

The Multidisciplinary Approach to Water Quality Research

Abstract

Our earth is a water cooled planet. As a liquid, water exhibits some unique chemical and physical characteristics. Its remarkable ability to dissolve a very large array of inorganic and organic substances makes it a "universal solvent" with serious implications on contamination and pollution of the aquatic environment. Further, it transcends all spheres of the planet, and the complex interactions of the hydrosphere with the atmosphere, lithosphere and the biosphere helps in maintaining a dynamic equilibrium within the earth. It is the disturbance of this dynamic equilibrium, mainly by man, with his environmental polluting activities that results in serious global impacts, including human health. There is probably no scientific discipline that does not involve the study and impact of water on society. Religion, history and civilisation, public health and sanitation, town and country planning, agriculture and economics, war and other conflicts, hydropower and engineering, earth sciences and environment, chemistry and biology are among these subject areas. Clearly, a multidisciplinary approach is vital for any in-depth study of the role of water in society.

Introduction

Water is a unique substance. Because of its uniqueness, it is the subject of extensive and intensive research. Paradoxically, water is both an absolute necessity for life and a poison responsible for the deaths of millions of people the world over. Its uniqueness stems from the fact that as liquid water has many chemical and physical properties quite distinct from many other liquids. Its relatively high boiling point, the wide liquid range (0° - 100° C) existence in three physical

states, namely, solid ice, liquid water and gaseous water vapour, hydrogen bonds, bent shape and polarity, high dielectric constants are some of these unique features. The exceptional behaviour of water as a good solvent, capable of dissolving a variety of inorganic and organic compounds makes it highly vulnerable for contamination, and hence, its status as a ubiquitous poison. Clear water is, therefore, clearly the need of the masses, and water quality research ranks very high in earth science.

The World Health Organisation (WHO), having realised the impact of water quality on health, has introduced guidelines (WHO, 1963) for water, indicating the maximum and permissible levels of the parameters and substances that may be present in the water. At best, these values should only be used as guidelines, since the values may not be applicable to all countries, in view of the fact that the daily consumption of water in the different populations will be vastly different, and also, in view of a variety of other factors such as the health status, lack of essential nutrients among others. People living in tropical lands are particularly vulnerable to diseases caused by changes in water quality.

Very broadly from a human perspective, chemical elements are classified as essential and toxic. Element irons such as calcium, phosphorous, potassium among several others are considered essential for human physiology, while others such as lead, mercury, cadmium, arsenic are classified as toxic. However, it is vitally important to bear in mind that, it is the dosage that matters, and that even a so-called essential element can cause ill health due to the inordinate amounts consumed (Dissanayake, 2005) The element iron necessary for the

**Vidya Jyothi Prof.
C.B. Dissanayake**

*Director,
Institute of Fundamental Studies,
Kandy.*

production of the all important body substance haemoglobin, may cause a disease if consumed in excessive quantities. Further, it should also be remembered that, it is not the amount of the total element that matters, but the chemical species of the element causing toxicity. Hence, water quality research places strong emphasis on species determination.

Terrain Geochemistry

Water quality changes depending on the terrain. A study of the hydrological cycle (Figure 1) shows the close interaction of the hydrosphere with the lithosphere (rocks, minerals and soils) atmosphere and the biosphere. The quality of groundwater depends on the chemical composition of the rocks and soils with which the water is associated (water-rock interaction) the period of time during which the water-rock interaction takes place and the quality of any extraneous matter such as pollutants introduced into the groundwater system by man. The chemical composition of the rocks, minerals and the soils control, to a very large extent, the quality of the groundwater, and therefore, it is logical to assume that different terrain with varying rocks, minerals and soils will have different water qualities. For example, the water underlying the rocks strata of the Jaffna Peninsula will have high levels of calcium and magnesium owing to the abundance of their carbonates in the limestone-rich terrain. As against this, the water in the highly laterite-rich terrain in the south-western parts of Sri Lanka may have high iron contents in the water,

often imparting a poor taste to the water.

Problems of salinity, high dissolved solid contents, high fluoride levels, as observed in the dry zone of Sri Lanka, are closely linked to the terrain geochemistry and climate. The high salt contents in the groundwater of the dry zone are generally attributed to the accumulation of the dissolved salts getting concentrated due to the high rates of evaporation. By contrast, many elements are leached out from the rocks in the wet zone resulting in much lower dissolved solid contents. Further, the nature of the underlying rocks, their structures, fractures and fissures also play an important role in the quality of water deeper down. The higher fluoride levels in the dry zone water, notably in some tube wells, occur due to the chemical composition of the rocks, presence of fluoride-rich minerals, greater water-rock interactions and longer passage of water through the rock fissures. Groundwater in the Jaffna Peninsula, for example, tends to get contaminated quite easily from seepage of waste matter in septic pits and latrines through the cracks and crevices of the underlying limestones.

Industry and Water Quality

Dumping of waste matter, particularly the industrial effluent, is one of the most important causes of water pollution. A large array of chemicals from substances such as paint, diesel, engine oil and lubricants, pulp, agrochemicals, detergents among many others pollute the water. Kelani River, due to its passage through the industrial regions of the western province, receives a significant quantity of industrial effluent. The danger caused by such chemical pollution is that toxic elements such as cadmium, lead, mercury, chromium, etc. accumulate in the sediments, and these find their way into plants and through the food chain into the human body. Several years ago, a study carried out by the Department of Chemistry of the University of Kelaniya highlighted the anomalous concentrations of chromium in the 'Keera' plants on the banks of the Kelani River, presumably caused by waste from leather factories. Further, some chemicals have a long residence time, and these may remain in the groundwater for decades. The extreme demand for land for housing coupled with the neglect of environmental concerns often cause serious water pollution.

Stringent laws are, indeed, required for the prevention of dumping of toxic chemical into the aqueous environment. However, their implementation is emphatically more important.

Algal Blooms and Algal Toxins

Stagnant water bodies such as lakes, reservoirs and drinking water wells often acquire a green to brown and cloudy appearance due to the growth of algae. Indeed, some lakes such as the Beira Lake and the Kandy Lake, both located in an urban environment, turn dark green due to the profuse growth of algae, of which, there are several varieties as classified by microbiologists. These algae, after extensive growth and reproduction, die and accumulate at the bottom of these water bodies, thereby releasing toxins to the water. Some of these toxins cause diseases, affecting the skin, liver, brain and the kidney. The algal blooms are ubiquitous, and have become a major pollution threat, notably in the tropics and in places where nutrients accumulate in excessive amounts. When lakes become badly affected by such algal blooms, they are termed eutrophic as against the lakes which have clear water, and where sunlight penetrates deep, termed oligotrophic lakes.

The sudden appearance of large quantities of dead fish in a lake is, very often, due to the highly eutrophic nature of the lake concerned with the concomitant release of toxins that had made the water uninhabitable for the fish and other forms of fauna.

Interestingly, some microbiologists consider these algal toxins which find their way into the drinking water of people in the North Central regions of Sri Lanka to be the cause of the chronic kidney diseases now spreading fast. More research is needed in this regard, and algal toxins may prove to be potent disease-causing substances in

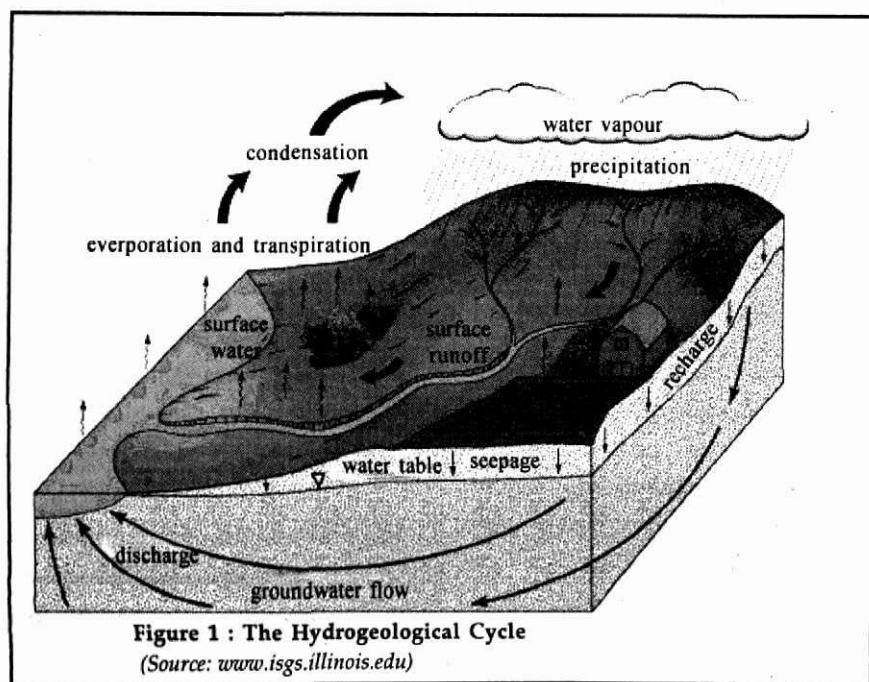


Figure 1 : The Hydrogeological Cycle
(Source: www.isgs.illinois.edu)

the disease-prone areas of North Central Province.

Agrochemicals and Fertiliser Inputs

In Sri Lanka, the agricultural sector uses the most amount of water. While the need for food production cannot be over emphasised, certain aspects in the agriculture sector is a matter of serious concern. Bearing in mind the extreme vulnerability of water to contamination and pollution, inputs from agrochemicals and fertiliser such as urea and phosphates do, indeed, cause significant damage to aquatic resources, mostly to groundwater.

The contamination of drinking water sources by potent agrochemicals, particularly those which have long residence times, poses a major health hazard. In the dry zone of Sri Lanka, where farming is the most dominant occupation, use of agrochemicals (haphazardly in most cases) is extremely common with the concomitant pollution of surface, ground and drinking water. Organophosphates are among the common compounds in these agrochemicals, and these are well known to cause a variety of neurological diseases.

Fertilisers, notably the phosphate types, carry a host of metals, among which, toxic elements such as cadmium, uranium and lead, are common. Even though some of them may be present in the original rocks, some others get introduced into the fertiliser material during the process of production. These are particularly common in some cheap imported phosphate fertilisers. The regular use of these poor-quality fertilisers in the paddy fields and other crops causes the accumulation of these toxic metals in the soils and water, thereby posing a major health hazard. In developed countries, all fertilisers used in plantations are subject to stringent regulations, and quality

Table 1 : Diseases and problems caused by organisms and chemical substances in water to humans

Causative item	Disease and problems
Bacteria	Typhoid, gastroenteritis, bacterial dysentery, cholera and tuberculosis
Virus	Poliomyelitis, meningitis, infectious hepatitis, respiratory diseases, diarrhoea and enteritis
Protozoa	Amoebic dysentery, diarrhoea and amoebic meningo encephalitis
Helminths	Hook worm, round worm, and threadworm infections
Fungi/algae	Colour, turbidity, taste, odour and toxins
Cadmium	Decalcification of the bones, protein and sugar in urine and kidney damage
Lead	Muscular paralysis, damage to nervous system, liver and kidney, lowered IQ, anaemia
Fluoride	Mottling of teeth (dental fluorosis), cracking of teeth and osteo fluorosis
Nitrate	Methaemoglobinaemia
Sulphate	Diarrhoea
Hydrogen sulphide	Taste and odour problems
Iron	Yellow colour, unpleasant taste and odour
Zinc	Unpleasant taste
Manganese	Unpleasant taste
Mercury	Affects kidney, nervous system, and causes brain damage
Chromium (hexavalent)	Kidney problem, lung cancer and skin diseases
Arsenic	Skin, bladder and lung cancer
Aluminium	Alzheimer (memory loss)
Pesticide	Kidney disease, reduced vision, joint pains and memory loss
Dissolved salts	Unpalatable if greater than 1200mg/ 1

Source: Sarath Amarasiri (2008).

control of fertilisers is a priority. In the case of nitrogen supplying fertilisers such as urea, the groundwater could easily get polluted with nitrates. In the Jaffna Peninsula and in the Kalpitiya regions, the underlying loose porous soils provide easy passage for nitrate-laden water which could enter drinking water wells.

Some diseases, notably bowel diseases, methaemoglobinaemia, and cancer are caused by nitrates through their reactions with other chemical species. From a public health point of view, there should be a safe distance between the septic outlets and drinking water sources such as dug wells. In the urban environment, faecal contamination is very often observed, and when

contaminated, water supplies could cause a series of diseases, including diarrhoea and hepatitis. Water quality should, therefore, be regularly tested for contamination. The WHO has given statistics pertaining to the impact of water-related and water-borne diseases on the global population.

- 1.8 million people die every year from diarrhoea diseases (including cholera); 90% are children under 5, mostly in developing countries.
- 88% of diarrhoea disease is attributed to unsafe water supply, inadequate sanitation and hygiene.

Contd. on page 22

- There are 396 million episodes of malaria every year, most of the disease burden is in Africa south of the Sahara.
- An estimated 160 million people are infected with schistosomiasis
- 500 million people are at risk from trachoma.
- 133 million people suffer from high intensity intestinal helminth infections, which often lead to severe consequences such as cognitive impairment, massive dysentery, or anaemia.
- Over 26 million people in China suffer from dental fluorosis due to elevated fluoride in their drinking water.

Pipe-borne water systems in Sri Lanka are still confined to the main cities. The majority of the population (approx. 70%) still depend on groundwater and surface water for their domestic requirements, the garden well being the commonest water source. Even though industrial contamination of

these rural water wells is very rare, some natural causes often render the water unsuitable for drinking. From among these, salinity, excess fluorides, excess total dissolved solids are the most important (Dissanayake and Weerasooriya, 1989). In the Jaffna Peninsula, excessive use of fresh water for irrigation causes an influx of brackish water thereby rendering the water unsuitable for drinking. Table 1 shows the types of diseases and problems caused by organisms and chemical substances in water to humans.

Conclusion

Water, due to its unique chemical and physical properties, dissolves many inorganic and organic substances, thereby, making it a 'Universal solvent'. It is, therefore, very easily contaminated. Due to the nature of planet earth, with its dynamic equilibrium between various spheres, water encompasses almost all disciplines. From among these, geology, chemistry, agriculture, medical science, industry, public health, town and country planning,

sociology, irrigation and power generation, engineering, microbiology, parasitology deal with various aspects of water. A multidisciplinary approach is, therefore, clearly required, and all stakeholders need to contribute their fair share of work aimed at keeping the environment clean and providing one of the most essential of all substance - pure water.

Acknowledgements :

Ms. Jeewa Kasthuri is thanked for typing the manuscript.

References :

- Amarasiri, Sarath (2008). *Caring for Water*. Publication of Sri Lanka Nature Forum. 160 pp.
- Dissanayake, C.B. (2005). *Of Stones and Health: Medical Geology in Sri Lanka*. Science Vol. 309, No.5736, pp. 883-885.
- Dissanayake, C.B. and Weerasooriya, S.V.R. (1989). *The Hydrogeochemical Atlas of Sri Lanka*. Publication of the Natural Resources Energy and Science Authority of Sri Lanka. 192 pp.
- W.H.O. (1963) *World Health Organization Guidelines for Drinking Water Quality*. WHO Geneva.