electron capture |
| ECD | electron capture detector |
| EDTA | edetic acid; ethylenediaminetetraacetic acid |
| EHC | Environmental Health Criteria monograph |
| EHEC | enterohaemorrhagic <i>E. coli</i> |
| EIEC | enteroinvasive <i>E. coli</i> |
| ELISA | enzyme-linked immunosorbent assay |
| EPEC | enteropathogenic <i>E. coli</i> |
| ETEC | enterotoxigenic <i>E. coli</i> |
| EURO | WHO Regional Office for Europe |
| | |
| FAAS | flame atomic absorption spectrometry |
| FAO | Food and Agriculture Organization of the United Nations |
| FD | fluorescence detector |
| FID | flame ionization detector |
| FPD | flame photodiode detector |
| | |
| GAC | granular activated carbon |
| GAE | granulomatous amoebic encephalitis |
| GC | gas chromatography |
| GL | guidance level (used for radionuclides in drinking-water) |
| GV | guideline value |
| | |
| HACCP | hazard analysis and critical control points |
| HAd | human adenovirus |
| HAstV | human astrovirus |
| HAV | hepatitis A virus |
| Hb | haemoglobin |
| HCb | hexachlorobenzene |
| HCBD | hexachlorobutadiene |
| HCH | hexachlorocyclohexane |
| HEV | hepatitis E virus |
| HIV | human immunodeficiency virus |
| HPC | heterotrophic plate count |
| HPLC | high-performance liquid chromatography |
| HRV | human rotavirus |
| HuCV | human calicivirus |
| HUS | haemolytic uraemic syndrome |

| | |
|----------|---|
| IAEA | International Atomic Energy Agency |
| IARC | International Agency for Research on Cancer |
| IC | ion chromatography |
| ICP | inductively coupled plasma |
| ICRP | International Commission on Radiological Protection |
| IDC | individual dose criterion |
| IPCS | International Programme on Chemical Safety |
| ISO | International Organization for Standardization |
| JECFA | Joint FAO/WHO Expert Committee on Food Additives |
| JMPR | Joint FAO/WHO Meeting on Pesticide Residues |
| K_{ow} | octanol/water partition coefficient |
| LI | Langelier Index |
| LOAEL | lowest-observed-adverse-effect level |
| MCB | monochlorobenzene |
| MCPA | 4-(2-methyl-4-chlorophenoxy)acetic acid |
| MCP | 2(2-methyl-chlorophenoxy) propionic acid; mecoprop |
| metHb | methaemoglobin |
| MMT | methylcyclopentadienyl manganese tricarbonyl |
| MS | mass spectrometry |
| MTBE | methyl <i>tertiary</i> -butyl ether |
| MX | 3-chloro-4-dichloromethyl-5-hydroxy-2(5H)-furanone |
| NAS | National Academy of Sciences (USA) |
| NOAEL | no-observed-adverse-effect level |
| NOEL | no-observed-effect level |
| NTA | nitrilotriacetic acid |
| NTP | National Toxicology Program (USA) |
| NTU | nephelometric turbidity unit |
| P/A | presence/absence |
| PAC | powdered activated carbon |
| PAH | polynuclear aromatic hydrocarbon |
| PAM | primary amoebic meningoencephalitis |
| PCP | pentachlorophenol |
| PCR | polymerase chain reaction |
| PD | photoionization detector |
| PMTDI | provisional maximum tolerable daily intake |

| | |
|------|------------------------------------|
| PT | purge and trap |
| PTDI | provisional tolerable daily intake |

ACRONYMS AND ABBREVIATIONS USED IN TEXT

| | |
|------------------|---|
| PTWI | provisional tolerable weekly intake |
| PVC | polyvinyl chloride |
| QMRA | quantitative microbial risk assessment |
| RDL | reference dose level |
| RIVM | Rijksinstituut voor Volksgezondheid en Milieu (Dutch National Institute of Public Health and Environmental Protection) |
| RNA | ribonucleic acid |
| SI | Système international d'unités (International System of Units) |
| SOP | standard operating procedure |
| SPADNS | sulfo phenyl azo dihydroxy naphthalene disulfonic acid |
| TBA | terbuthylazine |
| TCB | trichlorobenzene |
| TCU | true colour unit |
| TD ₀₅ | tumorigenic dose ₀₅ , the intake or exposure associated with a 5% excess incidence of tumours in experimental studies in animals |
| TDI | tolerable daily intake |
| TDS | total dissolved solids |
| THM | trihalomethane |
| TID | thermal ionization detector |
| TPH | total petroleum hydrocarbons |
| UF | uncertainty factor |
| UNICEF | United Nations Children's Fund |
| UNSCEAR | United Nations Scientific Committee on the Effects of Atomic Radiation |
| USA | United States of America |
| US EPA | United States Environmental Protection Agency |
| UV | ultraviolet |
| UVPAD | ultraviolet photodiode array detector |
| WHO | World Health Organization |
| WHOPES | World Health Organization Pesticide Evaluation Scheme |
| WQT | water quality target |
| WSP | water safety plan |
| YLD | years of healthy life lost in states of less than full health, i.e., years lived with a disability |
| YLL | years of life lost by premature mortality |

