

Physico-Chemical Analysis of Groundwater Quality in Pallikaranai Marshland

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Abstract – Groundwater is an important source of freshwater. It is being exploited due to increase in population, particularly in the developing countries. The quality of groundwater matters in a marshland, though groundwater is there in abundant. This study analyzes the groundwater quality for drinking and cooking purposes in the Pallikaranai marshland in Chennai, with the specifications of the Bureau of Indian Standards (BIS). A total of 20 groundwater samples from bore-wells used for drinking and cooking purposes were collected, five each from the north, south, east and west of the Pallikaranai marshland. Physico-chemical parameters of groundwater such as pH, total dissolved solids (TDS), calcium (Ca), magnesium (Mg), and iron (Fe) were studied. We have the Perungudi dump yard in the Pallikaranai marshland which is a low-lying area and it is close to the sea level. This dump yard does not have proper lining at the bottom to prevent leachate migration into underlying and surrounding groundwater. The impact of leachate generation from the dump yard on groundwater quality is being ignored. The present study looks into groundwater quality in the Pallikaranai marshland and suggests remedial measures. The water samples were analyzed at the Chennai Metropolitan Water and Sewerage Board's quality assurance wing and water analyst's laboratory. One of the findings is that high TDS concentrations in certain areas produce laxative effects and give an unpleasant mineral taste to water.

Keywords – Pallikaranai Marshland, Water Quality, Physico-chemical Parameters, Total Dissolved Solids, Dump Yard.

I. INTRODUCTION

Groundwater is an important source of water supply throughout the world. The dependency of people on groundwater has increased in the past few decades due to tremendous increase in crop production, population and industrialization. Groundwater levels and quality have undergone deterioration showing high levels of toxicity.

In urban areas, the construction of houses, roads and footpaths has left little exposed parts of the earth for water to soak in. Most of the water runs waste through drains. In rural areas, the water quickly takes the form of flood and flows into rivers which dry up as soon as the rain stops as the bulk of water flows away. If this water can be retained, it can seep into the ground and recharge groundwater.

Marshlands like that in Pallikaranai serve not only as floodplains but also as source of recharging groundwater, if only marshlands are not filled up, polluted or encroached upon. In fact, forests are considered beautiful but marshlands ugly; however, international awareness is being created about the sensitive eco-system of marshlands particularly after the Ramsar Convention on Wetlands.

Periodical observing of groundwater in marshlands is important. Water is polluted in places where population density is high. The Pallikaranai marshland in Chennai is no exception to these deteriorating qualities of groundwater. Various means of pollution of groundwater reservoirs include city drainage, domestic waste and industrial waste. There is a need to study physico-chemical characteristics of bore-well water around the Pallikaranai marshland which is one among the most important life-supporting ecosystems. There are standard desirable limits of water quality parameters in drinking water prescribed by different agencies. This study uses the water quality standards set by the Bureau of Indian Standards (BIS) 2012.

II. OBJECTIVES OF THE STUDY

The following are the objectives of the study:

- To analyze water quality parameters in groundwater in the Pallikaranai marshland.
- To find whether the analyzed parameters are within permissible limits.
- To suggest appropriate remedial techniques where groundwater is used for drinking or cooking purposes.

III. REVIEW OF LITERATURE

The paper of Parameswari and Mudgal [1] titled "Geochemical investigation of groundwater contamination in the Perungudi dump yard, south India" concludes that unscientific disposal of municipal solid waste causes groundwater contamination. Such an analysis helps to find an appropriate groundwater remediation technique to remove the specific heavy metal contaminants and thereby provide a safe drinking water for the surrounding community. It provides an appropriate groundwater remediation technique to remove the specific contaminant and thereby provide a safe drinking water for the surrounding community. The study concluded that unscientific disposal of municipal solid waste causes groundwater contamination.

Jayaprakash et al. [2] studied trace metals geo-accumulation in the Pallikaranai marshland in Chennai. The study suggests the need for a regular monitoring and management programme which will help to improve the quality of the Pallikaranai marshland.

A project on 'Inland Wetlands of India' [3] commissioned by the Ministry of Environment and Forests, Government of India, had prioritized the Pallikaranai marsh as one of the most significant wetlands of the country.

Analysis of the wildlife inventory of the Pallikaranai marshland by Raj et al. [4] and by a team of researchers

from the Zoological Survey of India (ZSI) [5] have pointed out a sharp decline in the number of resident and visiting species of birds and animals.

A study by Karpagavalli, Malini, and Ramachandran [6] on “Analysis of heavy metals in drying wetland Pallikaranai, Tamil Nadu, India” has revealed that the food web complexes in the Pallikaranai marshland are at the highest risk of induced heavy metal contamination.

A study by Aravind kumar et al. [7] on “Assessment of physio-chemical parameters of water at environmentally degraded Pallikaranai marsh area, Chennai, India” concluded that the parameters which were taken for studying the water quality exceeds the pollution level for groundwater and showed that the water is not safe for the use of various purposes such as domestic, aquatic life, agricultural and industrial uses.

Malar et al. [8] studied the groundwater quality for drinking purposes and compared it with the BIS standards. Pondur Village Panchayat, a revenue division of Kancheepuram district in Tamil Nadu which is under urban sprawl was taken up for the study. The study suggested that environmental audits and statutory status for industrial zones have to be made mandatory because of the pollution they cause. If proper action plan is not taken up we cannot pass on the natural resources intact to our future generations as it has been passed on to us by our ancestors.

IV. METHODOLOGY

The Bureau of Indian Standards (BIS) parameters for testing were prepared based on the water quality specification being followed by the Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB). While CMWSSB is checking for I.S.10500:1991 specification, this study has gone in for I.S.10500:2012 specification. There is no BIS permissible limit for phosphate for drinking water, while the U.S. Environmental Protection Agency (EPA) (1986) [9] has fixed it to be 0.1 mg/l. Those other parameters where permissible limit is not readily available were left out of the study. Thus 12 parameters were taken up for the study. The physico-chemical parameters of the water samples were tested at the Chennai Metropolitan Water and Sewerage Board's quality assurance wing and water analyst's laboratory at Kilpauk Water Works.

Five bore-well samples were taken from each of the four different residential localities in Pallikaranai marshland. The residential localities are: Anjugam Ammaiyar Nagar in the north, Re Nagar Extension in the east, Indira Nagar in the south, and Karapagambal Nagar in the west. In these places, bore-well water is normally used for cooking purpose though metro-water or packaged drinking water is

used for drinking purpose. Bore-wells of depth from 100 feet to 150 feet alone [which supply water from unconfined aquifers] were taken so that the samples are comparable.

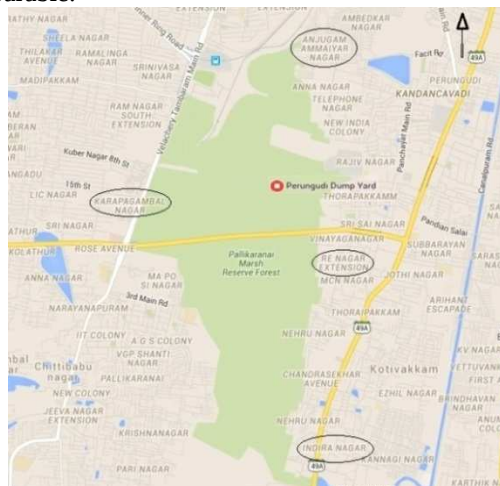


Fig. 1. Pallikaranai marshland with the four selected areas of study

The samples were collected from existing bore-wells from the four spots in clean polyethylene bottles of 2 litres each. The testing of water samples was done in the Chennai Metropolitan Water and Sewerage Board's quality assurance wing and water analyst's laboratory, and some of the parameters were re-checked for reliability in the laboratory of the Department of Chemistry, Anna University. Reasons for different excesses in water parameters are also sought to be found.

V. ANALYSIS AND INTERPRETATION

The average data of the five samples from each of the four study spots in Pallikaranai are presented here. Five bore-well samples were taken from each of the four different residential localities in the Pallikaranai marshland.

Although the average of the five samples has been taken and then the average data is compared with data in other areas, the five samples have wide variations in several cases. For instance, the five samples of Indira Nagar with regard to Total Dissolved Solids (750, 2175, 2330, 725, 1240 mg/l) vary so widely and the reasons why they vary have not been attempted by this study, and this forms a limitation of the study. The same is the case of Chlorides (Cl) with the samples measuring 250, 1150, 1180, 260 and 370 mg/l, and most other parameters. The study did not compare the data within the same place.

Table 1. Consolidated data on groundwater quality in Pallikaranai

Physico-Chemical Examinations	BIS:10500-2012 Permissible Limit	Indira Nagar	Re-Nagar Extension	Karpagambal Nagar	Anjugam Ammayar Nagar
Total Dissolved Solids at 105°C (mg/l)	2000	1444	1772	1283	2542
Calcium (Ca) (mg/l)	200	92	106	86.8	170.4
Magnesium (Mg) (mg/l)	100	61	96.4	61.6	57
Total Hardness (CaCO ₃) (mg/l)	600	482	664	447.6	662
Chlorides (Cl) (mg/l)	1000	642	738	494.4	1164
Ammoniacal Nitrogen (N) (mg/l)	50	2.4796	0.3392	7.844	1.5792
Hydrogen Ion Concentration (pH)	6.5 to 8.5	7	7.8	7.88	7.66
Alkalinity to Methyl Orange (CaCO ₃) (mg/l)	600	212	361.6	486.4	440.8
Sulphates (SO ₄) (mg/l)	400	111.2	138	71.8	350.8
Phosphates (PO ₄) (mg/l)	0.1 (EPA)	0.01	0.01	0.013	0.012
Iron (Fe) (mg/l)	0.3	0.27	0.71	1.15	0.17
Fluoride (F) (mg/l)	1.5	0.38	0.36	0.25	0.36

Total Dissolved Solids (TDS) is within the permissible limit in the places Indira Nagar (1444 mg/l), Re Nagar Extension (1772mg/l) and Karpagambal Nagar (1283mg/l) whereas in Anjugam Ammayar Nagar (2542mg/l) it has crossed the permissible limit of (2000mg/l). Anjugam Ammayar Nagar is in north of Pallikaranai and it is closer to the main city of Chennai and sewage disposal and the Perungudi dump yard impacts are at maximum here which contaminate groundwater too.

Total Dissolved Solids (TDS) are solids in water that can pass through a filter. TDS is a measure of the amount of material dissolved in water. This material can include carbonate, bicarbonate, chloride, sulphate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions. High concentrations of TDS reduce water clarity, contribute to a decrease in photosynthesis, and combine with toxic compounds and heavy metals. Water with high TDS often has a bad taste and/or high water hardness, and could result in a laxative effect and may give an unpleasant mineral taste to water.

Total hardness is not within the permissible limit of (600 mg/l) Re Nagar Extension (664mg/l) and Anjugam Ammayar Nagar (662mg/l). It is the result of metallic ions dissolved in the water. This decreases the lather formation of soap and increases scale formation in hotwater heaters. Mixing with sewage lines may also have increased total hardness.

In the study area, calcium, magnesium, chlorides, ammoniacal nitrogen, hydrogen ion concentration, alkalinity to methyl orange, sulphates, and phosphates are within the permissible limits and there is no problem due to the presence of these.

Iron exceeded the permissible limit of 1mg/l in Karpagambal Nagar (1.15mg/l). Organic iron occurs when iron combines with an organic acid.

Problems caused by sulphates are most often related to their ability to form strong acids which changes the pH. Sulphate ions are also involved in complexing and precipitation reactions which affect solubility of metals and other substances. EPA recommended limit for water used as a Domestic Water Supply is below 250 mg/l though BIS specifies 400 mg/l. In Anjugam Ammayar

Nagar, sulphates exceed this stringent permissible limit as the calculated value is 350.8mg/l.

Fluoride too is much below the permissible limit of 1.5mg/l in Indira Nagar (0.38mg/l), Re Nagar Extension (0.36mg/l), Karpagambal Nagar (0.25mg/l), and Anjugam Ammayar Nagar (0.36). Fluoride deficiency in drinking water is harmful to human beings and can cause diseases such as tooth decay. To prevent this fluoride may be added to drinking water but this cannot be done for bore-well water drawn individually. Since the fluoride is much below the permissible limit the use of toothpastes with fluoride addition may be encouraged for Pallikaranai residents.

VI. FINDINGS

Total dissolved solids (TDS) have crossed the BIS permissible limit of 2000mg/l in Anjugam Ammayar Nagar (2542mg/l). Anjugam Ammayar Nagar is in north of Pallikaranai and it is closer to the main city of Chennai and sewage disposal and solid waste dumping are at maximum here which contaminate groundwater too. Total hardness is not within the permissible limit of (600 mg/l) Re Nagar Extension (664mg/l) and Anjugam Ammayar Nagar (662mg/l). Hence people of Anjugam Ammayar Nagar are advised not to use bore-well water for cooking and drinking purposes.

Iron exceeded the permissible limit of 1mg/l in Karpagambal Nagar (1.15mg/l). Dissolved ferrous iron gives water a disagreeable metallic taste. When the iron combines with tea, coffee and other beverages, it produces a black appearance and a harsh, unacceptable taste.

VII. SUGGESTIONS

Since the fluoride is much below the permissible limit in all areas of the Pallikaranai marshland, the use of toothpastes with fluoride addition may be encouraged for Pallikaranai residents to avoid tooth decay.

The study confined to the analysis of the physico-chemical parameters, whereas the biological parameters too are important. Although biological contamination in

bore-well water may be limited it is suggested that water may be boiled when used for drinking or cooking purposes so as not to take a risk.

One major remedial measure is to shift municipal solid waste dump yard out of the Pallikaranai marshland. If this cannot be done, high density polyethylene sheets should be spread in the dump yard bottom before dumping wastes so that toxic materials do not leach into groundwater aquifer.

It is ideal for marshlands not to be filled up, polluted or encroached upon to serve as floodplains and as a source of recharging groundwater.

Stringent laws should be framed and enforced so that the marshland is not used for dumping garbage. Otherwise, not only a portion of the marshland is used officially as a dump yard but also people dump garbage casually in other areas of the marshland.

As the review of literature revealed there is a need for periodic environmental audits in eco-sensitive and inhabited areas like the Pallikaranai marshland to maintain the ecological parameters within permissible limits.

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