

groundwater supplies, adopting all practices to conserve water and adopting a scale of living in conformity with the dictates of nature. Drought-resistant quality of an area also depends upon the stability and the amount of its groundwater supplies.

Water, man's most precious and valuable natural resource is looked upon as a free and cheap commodity, which is being abused and wasted. One of the problems of water resource management includes the challenging situation of local people being called upon to govern their own affairs and to place upon them and their neighbours, restrictions and regulations, in order to preserve for the future some of the benefits that the present generation is enjoying. As the problem becomes acute, courage required to exercise the management authority increases. The authority should ban indiscriminate groundwater development by private agencies and by statute, prevent wastage and it should also have a hold over spacing of the well fields, developments, etc.

The conservation measures should include: (i) Minimizing the evaporation and transpiration losses; (ii) Lowering the water table in swampy and marshy places below the reach of the water-wasting plants; (iii) Increasing the energy charges for water consumption; (iv) Measures to reuse after recycling and treatment; (v) Advising irrigators to use water only as and when required.

Augmentation of the present supplies, recycling cleaned up sewage water and during peak monsoon period capture much of flood flow and runoff and store in artificial reservoirs. Though the drought condition has been mainly created by the

failure of monsoon, which is the main source of recharge for the surface water and groundwater resources, for a coastal city like Chennai, the effect of urbanization and population boom have also aggravated the water scarcity conditions. The water level has registered an all-time low and all the wells located in hard rock areas have dried up and in alluvial areas the water levels have gone too deep. The effect of urbanization is observed in increasing the size of impermeable areas with concrete cover and reducing areas for infiltration and percolation. In undisturbed condition in a coastal aquifer system, a delicate balance and hydraulic gradient exist between fresh water and salt water near the sea. Already over exploitation of groundwater in the coastal aquifer of south Chennai is causing concern regarding salt water intrusion in selected pockets. Through detailed geomorphological and geophysical investigations, the fresh water/salt water interface and zone of diffusion has to be identified on a detailed plan/map, in addition to demarcating principal intake areas (sand dunes, beach terraces, etc.) and discharge areas (creeks, backwaters, etc.). Only through legislation, ban and stringent punishment, can the problem be solved as water is a scarce commodity, in a fragile dynamic coastal environment.

The following measures can mitigate the problem to some extent:

1. Water should be declared an essential commodity just as items like rice, wheat, etc., given through public distribution system. As water is a precious and scarce commodity given by nature only during

monsoonal rains, an awareness should be created and thereby any misuse could be minimized.

2. Creating water banks (in the form of underground artificial storages and big containers) at important locations.
3. Cloud seeding operations to be carried out if the situation warrants and depending on the conditions in the catchment/reservoir areas.
4. Inferior quality water should be used for washing and domestic purposes.
5. Blending good quality with inferior quality depending upon the purpose of use and tolerance. For example, a good quality water with a Cl content of 50 ppm can be blended with inferior quality water of Cl content 250 ppm, depending on purpose of use.
6. The water supplies can be augmented through a battery of shallow dewatering filter points, collector wells and big diameter open wells of shallow depth, located in the sandy beach area in south and north Chennai.
7. Through various mass media, citizens are to be impressed upon the need to conserve water.
8. Rationing the water supply, till the situation improves.
9. Indiscriminate use of water for gardening purpose has to be curtailed.
10. The last resort will be to desalinate the sea water.

R. SRINIVASAN

*Department of Applied Geology,
University of Madras,
Guindy Campus,
Chennai 600 025, India
e-mail: geosree_99@yahoo.com*

Importance of environmental science: Medical geology

The tremendous progress in every sphere of science and technology has led ultimately to environmental impact resulting in extreme unhygienic conditions modifying our living environment. Environmental disturbances in the aquatic ecosystem against the backdrop of rapid population growth, uncontrolled urbanization and unregulated industrialization are mainly reflected by changes in the chemical element concentration patterns¹. Environmental degradation by trace metal

accumulation in eco-friendly aquatic systems caused by overexploitation of resource materials and human imposed inter-actions are the few unending problems encountered², which threaten the very basic economy of a nation and individuals by affecting both the progress of the nation as well as the health of human beings.

Environmental availability is important for the biological use of chemical elements³. Our health and wellbeing depends, primarily, on the intake of acceptable,

allowable chemical elements. The basis of life depends on the biological structures forming the fundamental units involving metals, which are associated with a wide range of proteins and enzymes⁴. For example, arsenic is an essential nutrient, which has a physiological role in methionine metabolism. Enhanced intake of arsenic lowers methionine levels, which have been associated with increased cancer risk⁵. Likewise, higher concentration of mercury increases oxidative stress on

cells and cell membranes, effecting cell injury⁶. Hence, intake of excess inorganic elements eventually affects the tissues and organs of living organisms, including man.

Enrichment of harmful trace metals in rivers running through metropolitan cities and infiltration of these metals into the groundwater, which is normally consumed by the inhabitants in the area, have deleterious effects on the human system. Contamination of river Cooum, running through Chennai metropolis, influences the adjoining groundwater system with toxic heavy metals. A detailed survey conducted with a random selection of 100 individuals in different age groups from 33 clusters of slum settlements clearly indicated the abnormality in health due to over consumption of trace metals by using nearby polluted water sources⁷.

Of the six metals analysed (As, Hg, Se, Cd, Cu and Pb), arsenic and mercury impose health-related problems. An excess of arsenic (maximum of 7.5 mg/l in river water and 2.3 mg/l in groundwater) imparts diseases such as constriction of the throat, epigastric discomfort, abdominal pain and bronchopneumonia in the case of individuals aged above 50. Diarrhoea, vomiting, leukoderma, loss of hair and irritation of eyes are common in the age group of 30–35 years. For children, arsenic intake causes dermatitis and skin eruptions. Mercury toxicity (maximum of 1.6 mg/l in river water and 0.05 mg/l in groundwater) is noticed first in the hands and later in the tongue. Salivation, loss of teeth and psychic disturbances in the form of irritability are quite common. The nervous system is also affected causing drowsiness, headache and slurred speech.

In India, the surface water resources have already been exploited to the extent of 90% due to overgrowth of population and there is no surface water for future development; hence, demand for groundwater has increased several folds. The availability of groundwater for drinking in hard crystalline rocks is considered to be meagre because of their heterogeneous nature. High ionic concentrations of groundwater in hard rock areas impose health problems. Fluorine, the most active ele-

ment in the halogen group, is one of the dangerous anions in groundwater, particularly in hard rock areas. The fluoride content of hard rocks has been reported to range from 20 to 4500 mg/l, whereas sedimentary rocks contain between 80 and 450 mg/l of fluoride⁸. More than 75% of the fluoride is retained in the human body and incorporated into the dental and skeletal structures, the remaining amount staying in the soft tissues.

Fluorosis is now one of the major health problems due to excess of fluoride in drinking water. In India, fluorosis has been detected in several areas in the states of Andhra Pradesh, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu and Uttar Pradesh.

The high content (1.5–2.0 mg/l) of fluoride in groundwater causes dental mottling, crumbling and skeletal deformation⁹. The optimum fluoride concentration for reduction of dental caries is about 1 mg/l. Dental fluorosis affects the entire dental structure, resulting in intense pain and decay of teeth with chalky, friable nature. Skeletal fluorosis is formed due to higher content (> 3 mg/l) of fluoride in water and diet, and the symptoms are body pain, lethargy, tingling sensations, abdominal breathing and bending of bones hindering natural movements⁹.

There are several fluoride-affected areas in Tamil Nadu, notably Ayodhyapattanam (av. 3.2 mg/l) and its surrounding villages (Sengattur, 5.1 mg/l; Adimalaipudur, 7.0 mg/l; Achanguttapatty, 4.5 mg/l) and Attyampatty (max. 5.5 mg/l) in Salem district, and Mallasamudram village (max. 4.1 mg/l) in Namakkal district. The groundwater in most areas contains less than 1.5 mg/l of fluoride but, in some areas, the concentration reaches above 5 mg/l. Concentrations above 15 mg/l are also exceptional in Ayodhyapattanam and surrounding villages. The symptoms of severe skeletal fluorosis noticed in these areas are irregular periosteal bone formation, ectopic calcification, rough and accentuated muscular attachments, irregular exostoses, and hypercementosis of the roots of teeth and genu-valgum. Skeletal fluorosis affects the bones and ligaments of old people. In advanced cases, the vic-

tims exhibit excessive leanness and loss of appetite. They finally become immobile and bedridden.

The need of the hour is awareness to clean up the environment. But how? Every branch of science in its own right has to make an effort to minimize the basic problems that man is facing today. But regarding health, man is very much conscious. Hence, an impetus for developing environmental studies through 'medical geology', a fast-developing branch of science, should be given to solve the man-made intolerable disturbances on earth and create a better and more beautiful world to live in. Medical geology has come to the limelight very recently and only few studies have been undertaken. Hence, public health issues like fluorosis can be tackled if this area of study and research could be developed. This could solve a lot of public health issues related to environmental geoscience.

1. Lobinski, R., *Analyst*, 1995, **120**, 615–621.
2. Matin, M. A., *Trends. Anal. Chem.*, 1995, **14**, 468–473.
3. Williams, R. J. P., *Proc. R. Soc. London Ser. B*, 1981, **213**, 361–397.
4. Sanz-Medel, A., *Analyst*, 1995, **120** 799–821.
5. Uthus, E. O., *Environ. Geochem. Health*, 1992, **14**, 55–58.
6. Peraza, M. A., Ayala-Fierro, F., Barber, D. S., Casarez, E. and Rael, L. T., *Environ. Health Perspect.*, 1998, **106**, 203–216.
7. Selvaraj, K., Jonathan, M. P. and Ram Mohan, V., *Eng. Geol. Environ.*, 1997, 2161–2165.
8. Jain, C. K., Imran Ali and Sharma, M. K., *Indian J. Environ. Protec.*, 1998, **19**, 260–266.
9. Chari, K. V. R. and Naidu, S. V. P., *Environ. Geochem.*, 1998, **1**, 63–66.

K. SELVARAJ

*Department of Geology,
School of Earth and Atmospheric Sciences,
University of Madras,
A.C. College Campus,
Chennai 600 025, India*