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EXPERT GROUP MEETING ON HEALTH ASPECTS OF THE LONG-TERM USE OF DESALINATED WATER

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I. INTRODUCTION

The principal objectives of the Expert Group Meeting on Health Aspects of the Long-Term Use of Desalinated Water for drinking purposes were to identify problems encountered in individual countries, to evaluate available water quality data and its potential impact on health, to determine the need for water quality guidelines specific to desalinated water, to encourage intersectoral cooperation at the national level and to develop recommendations for future action. Participants in the Expert Group Meeting are listed in Annex I.

Many countries in the Eastern Mediterranean Region face shortage of fresh water supply sources and have turned to the desalination of sea or brackish water for the provision of drinking water.

Preliminary work on desalinated water has been carried out to identify contaminants and beneficial elements, the concentration of which may be affected by desalination processes, to evaluate the potential health significance of their presence (or absence) in the final product water and to suggest remedial actions (1).

Contaminants may originate from the source sea water, from treatment chemicals and their reaction products, from construction materials and from distribution system materials. Bromine, iodine, boron, corrosion products (such as copper, iron, nickel, cadmium), organic compounds (e.g. phenols and petroleum hydrocarbons), leachates from membrane materials and anti-scale, corrosion and foaming agents, were identified as being of particular relevance to the quality of desalinated water.

Guidelines for Drinking Water Quality have been recently developed by WHO to describe the quality of water that is suitable for drinking purposes (2,3). Substances included in the Guidelines were selected on the basis of their potential health effects as well as frequency and levels of occurrence in drinking water. While many substances for which guideline values have been recommended are also of interest in cases where drinking water is derived from saline water sources, it is expected that certain substances of particular relevance to desalinated water have not been included in the Guidelines. Moreover, the Guidelines provide recommendations as to upper concentration limit values, not to be exceeded over long periods of time for various constituents in drinking water, which will not result in any significant risk to the health of the consumer and which will ensure an aesthetically pleasing water. Also no attempt was made in the Guidelines to define minimum desirable concentrations of essential elements in drinking water since, among other things, there is only limited information available on the relative intakes from food and water. Minimum levels of constituents, however, may be of relevance in desalinated water, for technological, health or aesthetic reasons.

Three sources of drinking water are of major importance in the Gulf Regions: Well water, desalinated water and bottled mineral water.

Although no detailed studies have been conducted to determine drinking water consumption habits in the Region, there is good reason to believe that a significant number of people consume bottled water. Furthermore, in some of the Gulf countries such as Saudi Arabia and Oman, a large percentage of the population consumes well water, some of which is highly mineralized.

The term "desalinated water" may refer to various types of water:

i) Pure desalinated water which is only treated to adjust the pH thus minimizing corrosion of pipes etc.

ii) Pure desalinated water artificially hardened.

iii) Desalinated water blended with sea water after the desalination process.

iv) Desalinated water (which may have been partially treated) and subsequently mixed with brackish water.

In its deliberations, the Group addressed the question of water quality standards or other requirements that might be considered for the necessary quality of potable water supplied to the public.

Since little information is available specific for the Gulf Region on the long-term health effects of desalinated water, the Group simply reviewed the available information and considered possibilities for future investigations, possibly to include morbidity studies, the determination of the nature and source of contaminants present in desalinated water, and studies of drinking water consumption and dietary habits in the Region.

Unlike drinking water from conventional sources, desalinated water involves processes which utilize numerous types of chemicals such as those used for anti-scaling or anti-foaming purposes (4). Although these chemicals are widely used within the Gulf countries, little seems to be known about their chemical composition, physical properties or possible health effects.

There is concern about the possibility that these chemicals, or impurities in the chemicals, under certain operational conditions (or after accidents, etc.) may escape and end up in the drinking water supplied to the public.

There is a need for all cooperating countries to determine the nature of such chemicals in order to assess the problems, if any, and determine the necessary actions to be taken.

II. SEAWATER CONSTITUENTS

Constituents discussed here have been selected on the basis of their relative abundance in sea water and their potential presence in desalinated water. Approximate concentrations of substances occurring in sea water are given in Annex II, together with the recommended drinking water guideline values and recommended daily dietary intakes (2,3,5,6). The parameters are listed in alphabetical order.

Alkalinity

Alkalinity is a measure of the capacity of a water to react with a strong acid to a designated pH. Anions of weak acids such as carbonate, bicarbonate, hydroxide, borates, silicates and phosphates contribute to the high buffering capacity or alkalinity of sea water. Alkalinities below 25 mg/L, such as $CaCO_3$, may lead to corrosive water when chlorination is practised. Low-alkalinity waters may also be difficult to stabilize by calcium carbonate saturation which would otherwise prevent corrosion. High-alkalinity waters may have a distinctly unpleasant taste (8).

Aluminium

The health aspects of aluminium in drinking water have recently been evaluated. A 7-day Suggested No Adverse Response Level (SNARL) was calculated to be 5.0 mg/L. This value exceeds the solubility of aluminium in non-acidic solutions. There are no adequate data from which to calculate a chronic SNARL (9). Aluminium has been associated with certain neurological disorders, such as dialysis dementia and Alzheimer's disease. It is not clear, however, whether the presence of aluminium causes such conditions or is simply an indicator of other factors. Discoloration of drinking water may occur at levels in the vicinity of 0.2 mg/L.

Ammonia

High concentrations of ammonia are indicative of pollution; for this reason recommendations have been made that ammonia nitrogen in public water supply sources not exceed 0.5 mg/L (8). The odour threshold for ammonia is reported to be 0.04 mg/L (7). There appear to be no toxic effects specifically due to ammonia concentrations that might occur in natural or polluted waters.

Boron

A maximum acceptable concentration of 5.0 mg/L has been proposed on the basis of health considerations (7). Boron is toxic to plants at levels of approximately 1 mg/L. Desalination processes must therefore reduce the level of boron if the product water is to be used for irrigation.

Bromine

Bromine is one of the major constituents in sea water, present at about 70 mg/L, and is commercially extracted from the sea. Data on toxicity are insufficient (10). The maximum acceptable daily intake (ADI) for total inorganic bromide is 1.0 mg/kg body weight (11). Using this figure and assuming a 70 kg/person, two litres water consumption and 1% intake from water, a guideline value of 0.35 mg/L can be calculated.

Bromine, like chlorine, reacts with ammonia and certain organic compounds to form bromamines and brominated organic compounds such as bromoform. Toxicity of these bromine-containing compounds is largely unknown.

Calcium

The recommended daily allowance for calcium ranges from 360 mg to 1200 mg depending on age, sex, pregnancy, lactation, etc. The taste threshold for calcium varies from 100-300 mg/L depending upon the anions present. Calcium is relatively non-toxic. The so-called "milk drinkers' syndrome" may occur when calcium is ingested in excess of 2000 mg/day (7). There are a number of studies which suggest that the hardness of water (which is mainly caused by calcium and magnesium) is inversely statistically associated with the incidence of certain cardiovascular diseases.

Chloride

Chloride is essential for maintaining proper fluid and electrolyte balance in the body. Recommended daily dietary intake of chloride varies from approximately 250 mg/day for infants to 5000 mg/day for adults. Taste threshold for chloride in drinking water is dependent upon the associated cation, but is usually in the range of 200 - 300 mg/L.

Copper

A daily copper intake of 2-3 mg has been recommended for adults. Based on toxicological considerations, a provisional maximum tolerable daily intake from all sources of 0.5 mg/kg body weight has been allocated (12). Assuming a 70 kg person, 2 litres water consumption and 10% intake from water, a value of 1.8 mg/L may be tolerated in drinking water. However, staining of laundry and plumbing fixtures occurs when copper concentrations exceed 1.0 mg/L. The taste threshold for copper is above 5.0 mg/L in drinking water and 2.6 mg/L in distilled water.

Hardness

Hardness is the sum of polyvalent metallic ions (Ca, Mg, Fe, Ba, Mn) and is usually expressed as equivalent concentration of $CaCO_3$ (soft waters about 60 mg/L; hard waters 180 mg/L.) Soft waters may cause corrosion of pipes, while hard water may cause incrustations. A hardness level of about 100 mg/L $CaCO_3$ is considered an acceptable balance. Water hardness greater than 500 mg/L is tolerated in many communities.

Magnesium

Recommended dietary allowances for magnesium range from 60 mg/day for infants to 450 mg/day for pregnant and lactating women. Magnesium salts have a laxative effect to which the body can, however, adapt. Some epidemiological studies indicate that the incidence of cardiovascular diseases is lower in areas where the magnesium levels in drinking water are elevated. The taste threshold for magnesium is somewhat less than that for calcium.

Manganese

The intake of manganese estimated to be safe and adequate for adults is in the range of 2.5 to 5 mg/day. There is no evidence of toxicity in individuals consuming high-manganese diets resulting in intakes of 8-9 mg/day (13). At concentrations greater than 0.15 mg/L, manganese stains plumbing fixtures and laundry and imparts an undesirable taste to beverages.

Petroleum Products

An extensive review of the health aspects of contamination of drinking water by crude oil or refined petroleum products has been carried out (9). It was concluded that:

> "... one may estimate the toxicity of drinking water contaminated by a crude oil or a refined petroleum solvent on the basis of its benzene and toluene contents. However, such estimates must be regarded only as approximations. More precise estimates of risk can be made only after there have been much more detailed and thorough evaluations of acute and chronic toxicities of all the thousands of chemicals present in crude and refine petroleum products, singly and in combination. There are obviously still many unknown factors associated with the toxicity of petroleum" (10).

Volatile components of petroleum products may be present in desalinated water and are perhaps a priority item in evaluating the health aspects of desalinated water.

Potassium

Estimated adequate and safe intake for potassium ranges from 350 mg/day for infants to 5600 mg/day for adults. Food is a good source of potassium and deficiences seldom occur under ordinary circumstances.

Sodium

Sodium plays an important part in the regulation of body fluids. A daily sodium intake in the reange of 1600-9600 mg is generally considered to have no adverse effect on the health of normal individuals. There are some studies that show a positive correlation between sodium intake and hypertension in man and others that do not. The taste threshold for sodium in water varies from 20 to 420 mg per litre, depending on the associated anion and the temperature. To ensure that drinking water is tasteless to the majority of the consumers, the salt composition in the water should approximate the salt content of saliva. The average sodium content of saliva is 300 mg/L but may well exceed this value by a factor of two.

Sulfate

The taste threshold for sulfates varies from 200-500 mg/L, according to the associated cation. A laxative effect is noted at approximately 700 mg/L and is enhanced in the presence of magnesium. However, with time, humans can adapt to higher concentrations of sulfate in their drinking water.

High sulfate concentrations in water may contribute to the corrosion of metals in the distribution system, particularly for water having low alkalinity.

Total Dissolved Solids (TDS)

Dissolved solids in sea water consist mainly of chloride, sodium, sulfate, magnesium, calcium, potassium, carbonate and bromide. Excessive dissolved solids in drinking water are aesthetically and/or physiologically harmful and may lead to corrosion or incrustation in water distribution systems. At concentrations greater than approximately 1200 mg/L the taste of water has been rated as unacceptable. Water with extremely low TDS may also be unacceptable because of its flat, insipid taste. There is no evidence of deleterious physiological effects occurring in persons consuming drinking water that has TDS levels in excess of 1000 mg/L.

Zinc

Recommended dietary allowances range from 3-25 mg/day for infants and lactating women respectively. Zinc has low toxicity when taken orally. A provisional maximum daily tolerable intake of 1 mg/kg body weight has been proposed (12). Water containing zinc in excess of 5 mg/L may appear opalescent and acquire an astringent taste.

III. ACCEPTANCE OF DESALINATED WATER

III-1. General

There is considerable concern that desalinated water is not readily accepted as drinking water in the Gulf region. People use it for watering of gardens, for car washing and general household purposes. For drinking, bottled water is preferred whenever people can afford it; the reasons are twofold:

i) the palatability of bottled as opposed to desalinated water is, rightly or wrongly, not considered to be inferior to that of "natural" water;

ii) desalinated water is blamed for certain health impairments, e.g. alopecia (baldness) and impotence, although there is no firm evidence that it causes these effects.

The quality of bottled water is difficult to monitor. Consumption of bottled water not only places an undue burden on those households which really are unable to afford it but still buy it out of health/ aesthetic considerations, but also on the economy as a whole.

III-2. Palatability

The palatability of water is a function of its taste, its temperature and any odour it may have. Taste is a function of the presence of inorganic parameters, for example magnesium, calcium, sodium, copper, iron and zinc at certain concentrations (2,3). Water odour is mainly due to the presence of certain organic substances (2,3).

Before desalination was introduced in any part of the Gulf region the sole source of drinking water was groundwater. Invariably, this groundwater was highly mineralized with a TDS content of 2000 mg/L or more being common. In contrast, desalinated water (even after remineralization) has a much lower mineral content, i.e. TDS being in the range of 200 to 700 mg/L. The change-over from groundwater to desalinated water as a source of drinking water requires some time for people to become accustomed to a new taste. Unfortunately this change process was hampered by a lack of stringent quality controls, leading to less than optimum aesthetic quality of desalinated water; these factors contributed to a general aversion toward desalinated water as a source of drinking water.

III-3. Health Effects

The situation is aggravated by a general belief that desalinated water has ill effects on people's health. These rumours have become intensified because of the aforementioned palatability problems.

There is no firm statistical evidence that a relationship exists between any of the complaints and the consumption of desalinated water; the Expert Group concluded too that there is no reason to believe that such a specific relationship exists. Poor water quality management and lack of public campaigning in favour of desalinated water have led to problems and misunderstandings; such problems have been highly exacerbated by the discoloration of desalinated water in many places, caused by corrosion.

IV. POTENTIALLY TOXIC CHEMICAL SUBSTANCES

In choosing the toxic substances for which Guideline Values for a range of drinking waters were to be recommended, the WHO task groups used information available on the frequency of occurrence and the concentrations and toxicities of a wide range of water contaminants (2). The amount of published information available on the detailed organic and inorganic composition of the product water from desalination plants is meagre; however, the possibility that potentially harmful substances are present cannot be ignored. Substances may be present in desalinated water that are not found in water derived from conventional sources; detailed analytical studies would be necessary to determine the nature and source of any trace inorganic and organic contaminants present in different types of desalinated water.

Even uncontamined sea water contains "natural" organic compounds, some of which may be volatile and therefore, at least theoretically, capable of contaminating the sea water distillate. The practice of chlorinating sea water at the intakes of desalination plants to control biological growth can also lead to the formation of volatile potentially carcinogenic haloforms. Because of the bromide concentration (60-80 mg/L) of sea water, bromine-substituted haloforms may be be present, together with chloroform for which a guideline value of 30 µg/L has been recommended (2). Elemental bromine may also possibly be formed and in theory could contaminate the distillate.

Petroleum hydrocarbons constitute a group of common sea water conminants some of which could contaminate desalinated water. Many of these may render water undrinkable at concentrations well below those which might be associated with possible health effects; of particular concern, however, would be certain carcinogenic hydrocarbons such as benzene, the latter having a guideline value of only 10 µg/L (2).

The need for better information on the composition of desalinated water is evident.

V. ESSENTIAL ELEMENTS

During the process of developing Guidelines for Drinking Water Quality (2,3) it was felt that it would be too difficult to set minimal levels for certain beneficial constituents of drinking water, taking account of the relative intakes from food and water. Guideline Values (i.e. upper limit values) were recommended for several inorganic constituents which were recognized as essential in human nutrition, but no attempt was made to define a minimum desirable concentration such substances in drinking water.

Several elements are believed to be essential in human and/or animal nutrition. These are arsenic, calcium, chloride, cobalt, copper, chromium, fluoride, iodine, iron, magnesium, mangenese, molybdenum, nickel, potassium, phosphorus, selenium, silicon, tin, vanadium and zinc. It is probable that other elements will be added to the essential list in future as further studies are carried out.

Estimates of dietary requirements for several of these elements have been made (6). It cannot be too strongly emphasized that there is no single minimum dietary requirement of an essential element (13). There is a series of such minimum requirements depending upon the population group (infants, children, adults) age within a population group (infants 0-0.5 yr; 0.5-1 yr), sex, physical activity (active, sedentary), physiological status (pregnant, lactating), nature of the whole diet, intake from sources other than food, such as air and water, and occupational exposure.

The type of diet ingested strongly influences the amount of essential element available for absorption. Furthermore, availability for absorption is expected to differ markedly between food and water; it is likely that a number of elements are more freely bio-available in water compared with the complex forms existing in certain foods. Lack of knowledge of the bio-availability of some essential elements in various foods and drinking water would make it difficult to estimate required levels of essential elements in drinking water.

There are large variations in the amounts of water consumed between population groups and individuals within a population group, as well as day-to-day variations for an individual; this can be particularly marked in the Gulf region when contrasting, say, the very hot outdoor environment for labourers, with that of workers in air-conditioned offices. In arriving at Guideline Values for various substances in water (2), the assumption was made that the daily per caput consumption was 2 litres of water. However, it was further recognized that variations in local or climatic conditions need to be taken into account when developing national drinking water standards based on the Guidelines. Within the Eastern Mediterranean Region, large departures from the 2-litres consumption figure may be expected. This will further complicate any attempt to set minimum levels of essential elements in water because of considerable uncertainties regarding the actual amount of water consumed.

All essential elements become toxic when the intake exceeds certain levels. For certain substances, the marging between the level for beneficial and for toxic effects is rather small and variability within a population may lead to excessive exposure and potential adverse health effects.

VI. HARDNESS AND CARDIOVASCULAR DISEASES

Over the past 20 years the inverse statistical relationship observed in many countries between hardness of drinking water and cardiovascular (CV) disease has been the subject of considerable research (Commission of the European Communities, 1976; US National Academy of Geochemistry, 1979). Despite some conflicting results, most large-scale studies indicate a negative statistical association between water hardness and cardiovascular mortality. The precise nature of the association remains uncertain and it is not clear whether the "water factor", if one exists at all, is something protective in hard water or something harmful in soft water. The evidence so far available does not justify introducing at the present time specific water treatment such as water hardening aimed at reducing the risk of CV disease.

In considering the implications of these studies for desalination practice, it must be emphasized that virtually all of the work undertaken so far has involved studies of populations that, in socio-economic, dietary and many other aspects, are different from those consuming desalinated water in the Middle East. The feasibility of comparing CV morbidity and mortality in population groups in this Region drinking different types of water could perhaps be considered. Changes in water quality, particularly those brought about by the the introduction of desalination processes, may afford opportunities for studying the population before, during and after such changes; any such study could be enhanced particularly if coupled with information on drinking water habits. The present uncertainty about this matter is reflected in the WHO Guidelines for Drinking Water Quality where no recommendation on the restriction of softening orthe maintenance of a minimum residual calcium or magnesium level is warranted at present on the basis of health considerations.

VII. SODIUM AND HYPERTENSIVE DISEASES

The prevalence of arterial hypertension/hypertensive diseases is not accurately known in some of the Gulf countries. As far as is known, no studies correlating hypertension with the consumption of desalinated water have been carried out there.

Despite several investigations suggesting that a high daily sodium intake has an impact upon the frequency of hypertension of the population, other studies have not shown such a correlation (14).

Normally sodium intake in drinking water constitutes only a minor part of the total daily intake. However, even with a relatively low sodium content in the consumer's water, the daily intake through water could be of importance in areas with a hot climate associated with high fluid intakes; the sodium intake by bottle-fed infants could also perhaps be significant under these conditions.

Sodium in desalinated water may stem from chemicals added after treatment or may originate from water (brackish water, groundwater or sea water) used for blending with deslinated water.

VIII. KIDNEY DISEASES

The prevalence of kidney stones and/or other types of kidney disorders is not accurately known in most Gulf countries.

Studies have shown the frequency of kidney diseases and the number of patients with kidney stones to be high in an area of Saudi Arabia, supplied with groundwater. Information on the prevalence of these disorders in areas where desalinated water is used as drinking water is sparse and needs further clarification.

IX. FLUORIDE AND DENTAL HEALTH

The role of fluoride in reducing the incidence of dental caries is well-known. Once fluoride is incorporated into teeth, it reduces the solubility of the enamel under acidic conditions, thus giving protection against dental caries. Frequent or continuous exposure of teeth to fluoride ions is considered beneficial in enhancing this protection, possibly acting by direct absorption of such ions into the enamel structure. The presence of fluoride in drinking water may be important in this context, even if the normal diet in a particular area contains adequate fluoride. Virtually all foodstuffs contain at least traces of fluoride; however, depending on the source of drinking water it may represent the main source of intake of fluoride. It is accepted that fluoride levels of approximately 1/mg/L water are safe in relation to the fluoridation of water supplies; the exact concentration depends on the ambient temperature (3). At this level, drinking water may be contributing approximately 50% of the daily dietary intake of fluoride in adults. Mottling of teeth and skeletal fluorosis are caused by higher intakes.

Data presented by participating countries indicate that potable waters produced from desalination plants are either devoid of any significant amounts of fluoride or well below desired levels. As far as is known, none of the participating countries currently carry out fluoridation of water. Fluoridation facilities are provided in all desalination plants in Kuwait and fluoridation was carried out in that country between 1967 and 1981. Fluoridation has since been suspended because of growing controversy over the actual dosing requirements, taking into consideration fluoride intake from other sources and selection of the fluoride compound for dosing. Statistics on dental health are not readily available from participating countries. In view of the normally very low levels of fluoride in desalinated water, consideration of the direct addition of fluoride to this type of water should possibly always be borne in mind.

X. QUALITY GUIDELINES

The newly issued WHO Guidelines for Drinking Water Quality (2) are intended for use by countries as a basis for the development of drinking water standards which, if properly implemented, will ensure the safety of supplies. The Guidelines describe the quality of water that is suitable for human consumption and for all other usual domestic purposes, including food formulation and preparation. Based on toxicological and epidemiological data, or aesthetic considerations, guideline values (as upper limits) have been recommended for various chemicals in drinking water (2); minimum levels in the case of essential elements for water potability reasons have not been defined by WHO.

During the development of the WHO Guidelines, the subject of water treatment and construction materials was considered. The conclusion reached was that chemicals used in potable water treatment are not usually a significant source of contamination (4). Furthermore, it was felt that any toxic chemicals in drinking water that are derived from treatment chemicals or construction materials used in water supply systems may be more appropriately controlled by product specifications then by the setting of a guideline value in drinking water. Even so, the guideline values (GV) recommended by WHO may be used to derive limits for impurities in water treatment chemicals (4). Using the approach adopted by the US National Research Council (15), a recommended maximum impurity content (RMIC) in the additive is calculated by using the following equation:

$$\text{RMIC (mg/kg)} = \frac{\text{GV (mg/L)} \times 10^6}{\text{MD (mg/L)} \times \text{SF}}$$

where MD is the maximum dosage for the water treatment chemical and a safety factor (SF) of 10 is judged as reasonable to limit to 10% of a given guideline value the contribution of a given impurity in a water treatment chemical.

XI. CONCLUSIONS

The accurate assessment of the health aspects of the long-term use of desalinated water is hampered by the lack of information on the chemical quality of the water produced from different desalination processes, the specification and bio-availability of elements in the water, and the nature and reaction of products of organic compounds that may accumulate in the product water. Additionally, water desalination practices and construction materials may possibly introduce chemicals of unknown toxicity into the water.

Desalinated water is usually unpalatable and corrosive. Long-term use of normal desalinated water would require adjustment of its mineral composition.

A variety of chemicals in desalination plants is used for scale control and removal, and for foam and corrosion control. All of these chemicals, and any coatings used and materials utilized for construction, may contaminate the product water.

Petroleum products (crude and refined) are a common source of contaminants in sea water. Volatile organic fractions of such petroleum products are likely to be found in the product water. The nature and toxicity of these chemicals and reaction products (for example those with chlorine, bromine or iodine) are largely unknown.

XII. RECOMMENDATIONS

XII-1. Chemicals

Some concern has been expressed about certain chemicals, additives, scale inhibitors, anti-foaming agents, etc., which are offered by chemical companies for use in processing desalinated water for drinking purposes.

In most cases, when purchasing these chemicals, reliable information regarding toxicity or otherwise, stability and suitability is not provided. Evidence produced by the manufacturers or distributors is not always reliable.

As a matter of urgency it is recommended that some appropriate means be found for obtaining more reliable information related to the suitability of such chemicals in desalination processes.

XII-2. Water Quality

It is difficult to recommend minimum levels of essential minerals in drinking water for the following reasons:

a) required daily mineral intakes vary markedly with the type of consumer (children, adults etc.);

b) intake from food varies with the nature of the diet;

c) intake from water will depend on the amount of water consumed which varies significantly between different populations and individuals;

d) lack of knowledge of the bio-availability of essential elements in water compared to food; and

e) inaccuracies which may arise when attempting to estimate minimum required mineral levels contributed by drinking water since the margin between levels of elements that are beneficial (i.e. essential) and those that could be harmful may be rather small (13).

For these reasons, no recommendations for minimum desirable levels of essential minerals or elements in drinking water can be made at present.

The quality of desalinated water should be kept under continual surveillance as there is a need for detailed information on the nature and source of any trace inorganic and organic contaminants present in different types of desalinated water, as well as on the processed water at different stages of the desalination process.

More accurate and reliable information should be obtained on the drinking water consumption habits of the relevant population so that a better assessment of exposure can be made.

A public information campaign could be mounted to provide reassurance as to the acceptability of desalinated water from a health standpoint.

Desalinated water is deficient in fluoride and in certain situations the fluoridation of drinking water would be beneficial to dental health.

XII-3. Health Aspects

There is no evidence at present of any adverse health effects due to consumption of desalinated water. However, should the need arise, the technology of the production of desalinated water is sufficiently flexible to provide any necessary modifications in the composition of the drinking water supplied for health or indeed aesthetic reasons.

Statistical data for cardiovascular, hypertensive and renal diseases as well as for kidney stones are limited in the Region; the feasibility of carrying out epidemiological studies in relation to water quality could perhaps be considered.

Comparative surveys of population groups, supplied with desalinated water and water from conventional sources, could be considered for evaluating possible effects on human health of drinking desalinated water.

XII-4. Corrosion

Desalinated water, especially before blending, has a slight buffer capacity and tends to be corrosive, resulting often in poor aesthetic quality of tap water. The problem is closely connected with the stabilization/conditioning of the product water through the addition of chemicals. It is recommended that total alkalinity and calcium content of the water be increased to ensure formation of protective coatings.

XII-5. Analytical problems

Desalinated water may contain impurities in minute concentrations. Determination of these low levels necessitates the availability of at least one central analytical chemical laboratory to carry out the required analyses. Such a laboratory could also be of value in testing and evaluating chemicals and materials used in the production of drinking water.

The following analytical equipment should be available:

- pH meter
- Conductivity meter
- Gas chromatograph
- Atomic absorption spectrophotometer
- Infra-red spectrophotometer
- Ultra-violet spectrophotometer
- Ion selective electrodes
- Autoanalyser

Currently available analytical methods yield reliable results in the mg/L range and when extraction-concentration is carried out their usefulness extends to the upper part of the µg/L range. In the lower scale of the µg/L range and below, no dependable procedures and techniques have hitherto been devised.

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ANNEX I

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ANNEX II

Guideline Values (GV), mg/L, and Recommended Dietary Intakes for Adults mg/day

Approximate Concentrations of Substances in Sea Water, mg/L

	Sea water, mg/L	GV, mg/L	Diet, mg/day
Cl	20,000	250	1,700-5,100
Na	10,000	200	1,100-3,300
SO_4	3,000	400	
Mg	1,000	-	300-350
Ca	400	-	800
K	400	-	1,875-5,625
CO_3+HCO_3	130	-	-
Br	70	-	-
Sr	15	-	-
B	5	-	-
Al	1.9	0.2	-
F	1.4	1.5	1.5-4
SiO_2	1.3	-	-
N-Compds.	0.9	10(NO_3-N)	-
Li	0.1	-	-
P	0.08-	-	800-
Fe	0.06	0.3	10-18
I	0.5	-	0.15
Ba	0.05	-	-
As	0.02	0.05	-
Rb	0.02	-	-
Cu	0.01	1.0	2-3
Zn	0.01	5.0	15
Mn	0.01	0.1	2.5-5
Pb	0.005	0.05	-
Se	0.004	0.01	0.05-0.2
Sn	0.004	-	-
Cs,U	0.002	-	-
Mo	0.0005	-	0.15-0.5
Ni	0.0005	-	-
Ga,Th	0.0005	-	-
Ce,Sc,La,Y,Ag	0.0005	-	-
Bi,Co,Au,Ra	0.0005	-	-
Hg	0.0005	0.001	-
V	0.0005	-	-
Cd	0.0005	0.005	-
Cr	0.0005	0.05	0.05-0.2