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Hydrochemical trend of ground water – Rajapalayam town, Tamil Nadu, India

L. Muthulakshmi[1], P.Thillai Arasu[1], R.Ilavarasi[1] and S. Selvanayagam[2]
[1]Department of Chemistry, Kalasalingam University Krishnankoil - 626 126, Tamil Nadu; [2]Department of Physics, Kalasalingam University, Krishnankoil - 626 126, Tamil Nadu.

***Corresponding author. **Email:** l_muthulakshmi@yahoo.co.in ; Tel: (9486613769)*

Abstract
The present study deals with hydrochemical trend of ground water and pollution in Rajapalayam. Water samples were collected from five different region of Rajapalayam town and analyzed for various physicochemical parameters, such as pH, electrical conductivity (EC), total dissolved solids (TDS), total alkalinity (TA), total hardness (TH), Cl^-, SO_4^{2-}, Ca^{2+}, Mg^{2+}, Na^+, K^+, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD) were examined through water analysis. The results were compared with standard values as prescribed by the Bureau of Indian Standard (BIS) and World Health Organization (WHO).The results indicate that the ground water samples in the residential area and as well as nearby industrial areas all have high water quality parameters. The persistence of dissolved oxygen (DO) deficit and very high BOD and COD values suggest the deoxygenation rate of ground water which is much higher than reoxygenation and attributed to the mixing of organic wastes, decomposition of plants and animals excretory to overall water quality. Heavy metal content values were present within the permissible limit as prescribed by BIS and WHO. The study samples have TDS values much higher than the maximum permissible level as stipulated by BIS and WHO. The high values of these parameters may have health implication and, therefore, these need attention.

Keywords: Water, electrical conductivity, hardness, alkalinity, Rajapalayam

1. Introduction
Water is very important to life, without water our life cannot move. Availability of quality freshwater is one of the most critical environmental issues of the twenty first century. Groundwater is an important water resource for domestic and agriculture in both rural and urban parts of India.

The chemical composition of groundwater is very important criteria that determine the quality of water. Water quality is very important and often degraded due to agricultural, industrial and human activities. Even though the natural environmental processes provide by means of removing pollutants from water, there are definite limits. It is up to the people to provide security to protect and maintain quality of water [1]. Pollution of groundwater comes from many sources. Discharge of waste disposal from industries, agriculture and municipalities are main source of groundwater pollution. Sometimes surface run-off also brings mud, leaves, and human and animal wastes into surface water bodies. These pollutants may enter directly into the groundwater and contaminate it.

The study area of Rajapalayam lies between latitudes 9.4525^o N and longitudes 77.5540^o E. Rajapalayam is an important town in Virudhunagar district in the Indian state of Tamil Nadu. It is located 85 km southwest of Madurai in the state of Tamil Nadu. The economy is based on the manufacture of textiles, and there are mills for spinning mills and weaving cotton, as well as a large cotton market.

Rajapalayam is one of the important places for its textile units. It is the fact that the processing of textile requires large amount of freshwater along with various chemicals. The textile industry in and around the Rajapalayam city pollute both surface and groundwater by discharging their wastes. Hence the present study has been undertaken to determine the physico-chemical characteristics of groundwater in some parts of Rajapalayam town.

2. Materials and method

pH: The pH of samples was determined by pH meter.
Electrical conductivity: Electrical conductivity values were measured by using Elico digital conductivity meter (Model No.L1 CM 180)
Determination of total dissolved solids: The water sample was filtered through Whatman No 4 and evaporated the sample on hot water bath until whole water was evaporated. After cooling noted the weight of evaporating dish and calculated total dissolved solids.
Total Alkalinity: The alkalinity was determined by titration using phenolphthalein and methyl orange indicators.
Total Hardness: The hardness was determined by titration Erichrome black T indicator and standard (0.01 N) EDTA solution.
Determination of chloride: The chloride content was determined by Argentometric titration using K2CrO4as an indicator.
Determination of Ca: The calcium content of water samples was determined by complexometric titration using EDTA solution and Eriochrome black T as indicator.
Determination of Na and K: The sodium and potassium content were determined by Flame Photometric method.
Dissolved Oxygen (DO): The DO was determined by using Starch as indicator and (maganous sulphate+ alkaline KI) as fixation reagent. COD was determined by redoxtitrometric method (open-reflex method). BOD was determined by using Winkler method [2].

2.1 Study Area

The selected sampling stations *viz*., Chatrapatti (RP1), Cotton Market Street (RP2), Thendral nagar (RP3), Solapuram (RP4), Thalavaipuram (RP5) in and around Rajapalayam, are highly populated and unhygienic, associated with open drains for sewage and industrial effluents and dumping of industrial waste which leads to the intrusion of chemical contaminants to the ground water.

3. Results and Discussion

The groundwater samples were collected in and around the area of Rajapalayam town. The obtained results are tabulated in Table 1. Figure 1 shows the bargraph of the water quality parameters with sampling sites. The experimental results are compared with the limits recommended by WHO [3] and BIS and discussed.

Table 1: Physico-Chemical Characteristics Of Ground Water In Rajapalayam

WQPs	pH	EC	TDS	TA	TH	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+	DO	COD	BOD
RP1	7.5	2245	1460	348	768	543	138	350	230	48	34	4.0	96	1.8
RP2	7.4	2260	1412	335	530	714.6	152	200	124	72	32	3.7	92	1.2
RP3	7.5	2147	1340	354	665	520	140	212	115	78	30	3.3	88	1.7
RP4	7.6	2125	1337	340	680	508	131	210	120	81	24	3.5	94	1.5
RP5	7.5	2600	1688	360	824	532	135	361	240	65	46	3.1	90	1.9

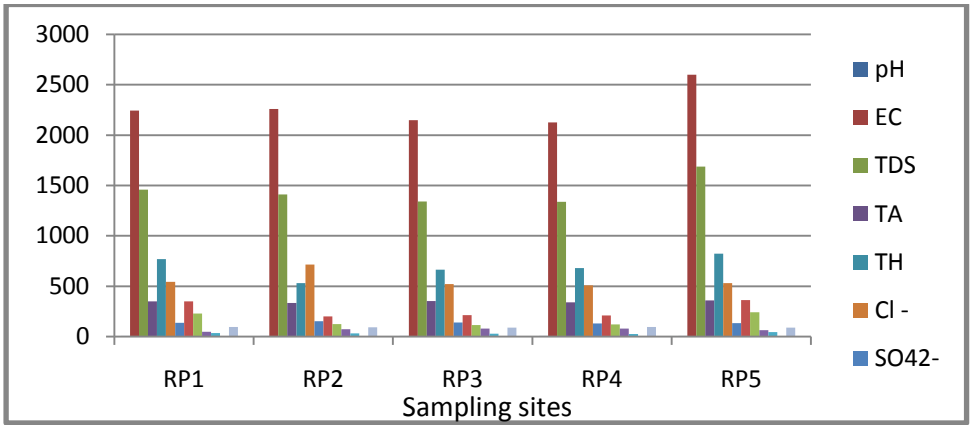

Figure 1. *Water Quality parameter of ground water in Rajapalayam*

3.1. pH

The pH values of all groundwater samples are found to be in the range of 7.4 - 7.6 (Table 1). The highest value of 7.6 is observed at station RP4 whereas the lowest value of 7.4 is observed at station RP2. The permissible limit of pH for drinking water is 7.0 - 8.5 (WHO). The groundwater sample is found to be

within the acceptable limit of WHO. There is no abnormal change of pH in the groundwater samples. If the pH is found beyond the permissible limit, it affects the mucous membrane of cells [4].

3.2. Electrical conductivity (EC)

The electrical conductivity values for all the groundwater samples are recorded within the range of 2125 - 2600 µmhos/cm. The electrical conductance is a good indication of total dissolved solids which is a measure of salinity that affects the taste of potable water [5]. Several factors like temperature, ionic mobility and ionic valences also influence the conductivity. The electrical conductivity value for all the groundwater samples are found above the permissible limit.

3.3. Total dissolved solids (TDS)

The total dissolved solids in water are due to the presence of sodium, potassium, calcium, magnesium, manganese, carbonates, bicarbonates, chlorides, phosphate, organic matter, and other particles [6]. The values of the total dissolved solids for all the groundwater samples vary between 1337 and 1688 mg/l. The maximum allowable limit of total dissolved solids in groundwater for domestic purpose is 1500 mg/l (WHO). The maximum value (1688 mg/l) is recorded at station RP5 and minimum value (442 mg/l) is recorded at station RP4. According to classification of drinking water on the basis of TDS values, all the groundwater samples except sampling sites RP5 are found to be non-saline. In this study, the TDS value for all the groundwater samples are well within the permissible limit of 1500 mg/l except the sampling station RP5 (1688 mg/l).

3.4. Total Alkalinity

The acceptable limit for total alkalinity (TA) in drinking water is 200 ppm. The total alkalinity values are found to be in the range 335 – 360 ppm, which indicates all sampling sites are above the permissible limit (200 ppm) prescribed by WHO and BIS. The higher alkalinity of ground water is owing to the presence of bicarbonates and trace amount of carbonates and hydroxide salts.

3.5. Total hardness (TH)

Total hardness values (530 to 824 ppm) of water are higher than the highest desirable limit (300 ppm), all sampling sites show a high degree of total hardness This may be attributed to the natural accumulation of lime due to rock-soil interaction kinetics or direct pollution by the industrial and domestic wastewater. Hard water causes horrific effects in digestive system. Moreover, the possibility of forming calcium oxalates crystals in urinary tracks has also been ascertained.

3.6. Chloride

The value of chloride for all the groundwater samples is ranged from 508 -716 mg/l. All the groundwater samples show chloride values above the acceptable limit (250 mg/l) of WHO. Excess chloride (>250 mg/l) imparts a salty taste to water. Excessive chloride in potable water is particularly not harmful but the criteria set for chloride value is based on its potentially high corrosiveness. Soil porosity and permeability also play an important role in building up the chloride value [7]. Increase of chlorine level in water is injurious to people suffering due to heart and kidney diseases. Heavy metal content results are reported in Table 2.

Table 2: Heavy metal content (ppm) of ground water in Rajapalayam

Heavy metal	Min	Max	Avg	SD
Cd	0.004	0.005	0.0045	0.0007
Cr	0.0019	0.025	0.0135	0.0163
Pb	0.041	0.044	0.0425	0.0021
Cu	0.235	0.277	0.256	0.0297
Zn	0.326	0.331	0.3285	0.0035
Mn	0.08	0.09	0.085	0.0071
Hg	0.0318	0.042	0.0369	0.0072

3.7. Sulphate (SO_4^{2-})

The sulphate values for the groundwater samples are exhibited between 131 and 152 mg/l. The maximum value (152 mg/l) is noted at station RP2 and minimum value sulphate (131 mg/l) is noted at RP4. The sulphate values for all the groundwater samples are well within the permissible limit (200 mg/l) of WHO. High concentration of sulphate may cause gastro – intestinal irritation particularly when magnesium and sodium ions are also present in drinking water resources [8].

3.8. Calcium (Ca^{2+})

The concentration of Ca varies from 200 to 361 mg/l. Calcium may dissolve readily from carbonate rocks and lime stones or be leached from soils. But calcium is an essential nutritional element for human being and aids in the maintaining the structure of plant cells and soils. For most of the groundwater samples, the calcium values are found above the maximum permissible limit (200 mg/l) this may be due to the may be due to the leaching of soil deposits of limestone, dolomite, gypsum, gypsiferous materials, granite and silicious sands into ground waters.

3.9. Magnesium (Mg^{2+})

The magnesium values are recorded between 115 to 240 mg/l for the groundwater samples. The highest value of magnesium is observed at station RP5 and the lowest value of magnesium is observed at station RP3. On comparison with the WHO standard value of magnesium, in this study it is confirmed that the magnesium value are found within the permissible limit (150 mg/l) in RP2, RP3 and RP4 sampling sites and higher values in RP1 and RP5 sample station. Magnesium generally occurs in lesser concentration than calcium because of dissolution of magnesium rich minerals is slow process and calcium is more abundant in earth crust [9].

Sodium and potassium are the naturally occurring elements in ground water. Industrial and domestic wastes may also add sodium to ground water. Sodium contents, in the analyzed water samples, are in the range 48 to 81 ppm, which is well above the permissible limit (20 ppm) [10]. Sodium content of more than 50 ppm makes the water unsuitable for drinking purposes' because heart diseases associated with long time usage of sodium in drinking water. Potassium content in the study area is in the range of 24 to 46 ppm, which is above the permissible limit. Sodium plays an important role in human body. Regulatory action is exercised by sodium, pottasim, calcium and magnesium. The flux of these ions through cell membranes and other boundary layers sends signals that turn metabolic reactions on or off. According to National Academy of Science, the higher concentrations of sodium can be related to cardiovascular diseases and in women toxemia associated with pregnancy.

3.10. Dissolved oxygen (DO) Biological oxygen demand (BOD) and Chemcial oxygen demand (COD)

DO is the ability of the surface and ground water to purify itself through biochemical process. The solubility of atmospheric oxygen in fresh water is ranged from 14.6 ppm at 0°C to 7.0 ppm at 35 °C under 1 atm. pressure. However, dissolved oxygen (DO) in water may be affected by the sample temperature, pressure and chemical constituents. Dissolved oxygen (DO) in potable water has crucial feature since, it greatly influences the solubility of metals, which are essential for biological life. DO values, in study samples, are found to be in the range of 3.1 to 4.0 ppm, almost all within the permissible limit (4 ppm). Generally, the persistence of DO deficit in water may be due to high deoxygenation (biological decomposition) rate of organic matter in water. Low DO recorded at all stations, may be due to the addition of higher amount of organic compounds in ground water from sewage disposal, leading to oxygen depletion. High depletion in oxygen content produces foul odour due to anerobic decomption of organic wastes leading to the evaluation H_2S.

The occurrence of inorganic and trace amount of organic substances in water may be defined by chemical oxygen demand (COD) which is closely related to the organic contaminations in water. Organic substances like decaying plants, animals and wastes of micro-organisms are the main contributors of biochemical oxygen demand (BOD) in water system. COD and BOD values are found to be in the range of 82 – 96 and 1.2 - 1.9 ppm, respectively. The overall increase in BOD values can be attributed to the discharge of organic waste and decomposition of plant and animal excretory wastes into water from the nearby domestic and dairy farms. The very low DO and high COD values are found mainly in water, which may be due to the mixing of domestic and industrial wastes.

In the present study, heavy metals like Cd, Cr, Pb, Cu, Zn, Mn and Hg, are present in considerable (detectable) concentrations in ground waters but within the desirable limit as prescribed by WHO and BIS in the study area (Figure 2), due to emission and discharge by heavy metals by industries and combustion of a large amount of fossil fuel and their precipitation on earth surface, dissolution into water bodies and seepage in the ground water aquifers [11]. The rain water may be the medium of distribution of trace metals in ground water since; rainfall is the chief source of ground water formation and recharge on earth.

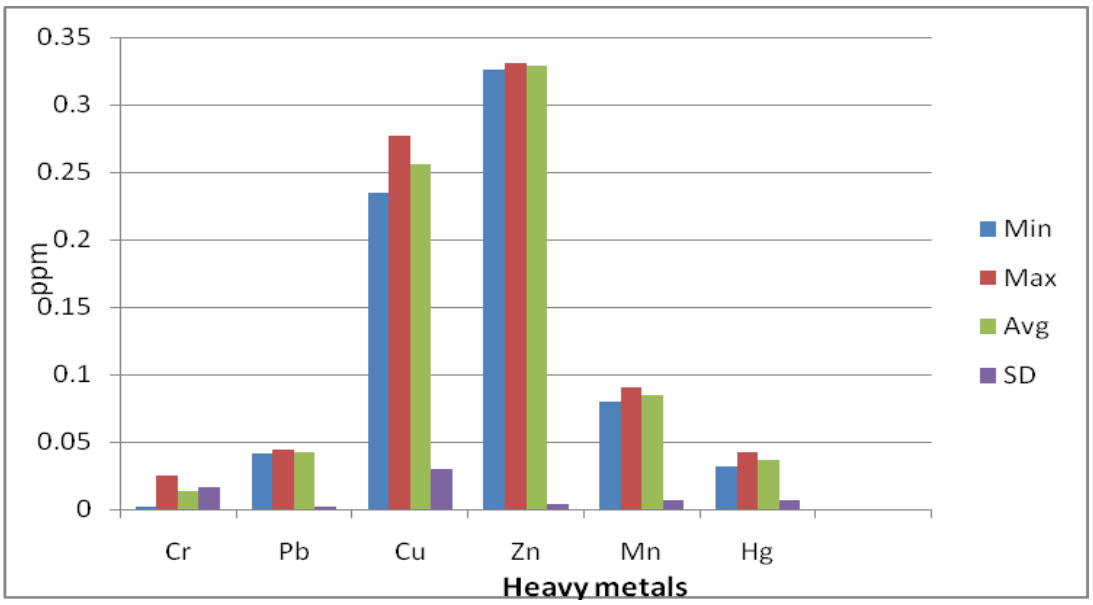

Figure 2. Statistical Values of Heavy metal content (ppm) of ground water

Conclusion

On the basis of the above discussion, it may conclude that the underground water in almost all the sites at Rajapalayam is highly polluted. Therefore, the use of ordinary hand pumps should be discouraged. People dependent on this water are often prone to health hazards due to polluted drinking water. Therefore, indigenous technologies should be adopted to make water fit for drinking after treatment of desalination. The safe drinking water in quality affected areas could also be provided by sanctioning schemes based on surface water sources.

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