## Contents

Preface xv
Acknowledgements xvii
Acronyms and abbreviations used in text xx

1. **Introduction**
   1.1 General considerations and principles 1
      1.1.1 Framework for safe drinking-water 3
      1.1.2 Microbial aspects 4
      1.1.3 Disinfection 5
      1.1.4 Chemical aspects 6
      1.1.5 Radiological aspects 7
      1.1.6 Acceptability aspects: taste, odour and appearance 7
   1.2 Roles and responsibilities in drinking-water safety management 8
      1.2.1 Surveillance and quality control 8
      1.2.2 Public health authorities 10
      1.2.3 Local authorities 11
      1.2.4 Water resource management 12
      1.2.5 Drinking-water supply agencies 13
      1.2.6 Community management 14
      1.2.7 Water vendors 15
      1.2.8 Individual consumers 15
      1.2.9 Certification agencies 15
      1.2.10 Plumbing 16
   1.3 Supporting resources to the Guidelines 18
      1.3.1 Published documents 18
      1.3.2 Capacity-building networks 18

2. **A conceptual framework for implementing the Guidelines** 19
   2.1 Health-based targets 20
   2.2 Water safety plans 22
      2.2.1 System assessment and design 22
      2.2.2 Operational monitoring 23
      2.2.3 Management plans, documentation and communication 24
GUIDELINES FOR DRINKING-WATER QUALITY

2.3 Surveillance 25
2.4 Verification of drinking-water quality 25
   2.4.1 Microbial water quality 26
   2.4.2 Chemical water quality 26
2.5 Identifying priority concerns 27
   2.5.1 Undertaking a drinking-water quality assessment 28
   2.5.2 Assessing microbial priorities 29
   2.5.3 Assessing chemical priorities 29
2.6 Developing drinking-water quality standards 30
   2.6.1 Adapting guideline values to locally relevant standards 31
   2.6.2 Periodic review and revision of standards 31
2.7 Drinking-water regulations and supporting policies and programmes 31
   2.7.1 Regulations 32
   2.7.2 Supporting policies and programmes 33

3. Health-based targets 35
   3.1 Setting health-based targets 36
   3.2 Disability-adjusted life years, tolerable disease burden and reference level of risk 37
   3.3 Types of health-based targets 38
      3.3.1 Health outcome targets 41
      3.3.2 Water quality targets 42
      3.3.3 Performance targets 43
      3.3.4 Specified technology targets 43

4. Water safety plans 45
   4.1 System assessment and design 49
      4.1.1 New systems 50
      4.1.2 Collecting and evaluating available data 51
      4.1.3 Resource and source protection 53
      4.1.4 Treatment 55
      4.1.5 Piped distribution systems 56
      4.1.6 Non-piped, community and household systems 58
      4.1.7 Validation 59
      4.1.8 Upgrade and improvement 60
   4.2 Operational monitoring and maintaining control 61
      4.2.1 Determining system control measures 61
      4.2.2 Selecting operational monitoring parameters 62
      4.2.3 Establishing operational and critical limits 63
      4.2.4 Non-piped, community and household systems 63
   4.3 Verification 64
      4.3.1 Verification of microbial quality 65
      4.3.2 Verification of chemical quality 66
      4.3.3 Source waters 67
      4.3.4 Piped distribution systems 67
      4.3.5 Verification for community-managed supplies 68
CONTENTS

4.3.6 Quality assurance and quality control 68
4.3.7 Verification of water safety plans 69
4.4 Management procedures for piped distribution systems 69
4.4.1 Predictable incidents (“deviations”) 71
4.4.2 Unplanned events 71
4.4.3 Emergencies 72
4.4.4 Preparing a monitoring plan 73
4.4.5 Supporting programmes 73
4.5 Management of community and household water supplies 74
4.6 Documentation and communication 75
4.7 Planned review 76
4.7.1 Periodic review 76
4.7.2 Post-incident review 76

5. Surveillance 77
5.1 Types of approaches 79
5.1.1 Audit 79
5.1.2 Direct assessment 80
5.2 Adapting approaches to specific circumstances 81
5.2.1 Urban areas in developing countries 81
5.2.2 Surveillance of community drinking-water supplies 81
5.2.3 Surveillance of household treatment and storage systems 82
5.3 Adequacy of supply 83
5.3.1 Quantity (service level) 83
5.3.2 Accessibility 85
5.3.3 Affordability 85
5.3.4 Continuity 86
5.4 Planning and implementation 87
5.5 Reporting and communicating 89
5.5.1 Interaction with community and consumers 89
5.5.2 Regional use of data 90

6. Application of the Guidelines in specific circumstances 93
6.1 Climate change, water scarcity and heavy rainfall 94
6.2 Rainwater harvesting 94
6.3 Vended water 96
6.4 Bulk water supply 97
6.5 Desalination systems 98
6.6 Dual piped water supply systems 99
6.7 Emergencies and disasters 100
6.8 Temporary water supplies 102
6.9 Buildings 104
6.10 Health-care facilities 107
6.11 Safe drinking-water for travellers 107
6.12 Aircraft and airports 109
6.13 Ships 112
GUIDELINES FOR DRINKING-WATER QUALITY

6.14 Packaged drinking-water 114
6.15 Food production and processing 116

7. **Microbial aspects** 117
   7.1 Microbial hazards associated with drinking-water 117
      7.1.1 Waterborne infections 118
      7.1.2 Emerging issues 122
      7.1.3 Persistence and growth in water 123
      7.1.4 Public health aspects 124
   7.2 Health-based target setting 124
      7.2.1 Health-based targets applied to microbial hazards 124
      7.2.2 Reference pathogens 125
      7.2.3 Quantitative microbial risk assessment 128
      7.2.4 Risk-based performance target setting 131
      7.2.5 Presenting the outcome of performance target development 133
      7.2.6 Adapting risk-based performance target setting to local circumstances 134
      7.2.7 Health outcome targets 135
   7.3 Occurrence and treatment of pathogens 136
      7.3.1 Occurrence 136
      7.3.2 Treatment 138
   7.4 Microbial monitoring 147
   7.5 Methods of detection of faecal indicator organisms 150
   7.6 Identifying local actions in response to microbial water quality problems and emergencies 150
      7.6.1 Boil water advisories 151
      7.6.2 Actions following an incident 153

8. **Chemical aspects** 155
   8.1 Chemical hazards in drinking-water 156
   8.2 Derivation of chemical guideline values 158
      8.2.1 Approaches taken 159
      8.2.2 Threshold chemicals 160
      8.2.3 Non-threshold chemicals 165
      8.2.4 Data quality 165
      8.2.5 Provisional guideline values 166
      8.2.6 Chemicals with effects on acceptability 167
      8.2.7 Chemicals not included in the Guidelines 167
      8.2.8 Mixtures 167
      8.2.9 Adapting guideline values to local circumstances 168
   8.3 Analytical achievability 168
   8.4 Treatment 170
      8.4.1 Treatment performance 171
      8.4.2 Process control measures for disinfection by-products 172
      8.4.3 Treatment for corrosion control 174
      8.4.4 Household treatment 175
## 8.5 Guideline values for individual chemicals, by source category

<table>
<thead>
<tr>
<th>8.5.1 Naturally occurring chemicals</th>
<th>176</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.5.2 Chemicals from industrial sources and human dwellings</td>
<td>177</td>
</tr>
<tr>
<td>8.5.3 Chemicals from agricultural activities</td>
<td>179</td>
</tr>
<tr>
<td>8.5.4 Chemicals used in water treatment or from materials in contact with drinking-water</td>
<td>182</td>
</tr>
<tr>
<td>8.5.5 Chemicals of emerging concern</td>
<td>189</td>
</tr>
</tbody>
</table>

## 8.6 Pesticides used in water for public health purposes

<table>
<thead>
<tr>
<th>8.6.1 Trigger for action</th>
<th>190</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.6.2 Investigating the situation</td>
<td>194</td>
</tr>
<tr>
<td>8.6.3 Talking to the right people</td>
<td>194</td>
</tr>
<tr>
<td>8.6.4 Informing the public</td>
<td>195</td>
</tr>
<tr>
<td>8.6.5 Evaluating the significance to public health and individuals</td>
<td>195</td>
</tr>
<tr>
<td>8.6.6 Determining appropriate action</td>
<td>198</td>
</tr>
<tr>
<td>8.6.7 Consumer acceptability</td>
<td>199</td>
</tr>
<tr>
<td>8.6.8 Ensuring remedial action, preventing recurrence and updating the water safety plan</td>
<td>199</td>
</tr>
<tr>
<td>8.6.9 Mixtures</td>
<td>199</td>
</tr>
<tr>
<td>8.6.10 Water avoidance advisories</td>
<td>200</td>
</tr>
</tbody>
</table>

## Radiological aspects

<table>
<thead>
<tr>
<th>9.1 Sources and health effects of radiation exposure</th>
<th>203</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.1.1 Radiation exposure through ingestion of drinking-water</td>
<td>204</td>
</tr>
<tr>
<td>9.1.2 Radiation-induced health effects through drinking-water</td>
<td>205</td>
</tr>
<tr>
<td>9.2 Rationale for screening levels and guidance levels</td>
<td>206</td>
</tr>
<tr>
<td>9.3 Monitoring and assessment for dissolved radionuclides</td>
<td>207</td>
</tr>
<tr>
<td>9.3.1 Screening of drinking-water supplies</td>
<td>208</td>
</tr>
<tr>
<td>9.3.2 Strategy for assessing drinking-water if screening levels are exceeded</td>
<td>209</td>
</tr>
<tr>
<td>9.3.3 Strategy for assessing drinking-water if guidance levels are exceeded</td>
<td>210</td>
</tr>
<tr>
<td>9.3.4 Sampling frequency</td>
<td>210</td>
</tr>
<tr>
<td>9.4 Guidance levels for radionuclides commonly found in drinking-water</td>
<td>212</td>
</tr>
<tr>
<td>9.5 Analytical methods</td>
<td>213</td>
</tr>
<tr>
<td>9.5.1 Measuring gross alpha and gross beta activity concentrations</td>
<td>214</td>
</tr>
<tr>
<td>9.5.2 Measuring specific radionuclides</td>
<td>214</td>
</tr>
<tr>
<td>9.6 Remedial measures</td>
<td>215</td>
</tr>
<tr>
<td>9.7 Radon</td>
<td>216</td>
</tr>
<tr>
<td>9.7.1 Radon in air and water</td>
<td>217</td>
</tr>
<tr>
<td>9.7.2 Health risks from radon</td>
<td>218</td>
</tr>
<tr>
<td>9.7.3 Guidance on radon in drinking-water supplies</td>
<td>219</td>
</tr>
<tr>
<td>9.7.4 Measuring radon in drinking-water</td>
<td>220</td>
</tr>
</tbody>
</table>
9.7.5 Decreasing radon concentrations in drinking-water 217

9.8 Risk communication 217
9.8.1 Reporting results 217
9.8.2 Communicating risks 217

10. Acceptability aspects: Taste, odour and appearance 219
10.1 Biologically derived contaminants 221
   Actinomycetes and fungi 221
   Cyanobacteria and algae 221
   Invertebrate animal life 221
   Iron bacteria 222
10.2 Chemically derived contaminants 222
   Aluminium 222
   Ammonia 223
   Chloramines 223
   Chloride 223
   Chlorine 223
   Chlorobenzenes 223
   Chlorophenols 224
   Colour 224
   Copper 224
   Dissolved oxygen 225
   Ethylbenzene 225
   Hardness 225
   Hydrogen sulfide 225
   Iron 226
   Manganese 226
   Petroleum oils 226
   pH and corrosion 226
   Sodium 227
   Styrene 227
   Sulfate 227
   Synthetic detergents 227
   Toluene 228
   Total dissolved solids 228
   Turbidity 228
   Xylenes 229
   Zinc 229

10.3 Treatment of taste, odour and appearance problems 230
10.4 Temperature 230

11. Microbial fact sheets 231
11.1 Bacterial pathogens 232
   *Acinetobacter* 232
   *Aeromonas* 234
   *Bacillus* 235
Burkholderia pseudomallei 236
Campylobacter 237
Enterobacter sakazakii 239
Escherichia coli pathogenic strains 240
Helicobacter pylori 241
Klebsiella 242
Legionella 244
Leptospira 245
Mycobacterium 247
Pseudomonas aeruginosa 249
Salmonella 250
Shigella 252
Staphylococcus aureus 253
Tsukamurella 254
Vibrio 255
Yersinia 257

11.2 Viral pathogens 258
Adenoviruses 258
Astroviruses 260
Caliciviruses 261
Enteroviruses 263
Hepatitis A virus 264
Hepatitis E virus 265
Rotaviruses and orthoreoviruses 267

11.3 Protozoan pathogens 268
Acanthamoeba 269
Balantidium coli 270
Blastocystis 271
Cryptosporidium 273
Cyclospora cayetanensis 274
Entamoeba histolytica 276
Giardia intestinalis 277
Isospora belli 279
Microsporidia 280
Naegleria fowleri 282
Toxoplasma gondii 283

11.4 Helminth pathogens 285
Dracunculus medinensis 285
Fasciola spp. 287
Free-living nematodes 288
Schistosoma spp. 290

11.5 Toxic cyanobacteria 293

11.6 Indicator organisms 294
Total coliform bacteria 294
Escherichia coli and thermotolerant coliform bacteria 296
12. Chemical fact sheets

12.1 Chemical contaminants in drinking-water

- Acrylamide
- Alachlor
- Aldicarb
- Aldrin and dieldrin
- Aluminium
- Ammonia
- Antimony
- Arsenic
- Asbestos
- Atrazine and its metabolites
- Barium
- Bentazone
- Benzene
- Beryllium
- Boron
- Bromate
- Bromide
- Brominated acetic acids
- Cadmium
- Carbaryl
- Carbofuran
- Carbon tetrachloride
- Chloral hydrate
- Chloramines (monochloramine, dichloramine, trichloramine)
- Chlordane
- Chloride
- Chlorine
- Chlorite and chlorate
- Chloroacetones
- Chlorophenols (2-chlorophenol, 2,4-dichlorophenol, 2,4,6-trichlorophenol)
- Chloropicrin
- Chlorotoluron
- Chlorpyrifos
- Chromium
- Copper
CONTENTS

Cyanazine 342
Cyanide 342
Cyanobacterial toxins: Microcystin-LR 344
Cyanogen chloride 346
2,4-D 347
2,4-DB 348
DDT and metabolites 349
Dialkyltins 350
1,2-Dibromo-3-chloropropane 350
1,2-Dibromoethane 351
Dichloroacetic acid 352
Dichlorobenzenes (1,2-dichlorobenzene, 1,3-dichlorobenzene,
   1,4-dichlorobenzene) 353
1,1-Dichloroethane 354
1,2-Dichloroethane 355
1,1-Dichloroethene 355
1,2-Dichloroethene 356
Dichloromethane 357
1,2-Dichloropropane 358
1,3-Dichloropropane 359
1,3-Dichloropropene 359
Dichlorprop 360
Di(2-ethylhexyl)adipate 361
Di(2-ethylhexyl)phthalate 361
Dimethoate 362
1,4-Dioxane 363
Diquat 364
Edetic acid 364
Endosulfan 365
Endrin 366
Epichlorohydrin 367
Ethylbenzene 368
Fenitrothion 368
Fenoprop 369
Fluoride 370
Formaldehyde 373
Glyphosate and AMPA 374
Halogenated acetonitriles (dichloroacetonitrile,
   dibromoacetonitrile, bromochloroacetonitrile,
   trichloroacetonitrile) 375
Hardness 376
Heptachlor and heptachlor epoxide 377
Hexachlorobenzene 378
Hexachlorobutadiene 379
Hydrogen sulfide 380
Inorganic tin 380
Iodine 381
Iron 381
Isoproturon 382
Lead 383
Lindane 385
Malathion 386
Manganese 386
MCPA 387
Mecoprop 388
Mercury 389
Methoxychlor 390
Methyl parathion 391
Methyl tertiary-butyl ether 392
Metolachlor 393
Molinate 393
Molybdenum 394
Monochloroacetic acid 395
Monochlorobenzene 395
MX 396
Nickel 396
Nitrate and nitrite 398
Nitrilotriacetic acid 403
Nitrobenzene 404
N-Nitrosodimethylamine 405
Parathion 406
Pendimethalin 407
Pentachlorophenol 407
Petroleum products 408
pH 409
2-Phenylphenol and its sodium salt 409
Polynuclear aromatic hydrocarbons 410
Potassium 412
Propanil 413
Selenium 413
Silver 415
Simazine 415
Sodium 416
Sodium dichloroisocyanurate 416
Styrene 418
Sulfate 419
2,4,5-T 419
Terbuthylazine 420
Tetrachloroethene 421
Toluene 422
<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total dissolved solids</td>
<td>423</td>
</tr>
<tr>
<td>Trichloroacetic acid</td>
<td>423</td>
</tr>
<tr>
<td>Trichlorobenzenes (total)</td>
<td>424</td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td>424</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>425</td>
</tr>
<tr>
<td>Trifluralin</td>
<td>426</td>
</tr>
<tr>
<td>Trihalomethanes (bromoform, bromodichloromethane, dibromochloromethane, chloroform)</td>
<td>427</td>
</tr>
<tr>
<td>Uranium</td>
<td>430</td>
</tr>
<tr>
<td>Vinyl chloride</td>
<td>431</td>
</tr>
<tr>
<td>Xylenes</td>
<td>432</td>
</tr>
<tr>
<td>Zinc</td>
<td>433</td>
</tr>
<tr>
<td>12.2 Pesticides used for vector control in drinking-water sources and containers</td>
<td>434</td>
</tr>
<tr>
<td>Bacillus thuringensis israelensis</td>
<td>434</td>
</tr>
<tr>
<td>Diflubenzuron</td>
<td>435</td>
</tr>
<tr>
<td>Methoprene</td>
<td>436</td>
</tr>
<tr>
<td>Novaluron</td>
<td>437</td>
</tr>
<tr>
<td>Permethrin</td>
<td>438</td>
</tr>
<tr>
<td>Pirimiphos-methyl</td>
<td>438</td>
</tr>
<tr>
<td>Pyriproxyfen</td>
<td>439</td>
</tr>
<tr>
<td>Spinosad</td>
<td>440</td>
</tr>
<tr>
<td>Temephos</td>
<td>441</td>
</tr>
<tr>
<td>Annex 1 Supporting documentation to the Guidelines</td>
<td>443</td>
</tr>
<tr>
<td>Annex 2 References cited</td>
<td>449</td>
</tr>
<tr>
<td>Annex 3 Chemical summary tables</td>
<td>468</td>
</tr>
<tr>
<td>Annex 4 Analytical methods and achievability</td>
<td>476</td>
</tr>
<tr>
<td>Annex 5 Treatment methods and performance</td>
<td>485</td>
</tr>
<tr>
<td>Annex 6 Supporting information on radionuclides</td>
<td>504</td>
</tr>
<tr>
<td>Annex 7 Contributors to the development of the fourth edition of the Guidelines for drinking-water quality</td>
<td>509</td>
</tr>
<tr>
<td>Index</td>
<td>518</td>
</tr>
</tbody>
</table>
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. The UN General Assembly declared the period from 2005 to 2015 as the International Decade for Action, “Water for Life”. Most recently, the UN General Assembly declared safe and clean drinking-water and sanitation a human right essential to the full enjoyment of life and all other human rights.

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, as the reductions in adverse health effects and health-care costs outweigh the costs of undertaking the interventions. This is true for investments ranging from major water supply infrastructure 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.

The World Health Organization (WHO) published three editions of the Guidelines for drinking-water quality in 1983–1984, 1993–1997 and 2004, as successors to previous WHO International standards for drinking water, published in 1958, 1963 and 1971. From 1995, the Guidelines have been kept up to date through a process of rolling revision, which leads to the regular publication of addenda that may add to or supersede information in previous volumes as well as expert reviews on key issues preparatory to the development of the Guidelines.

Leading the process of the development of the fourth edition was the Water, Sanitation, Hygiene and Health Unit within WHO Headquarters, with the Programme on
Chemical Safety providing input on chemical hazards and the Radiation and Environmental Health Unit providing input on radiological hazards. All six WHO Regional Offices participated in the process, in consultation with Member States.


This edition of the Guidelines further develops concepts, approaches and information introduced in previous editions, including the comprehensive preventive risk management approach for ensuring drinking-water quality that was introduced in the third edition. It considers:

- drinking-water safety, including minimum procedures and specific guideline values and how these are intended to be used;
- approaches used in deriving the Guidelines, including guideline values;
- microbial hazards, which continue to be the primary concern in both developing and developed countries. Experience has shown the value of a systematic approach to securing microbial safety. This edition builds on the preventive principles introduced in the third edition on ensuring the microbial safety of drinking-water through a multiple-barrier approach, highlighting the importance of source water protection;
- climate change, which results in changing water temperature and rainfall patterns, severe and prolonged drought or increased flooding, and its implications for water quality and water scarcity, recognizing the importance of managing these impacts as part of water management strategies;
- chemical contaminants in drinking-water, including information on chemicals not considered previously, such as pesticides used for vector control in drinking-water; revisions of existing chemical fact sheets, taking account of new scientific information; and, in some cases, reduced coverage in the Guidelines where new information suggests a lesser priority;
- those key chemicals responsible for large-scale health effects through drinking-water exposure, including arsenic, fluoride, lead, nitrate, selenium and uranium, providing guidance on identifying local priorities and on management;
- the important roles of many different stakeholders in ensuring drinking-water safety. This edition furthers the discussion introduced in the third edition of the roles and responsibilities of key stakeholders in ensuring drinking-water safety;
- guidance in situations other than traditional community supplies or managed utilities, such as rainwater harvesting and other non-piped supplies or dual piped systems.

This edition of the Guidelines is accompanied by a series of supporting publications. These include internationally peer-reviewed risk assessments for specific chemicals (see list of chapter 12 background documents in Annex 2) and other publications explaining the scientific basis of the development of the Guidelines and providing guidance on good practice in their implementation (see Annex 1). The Guidelines

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.

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 preparation of the fourth edition of the Guidelines for drinking-water quality and supporting documentation covered a period of more than 5 years and involved the participation of hundreds of experts from a wide range of developing and developed countries. The contributions of all who participated in the preparation and finalization of the fourth edition, including those individuals listed in Annex 7, are gratefully acknowledged.

The work of the following working group coordinators and other Drinking-water Quality Committee members was crucial to the development of the fourth edition:

Dr F. Ahmed, Bangladesh University of Engineering and Technology, Bangladesh (Small systems)
Dr I. Chorus, Federal Environment Agency, Germany (Resource and source protection)
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Mr O. Schmoll, Federal Environment Agency, Germany (*Water safety plan capacity building and monitoring*)

Professor M. Sobsey, University of North Carolina, USA (*Risk management*)

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Ms P. Ward provided invaluable administrative support throughout the review and publication process. Ms M. Sheffer of Ottawa, Canada, was responsible for the scientific editing of the document.

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

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Acronyms and abbreviations used in text

2,4-D 2,4-dichlorophenoxyacetic acid
2,4-DB 2,4-dichlorophenoxybutyric acid
2,4-DP dichlorprop
2,4,5-T 2,4,5-trichlorophenoxyacetic acid
2,4,5-TP 2,4,5-trichlorophenoxy propionic acid; fenoprop

AAS atomic absorption spectrometry
Absor absorptiometry
ADI acceptable daily intake
AES atomic emission spectrometry
AIDS acquired immunodeficiency syndrome
AMPA aminomethylphosphonic acid
ARfD acute reference dose
BDCM bromodichloromethane
BMD benchmark dose
BMDL lower confidence limit on the benchmark dose
BTEX benzene, toluene, ethylbenzene and xylenes
Bti Bacillus thuringiensis israelensis
bw body weight

CAS Chemical Abstracts Service
Col colorimetry
CSAF chemical-specific adjustment factor
Ct product of disinfectant concentration and contact time
DAEC diffusely adherent E. coli
DALY disability-adjusted life year
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>DBCM</td>
<td>dibromochloromethane</td>
</tr>
<tr>
<td>DBCP</td>
<td>1,2-dibromo-3-chloropropane</td>
</tr>
<tr>
<td>DBP</td>
<td>disinfection by-product</td>
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<tr>
<td>DCA</td>
<td>dichloroacetic acid</td>
</tr>
<tr>
<td>DCB</td>
<td>dichlorobenzene</td>
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<tr>
<td>DCP</td>
<td>dichloropropane</td>
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<tr>
<td>DDT</td>
<td>dichlorodiphenyltrichloroethane</td>
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<tr>
<td>DEHA</td>
<td>di(2-ethylhexyl)adipate</td>
</tr>
<tr>
<td>DEHP</td>
<td>di(2-ethylhexyl)phthalate</td>
</tr>
<tr>
<td>DNA</td>
<td>deoxyribonucleic acid</td>
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<tr>
<td>EAAS</td>
<td>electrothermal atomic absorption spectrometry</td>
</tr>
<tr>
<td>EAEC</td>
<td>enteroaggregative <em>E. coli</em></td>
</tr>
<tr>
<td>ECD</td>
<td>electron capture detector</td>
</tr>
<tr>
<td>EDTA</td>
<td>ethylenediaminetetraacetic acid; edetic acid</td>
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<tr>
<td>EHEC</td>
<td>enterohaemorrhagic <em>E. coli</em></td>
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<tr>
<td>EIEC</td>
<td>enteroinvasive <em>E. coli</em></td>
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<tr>
<td>ELISA</td>
<td>enzyme-linked immunosorbent assay</td>
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<tr>
<td>EPEC</td>
<td>enteropathogenic <em>E. coli</em></td>
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<tr>
<td>ETEC</td>
<td>enterotoxigenic <em>E. coli</em></td>
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<tr>
<td>FAAS</td>
<td>flame atomic absorption spectrometry</td>
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<tr>
<td>FAO</td>
<td>Food and Agriculture Organization of the United Nations</td>
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<tr>
<td>FD</td>
<td>fluorescence detector</td>
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<tr>
<td>FID</td>
<td>flame ionization detector</td>
</tr>
<tr>
<td>FPD</td>
<td>flame photodiode detector</td>
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<tr>
<td>GAC</td>
<td>granular activated carbon</td>
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<tr>
<td>GC</td>
<td>gas chromatography</td>
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<tr>
<td>GL</td>
<td>guidance level (used for radionuclides in drinking-water)</td>
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<tr>
<td>GV</td>
<td>guideline value</td>
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<tr>
<td>HAA</td>
<td>haloacetic acid</td>
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<td>HAV</td>
<td>hepatitis A virus</td>
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<tr>
<td>HCB</td>
<td>hexachlorobenzene</td>
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<td>HCBD</td>
<td>hexachlorobutadiene</td>
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<td>HCH</td>
<td>hexachlorocyclohexane</td>
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<tr>
<td>HEV</td>
<td>hepatitis E virus</td>
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<tr>
<td>HIV</td>
<td>human immunodeficiency virus</td>
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<tr>
<td>HPC</td>
<td>heterotrophic plate count</td>
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<tr>
<td>HPLC</td>
<td>high-performance liquid chromatography</td>
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<td>Acronym</td>
<td>Term</td>
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<tr>
<td>IARC</td>
<td>International Agency for Research on Cancer</td>
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<tr>
<td>IC</td>
<td>ion chromatography</td>
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<tr>
<td>ICP</td>
<td>inductively coupled plasma</td>
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<tr>
<td>ICRP</td>
<td>International Commission on Radiological Protection</td>
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<tr>
<td>IDC</td>
<td>individual dose criterion</td>
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<tr>
<td>IPCS</td>
<td>International Programme on Chemical Safety</td>
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<tr>
<td>IQ</td>
<td>intelligence quotient</td>
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<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
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<tr>
<td>JECFA</td>
<td>Joint FAO/WHO Expert Committee on Food Additives</td>
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<tr>
<td>JMPR</td>
<td>Joint FAO/WHO Meeting on Pesticide Residues</td>
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<tr>
<td>LC</td>
<td>liquid chromatography</td>
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<tr>
<td>LOAEL</td>
<td>lowest-observed-adverse-effect level</td>
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<tr>
<td>LRV</td>
<td>log₁₀ reduction value</td>
</tr>
<tr>
<td>MCB</td>
<td>monochlorobenzene</td>
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<tr>
<td>MCPA</td>
<td>4-(2-methyl-4-chlorophenoxy)acetic acid</td>
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<tr>
<td>MCPB</td>
<td>2,4-MCPB; 4-(4-chloro-o-tolyloxy)butyric acid; 4-(4-chloro-2-methylphenoxy)butanoic acid</td>
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<tr>
<td>MCPP</td>
<td>2(2-methyl-chlorophenoxy)propionic acid; mecoprop</td>
</tr>
<tr>
<td>MMT</td>
<td>methylcyclopentadienyl manganese tricarbonyl</td>
</tr>
<tr>
<td>MS</td>
<td>mass spectrometry</td>
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<tr>
<td>MTBE</td>
<td>methyl tertiary-butyl ether</td>
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<tr>
<td>MX</td>
<td>3-chloro-4-dichloromethyl-5-hydroxy-2(5H)-furanone</td>
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<tr>
<td>NDMA</td>
<td>N-nitrosodimethylamine</td>
</tr>
<tr>
<td>NOAEL</td>
<td>no-observed-adverse-effect level</td>
</tr>
<tr>
<td>NOEL</td>
<td>no-observed-effect level</td>
</tr>
<tr>
<td>NTA</td>
<td>nitrilotriacetic acid</td>
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<tr>
<td>NTP</td>
<td>National Toxicology Program (USA)</td>
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<tr>
<td>NTU</td>
<td>nephelometric turbidity unit</td>
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<tr>
<td>PAC</td>
<td>powdered activated carbon</td>
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<tr>
<td>PAH</td>
<td>polynuclear aromatic hydrocarbon</td>
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<tr>
<td>PCP</td>
<td>pentachlorophenol</td>
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<tr>
<td>PCR</td>
<td>polymerase chain reaction</td>
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<td>PD</td>
<td>photoionization detector</td>
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<tr>
<td>PMTDI</td>
<td>provisional maximum tolerable daily intake</td>
</tr>
<tr>
<td>PPA</td>
<td>protein phosphatase assay</td>
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<tr>
<td>PT</td>
<td>purge and trap</td>
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<tr>
<td>PTDI</td>
<td>provisional tolerable daily intake</td>
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</table>
ACRONYMS AND ABBREVIATIONS USED IN TEXT

PTMI provisional tolerable monthly intake
PTWI provisional tolerable weekly intake
PVC polyvinyl chloride
QMRA quantitative microbial risk assessment
RNA ribonucleic acid
SI Système international d’unités (International System of Units)
SODIS solar water disinfection
sp. species (singular)
spp. species (plural)
subsp. subspecies (singular)
TBA terbuthylazine
TCB trichlorobenzene
TCU true colour unit
TD$_{05}$ tumorigenic dose$_{05}$, the dose associated with a 5% excess incidence of tumours in experimental animal studies
TDI tolerable daily intake
TDS total dissolved solids
THM trihalomethane
TID thermal ionization detector; total indicative dose
UF uncertainty factor
UN United Nations
UNICEF United Nations Children’s Fund
UNSCEAR United Nations Scientific Committee on the Effects of Atomic Radiation
USA United States of America
UV ultraviolet
UVPAD ultraviolet photodiode array detector
WHO World Health Organization
WHOPES World Health Organization Pesticide Evaluation Scheme
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