Chloroacetones in Drinking-water

Background document for development of WHO Guidelines for Drinking-water Quality

Preface

One of the primary goals of WHO and its member states is that “all people, whatever their stage of development and their social and economic conditions, have the right to have access to an adequate supply of safe drinking water.” A major WHO function to achieve such goals is the responsibility “to propose regulations, and to make recommendations with respect to international health matters ....”

The first WHO document dealing specifically with public drinking-water quality was published in 1958 as International Standards for Drinking-Water. It was subsequently revised in 1963 and in 1971 under the same title. In 1984–1985, the first edition of the WHO Guidelines for drinking-water quality (GDWQ) was published in three volumes: Volume 1, Recommendations; Volume 2, Health criteria and other supporting information; and Volume 3, Surveillance and control of community supplies. Second editions of these volumes were published in 1993, 1996 and 1997, respectively. Addenda to Volumes 1 and 2 of the second edition were published in 1998, addressing selected chemicals. An addendum on microbiological aspects reviewing selected microorganisms was published in 2002.

The GDWQ are subject to a rolling revision process. Through this process, microbial, chemical and radiological aspects of drinking-water are subject to periodic review, and documentation related to aspects of protection and control of public drinking-water quality is accordingly prepared/updated.

Since the first edition of the GDWQ, WHO has published information on health criteria and other supporting information to the GDWQ, describing the approaches used in deriving guideline values and presenting critical reviews and evaluations of the effects on human health of the substances or contaminants examined in drinking-water.

For each chemical contaminant or substance considered, a lead institution prepared a health criteria document evaluating the risks for human health from exposure to the particular chemical in drinking-water. Institutions from Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Poland, Sweden, United Kingdom and United States of America prepared the requested health criteria documents.

Under the responsibility of the coordinators for a group of chemicals considered in the guidelines, the draft health criteria documents were submitted to a number of scientific institutions and selected experts for peer review. Comments were taken into consideration by the coordinators and authors before the documents were submitted for final evaluation by the experts meetings. A “final task force” meeting reviewed the health risk assessments and public and peer review comments and, where appropriate, decided upon guideline values. During preparation of the third edition of the GDWQ, it was decided to include a public review via the world wide web in the process of development of the health criteria documents.

During the preparation of health criteria documents and at experts meetings, careful consideration was given to information available in previous risk assessments carried out by the International Programme on Chemical Safety, in its Environmental Health
Criteria monographs and Concise International Chemical Assessment Documents, the International Agency for Research on Cancer, the joint FAO/WHO Meetings on Pesticide Residues, and the joint FAO/WHO Expert Committee on Food Additives (which evaluates contaminants such as lead, cadmium, nitrate and nitrite in addition to food additives).

Further up-to-date information on the GDWQ and the process of their development is available on the WHO internet site and in the current edition of the GDWQ.
Acknowledgements

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J.K. Fawell, Water Research Centre, United Kingdom
  (inorganic constituents)
U. Lund, Water Quality Institute, Denmark
  (organic constituents and pesticides)
B. Mintz, Environmental Protection Agency, USA
  (disinfectants and disinfectant by-products)

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Ms Marla Sheffer of Ottawa, Canada, was responsible for the scientific editing of the document.

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GENERAL DESCRIPTION

Identity

<table>
<thead>
<tr>
<th>Compound</th>
<th>CAS no.</th>
<th>Molecular formula</th>
</tr>
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<tbody>
<tr>
<td>1,1-Dichloroacetone</td>
<td>513-88-2</td>
<td>Cl₂CHCOCH₃</td>
</tr>
<tr>
<td>1,3-Dichloroacetone</td>
<td>534-07-6</td>
<td>ClCH₂COCH₂Cl</td>
</tr>
</tbody>
</table>

The IUPAC name for chloroacetone is chloropropanone.

Physicochemical properties (1–3)

<table>
<thead>
<tr>
<th>Property</th>
<th>1,1-Dichloroacetone</th>
<th>1,3-Dichloroacetone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiling point (°C)</td>
<td>120</td>
<td>173</td>
</tr>
<tr>
<td>Melting point (°C)</td>
<td>–</td>
<td>45</td>
</tr>
<tr>
<td>Density at 20 °C (g/cm³)</td>
<td>1.3</td>
<td>1.4</td>
</tr>
<tr>
<td>Water solubility at 20 °C</td>
<td>Slightly soluble</td>
<td>Soluble</td>
</tr>
</tbody>
</table>

Conversion factor in air: 1 ppm = 5.19 mg/m³.

Major uses

Chlorinated acetones have been proposed for use in tear gas because they are lachrymators. Chloroacetone is used as a reagent in the synthesis of drugs, perfumes, insecticides, and vinyl compounds (3).

ANALYTICAL METHODS

Chloroacetones in water are usually determined by liquid–liquid extraction and gas chromatography with electron-capture detection. A detection limit of 13 ng/litre for 1,1,1-trichloroacetone has been achieved (4).

ENVIRONMENTAL LEVELS AND HUMAN EXPOSURE

Water

Dichloroacetones may be formed in water by the oxidation reaction between chlorine and large organic molecules. Concentrations in finished drinking-water are estimated at less than 10 µg/litre (5). Quarterly mean concentrations of 1,1-dichloroacetone ranged from 0.46 to 0.55 µg/litre in grab samples from 35 drinking-water treatment plants in the USA (6).

EFFECTS ON LABORATORY ANIMALS AND IN VITRO TEST SYSTEMS

Acute exposure

Oral LD₅₀s of 250 mg/kg of body weight for 1,1-dichloroacetone and 25 mg/kg of body weight for 1,3-dichloroacetone have been reported in the mouse (7).
Short-term exposure

The hepatotoxicity of 1,1- and 1,3-dichloroacetone was investigated in mice. Single oral doses of each compound were administered to CD-1 mice (5–12 per dose). A dose of 0.25 ml/kg of body weight (325 mg/kg of body weight) of 1,1-dichloroacetone caused significant increases in liver enzymes in serum, and histological examination showed evidence of periportal necrosis. These effects were not observed at doses of 130 mg/kg of body weight or lower. Liver glutathione levels were decreased at doses of 0.1 and 0.25 ml/kg but not at 0.05 ml/kg (65 mg/kg of body weight). Based on measurements of serum enzymes, liver glutathione, and histopathological examination, 1,3-dichloroacetone did not cause liver toxicity at doses of up to 20 mg/kg of body weight. NOAELs of 65 and 20 mg/kg of body weight for 1,1-dichloroacetone and 1,3-dichloroacetone, respectively, were identified in this study (7).

Mutagenicity and related end-points

A number of chlorinated acetones, including 1,1-, 1,3-, 1,1,1-, 1,1,3,3-, and pentachloroacetone, were direct-acting mutagens in one or both of Salmonella typhimurium strains TA98 and TA100. Mutagenic activity decreased with increased chlorine substitutions at the C-1 and C-3 positions, although 1,1,1-trichloroacetone was 25 times as potent as 1,1-dichloroacetone (8).

Carcinogenicity

The carcinogenic activity of 1,1-dichloroacetone and 1,1,1-trichloroacetone was studied in female SENCAR mice (60 per dose) that received a single oral (200 mg/kg) or topical (400 mg/kg) dose of 1,1-dichloroacetone or a single oral (50 mg/kg) or topical (400 mg/kg) dose of 1,1,1-trichloroacetone. The vehicle was 0.2 ml of dimethyl sulfoxide for oral exposure and 0.2 ml of ethanol for topical exposure. Two weeks after dosing, a tumour promotion schedule was begun with 1 µg of 12-0-tetradecanoyl-phorbol-13-acetate (TPA) three times per week for 20 weeks. However, 24 weeks after the start of the promotion schedule, there was no evidence of an increase in skin tumours attributable to either chemical (9).

The results of carcinogenicity studies with chlorinated acetones using the mouse skin assay have also been reported. Groups of 40 SENCAR mice received topical doses of 1,1-dichloroacetone at 400, 600, or 800 mg/kg; 1,3-dichloroacetone at 50, 75, or 100 mg/kg; or 1,1,3-trichloroacetone or 1,1,1-trichloroacetone at 50 mg/kg. Doses were applied six times over a 2-week period using 0.2 ml of ethanol as the vehicle. After 2 weeks, 1.0 µg of TPA in 0.2 ml of acetone was applied three times per week for 20 weeks. After 24 weeks, the percentages of animals with tumours in the respective dose groups were: 5% in controls; 0, 5%, and 5% for 1,1-dichloroacetone; 48%, 45%, and 30% for 1,3-dichloroacetone; 10%, 5%, and 0% for 1,1,3-trichloroacetone; and 10% for 1,1,1-trichloroacetone. The authors concluded that 1,3-dichloroacetone is a tumour initiator in mouse skin (10).

CONCLUSIONS

The toxicological data on the chloroacetones are very limited, although studies with single doses of 1,1-dichloroacetone indicate that it affects the liver. There are insufficient data at present to permit the proposal of guideline values for any of the chloroacetones.
REFERENCES