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# HYDROCHEMISTRY OF GROUNDWATER IN AND AROUND THE INDUSTRIAL AREA OF CUDDALORE DISTRICT, TAMILNADU

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***Abstract:*** Groundwater is a supreme substance for all living things. The taste of groundwater varies depending on factors such as minerals and rocks surrounding it. Because of dissolved impurities such as bacteria, salts, metals, and gases, natural water seems to have become polluted. Hydrochemistry analysis of the groundwater helps to determine the type of groundwater and its source. For the present study, the groundwater samples have been collected from five bore wells around the industrial zone of the Cuddalore district. The groundwater samples were tested utilizing physical and chemical methods. The results were compared with the Bureau of Indian Standards (BIS). The piper plot was used to define the geochemical characteristics of groundwater, and it revealed that the study samples are sodium chloride and mixed calcium, magnesium, chloride. Gibb's plot identifies the source of groundwater and demonstrates that it might be caused by rock domination, evaporation and diffusion of seawater. This study could assist people in effectively understanding the factors that influence groundwater quality.

***Key words:*** Groundwater, Physico-chemical property, Piper plot, Gibb's diagram and Saltwater.

## Introduction

The quality of drinking water is a very vital role in living beings. Since groundwater keeps moving at a much slower speed than surface water, it contains a higher concentration of minerals. Untreated water from industries, artificial fertilizers in farming, landfills, saltwater intrusion, sewage, and domestic activities may pollute groundwater. As a result of the various types of rocks, the excess amount of elements such as Calcium Magnesium and Sodium salts may be present (Sainul et. al, 2009; Selvaraju and Mahalakshmi, 2021). The analysis of physical and chemical properties in groundwater is not enough to determine its quality. The hydrochemistry of drinking water has been used to examine the quality, and it categorized the groundwater as fit for domestic, agricultural, and industrial use. In coastal region the salinity of groundwater may be increases due to evaporation or intrusion of saltwater (Remy and Manivannan, 2020; Sivakumar et. al, 2018; Inbanila and Arutchelvan, 2015; Sundaryanto and Wilda Naily, 2017; Panno et. al, 2006; Oumabady et. al, 2013). According to writers, the groundwater in the Cuddalore district has a high hardness and is noncarbonated. It is also known as permanent hardness. This region is dominated more by cations Sodium and Chloride (Srinivasamoorthy et. al, 2011). The objective of this research is to determine the level of pollution in the Cuddalore district's industrial area zone.

## Materials and Methods

The study area (Fig.1) is around the industrial zone of Cuddalore district, the southern state of Tamilnadu. Its coordinates are 11°44'46.64"N, 79°45'51.7"E. It is both an industrial spot and a coastal region. The district has more different types of chemical industries and they are under the State Industries Promotion Corporation of Tamil Nadu. The groundwater samples are collected from the five bore wells located in and around the industrial zone of the Cuddalore district. The samples were carefully collected in clean containers, and analysis began the same day at the Chennai Testing Laboratory, Private Limited, Gundy, Chennai, Tamilnadu. The samples were tested in accordance with the appropriate procedures (APHA 2017).

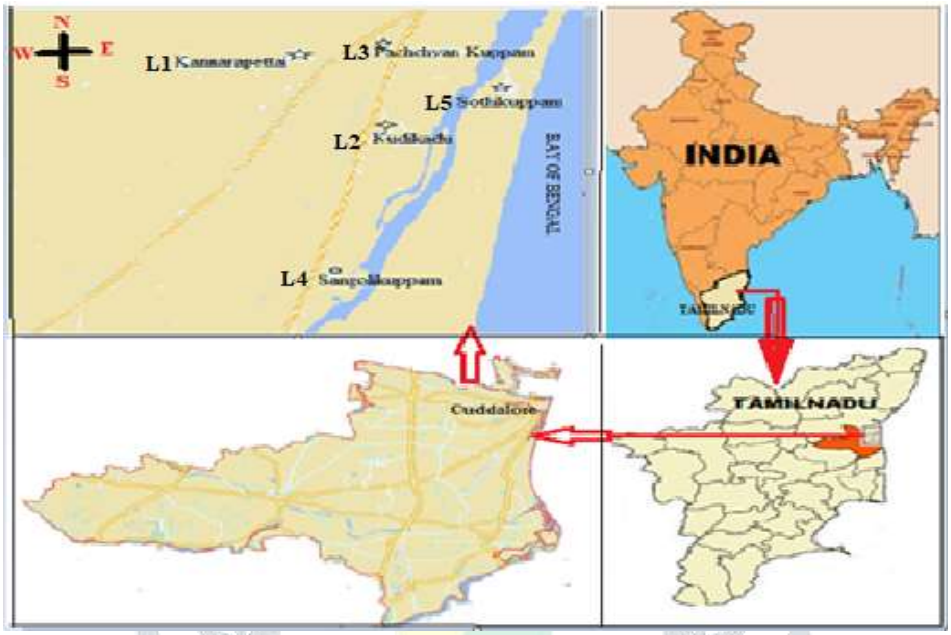


Figure1. Study area of five samples

Table 1 displays the physical parameters determined, such as hydrogen potential (pH) and turbidity. The chemical variables like Electrical Conductivity (EC), Total Hardness (TH), Total Dissolved Solids (TDS), Total Alkalinity (TA), Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Chloride ($Cl^-$), Fluoride (F) and Sulphate ($SO_4^{2-}$) are also listed in the table 1.

Table 1.Physico-chemical parameters of the water samples collected from the study locations L1 to L5.

| Sl.No. | Parameters | Acceptable limit of BIS 2012 | Study Location | | | | |
|---|---|---|---|---|---|---|---|
| | | | L1 | L2 | L3 | L4 | L5 |
| 1 | pH | 6.5 to 8.5 | 6.3 | 7.4 | 7.3 | 7.6 | 7.9 |
| 2 | Conductivity (µS/cm) | - | 454 | 1314 | 1326 | 1602 | 1709 |
| 3 | Turbidity (NTU) | 1 | <1 | <1 | 2 | <1 | <1 |
| 4 | Total Hardness (mg/l) | 200 | 103 | 237 | 536 | 422 | 371 |
| 5 | Total Dissolved Solids (mg/l) | 500 | 270 | 786 | 798 | 958 | 1020 |
| 6 | Total Alkalinity (mg/l) | 200 | 12 | 200 | 280 | 270 | 150 |
| 7 | Calcium (mg/l) | 75 | 29 | 58 | 140 | 111 | 87 |
| 8 | Magnesium (mg/l) | 30 | 8 | 23 | 45 | 35 | 38 |
| 9 | Sodium (mg/l) | - | 27.8 | 138 | 44.1 | 99.2 | 132.8 |
| 10 | Potassium (mg/l) | - | 2.9 | 26.5 | 3.86 | 38.9 | 25.7 |
| 11 | Chloride ( mg/l) | 250 | 70 | 113 | 71 | 160 | 226 |
| 12 | Fluoride (mg/l) | 1 | BDL | 0.29 | 0.2 | BDL | BDL |
| 13 | Sulphate ( mg/l) | 200 | 47.6 | 189 | 246 | 109 | 79.8 |

BDL- Below Detection Limit (Detection Limit is 0.1)

The Piper diagram has been used to determine the hydro geochemical properties of groundwater samples. It is used to categorize the type of groundwater based on the presence of positive ions and negative ions. Cations like Calcium (Ca), Magnesium (Mg), Sodium (Na) and Potassium (K) are in one triangle, Anions like Chloride ($Cl^-$), Sulphate ($SO_4^{2-}$), Carbonate ($CO_3$) and Bicarbonate ($HCO_3$) are in another triangle. The diamond portion of the Piper trilinear figure (Fig. 3) indicates the location of both cations and anions (Arulbalaji and Gurugnanam, 2017).

Gibb's diagram (Fig. 4) is a graphical method for determining the source of geochemical processes in groundwater. The total dissolved solids are measured along the Y-axis, and the fraction of $Na^+$ and the total of $Na^+$ and $Ca^{2+}$ cations are measured along the x-axis. For characterizing anions, the ratio of $Cl^-$ and sum of the Cl- and $HCO_3^-$ is along the x-axis with TDS along Y-axis. Precipitation, rock dominance, evaporation, and seawater superiority, characterize the source of the groundwater samples. This can be identified by Gibb's plot. Furthermore, the high value of pollutants may be associated with environmental change caused by human activities on the growth of industrialization (Jong et. al., 2017).

## Results and Discussion

The Physicochemical parameters are examined and compared to values provided by the Bureau Indian standards (BIS, 2012). The pH ranges from 6.3 to 7.9 in every one of the five locations. According to BIS 2012, the permissible pH range is 6.5 to 8.5. All of the data are well within the BIS 2012 acceptable level. The sample L5 has the highest value of electrical conductivity, 1709 µS/cm. The site with the lowest concentration of it was L1. The sample taken from location L3 had the highest turbidity level among the five, measuring 2 NTU. The total hardness of drinkable water should've been 200 mg/l as per BIS standards, but except for sample L1, all the samples have been the total hardness levels that exceeded the acceptable limit. The total hardness was also highest in site L3, with similar turbidity. The minimum value of TDS was observed in the location L1. The maximum concentration of it was recorded in the sample L5 as 1020 mg/l. The sample from locations L2, L3, L4, and L5 had a TDS value that was over the permitted limit. The highest value of TA was obtained as 280mg/l in L3 and lowest in L1 as 12 mg/l. Total alkalinity is equal to the sum of the concentration of Carbonate and Bicarbonate if pH value is from 6 to 8.2 (APHA, 2017). If the total hardness is less than the total alkalinity, it is named as the carbonate hardness or temporary hardness otherwise it will be permanent hardness. In this study, TH is significantly larger than TA throughout all locations. It was found that all of the samples possessed the permanent hardness property ( Thilagavathi et. al., 2012).

The acceptable quantity of Calcium is 75 mg/l by the record of BIS. Calcium levels were found to be above acceptable levels in L3, L4, and L5, but they were below the required levels in L1 and L2. In the case of magnesium, the 30 mg/l is the acceptable one for the drinking water. But L3, L4 and L5 were having Mg greater than the required level. The concentration of Sodium is highest in L2 and lowest in the sample L1. Potassium is greatest in L4 and very minimum value in L1. All the samples are within the required limit of Chloride as the record of BIS, 250 mg/l Fluoride content is also below the acceptable limit of BIS, 2012. Acceptable value of Sulphate is 200 mg/l, L3 sample only having above the acceptable limit of BIS, 2012.

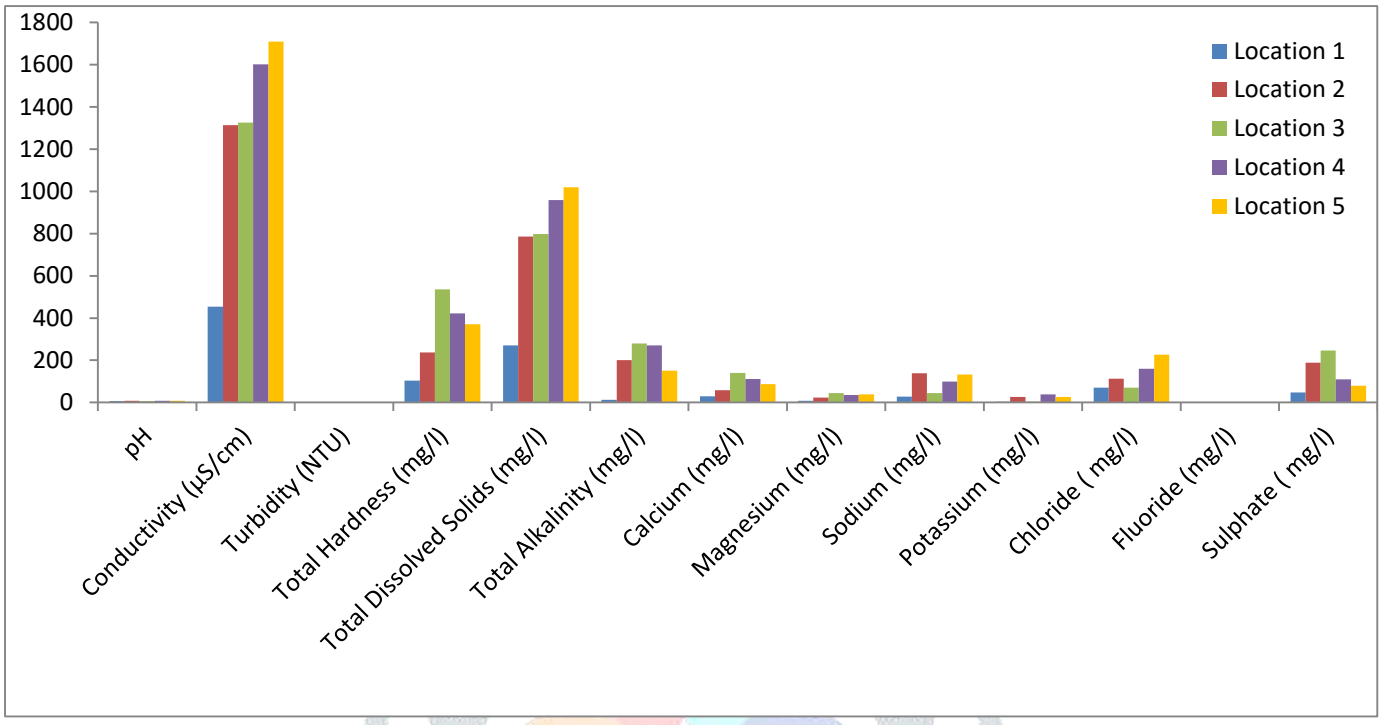


Figure 2.Comparison of Physicochemical parameters of water samples from five locations

Through Figure.2, every one of the measured physical and chemical parameters is compared for five different locations.

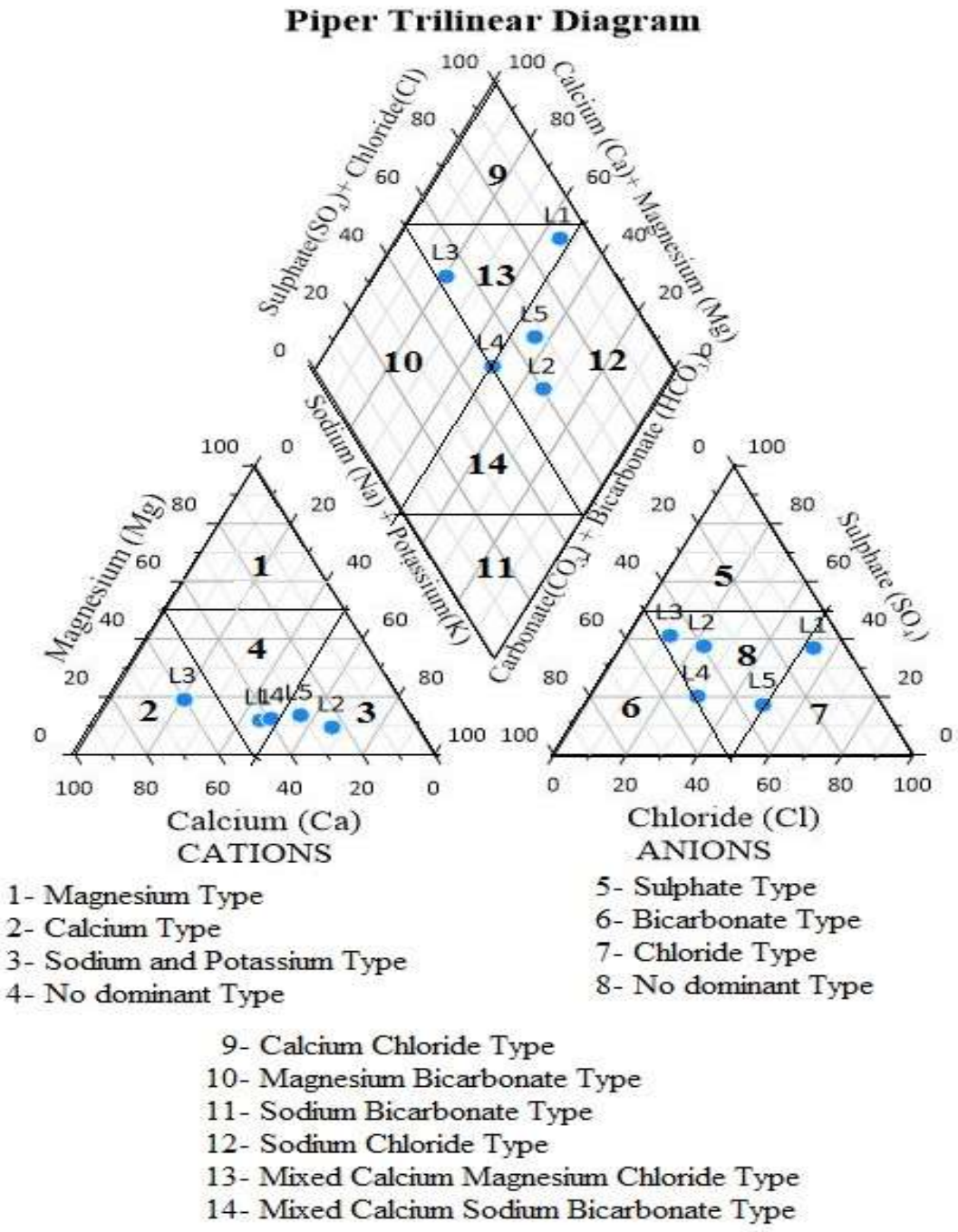


Figure 3. Piper Trilinear plot of study samples

According to the Piper plot, the sample taken from site L3 has calcium type cations, L2 and L5 have sodium & potassium type cations, L1 and L4 were not dominating types of cations. The anions at the L1 location are of the Chloride type, while the anions in the other samples were of the non-dominant type. The projection points in the diamond portion of the Piper plot revealed that L2 (Kudikadu) and L5 (Sothikuppam) samples contained Sodium Chloride, while L1 (Kannarapetai) and L3 (Pachayankuppam) locations have mixed Calcium Magnesium Chloride. L4 (Sangolikuppam) is at the centre and it proved that it has no dominant cations and anions.

Now Gibb's plot is necessary to demonstrate the sources of each type of water. L4 and L5 samples are on the trace line showed that the groundwater have been polluted due to the sea water interaction, evaporation or industrial effluents. L2 and L3 are just below the trace line and they were in the mixed type due to the rock water interaction, evaporation or moderately polluted by seawater. The sample collected from L1 location has mixed Calcium Magnesium Chloride type identified the rock dominance.

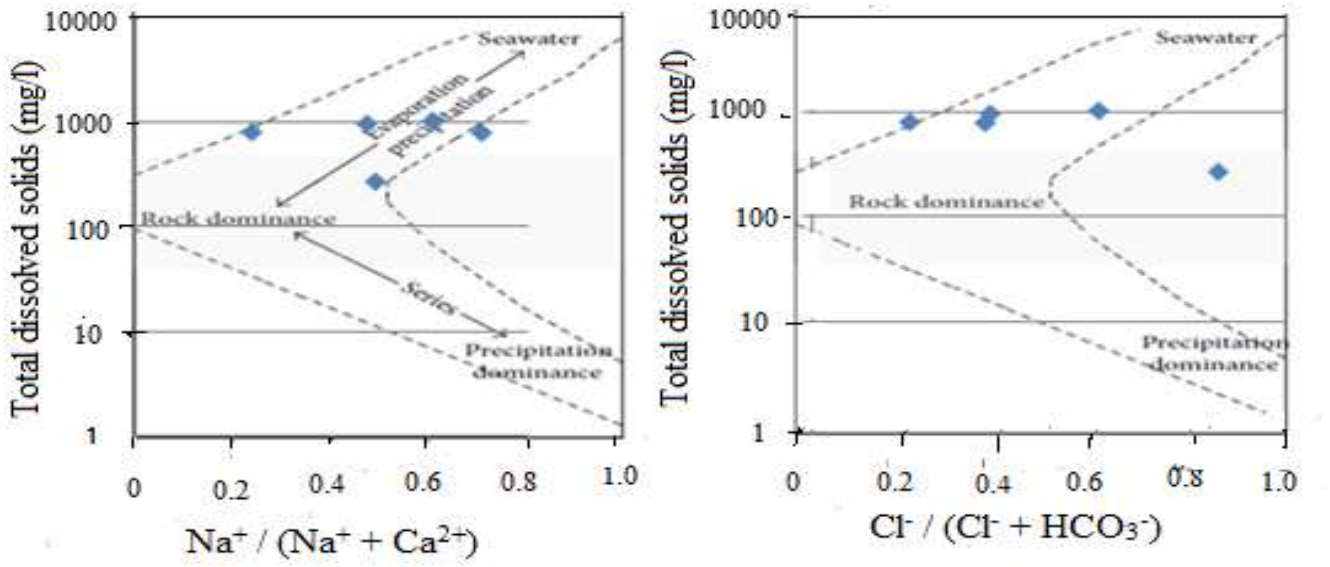


Figure 4. Gibb's plot of study samples

## Conclusion

The samples for this study were taken from five separate locations, labelled L1 to L5. The physicochemical parameters were examined and compared to the acceptable limits set by the Bureau of Indian Standards. The hydrochemistry of the samples reveals that they are primarily Calcium Magnesium Chloride and Sodium Chloride, which could be owing to saltwater interaction or rock water dominance. It demonstrates that the samples under study have a permanent hardness feature. As a result, it is essential to do regular groundwater monitoring near industrial zones.

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