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HYDROCHEMICAL EVALUATION OF THE GROUNDWATER QUALITY IN CHENNAI CITY

S. Damodhar Kumar, A. Loganayagi and S. Murugesan*
P.G. and Research Department of Chemistry, Pachaiyappa's College, Chennai-600 030, T.N.
*P.G. and Research Department of Plant Biology and Biotechnology, Unit of Environmental Biotechnology, Pachaiyappa's College, Chennai-600 030, T.N.

ABSTRACT

The paper deals with physico-chemical analysis of groundwater of Chennai city. The analysis of groundwater was carried out to examine its suitability for drinking purposes. The data generated were compared with reference to BIS and WHO standards. It was found that some of the physico-chemical parameters were within the maximum permissible limits of drinking water standards. The study also reveals that the groundwater of the area is very hard, which was determined by carbonate and bicarbonates ions with calcium and magnesium.

INTRODUCTION

Water is a renewable natural resource essential for all life sustaining systems on the earth. Majority of water available on earth is saline in nature; only a small quantity exists as freshwater. Freshwater becomes a scarce commodity due to overexploitation and pollution of water. Increasing population and its necessities healed to the deterioration of surface and subsurface water. The causative factors for the pollution of water are industries, agriculture and domestic activities. To quantify the effects of contamination of aquatic habitats, which are based on the type, composition of the constituent and extent of contamination, physico-chemical and biological analysis was carried out. Several studies have been earlier carried out on groundwater quality (Gupta et al. 1993, Kaur et al. 1992). Dhembare et al. (2002) and Tripathi (2003) have exhaustively studied the groundwater quality. Murugesan et al. (2005) studied groundwater quality in seashore region of Chennai. The quality of groundwater is highly related to the local environmental and geological conditions. Studies have shown that no two regions show similar characteristics for groundwater. The studies on groundwater quality are confined to a particular region and depend on factors like hydrological conditions, geology and land use pattern of the region.

The quality of water is of vital concern for mankind, since it is directly linked with human welfare. It is now recognized that the quality of groundwater available in an area is as important as the quantity. The knowledge of hydrogeochemistry is essential to determine the origin of chemical composition of groundwater and the relationship between rock chemistry (Zaprozec 1972). The term water quality management has come in vogue in recent years as part of the current environmental crisis. Increasing water quality problems and demands for the beneficial use of water have combined to make it impossible that water quality be truly managed on a scale never before considered. In such instance, it is not unreasonable to say that the traditional approach to water quality management is no longer very satisfactory. Therefore, specific approach confined to Chennai has been adopted to monitor surface and subsurface waters.

MATERIALS AND METHODS

A total of 24 water samples were collected from five different locations in and around Chennai city. Sampling was done during the period of December 2005 to May 2006. The details of sampling points chosen for obtaining the water samples are given in Table 1. The various physico-chemical parameters were analysed according to the standard procedures of APHA (2000). Standards have been laid down by various agencies such as the World Health Organization (WHO 1991), U.S. Environmental Protection Agency and Bureau of Indian standards for determining water quality for various uses.

RESULTS AND DISCUSSION

The results of the physico-chemical analysis of water samples are shown in Figs. 1 and 2. The temperature of the water samples ranged from 27ºC to 33ºC. In this study deep aquifers, however, have higher temperature due to earth's thermal gradient. A rise in the temperature of the water leads to the speeding up of the chemical reactions in water, reduces the solubility of gases and amplifies the taste and odour. Most waters were colourless and odourless. The taste and odour are mainly due to the dissolved impurities often organic in nature. Water containing taste and odour may not be toxic, but may be rejected on the aesthetic grounds. At some stations the water was slightly yellowish in colour with earthy odour. Brown et al. (1967) pointed out that fluctuation in temperature was dependent on the types and concentration of polluted matter, especially during summer.

The turbidity of water samples ranged from 1.4 to 7.2 NTU. The minimum variation was observed in station 2 in the month of February, and the maximum in Station 3 in the month of May. The reported values were above the prescribed limits (BIS: 10500-1991). Clear water is more appealing for drinking.

The TDS value varied between 360 and 3100 mg/L. High TDS greater than 2000 mg/L, is commonly objectionable. The minimum variation was found in the month of December in station 4, and the maximum in the month of May in station 3. A high TDS (level above 1000 mg/L) may cause corrosion of pipes and plumbing systems. The TDS may affect water quality adversely in a number of ways. It is generally inferior in palatability and may induce an unfavourable physiological reaction in the transient consumer (Dhembare et al. 1998). Sangeetha et al. (2000) observed greater values of TDS than that of ISI standard, the reason may be due to entry of pollutants. TDS signifies the inorganic pollution load of any water body. The higher values indicate effect of overland flow.

The electrical conductivity values in the present study vary from 220 to 4250 µS/cm. The minimum variation was seen in the month of May at Station 1, and maximum in the month of May at Station 3. The electrical conductivity value greater than 400 µS/cm may be attributed to a high chloride concentration in groundwaters (Davies & De Wist 1966).

Table 1: Details of sampling stations.

Station No.	Sampling Station	Source	Depth in Feet
1	Koyambedu, Chennai - 107 Domestic area	Bore well	110
2	Arumbakkam, Chennai - 106 Domestic area	Bore well	140
3	Aminjikarai, Chennai - 30 Domestic area	Bore well	80
4	Kilpauk, Chennai -10 Domestic area	Bore well	95

The results of the present study shows clearly the dominance of bicarbonate, which exists mostly between pH 6.8 and 7.71. The carbonate ion is dominant when pH is above 8.5. In the present study carbonate in most of the samples was absent, but where the pH was above 8.5, quantity of carbonate was comparatively high. Jain (1998) observed that the groundwater pH varied from 6.8-8.3 with a mean value of 7.4 which was a safe range for drinking as well as for the growth of plants.

Alkalinity of the water sample was ranged from 66 to 400 mg/L, and it was within the prescribed limit of 600 mg/L (BIS 10500-1991). The minimum variation was seen in the month of January at Station 1, and the maximum in the month of May at Station 3. In natural water, alkalinity was due to the dissolution of CO_2 in water. Alkalinity itself is not harmful to human beings; still the water samples with less than 100 mg/L are desirable for domestic use.

Total hardness is an important parameter of water quality, whether it is to be used for domestic or industrial purposes. The hardness of water is caused by polyvalent cations. Calcium and magnesium are the principal cations, which are responsible for hardness. Calcium, magnesium and total hardness in the water are interrelated. In the present study total hardness, calcium and magnesium ranged from 60 to 800 mg/L, 23 to 197 mg/L and 11 to 71 mg/L respectively. The minimum variation of calcium was seen in the month of December at station 4, and the maximum in the month of May at Station 3. An important source of calcium is the dissolution of small quantities of carbonate minerals. The minimum variation of magnesium was seen in the month of December at Station 1, and the maximum in the month of May at Station 3. The results revealed that the water has little soda taste and the formation of soap curd.

Sodium and potassium concentrations are interrelated. Potassium is also a naturally occurring element and ranks seventh among the elements in the order and abundance. The concentration of sodium in the present study was from 33 to 523 mg/L, whereas, the concentration of potassium was from 8 to 42 mg/L. High concentration of sodium and potassium give a salty taste and may cause foaming in boilers and limit the use of water for irrigation. The maximum concentration of sodium was observed in the month of May at Station 3, and of potassium in the month of May at Station 1. The minimum concentration of sodium was observed in the month of December at Station 4, and of potassium in the month of May at Station 4.

Iron was in the range of 0.1 to 8 mg/L which was above the prescribed limit (BIS: 10500-1991) (Docter et al. 1998). The minimum concentration was seen in the month of December at Station 3, and maximum in the month of May at Station 4. Iron (Fe^{+2} to Fe^{+3}) in many groundwaters provides the tropical well water rust taste. Not only the unpleasant taste, iron can also stain plumbing fixtures, clothes and dishes. Treatment for the reduction of iron can be done by several methods depending upon the concentration and pH of the water. The US Environment Protection Agency (USEPA) recommends that domestic water should not exceed 0.3 mg/L of iron. Iron concentration exceeding this level may cause the characteristic reddish staining.

The concentration of nitrite was in the range of 0.01 to 0.37 mg/L. Presence of even small quantity of nitrite will indicate the organic pollution and the availability of partially oxidized nitrogenous matter. Nitrate is one of the several inorganic pollutants contributed by organic manures, human and animal wastes and industrial effluents through the biochemical activities of microorganisms. The concentration of nitrate was in the range of 0.5 to 9 mg/L, which was within the permissible limits of 45 mg/L. The minimum concentration was seen in the month of December at Station 4, and the maximum in the month of May at Station 2. The high amount of nitrate in water causes a disease in children called blue baby syndrome (methaemoglobinemia) (Deshpande et al. 1999).

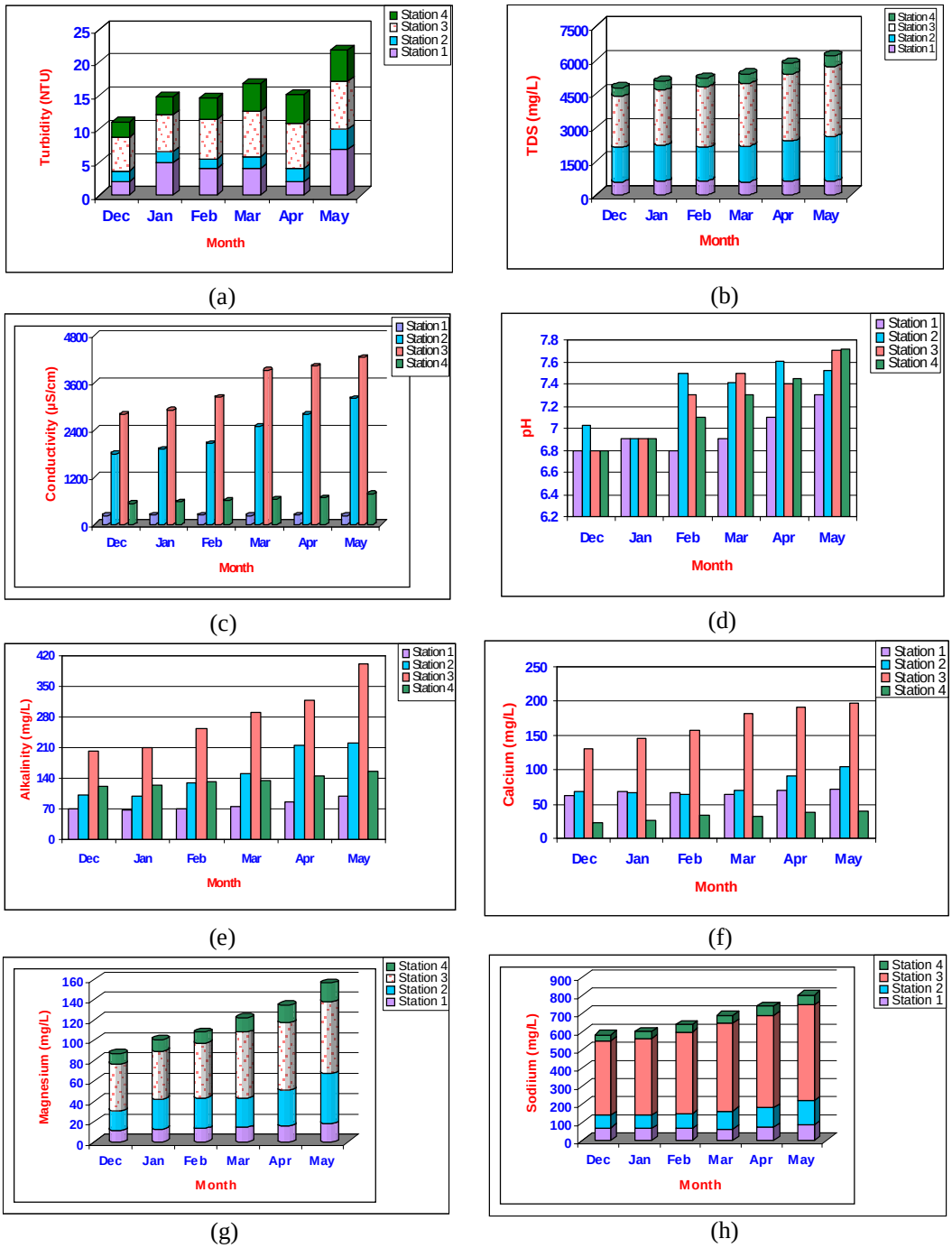

Fig.1: The change in a) Turbidity, b) TDS, c) Conductivity, d) pH, e) Alkalinity, f) Calcium, g) Magnesium and h) Sodium in bore well waters at different stations.

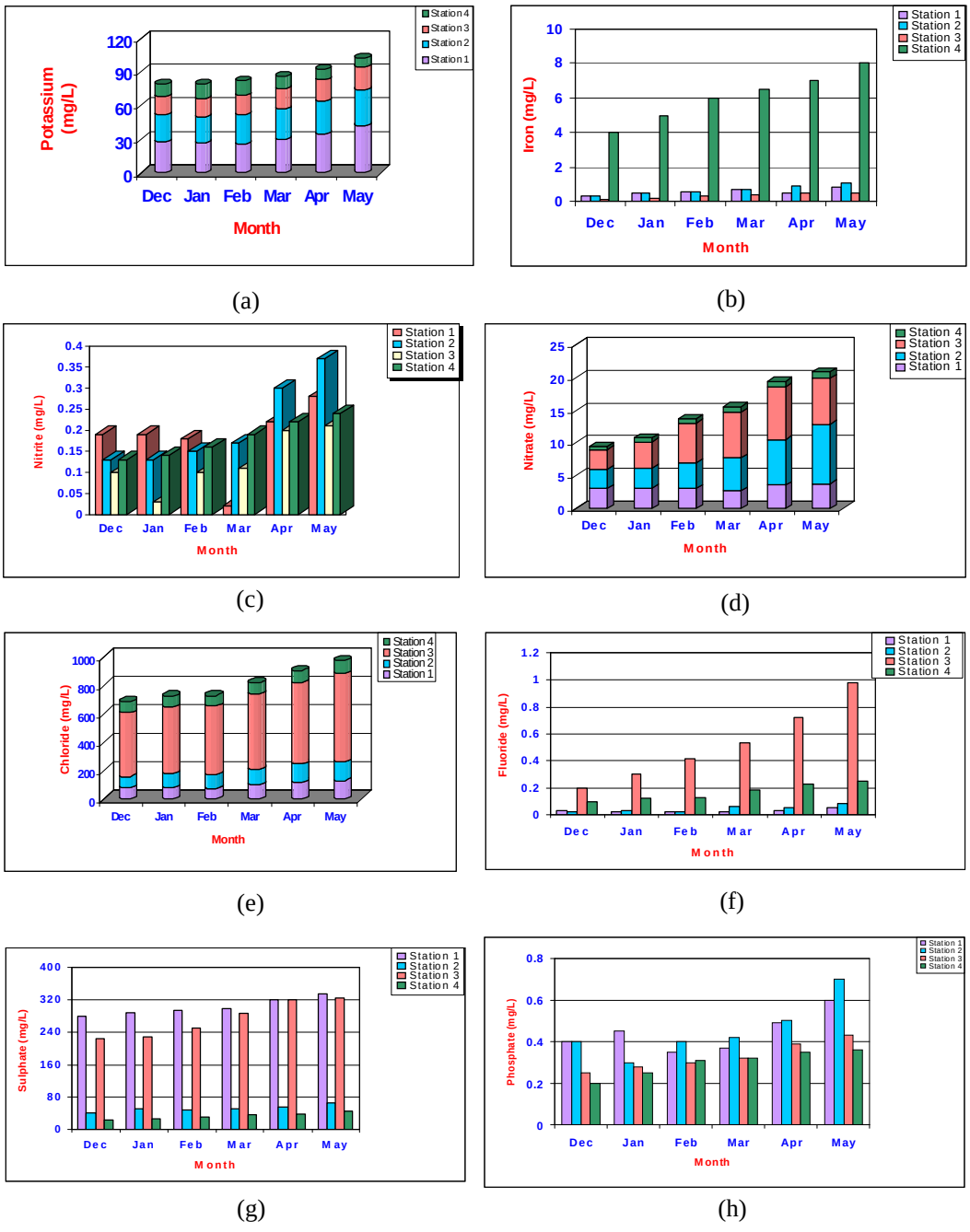

Fig. 2: The change in a) Potassium, b) Iron, c) Nitrite, d) Nitrate, e) Chloride, f) Fluoride, g) Sulphate and h) Phosphate in bore well waters at different stations.

Chloride occurs naturally in all types of waters. The concentration of chloride was in the range of 74 to 620 mg/L. The chloride values were above the permissible limits (BIS: 10500-1991). The minimum value was observed in the month of February at Stations 1 and 4, and the maximum in the month of May at Station 3. Chloride in excess of 100 mg/L imparts a salty taste to water, and above 250 mg/L may have a laxative effect. The chloride concentration is an indicator of pollution by sewage. Industries are also an important source of chloride. It is harmless for health up to 1000 mg/L.

The concentration of fluoride in the water samples ranged from 0.02 to 0.98 mg/L. Fluoride concentration less than 0.5 mg/L may be harmful and may cause dental caries. Higher fluoride concentration greater than 1.5 mg/L may cause dental and skeletal fluorosis and other nonskeletal manifestations. Fluoride showed maximum concentration in the month of May at Station 3. Fluoride is known to contaminate groundwater reserves globally. In India, its occurrence in top aquifer systems is endemic in many places of Andhra Pradesh, Tamilnadu, Karnataka, Goa and Kerala. The study reveals that the fluoride concentration seems to accumulate over a period and shows stronger sign of symptoms in the age group of children.

Sulphate is a naturally occurring ion found in almost all kinds of water bodies. It may undergo transformation to sulphur or hydrogen sulphide. It is also an important anion imparting hardness to the waters (Trivedy et al. 1987). The sulphate ions are probably derived from the solution of calcium and magnesium ions. Sulphate is a naturally occurring anion found almost in all types of waters. The sulphate although may be present in sedimentary rocks and in minor quantities in igneous rocks is largely recycled from the atmosphere. The concentration of sulphate was in the range 25 to 336 mg/L. The concentration of sulphate was high in the month of May at Station 1, and low in the month of December at Station 4.

Phosphate was in the range of 0.20 to 0.70 mg/L, which was within the permissible limit. Excess phosphate is actually a constituent of pollution usually by infiltration of wastewaters from domestic and industrial sources, and agricultural run off. Phosphate content in groundwater samples, in general, was due to leaching from minerals or ores, agricultural run off, and a major constituent of municipal sewage (Trivedy & Goel 1986).

Groundwater crisis is not always the result of natural factors, but it has also been caused by human activities. The demand for water has increased over the year and this has led to water scarcity in many parts of the India. Considering the water crisis in Tamil Nadu, especially in Chennai city, rain water harvesting is an excellent method of recharging groundwater.

CONCLUSION

The present study on the groundwaters reveals that water of Chennai city is not suitable for drinking because of high values of turbidity, TDS, conductivity, total hardness, calcium, magnesium, iron, nitrogen and chloride.

Groundwater protection and management should be given great importance to preserve and protect water from contamination by various sources. The general public, especially the consumers, should be trained and create awareness regarding different water polluting sources and their effects. Since the quality of water is important for human life, the results obtained from the present study can be implemented for better water management system in the cities of our country.

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