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# Total dissolved solids in Drinking-water

Background document for development of
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*

Total dissolved solids (TDS) is the term used to describe the inorganic salts and small amounts of organic matter present in solution in water. The principal constituents are usually calcium, magnesium, sodium, and potassium cations and carbonate, hydrogencarbonate, chloride, sulfate, and nitrate anions.

### *Organoleptic properties*

The presence of dissolved solids in water may affect its taste (*1*). The palatability of drinking-water has been rated by panels of tasters in relation to its TDS level as follows: excellent, less than 300 mg/litre; good, between 300 and 600 mg/litre; fair, between 600 and 900 mg/litre; poor, between 900 and 1200 mg/litre; and unacceptable, greater than 1200 mg/litre (*1*). Water with extremely low concentrations of TDS may also be unacceptable because of its flat, insipid taste.

## ANALYTICAL METHODS

The method of determining TDS in water supplies most commonly used is the measurement of specific conductivity with a conductivity probe that detects the presence of ions in water. Conductivity measurements are converted into TDS values by means of a factor that varies with the type of water (*2,3*). The practical quantitation limit for TDS in water by this method is 10 mg/litre (M. Forbes, personal communication, 1988). High TDS concentrations can also be measured gravimetrically, although volatile organic compounds are lost by this method (*4*). The constituents of TDS can also be measured individually.

## ENVIRONMENTAL LEVELS AND HUMAN EXPOSURE

### *Water*

TDS in water supplies originate from natural sources, sewage, urban and agricultural run-off, and industrial wastewater. Salts used for road de-icing can also contribute to the TDS loading of water supplies.

Concentrations of TDS from natural sources have been found to vary from less than 30 mg/litre to as much as 6000 mg/litre (*5*), depending on the solubilities of minerals in different geological regions. Thus values, expressed as the sum of the constituents, were below 500 mg/litre in 36 of 41 rivers monitored in Canada (*6*), while, in a survey of the Great Lakes, levels ranged from 65 to 227 mg/litre (*7*). The levels of TDS in all of the Great Lakes except Lake Superior have increased in the last 70 years, by 50–60 mg/litre in Lakes Erie and Ontario (*7–10*). Between 1960 and 1980, a threefold increase in TDS was observed in the Kent River, Australia (*5*). Between 1955 and 1970, a tenfold increase in the salinity of the groundwater at Burlington, MA, was noted, resulting from road de-icing. The use of de-icing chemicals was prohibited thereafter (*5*).

## EFFECTS ON HUMANS

No recent data on health effects associated with the ingestion of TDS in drinking-water appear to exist; however, associations between various health effects and hardness, rather than TDS content, have been investigated in many studies (see **Hardness**).

In early studies, inverse relationships were reported between TDS concentrations in drinking-water and the incidence of cancer (*11*), coronary heart disease (*12*), arteriosclerotic heart disease (*13*), and cardiovascular disease (*14,15*). Total mortality rates were reported to be inversely correlated with TDS levels in drinking-water (*15,16*).

It was reported in a summary of a study in Australia that mortality from all categories of ischaemic heart disease and acute myocardial infarction was increased in a community with high levels of soluble solids, calcium, magnesium, sulfate, chloride, fluoride, alkalinity, total hardness, and pH when compared with one in which levels were lower (*17*). No attempts were made to relate mortality from cardiovascular disease to other potential confounding factors.

The results of a limited epidemiological study in the former Soviet Union indicated that the average number of "cases" of inflammation of the gallbladder and gallstones over a 5-year period increased with the mean level of dry residue in the groundwater (*18*). It should be noted, however, that the number of "cases" varied greatly from year to year in one district, as did the concentration of dry residue in each district, and no attempt was made to take possible confounding factors into account.

## OTHER CONSIDERATIONS

Certain components of TDS, such as chlorides, sulfates, magnesium, calcium, and carbonates, affect corrosion or encrustation in water-distribution systems (*4*). High TDS levels (>500 mg/litre) result in excessive scaling in water pipes, water heaters, boilers, and household appliances such as kettles and steam irons (*19*). Such scaling can shorten the service life of these appliances (*20*).

## CONCLUSIONS

Reliable data on possible health effects associated with the ingestion of TDS in drinking-water are not available. The results of early epidemiological studies suggest that even low concentrations of TDS in drinking-water may have beneficial effects, although adverse effects have been reported in two limited investigations.

Water containing TDS concentrations below 1000 mg/litre is usually acceptable to consumers, although acceptability may vary according to circumstances. However, the presence of high levels of TDS in water may be objectionable to consumers owing to the resulting taste and to excessive scaling in water pipes, heaters, boilers, and household appliances (see also the section on **Hardness**). Water with extremely low concentrations of TDS may also be unacceptable to consumers because of its flat, insipid taste; it is also often corrosive to water-supply systems.

In areas where the TDS content of the water supply is very high, the individual constituents should be identified and the local public health authorities consulted. No health-based guideline value is proposed for TDS. However, drinking-water guidelines are available for some of its constituents, including boron, fluoride, and nitrate.

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