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REVISION OF THE WHO GUIDELINES FOR DRINKING-WATER QUALITY

REPORT OF THE FIRST REVIEW GROUP MEETING ON INORGANICS
BILTHOVEN, NETHERLANDS, 18 - 22 MARCH 1991

WORLD HEALTH ORGANIZATION GENEVA 1991

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1. INTRODUCTION

The recommended values contained in the WHO Guidelines for Drinking-Water Quality issued in 1984 (referred to henceforth as the Guidelines) are based on toxicological and other support data available up to 1981. Since that time new toxicological and other relevant data have become available for some of the substances for which guidelines or tentative guidelines were established in the 1984 Guidelines as well as for other compounds for which there had been insufficient data available to establish guideline values. In addition, concern has been expressed regarding a number of substances which had not previously been considered.

A Consultation to initiate the work on the revision of WHO Guidelines for Drinking Water Quality was convened by WHO in Rome from 17-19 October 1988. The principal objective of this Consultation was to discuss and agree upon the principles under which the revision of the Guidelines would be carried out. The consultation reaffirmed the concept of WHO Guidelines including approaches to risk assessment, and produced specific recommendations regarding assumptions and techniques which should be used during the process of development of the revised Guidelines. Furthermore, the consultation determined a common format for the evaluation of drinking-water contaminants and finalized the list of substances for which evaluation should be undertaken.

With the scientific principles of the revision agreed upon at the Rome consultation, it appeared useful to have a small co-ordination group meet at periodic intervals to elaborate detailed practical arrangements for the drafting of evaluation documents and for the organization of the review meetings. Participation was limited to the scientific co-ordinators for organics and inorganics and principal investigators of institutes which would host the review meetings. Two consultations of this co-ordinating group have been organized so far, the first one in Copenhagen, 4-5 September 1989, and the second in Geneva 13-14 March 1990.

Based on the established principles for the preparation and review of the draft evaluations of individual substances, and based on the assessment of actual and/or expected availability of draft evaluation documents, detailed arrangements for review meetings in 1990 and tentative plans for 1991 were made during the Geneva meeting in March 1990.

The First Review Group Meeting on Inorganics was convened by WHO Headquarters in Bilthoven, the Netherlands, 18-22 March 1991 with the financial support of the Netherlands National Institute of Public Health and Environmental Protection who also hosted the meeting. The list of participants is given as Annex I.

On behalf of the board of directors of the National Institute of Public Health and Environmental Protection (RIVM), Mr van Egmond welcomed the participants of the First Review Group Meeting on Inorganics to Bilthoven. He emphasized the importance of reviewing the present WHO Guidelines for Drinking-Water Quality, since these guidelines can give major guidance to individual countries in setting national standards. He fully endorsed the involvement of the RIVM in this international collaboration, which had already resulted in the presence of a RIVM representative at the Rome Consultation in 1988 and the participation of individual scientists in earlier review meetings dedicated to pesticides and organic compounds. Mr van Egmond, recognizing the heavy workload of the meeting, expressed his confidence in the participating scientists and wished them a successful outcome to the difficult deliberations ahead of them.

Dr H. Galal-Gorchev of IPCS welcomed the participants on behalf of the Director-General of the WHO, Dr Nakajima. She expressed WHO's gratitude to the National Institute of Public Health and Environmental Protection for providing the scientific, financial and administrative support in organizing the meeting. Moreover, the preparation of draft evaluation documents, on substances under consideration at this meeting, by Canada, Finland, Japan, the Netherlands, the United Kingdom and the United States of America was gratefully acknowledged. She also thanked the Inorganics Co-ordinator, Mr J Fawell, of the UK Water Research Centre (WRc) who had issued the documents and prepared overviews incorporating the comments received.

Dr van Leeuwen served as the Chairman and Mr Fawell as the Rapporteur.

2. SUMMARY STATEMENTS

2.1 Aluminium

Aluminium is a widespread and abundant element comprising some 8% of the earths crust. Aluminium compounds are widely used as coagulants in drinking-water treatment. Human exposure may occur by a variety of routes with drinking-water probably contributing less than 5% of the total intake.

The metabolism of aluminium in humans is not well understood but it seems to be poorly absorbed and most of the absorbed aluminium appears to be rapidly excreted in the urine.

Aluminium is of low toxicity in laboratory animals and JECFA established a PTWI of 7 mg/kg b.w. in 1988. This was based on studies of aluminium phosphate (acidic) but the chemical form of aluminium in drinking-water is different.

Aluminium appears to be associated with the brain lesions characteristic of Alzheimers disease and the incidence of Alzheimers disease has been associated with aluminium in drinking-water in several ecological epidemiological studies. These ecological analyses must be interpreted with caution and should be confirmed in analytical epidemiological studies of individuals.

There is a need for further studies but at present the balance of evidence does not clearly support a causal role for aluminium in Alzheimers disease. The guideline value is therefore based on possible aesthetic effects in drinking-water. The recommended guideline value is 200 μg/l.

2.2 Antimony

Salts and, possibly, organic complexes of antimony are typically found in food and water at low levels. However, since antimony-tin solder is beginning to replace lead solder, exposure to antimony may increase in the future.

Reported concentrations of antimony in drinking-water are usually less than 5 μg/litre. Estimated dietary intake for adults is about 20 μg/day.

In a limited lifetime study in which rats were exposed to antimony in drinking-water at a single dose level of 0.43 mg/kg b.w./day, effects observed were decreased longevity and altered blood levels of glucose and cholesterol. No effects were observed on the incidence of benign or malignant tumours.

An uncertainty factor of 500 was used to reflect inter and intraspecies variation and the use of a LOAEL, giving a tolerable daily intake (TDI) of 0.86 μg/kg b.w. An allocation of 10% of the TDI to drinking-water gave a proposed guideline value of 3 μg/litre.

The working group recognised that this may be below the limit of practical quantitative analysis.

2.3 Arsenic

Arsenic is widely distributed throughout the earth's crust and is used commercially primarily in alloying agents. It is introduced into water through the dissolution of minerals and ores, from industrial effluents and atmospheric deposition; concentrations particularly in ground water in some areas are elevated due to erosion from natural sources. The average daily intake of inorganic arsenic in water is estimated to be similar to that from food; intake from air is negligible.

Inorganic arsenic is a documented human carcinogen which has been classified by IARC in Group 1. A relatively high incidence of skin and possibly other cancers which increase with dose and age has been observed in populations ingesting water containing high concentrations of arsenic.

Arsenic has not been carcinogenic in the limited bioassays in animal species which are available, but has been positive in studies designed to assess the potential for tumour promotion. Arsenic has not been mutagenic in bacterial and mammalian assays, although in a variety of cultured cell types, including human cells, it has induced chromosome aberrations; such effects have not been observed *in vivo*.

Owing to the documented carcinogenicity of arsenic in drinking-water in human populations, the lifetime risk of skin cancer has been estimated using a multistage model which is both linear and quadratic in dose. On the basis of observations in a Taiwanese population ingesting arsenic-contaminated drinking-water, the concentrations associated with lifetime skin cancer risks of 10-4, 10-5 and 10-6 are 1.4 μg/l, 0.14 μg/l and 0.014 μg/l. These values may, however, overestimate the actual risk of skin cancer owing to the possible contribution of other factors to disease incidence in the Taiwanese population and to possible dose-dependent variations in metabolism which could not be taken into consideration. Moreover, 1-14% of arsenic-induced skin cancers are fatal. Data on the association between internal cancers and ingestion of arsenic in drinking-water are insufficient for quantitative assessment of risk.

With a view to reducing the concentration of this carcinogenic contaminant in drinking-water, a temporary guideline of 10 μg/l for arsenic in drinking-water is recommended. The estimated lifetime skin cancer risk associated with exposure to this concentration is 7×10^{-4} (or 7×10^{-6} to 9.8×10^{-5} lifetime risk of fatal skin cancers).

In 1983, the Joint FAO/WHO Expert Committee on Food Additives (JECFA) established a provisional maximum tolerable daily intake (PMTDI) for inorganic arsenic of 0.002 mg/kg b.w. which was confirmed in 1988 by establishing a PTWI of 0.015 mg/kg b.w. for inorganic arsenic. The Committee noted, however, that the margin between the PTWI and intakes reported to have toxic effects in epidemiological studies was narrow. A value derived on the basis of this PMTDI (12 μg/l based on 20% allocation to drinking-water) is similar to the recommended guideline value.

2.4 Barium

Barium occurs as a number of compounds in the earth's crust and is used in a wide variety of industrial applications but it is present in water primarily from natural sources. In general, food is the principal source of exposure to barium; however, in areas where barium concentrations are high, drinking-water may contribute significantly to total intake. Intake from air is negligible.

Although an association between mortality from cardiovascular disease and the barium content of drinking-water has been reported in an ecological epidemiological study, these results were not confirmed in an analytical epidemiological study of individuals in the same population. Moreover, in a short-term study in a small number of volunteers, there was no consistent indication of adverse cardiovascular effects following exposure to up to 10 mg/l barium in water. There was, however, an increase in the systolic blood pressure of rats exposed to relatively low concentrations of barium in drinking-water.

A guideline value of 0.7 mg/l has, therefore, been derived using the no observed adverse effect level in the most sensitive epidemiological study conducted to date (7.3 mg/l) and incorporating an uncertainty factor of 10 to account for intraspecies variation. This value is within the range of that derived on the basis of the results of toxicological studies in animal species. A tolerable daily intake of 0.051 mg/kg b.w. was calculated based on a NOAEL of 0.51 mg/kg b.w./day in a chronic study in rats and incorporating an uncertainty factor of 10 for intraspecies variation and 1 for interspecies variation since the results of a well conducted epidemiological study indicate that humans are not more sensitive than rats to barium in drinking-water. (A level derived from this TDI based on 20% allocation to drinking-water would have been about 0.3 mg/l).

2.5 Beryllium

Beryllium has a number of important minor uses based mostly on its heat resistance. It is found infrequently in drinking-water and only at very low concentrations, usually less than 1.0 μg/l.

It appears to be poorly absorbed from the gastro-intestinal tract. Beryllium is classified in class 2A by IARC on the basis of occupational epidemiology and inhalation studies in laboratory animals. There are no adequate studies to judge whether it is carcinogenic by oral exposure.

Beryllium interacts with DNA and causes gene mutations, chromosomal aberrations, and sister chromatid exchange in cultured mammalian somatic cells, though it is not mutagenic in bacterial test systems.

There are no suitable oral data on which to base a toxicologically supportable guideline value. However, the very low concentrations of beryllium normally found in drinking-water seem unlikely to pose a hazard to consumers.

2.6 Boron

Elemental boron is used principally in composite structural materials and boron compounds are used in some detergents and industrial processes. They are released into water by industrial and domestic effluents. Boron is usually only present in drinking-water at concentrations of up to 1 mg/l but some higher levels have been found due to naturally occurring boron. The total daily intake is estimated at 2-5 mg Boron.

Boron, when administered as borates or boric acid, is rapidly and almost completely absorbed from the intestinal tract. Boron excretion occurs mainly through the kidney.

Chronic exposure of humans to boron compounds leads to mild gastro-intestinal irritation. In short- and long-term animal studies and in reproductive studies with rats, testicular atrophy was observed. Boric acid and borates were not mutagenic in various <u>in vitro</u> test systems. No increased tumour incidences were observed in long-term carcinogenicity studies in mice and rats.

Therefore, a tolerable daily intake of 0.088 mg/kg b.w. has been derived by applying an uncertainty factor of 100 (to reflect inter and intraspecies variation) to a NOAEL, for testicular atrophy, of 8.8 mg B/kg b.w./day in a 2-year diet study in dogs. This gives a proposed guideline value of 0.3 mg B/l allowing 10% of the tolerable daily intake from drinking-water.

2.7 Cadmium

Cadmium metal is used in the steel industry and in plastics. Cadmium compounds are widely used in batteries. Cadmium is released to the environment in waste water and diffuse pollution is caused by contamination in fertilizers and local air pollution. Contamination in drinking-water is also caused by impurities in the zinc of galvanized pipes and solders, although levels in drinking-water are usually less than 1 μg/l. Food intake is the main source of daily exposure to cadmium. The daily oral intake is 10-35 μg. Smoking is a significant additional source of cadmium exposure.

Absorption of cadmium compounds is dependent on the speciation. Cadmium accumulates primarily in the kidneys and has a long biological half-life in man, viz. 10-30 years.

There is evidence for the carcinogenicity of cadmium by the inhalation route and IARC has classified cadmium in group 2A. However, there is no evidence of carcinogenicity by the oral route and there is no clear evidence for the genotoxicity of cadmium.

The kidney is the main target organ for cadmium toxicity. The critical Cd-concentration in the renal cortex at which a 10% prevalence of low-molecular weight proteinuria in the general population would occur is about 200 mg/kg.

Assuming an absorption rate for dietary cadmium of 5% and a daily excretion rate of 0.005% of body burden, JECFA concluded that, if levels of cadmium in renal cortex are not to exceed 50 mg/kg, a total intake of cadmium should not exceed 1 μg/kg b.w./day. The Provisional Tolerable Weekly Intake (PTWI) was therefore set at 7 μg/kg b.w. The Review Group recognized that the margin between the PTWI and the actual weekly dietary intake of cadmium by the general population is small, less than ten fold, and that this margin can be decreased in smokers. A guideline value of 3.0 μg/l was proposed based on an allocation of 10% of the PTWI to drinking-water.

2.8 Chromium

Chromium is widely distributed in the earth's crust. It can exist in valencies from -(II) to +(VI). Total Cr concentrations in drinking-water are usually less than 5 μg/l, although concentrations between 60-120 μg/l have been reported. In general, food appears to be the major source of intake.

The absorption of chromium after oral exposure is relatively low and depends on the speciation. Cr(VI) is more readily absorbed from the gastro-intestinal tract than Cr(III) and is able to penetrate cellular membranes. There are no adequate toxicity studies available to provide a basis to determine a NOAEL. In a long-term carcinogenicity study in rats by the oral route with Cr(III) no increase in tumour incidence was observed. In rats Cr(VI) is a carcinogen via the inhalation route. The limited data available do not show evidence for carcinogenicity via the oral route. In epidemiological studies an association has been found between exposure to Cr(VI) and lung cancer. IARC has classified Cr(VI) as a human carcinogen (group 1) and Cr(III) in group 3.

Cr(VI) compounds are positive in a wide range of <u>in vitro</u> and <u>in vivo</u> genotoxicity tests, whereas Cr(III) compounds are not. The mutagenic activity of Cr(VI) can be decreased or abolished by reducing agents, such as human gastric juice.

The Review Group considered that in principle different guideline values for Cr(III) and Cr(VI) should be derived, however, current analytical methods favour a guideline value for total chromium. Due to the carcinogenicity of Cr(VI) by the inhalation route and its genotoxicity, the working party questioned the present guideline value of 50 μg Cr/l, but the available toxicological data did not support the derivation of a new value. However, as a practical measure 50 μg/l, which was considered to be unlikely to give rise to significant risks to health, has been retained as the guideline value.

The Review Group recommends a re-evaluation of chromium, when additional information is available.

2.9 <u>Cyanide</u> *)

Cyanides are highly acutely toxic and can be found in some foods, particularly in some third world countries. They are occasionally found in drinking-water primarily as a consequence of industrial contamination.

Chronic effects on the thyroid and particularly the nervous system were observed in some populations as a consequence of the consumption of inadequately processed cassava containing high cyanide. This problem seems to have decreased significantly in the West African populations, in which it was widely reported, following a change in processing and a general improvement in nutritional status.

There are a very limited number of toxicological studies suitable for deriving a guideline value. There is, however, some indication in the literature that pigs may be more sensitive than rats. There is only one study available in which a clear effect-level was observed, at 1.2 mg/kg b.w./day, in pigs exposed for 24 weeks. The effects observed were in behavioural patterns and in serum biochemistry.

Using the LOAEL from this study and applying an uncertainty factor of 100 to reflect inter and intraspecies variation, (no additional factor for a LOAEL was considered necessary because of the doubts over the biological significance of the observed changes and the use of a very sensitive species), a TDI of 12 μg/kg b.w. can be calculated.

An allocation of 20% of the TDI to drinking-water was made because exposure to cyanide from other sources is normally small and exposure from water is only intermittent. This results in a proposed guideline value of 70 μg/l which is considered to be protective for acute and chronic exposure.

*) Draft evaluation possibly to be reconsidered at the second meeting on inorganics pending receipt of results of an additional sub-chronic bioassay in rats.

2.10 Fluoride

Fluorine comprises about 0.3 g/kg of the earth's crust. Inorganic fluorine compounds are used in the production of aluminium and fluoride is released from the manufacture of fertilizers from phosphate ores, which contain up to 3.8% F.

Daily exposure depends on the geographic area. The exposure via food may be high especially due to consumption of fish and tea. In specific areas food and indoor air pollution may contribute considerably to total exposure. Additional intake may result from the use of fluoride toothpastes.

Exposure to fluoride from drinking-water depends greatly on natural circumstances. Levels in drinking-water are normally below 1.5 mg/l, but in areas which are rich in fluoride-containing minerals, underground waters may contain about 10 mg F/l. Fluoride is sometimes added to drinking-water to prevent dental caries.

Soluble fluorides are rapidly absorbed in the gastrointestinal tract after uptake via drinking-water.

In 1987 IARC classified inorganic fluorides in group 3. Fluoride has not been carcinogenic in more recent studies including the US National Toxicology Program bio-assay in draft in 1990.

There is an overlap between concentrations in drinking-water for caries prevention and those producing objectionable fluorosis. There is reason to consider that exposure to fluoride has increased in recent decades, due in part to the use of fluoride in dental preparations. Based on dental fluorosis observed in humans a guideline value of 1.0 mg/l is proposed to accommodate this increase in fluoride intake. The Review Group recognized that daily water intake may vary with the climate and that in areas with a high water intake, dental fluorosis may already develop at this concentration. Some variation from this guideline could be considered where exposure from other sources is low.

The Review Group noted that extensive reviews are in progress, and recommends that the guideline be re-examined when these have been made available.

2.11 Hydrogen sulphide

Hydrogen sulphide is a gas with an offensive "rotten-eggs odour", which is detectable at very low concentrations, below 0.13 ppm in air. It is formed when sulphides are hydrolysed, however, the level of hydrogen sulphide found in drinking-water is usually low because sulphides are readily oxidised in well aerated water.

Hydrogen sulphide is highly acutely toxic to man following inhalation of the gas; irritation can be observed at concentrations as low as 5 ppm (7 mg/m^3).

The taste and odour threshold for hydrogen sulphide in water has been estimated to be as low as 0.05 mg/l. Although oral toxicity data are lacking the Review Group concluded that it is unlikely that a person could consume a harmful dose of hydrogen sulphide. Consequently no guideline value has been recommended but hydrogen sulphide should not be detectable by taste or odour.

2.12 Mercury

Mercury is present in the inorganic form in surface and groundwaters at concentrations usually less than 0.5 μg/l. Levels in air are in the range of 2-10 ng/m3. Mean dietary intake of mercury in various countries ranges from 2 to 20 μg/person/day.

The kidney is the main target organ for the toxicity of inorganic mercury while methylmercury affects mainly the central nervous system.

JECFA has established a provisional tolerable weekly intake (PTWI) of 300 μg of total mercury per person, of which no more than 200 μg should be present as methylmercury. In 1988, the Committee re-assessed methylmercury as new data were only then available on this compound, and confirmed the previously recommended provisional tolerable weekly intake of 200 μg of methylmercury (3.3 μg/kg b.w.) for the general population, but noted that pregnant women and nursing mothers are likely to be at greater risk from the adverse effects of methylmercury. The available data were considered insufficient to recommend a specific methylmercury intake for this population group.

To be on the conservative side, the PTWI for methylmercury is used to derive a guideline value for inorganic mercury in drinking-water. Since the main exposure is from food a 10% allocation of the PTWI to drinking-water was made. The calculated guideline value for total mercury is 1.4 μg/l which can be rounded to 1.0 μg/l.

2.13 Molybdenum

Concentrations of molybdenum in drinking-water are usually less than 10 μg/l. However, in areas near mining sites, molybdenum concentrations as high as 200 μg/l have been reported. Dietary intake of molybdenum is between 0.1-0.5 mg/person/day. Molybdenum is considered to be an essential element with an estimated daily requirement of about 0.5 mg/day for adults.

No data are available on the carcinogenicity of molybdenum by the oral route. In a 2-year study of humans exposed through their drinking-water, a NOAEL of 200 μg/l was identified.

The Review Group had some concerns about the quality of the study. An uncertainty factor of 10 would normally be applied to reflect intraspecies variation. However, the working group recognised that molybdenum is an essential element and therefore considered that a factor of 3 would be adequate. This gives a guideline value of 70 μg/l.

This value is within the range of that derived on the basis of results of toxicological studies in animal species and is consistent with the essential daily requirement.

2.14 Nitrate and nitrite

Nitrate and nitrite are naturally occurring ions which make up part of the nitrogen cycle. Naturally occurring nitrate levels in surface and ground water are generally a few mg/l.

In many groundwaters, an increase of nitrate levels is observed due to the intensification of farming practice. Concentrations can reach several hundreds of mg/l. In some countries, the percentage of the population exposed to nitrate levels in drinking-water above 50 mg/l reaches 10%.

In general, vegetables will be the main source of nitrate intake, when values in drinking-water do not exceed 10 mg/l. When nitrate levels in drinking-water exceed 50 mg/l, nitrate from drinking-water will be the major source of total nitrate intake.

Experiments suggest that neither nitrate nor nitrite act directly as carcinogens in animals, but there is some concern about increased risk of cancer in humans from the endogenous and exogenous formation of N-nitroso compounds, many of which are carcinogenic in animals. Suggestive evidence relating dietary nitrate exposure to cancer, especially gastric cancer, is available from geographic-correlation or ecological epidemiology studies, but these results have not been confirmed in more definitive analytical studies. It must be recognized that many factors in addition to environmental nitrate exposure may be involved.

In summary, insufficient epidemiologic evidence is available for an association between dietary nitrate and cancer, and the guideline value for nitrate in drinking-water is established solely to prevent methaemoglobinaemia, which depends upon the conversion of nitrate to nitrite. Although bottle-fed infants of less than 3 months of age are most susceptible, occasional cases have been reported in some adult populations.

Extensive epidemiological data support the current guideline value for nitrate of 10 mg nitrate-N per litre. The Review Group was of the opinion that this value should not be expressed on the basis of nitrate-nitrogen but on the basis of nitrate itself, and therefore proposed a guideline value of 50 mg/l nitrate.

As a result of recent evidence of the presence of nitrite in some water supplies, the Review Group concluded that a guideline value for nitrite should be proposed. However, it felt that the available animal studies were inappropriate to establish a firm NOAEL for methaemoglobinaemia in rats. Therefore, a pragmatic approach was followed, accepting a relative potency for nitrite and nitrate with respect to methaemoglobin formation of 10:1 (on a molar basis) and a temporary guideline value of 3 mg/l nitrite was proposed. Due to the possibility of simultaneous occurrence of nitrite and nitrate in drinking-water the sum of the ratio of the concentration of each to their guideline values as shown in the following formula should not exceed 1.

$$\frac{C_{NO_2}}{GV_{NO_2}} + \frac{C_{NO_3}}{GV_{NO_3}} \leq 1$$

C - concentration
GV - guideline value

2.15 <u>Sodium</u>

Sodium salts (e.g., sodium chloride) are found in virtually all food (the main source of daily exposure) and drinking-water. While concentrations of sodium in potable water are typically less than 20 mg/l, they can greatly exceed this in some countries. The levels of sodium salts in air are normally quite small in relation to food or water. It should be noted that some water softeners can add significantly to the sodium content of drinking-water.

No firm conclusions can currently be drawn concerning the possible association of sodium in drinking-water with the occurrence of hypertension. Thus, it is recommended that the current guideline value of 200 mg/l based on taste, be maintained.

2.16 Sulphate

Sulphates occur naturally in numerous minerals and are used commercially, principally in the chemical industry, They are discharged into water in industrial wastes and through atmospheric deposition, however, the highest levels usually occur in groundwater and are from natural sources. In general, food is the principal source of exposure to sulphate though in areas with high concentrations, intake from drinking-water can exceed that from food; the contribution of air to total intake is negligible.

Sulphate is one of the least toxic anions; however, catharsis, dehydration and gastrointestinal irritation have been observed at high concentrations. Magnesium sulphate, epsom salts, has been used as a cathartic for many years. The presence of sulphate in drinking-water can also cause noticeable taste. Taste impairment varies with the nature of the associated cation, however, it is considered that taste impairment would be minimal at levels below 250 mg/l.

Based on considerations of taste, the recommended guideline value is 250 mg/l. Due to the gastrointestinal effects resulting from ingestion of high sulphate levels in drinking-water, it is also recommended that health authorities be notified of sources of drinking-water that contain sulphate concentrations in excess of 500 mg/l.

2.17 Inorganic tin

Tin is used principally in the production of coatings used in the food industry. Food, and particularly canned food, therefore represents the major route of human exposure to tin. For the general population, drinking-water is not a significant source of tin, and values greater than 1-2 μg Sn/l water are exceptional. However, there is an increasing use of tin in solder which may be used in domestic plumbing.

Tin and inorganic tin compounds are poorly absorbed from the gastro-intestinal tract, do not accumulate in tissues and are rapidly excreted, primarily in the faeces.

No increased tumour incidences were observed in long-term carcinogenicity studies conducted in mice and rats fed with stannous chloride. It has not been shown to be teratogenic or foetotoxic in mice, rats and hamsters. In rats the NOAEL in a long-term feeding study was 20 mg/kg b.w./day.

The main adverse effect with excessive levels (above 150 mg/kg) of tin in foods, such as canned fruit has been acute gastric irritation. There is no evidence of adverse effects in man associated with chronic exposure to tin.

The Review Group concluded that due to the low toxicity of inorganic tin a tentative guideline value could be derived three orders of magnitude higher than the normal tin concentrations in drinking-water. Therefore, the presence of tin in drinking-water does not represent a hazard to human health. For that reason, the establishment of a numerical guideline value for inorganic tin was not deemed necessary.

2.18 Zinc

Zinc is an essential trace element that is found in virtually all food and potable water in the form of salts and/or organic complexes. The diet is normally the principal source of zinc. While levels of zinc in surface and groundwater normally do not exceed 0.01 and 0.04 mg/l, respectively, concentrations in tap water can reach much higher levels due to dissolution of zinc from pipes.

JECFA proposed a provisional maximum tolerable daily intake for zinc of 0.3 to 1.0 mg/kg b.w. in 1982. The daily requirement for adult men is 15-22 mg/person/day. Levels of zinc in drinking-water above about 3 mg/l have an undesirable astringent taste and may result in discolouration. For this reason, a guideline value of 3 mg/l is recommended. The working group considered that taking into account recent studies on humans, this concentration would not be likely to present a hazard to health.

3. RECOMMENDATIONS

1. The Review Group recommended that a body-weight of 60 kg be adopted for the revision of the Guidelines, in line with the current practice of WHO expert committees.

2. An overall position with regard to consistency in the allocation of a proportion of a tolerable daily intake (TDI) to drinking-water is required for the guidance of the review groups. It is recommended that for inorganics this should be 10% unless a different figure can be justified.

4. COMMENTS

1. When considering epidemiological studies for a number of inorganics, problems were encountered with ecological epidemiological studies. These make use of available health statistics to describe associations in populations with environmental measurements over various geographic areas. While the analysis of these data is relatively simple and straighforward, the interpretation of the analysis presents many problems, primarily because inferences do not necessarily relate to the individuals within the populations studied. Information from ecological (also called descriptive or geographical correlational studies) epidemiological studies cannot establish causality and is therefore of limited value in establishing drinking-water guidelines.

   Analytical epidemiological studies are recommended because they consider exposures, disease and confounding characteristics in individuals and are able to provide an estimate of the risk of disease from environmental exposures.

2. In evaluating the inorganics, the Review Group encountered major deficiencies in the toxicological information for a number of compounds. These deficiencies cause serious difficulties in setting guideline values.

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Annex I

REVISION OF WHO GUIDELINES FOR DRINKING-WATER QUALITY

REPORT OF THE
FIRST REVIEW GROUP MEETING ON INORGANICS

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