

Chloride in Drinking-water

Background document for development
WHO Guidelines for Drinking-water Quality

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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.

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GENERAL DESCRIPTION

Identity

Chlorides are widely distributed in nature as salts of sodium (NaCl), potassium (KCl), and calcium (CaCl₂).

Physicochemical properties (1)

Salt	Solubility in cold	Solubility in hot
	water (g/litre)	water (g/litre)
Sodium chloride	357	391
Potassium chloride	344	567
Calcium chloride	745	1590

Organoleptic properties

The taste threshold of the chloride anion in water is dependent on the associated cation. Taste thresholds for sodium chloride and calcium chloride in water are in the range 200–300 mg/litre (2). The taste of coffee is affected if it is made with water containing a chloride concentration of 400 mg/litre as sodium chloride or 530 mg/litre as calcium chloride (3).

Major uses

Sodium chloride is widely used in the production of industrial chemicals such as caustic soda, chlorine, sodium chlorite, and sodium hypochlorite. Sodium chloride, calcium chloride, and magnesium chloride are extensively used in snow and ice control. Potassium chloride is used in the production of fertilizers (4).

Environmental fate

Chlorides are leached from various rocks into soil and water by weathering. The chloride ion is highly mobile and is transported to closed basins or oceans.

ANALYTICAL METHODS

A number of suitable analytical techniques are available for chloride in water, including silver nitrate titration with chromate indicator (5), mercury(II) nitrate titration with diphenylcarbazone indicator, potentiometric titration with silver nitrate, automated iron(III) mercury(II) thiocyanate colorimetry, chloride ion-selective electrode, silver colorimetry, and ion chromatography. Limits of detection range from 50 μ g/litre for colorimetry to 5 mg/litre for titration (6).

ENVIRONMENTAL LEVELS AND HUMAN EXPOSURE

Air

Exposure to chloride in air has been reported to be negligible (4).

Water

Chloride in surface and groundwater from both natural and anthropogenic sources, such as run-off containing road de-icing salts, the use of inorganic fertilizers, landfill leachates, septic

tank effluents, animal feeds, industrial effluents, irrigation drainage, and seawater intrusion in coastal areas (4).

The mean chloride concentration in several rivers in the United Kingdom was in the range 11–42 mg/litre during 1974–81 (7). Evidence of a general increase in chloride concentrations in groundwater and drinking-water has been found (8), but exceptions have also been reported (9). In the USA, aquifers prone to seawater intrusion have been found to contain chloride at concentrations ranging from 5 to 460 mg/litre (10), whereas contaminated wells in the Philippines have been reported to have an average chloride concentration of 141 mg/litre (11). Chloride levels in unpolluted waters are often below 10 mg/litre and sometimes below 1 mg/litre (4).

Chloride in water may be considerably increased by treatment processes in which chlorine or chloride is used. For example, treatment with 40 g of chlorine per m³ and 0.6 mol of iron chloride per litre, required for the purification of groundwater containing large amounts of iron(II), or surface water polluted with colloids, has been reported to result in chloride concentrations of 40 and 63 mg/litre, respectively, in the finished water (8).

Food

Chloride occurs naturally in foodstuffs at levels normally less than 0.36 mg/g. An average intake of 100 mg/day has been reported when a salt-free diet is consumed. However, the addition of salt during processing, cooking, or eating can markedly increase the chloride level in food, resulting in an average dietary intake of 6 g/day, which may rise to 12 g/day in some cases (4).

Estimated total exposure and relative contribution of drinking-water

If a daily water consumption of 2 litres and an average chloride level in drinking-water of 10 mg/litre are assumed, the average daily intake of chloride from drinking-water would be approximately 20 mg per person (4), but a figure of approximately 100 mg/day has also been suggested (8). Based on these estimates and the average dietary (not salt free) intake of 6 g/day, drinking water intake accounts for about 0.33–1.6% of the total intake.

KINETICS AND METABOLISM IN LABORATORY ANIMALS AND HUMANS

In humans, 88% of chloride is extracellular and contributes to the osmotic activity of body fluids. The electrolyte balance in the body is maintained by adjusting total dietary intake and by excretion via the kidneys and gastrointestinal tract. Chloride is almost completely absorbed in normal individuals, mostly from the proximal half of the small intestine. Normal fluid loss amounts to about 1.5–2 litres/day, together with about 4 g of chloride per day. Most (90–95%) is excreted in the urine, with minor amounts in faeces (4–8%) and sweat (2%) (4).

EFFECTS ON LABORATORY ANIMALS AND IN VITRO TEST SYSTEMS

Acute exposure

The oral LD₅₀ values for calcium chloride, sodium chloride, and potassium chloride in the rat have been reported as 1000, 3000, and 2430 mg/kg of body weight, respectively (8).

Short-term exposure

The toxicity of chloride salts depends on the cation present; that of chloride itself is unknown. Although excessive intake of drinking-water containing sodium chloride at concentrations above 2.5 g/litre has been reported to produce hypertension (12), this effect is believed to be related to the sodium ion concentration.

EFFECTS ON HUMANS

A normal adult human body contains approximately 81.7 g chloride. On the basis of a total obligatory loss of chloride of approximately 530 mg/day, a dietary intake for adults of 9 mg of chloride per kg of body weight has been recommended (equivalent to slightly more than 1 g of table salt per person per day). For children up to 18 years of age, a daily dietary intake of 45 mg of chloride should be sufficient (4). A dose of 1 g of sodium chloride per kg of body weight was reported to have been lethal in a 9-week-old child (8).

Chloride toxicity has not been observed in humans except in the special case of impaired sodium chloride metabolism, e.g. in congestive heart failure (13). Healthy individuals can tolerate the intake of large quantities of chloride provided that there is a concomitant intake of fresh water. Little is known about the effect of prolonged intake of large amounts of chloride in the diet. As in experimental animals, hypertension associated with sodium chloride intake appears to be related to the sodium rather than the chloride ion (4).

OTHER CONSIDERATIONS

Chloride increases the electrical conductivity of water and thus increases its corrosivity. In metal pipes, chloride reacts with metal ions to form soluble salts (8), thus increasing levels of metals in drinking-water. In lead pipes, a protective oxide layer is built up, but chloride enhances galvanic corrosion (14). It can also increase the rate of pitting corrosion of metal pipes (8).

CONCLUSIONS

Chloride concentrations in excess of about 250 mg/litre can give rise to detectable taste in water, but the threshold depends upon the associated cations. Consumers can, however, become accustomed to concentrations in excess of 250 mg/litre. No health-based guideline value is proposed for chloride in drinking-water.

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