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Water pollution and human health



Water is said to be the most common but the least understood solvent. It has unique physical and chemical properties which have allowed life to evolve in it. To quote Szent-Gyorgyi (ref.1) "That water functions in a variety of ways within a cell can not be disputed. Life originated in water, is thriving in water, water being its solvent and medium. It is the matrix of life". All biological reactions occur in water and that being so, pollution of water becomes significant only when it affects living or biological systems. Generally, the reference point for identifying and assessing pollution is the impact it has on human interests, the most important of these being health.

The primary area of concern over the years about water contamination and its ecological ramification has been the transmission of disease via the water route. Increasing developmental activities, both agricultural and industrial, though imperative for improving the quality of human life have added to the water contamination problems. Some of these activities merely increase the levels of contaminants already existing in water through natural processes, others generate pollutants of a new kind which normally do not exist in nature. The latter are more hazardous to human health since the biological adaptations against them have not been developed (ref.2).

The most common but the most significant aspect of water vis-a-vis human health is the drinking water, which is one of the most important elements of human nutrition, whether consumed directly or through food and beverages. Drinking water characteristics vary regionally because of varying surface and ground water qualities and attempts have been made in recent years to investigate whether they can be correlated with regional differences in morbidity and mortality (ref.3). Apart from the incidence of water borne diseases like diarrhoea, jaundice, typhoid, dysentery, cholera etc., epidemiological studies have helped in understanding the correlations between drinking water quality and a variety of diseases such as cardiovascular and circulatory system problems, dental and skeletal fluorosis, goiter formation, nitrate toxicity including

methemoglobinemia and so on. There is even evidence to suggest that lead contamination from the pipes carrying drinking water may increase blood-lead levels and this may cause physiological problems like aggressiveness and delinquency (ref.4).

Many epidemiological studies have been conducted, particularly in USA and Britain, to investigate the correlation, if any, between drinking water characteristics and cardiovascular diseases. Schroeder *et al* (ref.5), in a comparison of 94 large cities in USA found confirmed correlations between potassium, sodium, other ions and arteriosclerotic heart diseases, but no association regarding hardness, calcium and magnesium. No association has been firmly established between region-wise mortality from heart diseases and water hardness. There are many factors which are indirectly related to water hardness, and in turn, could be related to regional differences in mortality and morbidity from cardiovascular diseases (ref.3).

Water hardness has also been investigated vis-a-vis diseases of the circulatory system and other health parameters but no statistically confirmed correlations have been established (ref.6). Soft water has been sometimes held responsible for high cardiovascular mortality because it often dissolves large amounts of metals, eg. cadmium, lead etc. from the supply pipes but this hypothesis is neither confirmed nor refuted. This confusing picture may be explained by the fact that water hardness is a sum parameter of water quality and does not take care of the presence of various individual ions which may be different in soft and hard waters and which may be contributing towards cardiovascular diseases (ref.3).

A contaminant of concern in drinking water is fluoride. This is one of the contaminants that occurs naturally in some surface and ground waters as well as has anthropogenic sources eg. aluminium industry, super phosphate manufacturing plants etc. Drinking water is the main source of supply for human fluoride consumption. Levels of 1-25 mg/l are common in many sources of drinking water in India (ref.7).

The daily fluoride intake with food by humans is approximately 0.2 to 0.5 mg. although the total intake may vary considerably depending on the individual food habits, water intake, the variations in fluoride concentration in drinking water and other food constituents (ref.3). At low concentration fluoride is beneficial to human health and reduces dental caries. Therefore, WHO recommended fluoridation of drinking water supply in 1969 and laid down a value of 1.5 mg/l above which mottling of teeth may occur. At 3-6mg/l, skeletal fluorosis may occur. It is estimated that 20 million individuals are at present suffering from this disease in India, particularly in those areas which do not get treated water supply. An equal number may be affected in later years because of the chronic intake (ref.7). This crippling disease mostly affects the vertebral column, pelvic girdle and ribs. Skeletal fluorosis is caused because of the antagonistic nature of fluoride in relation to calcium; it holds calcium as a complex, preventing or reducing its absorption into the human skeleton; similarly, as an antagonist of iodide, chronic absorption of fluoride may interfere with the physiological function of the thyroid gland and lead to goiter formation (ref.8). Persistent intake of fluorides over a number of years can adversely influence soft tissues as well, the most important manifestations being gastrointestinal, neuromuscular, respiratory and cardiovascular symptoms as well as allergic skin lesions (ref.9).

Drinking water is a natural carrier of iodide. WHO recommends a daily optimum iodide consumption of 150 to 200 µg. Lack of iodide impairs the production of the amino acid thyroxine in the thyroid gland which, in turn, leads to an increase in the level of thyroid stimulating hormone in the blood and growth of thyroid gland, i.e., goiter formation. Thus in goiter prone areas and there are many such areas in India - iodide may have to be added in drinking water. Since this would amount to forced medication, iodide is added to common salt as an option.

Nitrogen and nitrates provide good examples of complex interactions and pathways within the environment, apart from water pollution per se, which can affect human health. Normally the nitrate level of ground water is below 10 mg/l, but increasing amounts of organic refuse - both anthropogenic and natural - and nitrogen fertilisers from intensified agricultural practices have increased the nitrate levels in ground waters considerably (ref.10).

This would increasingly affect drinking water quality. For the total intake of nitrate, again drinking water plays a major role. Nitrate toxicity has been distinguished in three types, viz., primary toxicity, secondary toxicity, after its reduction to nitrite and tertiary toxicity, through formation of nitrosamines (ref.3).

Nitrate ion itself, in concentrations normally found in drinking water and food, does not pose a great threat to human health. However, intake of larger quantities of nitrate (> 2 g) and nitrate levels in drinking water above 10 mgN/l may cause concern. The deleterious effects on health are irritations of mucous membranes of stomach and intestines leading to vomiting, nausea and blood in stools (ref.11). WHO has established a tolerable daily intake of 5 mg. sodium nitrate per kg body weight, but has found no evidence of a relationship between gastric cancer and consumption of drinking water containing upto 10 mg N/l (ref.10). Nitrates have been held responsible by many researchers for having an effect on the cardiac functions of man and a recent study has indicated a correlation between high nitrate levels in drinking water and hypertension (ref.12).

Nitrite, which is the reduced form of nitrate and can be formed in zinc or iron pipes of the supply system or during the preparation of food and drinks with water possessing high nitrate content or with the help of the enzyme nitrate reductase and bacteria in the stomach, is more poisonous (ref.3). The manifestation of utmost concern is methemoglobinemia in infants leading to cyanosis, similar to carbon monoxide poisoning, or in more severe cases, even death. WHO had prepared an exhaustive report on the harmful effect of nitrate on infants (ref.13) and there are many investigations on methemoglobinemia reported in literature.

Apart from these, nitrate toxicity acts through the formation of nitrosamine compounds, a number of which are usually effective carcinogens and can be toxic, mutagenic and teratogenic also (ref.3). Nitrosamines are formed in the human stomach as the reactions are favoured by the pH range there, and may be responsible for gastric cancers. However, this has not yet been confirmed (ref.10). However, two case studies in Colombia and England show a direct correlation between nitrate in drinking water and incidence of stomach cancer (ref.14, 15).

There is another important group of water contaminants which affects human health and these are toxic heavy metals. Following increasing industrialisation and other activities involving metals, contamination of water by toxic heavy metals has assumed significant importance as most of the industrial effluents are discharged into surface waters. It has been established by experimental and clinical studies that long term or chronic exposure to low doses of metals, as for example, by intake of contaminated water can lead to more complex situations than the well established acute manifestations of metal poisoning. There is firm evidence to link five metals, viz, As, Cr, Ni, Be and Cd and their compounds to human cancer although many more compounds have been found to be carcinogenic in animal studies (ref.16). Of course, it has become now increasingly clear that one should not talk about carcinogenicity of metals but of some metal compounds and compounds of the same metal may highly differ in toxicokinetics and toxicodynamics; they may carry essentially different health risks (ref.17). It must be added here, however, that certain metals in trace quantities are essential for health and water is the main source for them. Also, there are modifiers which protect against the toxic effects of metals. Indeed, some of them are essential to a certain degree even for survival.

Health risks to man from water emanate not only from water borne diseases or ingestion of water contaminated in other ways, but also from amenity aspects like bathing or swimming in polluted waters as well as from waste and effluent reuse. The most important function of water treatment and supply is, of course, prevention of occurrence of water borne diseases. Public water supplies must obviously be safeguarded against any risk of exposure to harmful chemicals. Due to the complexities of various reactions and pathways of pollutants, the magnitude of immediate and long term health hazards posed by a particular quality of water cannot be fully assessed. The quality of water itself depends on so many local conditions, WHO has, therefore, been avoiding the use of the word "standard" in global terms and prescribing "guidelines" embodying microbiological, biological, inorganic, organic, radioactivity and organoleptic parameters. Increasing pollution of surface and ground waters by proliferation of chemicals, particularly synthetic organic compounds, over the years has also been given special attention in these guidelines. (ref.10). However, there is little information on potential mechanisms of infection or

minimum infective doses of various pollutants and intensive epidemiological studies are needed in these areas.

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