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Toxicology Newsletter is an up-dated information collection for the healthcare practitioner that intended to enhance knowledge, stimulate research and promote better management of patients with poisoning. The newsletter also publishes clinically relevant review articles, letters to the editor and commentaries. Themes covers are of interest to clinicians, researchers, epidemiologists and other health care professionals.

Health Risks of Drinking Demineralized Water

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Introduction

The composition of water varies widely with local geological conditions. Neither groundwater nor surface water has ever been chemically pure water, since water contains small amounts of gases, minerals and organic matter of natural origin.

The knowledge that water may contain some constituents that are undesirable is the point of departure for establishing guidelines and regulations for drinking water quality. Maximum acceptable concentrations of inorganic and organic substances and microorganisms have been established internationally and in many countries to assure the safety of drinking water. The potential effects of totally unmineralized water had not generally been considered, since this water is not found in nature except possibly for rainwater and naturally formed ice. Although rainwater and ice are not used as community drinking water sources in industrialized countries where drinking water regulations were developed, they are used by individuals in some locations. In addition, many natural waters are low in many minerals or soft, and hard waters are often artificially softened (1).

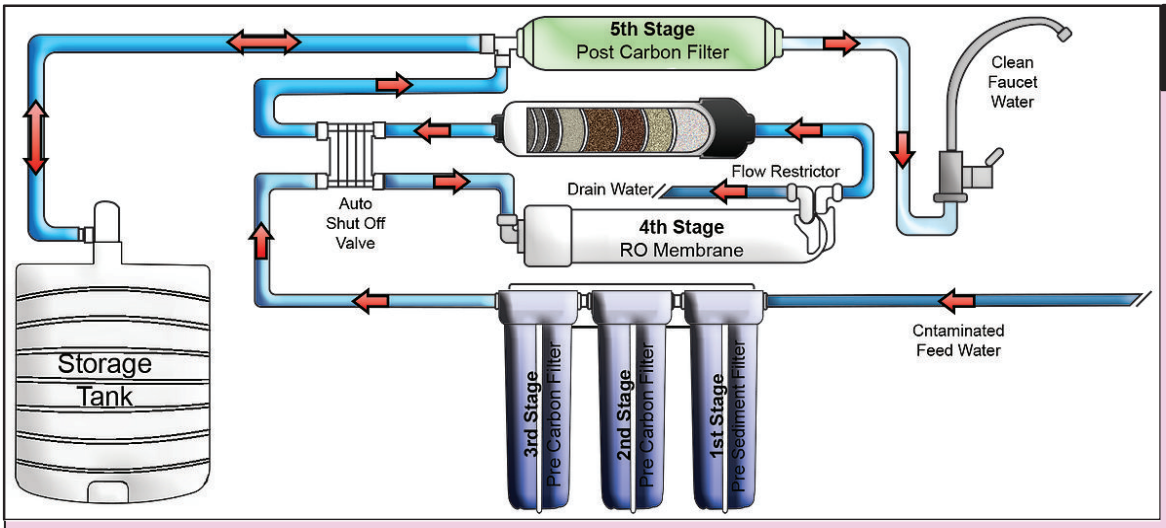
Artificially-produced demineralized waters, first distilled water and later also deionized or reverse osmosis-treated water, had been used mainly for industrial, technical and laboratory purposes. These technologies became more extensively applied in drinking water treatment in the 1960's as limited drinking water sources in some coastal and inland arid areas could not meet the increasing water demands resulting from increasing populations, higher living standards, development of industry, and mass tourism. Demineralization of water was needed where the primary or the only abundant water source available was highly mineralized brackish water or sea water. Drinking water supply was also of concern to ocean-going ships, and spaceships as well. Initially, these water treatment methods were not used elsewhere since they were technically exacting and costly.

Demineralized water is defined as water almost or completely free of dissolved minerals as a result of distillation, deionization, membrane filtration (reverse osmosis or nanofiltration), electrodialysis or other technology. The total dissolved solids (TDS) in such water can vary but TDS could be as low as 1 mg/L. Actually, desalinated or demineralized water without further enrichment with some minerals might not be fully appropriate for consumption. **There were three reasons for this:**

• Demineralized water is highly aggressive and if untreated, its distribution through pipes and storage tanks would not be possible. The aggressive water attacks the water distribution piping and leaches metals and other materials from the pipes and associated plumbing materials.

• Distilled water has poor taste characteristics.

• Preliminary evidence was available that some substances present in natural water could have beneficial effects on human health.



Reverse Osmosis

Reverse osmosis is the process of forcing a solvent from a region of high solute concentration through a semipermeable membrane to a region of low solute concentration by applying a pressure in excess of the osmotic pressure. The largest and most important application of reverse osmosis is the separation of pure water from seawater and brackish waters (desalination); seawater or brackish water is pressurized against one surface of the membrane, causing transport of salt-depleted water across the membrane and emergence of potable drinking water from the low-pressure side. Since the early 1970s, reverse osmosis has been used to purify fresh water for medical, industrial, and domestic applications (2).

Reverse osmosis not only removes harmful contaminants present in the water, but it also may remove many of the desirable minerals from the water. Thus, recent developmental work has focused on integrating reverse osmosis with electrodialysis to improve recovery of valuable deionized products. In the production of drinking water, the latest developments include nanoscale and graphene membranes.

The potential for adverse health effects from long term consumption of demineralized water is of interest not only in countries lacking adequate fresh water, but also in countries where some types of home water treatment systems are widely used or where some types of bottled water are consumed. Some natural mineral waters, in particular glacial mineral waters, are low in TDS (less than 50 mg/l) and in some countries, even distilled bottled water has been supplied for drinking purposes. Thus, persons consuming certain types of water may not be receiving the additional minerals that would be present in more highly mineralized waters. Consequently, the exposures and risks should be considered not only at the community level, but also at the individual or family level (1).

The possible adverse consequences of demineralized / low mineral content water consumption:

1. Direct effects on the intestinal mucous membrane, metabolism and mineral homeostasis or other body functions.

-Distilled and low mineral content water (TDS < 50 mg/L) can have negative taste characteristics to which the consumer may adapt with time. This water is also reported to be less thirst quenching.

It has been adequately demonstrated that consuming water of low mineral content has a negative effect on homeostasis mechanisms, compromising the mineral and water metabolism in the body.

This imbalance increases urine output (and thus the additional loss of calcium, magnesium, potassium, and chloride ions), changes the balance of minerals and water inside and outside cell membranes, and affects hormones that are key to the managing of body water balance.

When demineralized water is consumed, our intestines have to add electrolytes to this water first, pulling them from body reserves. This leads to the dilution of electrolytes and insufficient body

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water redistribution which may compromise the function of vital organs.

At the early stages of this condition, symptoms may include fatigue, headaches, weakness, as well as muscle cramps and even heart rate abnormalities.

2. Little or no intake of calcium and magnesium from low-mineral water.

-Even though food is a much richer source of calcium and magnesium intake than water, demineralized water can significantly affect the balance of these key minerals in the body. One of the reasons for this is because "the elements are usually present in water as free ions and, therefore, are more readily absorbed from water compared to food where they are mostly bound to other substances" (3).

Many studies throughout the world have reported that people who consume water that is low in calcium and magnesium (i.e., soft water) is tied to higher incidence of death from cardiovascular disease compared to those drinking regular water (4).

Recent studies also suggest that the intake of soft water may be associated with a higher risk of fracture in children and decreased bone density in adults (5).

3. Low intake of other essential elements and microelements.

-The modern diet of many people may not be an adequate source of minerals and microelements. In the case of borderline deficiency of a given element, even the relatively low intake of the element with drinking water may play a relevant protective role. This is because the elements are usually present in water as free ions and therefore, are more readily absorbed from water compared to food where they are mostly bound to other substances.

According to World Health Organization recommendations for **Magnesium** have been put at a minimum of 10 mg/L with 20–30 mg/L optimum; for **Calcium** a 20 mg/L minimum and a 40–80 mg/L optimum, and a **total water hardness** (adding magnesium and calcium) of 2–4 mmol/L. At water hardness above 5 mmol/L, higher incidences of gallstones, kidney stones, urinary stones, arthrosis, and arthropathies have been observed. For **Fluoride**, the concentration recommended for dental health is 0.5–1.0 mg/L, with a maximum guideline value of 1.5 mg/L to avoid dental fluorosis.

4. Loss of calcium, magnesium and other essential elements in prepared food.

- When used for cooking, soft water was found to cause substantial losses of all essential elements from food (vegetables, meat, cereals). Such losses may reach up to 60 % for magnesium and calcium or even more for some other microelements (e.g., copper 66 %, manganese 70 %, cobalt 86 %). In contrast, when hard water is used for cooking, the loss of these elements is much lower, and in some cases, an even higher calcium content was reported in food as a result of cooking.

5. Possible increased dietary intake of toxic metals.

Some places in Sri Lanka to measure mineral content of water

- Sri Lanka standard Institution
- Industrial Technology Institute
- Government Analyst's Department
- Colombo Municipal Council's Microbiology and City Analyst Laboratory

- Since low mineral water is unstable, it is highly corrosive. It will much more likely absorb metals and organic substances from pipes, tanks and other water holdings. In addition, calcium and magnesium in food and water, help to prevent the absorption of heavy metals from the intestines into the blood. In general, people who drink low mineral water may be at higher risk of exposure to toxic metals compared to those who drink mineral water.

Accordingly, drinking water that contains little or no essential minerals has been associated with various health risks related to water and mineral imbalance, increased risk of fractures in children and decalcification of bone in adults.

It is also related to high blood pressure and heart disease, gastric and duodenal ulcers, pregnancy complications, thyroid issues, muscle cramps and weakness, fatigue, and several complications with newborns and infants (5) (6).

Drinking water should contain at least minimal levels of essential minerals and other natural substances. Several researchers have recommended a minimum of 20 mg/l of calcium and 10 mg/l of magnesium in drinking water.

"Demineralized water that has not been remineralized is not considered ideal drinking water," according to the WHO, and "therefore, its regular consumption may not be providing adequate levels of some beneficial nutrients."

Usually, demineralized waters are further treated by adding chemical constituents such as calcium carbonate or limestone, or blended with small volumes of more

mineral-rich waters to improve their taste and reduce their aggressiveness to the distribution network as well as plumbing materials. However, desalinated waters may vary widely in composition, especially in terms of the minimum TDS content (7).

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