SJIF: 4.756

ISSN 2455 7285

ASIAN JOURNAL OF INNOVATIVE RESEARCH

Available online at http://www.asianjir.com

Article

Industries and Earth Sciences

# EXPLORATION OF THE GROUNDWATER QUALITY IN THE CUDDALORE DISTRICT, TAMIL NADU, INDIA

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**Received on 24th Oct 2025; Revised on 29th Nov 2025 Online 14th Dec. 2025**

## ABSTRACT

The most crucial natural resource for human survival on Earth is groundwater. One of the most valuable natural resources on Earth is groundwater. Groundwater is the only supply of drinking water in many rural regions, which is essential for both industrial growth and human existence. The physicochemical aspects of groundwater quality were investigated in this study. In the Cuddalore district, 100 groundwater samples were gathered. Standard protocols were used to examine the physical and chemical properties of the obtained samples. In the Cuddalore district, physico-chemical characteristics including pH, electrical conductivity, total dissolved solids, bicarbonate, chloride, sulphate, calcium, magnesium, sodium, and potassium were examined. The ground water is odorless and colorless throughout much of the study area. The BIS (1998), ICMR (1994), and WHO (1998) drinking water standards were compared to the physico-chemical properties of the ground water samples under study. There have been notable physicochemical changes to the groundwater in Tamil Nadu's Cuddalore area. The main causes of the pollution include intensive agricultural activities, seawater intrusion in coastal zones, and industrial waste.

**Keywords:** Groundwater, Cuddalore district, Physio and chemical analysis, Water quality.

***Citation:*** G. Kalidhasan and K. Sankar. (2025). Exploration of the quality of groundwater in the Cuddalore district, Tamil Nadu, India. Asian Journal of Innovative Research. 9 (4): 01-12.

## INTRODUCTION

Groundwater is an essential component of the environment and economy. It sustains the flow in our rivers and plays an important role in maintaining the fragile ecosystems. Ground water contributes to about eighty percent of the drinking water requirements in the rural areas, fifty percent of the urban water requirements and more than fifty percent of the irrigation requirements of the nation. The quality of groundwater is a major concern for humanity because variation in quality can give hazardous effect to human health and society as well. In India groundwater is having a great value as it is the major source of drinking and irrigation purposes (Kumar, 2006). In recent times exploitation works for groundwater has been increased significantly, especially for agricultural purposes as many regions. The frequent failure of monsoon has resulted in the decrease of the groundwater recharge. This component serves as a essential contributor for the domestic, irrigation and industrial sector. The Quality of groundwater is determined by physical, chemical and biological parameters. This quality affects determines the utility of groundwater. The chemistry of groundwater have an important function in assessment of water quality (CGWB, 1992). The physicochemical aspects of groundwater quality were investigated in this study. In the Cuddalore district, 100 groundwater samples were gathered. Standard protocols were used to examine the physical and chemical properties of the obtained samples.

## MATERIALS AND METHODS

### Study Area

The study area, viz. Cuddalore district lies on the East Coast of Southern India, bound on the north, south and west by Villupuram, Nagapattinam and Perambalur districts and on the east by Bay of Bengal. The district lies between $78^{0}$ 42’and $80^{0}$ 12’east latitude and $12^{0}$ 27'30″and $11^{0}$ 10’45″north longitude (Figure 1). The average rainfall is 1164mm per year. There are 7 talukas situated in cuddalore district and the total population is around 2,605,914 according to the census report of 2011. The drinking water source of cuddalore district is mainly ground water for their drinking purpose and for day today activities. Bore well is the only supply of ground water in cuddalore district which is distributed through pipelines. The list of places were listed in Figure 2. Hence, the study was designed to evaluate the parameters significant for potability purpose and the concentration in the water was compared with the standards prescribed by WHO (World Health Organization) and BIS (Bureau of Indian Standards).

### Physico-chemical analysis

Groundwater samples were collected from 100 representative bore wells, during pre and post moonson 2014. Samples were collected in 1 L polythene bottles which were previously cleaned. Each bottle was rinsed with distilled water to avoid any possible contamination. The analysis was carried out systematically both volumetrically and by instrumental techniques. The procedures were followed from standard books and manuals (APHA, 2005; BIS, 2003; APHA, 1985, 1989, 1998, Gloterman *et al.*, (1978) and National Environmental Engineering Research Institute (NEERI, 1988).). The analysis was carried out immediately for pH, EC, DO and for all other parameters.

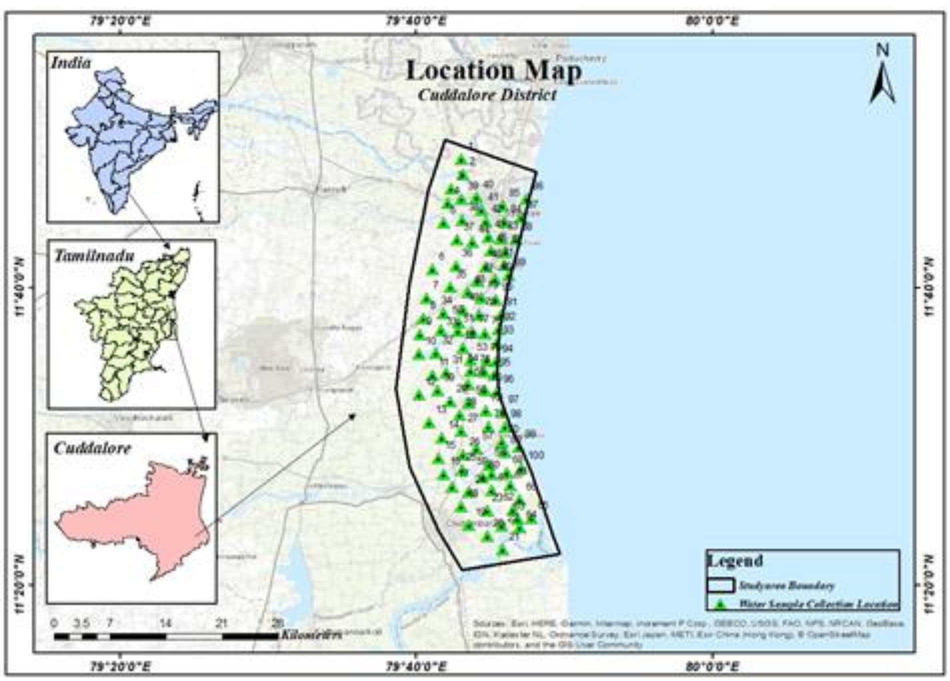



**Figure 1: Location Map of the Study area**

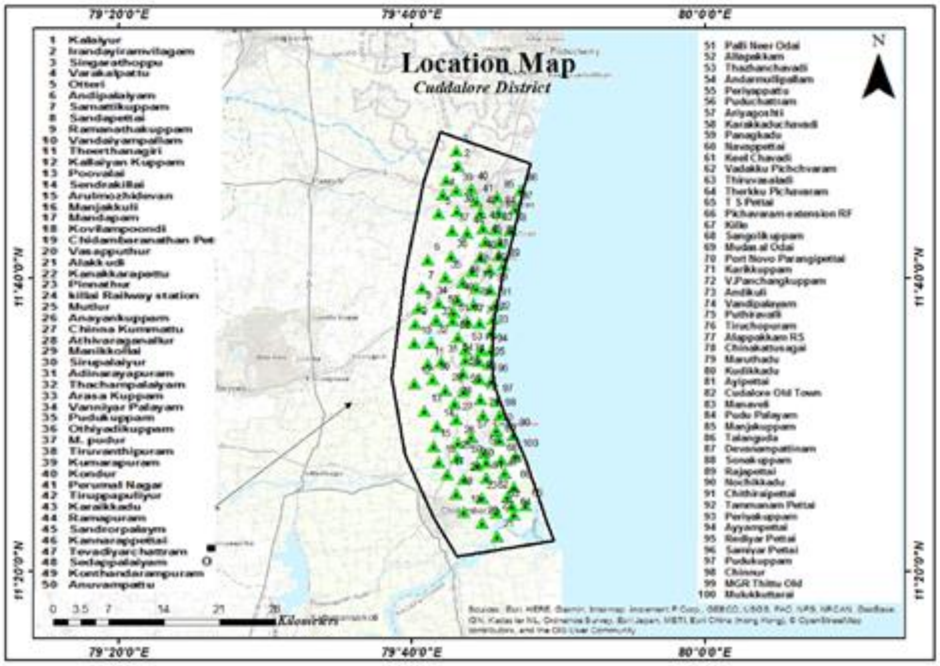


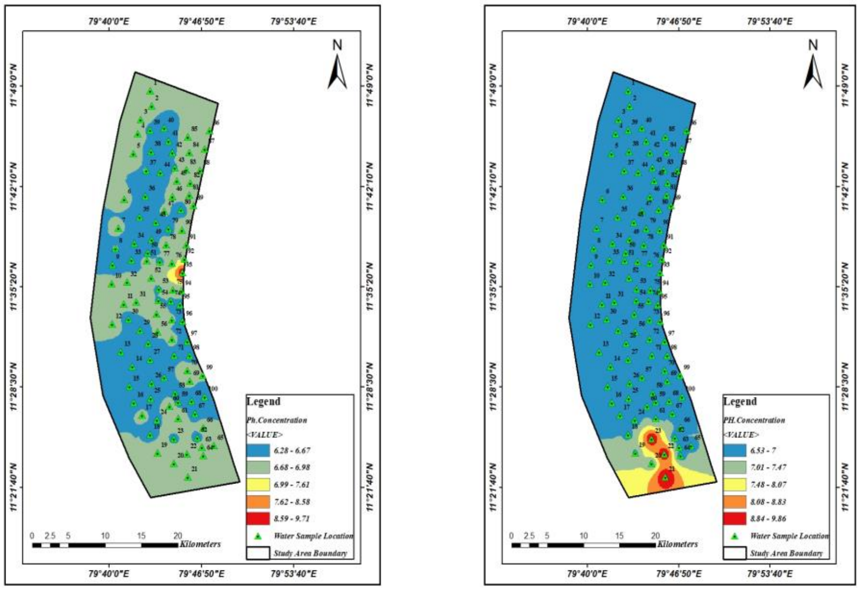

**Figure 2: Sample location of the study area**

## RESULTS AND DISCUSSION

The average results of the physicochemical parameters for water samples are presented in figure 1 to 11.

### pH

The range of pH of water prescribed for drinking purpose by ISI (1983) and WHO (1984) is from 6.5 to8.5, while that of the EEC (Lloyd and Healthcote, 1984) is from 6.5to9.0. In the study area, the pH value ranges from 6.2 to 9.7 with a average value 6.70 during the pre-monsoon and from 6.5 to 9.8 with a average value during post-monsoon respectively, indicating the overall slight alkaline nature of the samples. It was found to fluctuate in certain locations with few abnormalities. Results show that the spatial distribution of pH is found to be above the permissible limit in the, Central part of the study area during pre monsoon and in Northern and Southern part of the study area during post monsoon (Figure 3). In the Northeastern part of the study area, the salinity of the groundwater samples is influenced by the saline water intrusion from the nearby coastal area and backwater recharge. The pH value of all the samples does not exceed the recommended limit (pH 6.5-8.5) of BIS (1991) and WHO (2011) whereas the water samples were slight alkaline in characteristic. Similar pH value 7.1 -8.4 for the ground water of the selected area of Mysore city, Karnataka and it is stated that the reason for such conditions may be due to different types of buffers that may present in the ground water and presence of weak basic salt in the soil (Nirmala and Ranjitha, 2011).

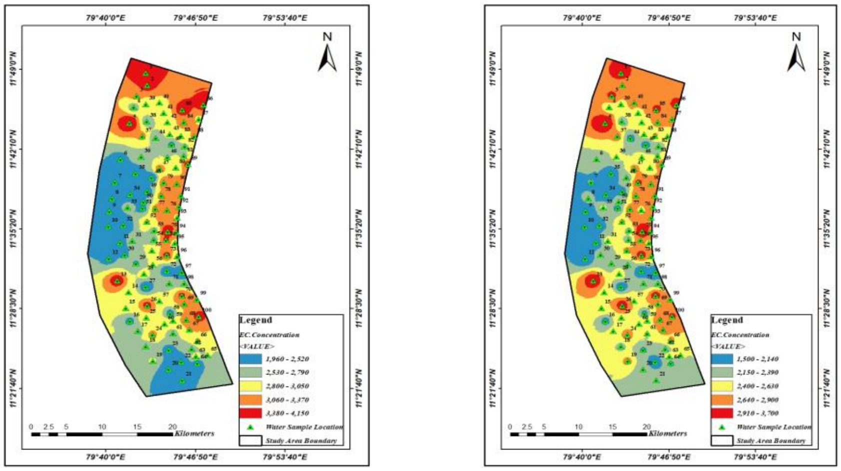



**Pre monsoon** **Post monsoon**

**Figure 3: Spatial distribution of pH during pre and post-monsoon**

**Electrical Conductivity**

Electrical conductivity is a measure of water capacity to convey electric current. EC value is manifestation to signify the concentration of soluble salts in water. The electrical conductance is an indication of total dissolved solids which is a measure of salinity that affects the taste of potable water. In the study area, the EC value ranges from 419 to 2470 µS/cm and the average of the electrical conductivity value found as 1213µS/cm during the pre-monsoon and from 220 to 2450 µS/cm and the average of the electrical conductivity value found as 1203µS/cm during post-monsoon respectively. Groundwater quality has significantly declined as a result of the intrusion of saline water; despite the northeast monsoon, salinity is considerable in some areas (Mondal *et al.*, 2011). The percentage of brackish water is higher than that of saline water that exists in the study area. Results show that the spatial distribution of EC is found to be above the permissible limit in the Northern, Central, Northeastern and Southern part of the study area (Figure 4). In the Northeastern part of the study area, the salinity of the groundwater samples is influenced by the saline water intrusion from the nearby coastal area and backwater recharge. Most of the sample EC exceeds the permissible limit of 500 recommended by BIS (1991) and WHO (2011). Patil and Patil (2007) also found that high range of electrical conductivity was observed in Amalner Town ground waters in the range of 398 µS to 2827µs. In addition, Senthilkumar *et al* (2012) also reported the range of electrical conductivity was observed in coastal stretch of Cuddalore district is about 10km in the range of 198 µS to 3104µs.

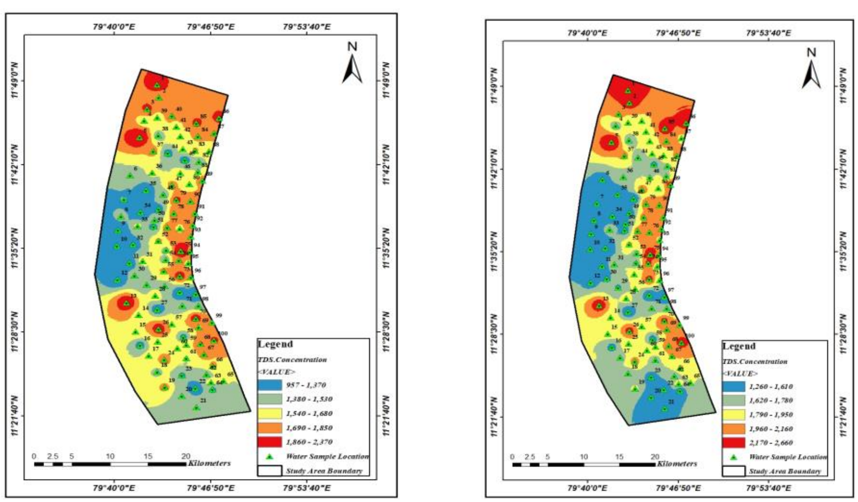



**Pre monsoon** **Post monsoon**

**Figure 4: Spatial distribution of EC during pre and post-monsoon**

**Total dissolved solids (TDS)**

In pre-monsoon data revealed that the total dissolved substances value is ranged from 270 to 1582 and the average of the total dissolved substances value was found to be 776.2. In post-monsoon data revealed that the total dissolved substances value is ranged from 141 to 1470 and the average of the total dissolved substances value was found to be 767.4. In about 50% of the samples TDS exceeds the BIS limit of 500 mg/L because incidence of higher level of TDS is considered to be objectionable. As per the classification (Durfor and Becker, 1964), total dissolved solids for around 8 samples made the water slightly saline. Results show that the spatial distribution of TDS higher value was observed in the Northern, central and Southern part of the study area during both seasons (Figure 5). It is interesting to note that in all the seasons, the Northern part of the study area has TDS higher value which may be attributed to the presence of salt pan and landfill site regions. In the southeastern part of the study area, the higher values of TDS are due to saline water intrusion from nearby coastal area and the influence of salt plan. As per the classification (Durfor and Becker, 1964), total dissolved solids for around 8 samples made the water slightly saline. Similarly high levels of TDS ranging from 700 to 3200 mg/L were found in groundwater samples in Kotputli Town, Jaipur, Rajasthan. This parameter in general gains its entry in to ground water through various means such as sea water intrusion, sewage, urban runoff, industrial wastewater (Mittal et al., 1994).

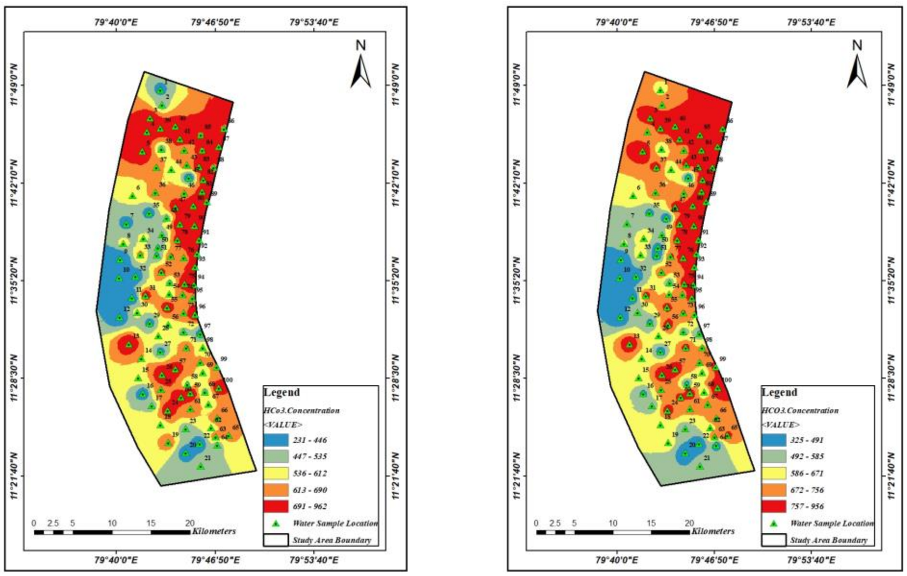



**Pre monsoon** **Post monsoon**

**Figure 5: Spatial distribution of TDS during pre and post monsoon**

**Bicarbonate ($HCO_3$)**

The $HCO_3$ (ppm) value of pre-monsoon and post-monsoon of selected area of Cuddalore district. In pre-monsoon data revealed that the $HCO_3$ value is ranged from 231 to 995 and the average of the $HCO_3$ value found as 666.1. In post-monsoon data revealed that the $HCO_3$ value is ranged from 325 to 988.2 and the average of the $HCO_3$ value found as 705.12. Most of the sample bicarbonate does not exceeds the permissible limit of 500 recommended by BIS (1991) and WHO (2011). Results show that the spatial distribution of $HCO_3$ higher value were observed in the Northern, central and Southern part of the study area during both season (Figure 6). Most of the sample bicarbonate exceeds the permissible limit of 500 recommended by BIS (1991) and WHO (2011).

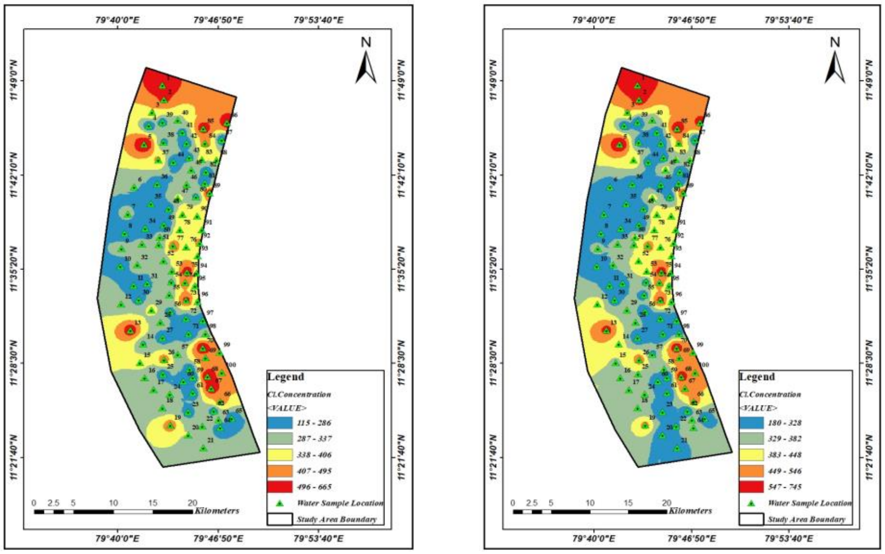



**Pre monsoon** **Post monsoon**

**Figure 6: Spatial distribution of $HCO_3$ during pre and post monsoon**

**Chloride (Cl)**

the chloride (ppm) value of pre-monsoon and post-monsoon of selected area of Cuddalore district. In the study area, the $Cl^-$ value range from 115 to 665 ppm with a mean value of 332.38 ppm during the pre-monsoon and from 180 to 745ppm with a mean value of 366.73 ppm during post-monsoon respectively. The concentration of $Cl^-$ is higher in this region which may be due to the impact of saline water and base exchange reactions (Freeze and Cherry, 1979). Spatial distribution of $Cl^-$illustrates that the Northern part of the study area shows values higher than the permissible limit during both seasons (Figure 7). This may be attributed to the presence of salt pan and landfill site regions. It was likely that Na and Cl in the groundwater were increased due to the influence of seawater intrusion. They may be due to the lack of underground drainage system and bad maintenance of environment around the sources. The chloride ion is the most predominant natural form of the element chlorine and is extremely stable in water. The chloride in groundwater may be from diverse sources such as weathering, various chemical industries and leaching of soil, domestic and municipal effluents (Sarath Prasanth et al. 2012). The chloride concentration serves as an indicator of pollution by sewage. People accustomed to higher chloride in water are subjected to laxative effects. The range of chloride is found to vary between 104 and 2493 mg/l for water samples. As per (World Health Organization 2011) and Indian standards (BIS, 1991) the desirable limit for chloride is 250 mg/l. They may be due to the lack of underground drainage system and bad maintenance of environment around the sources.

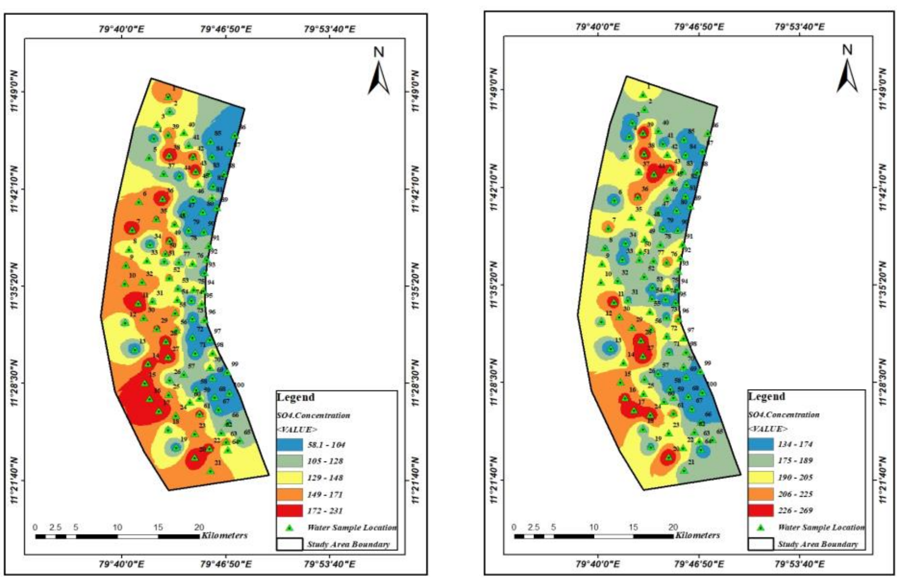



**Pre monsoon** **Post monsoon**

**Figure 7: Spatial distribution of Cl during pre and post monsoon**

**Sulphate**

The sulphate (ppm) value of pre-monsoon and post-monsoon of selected area of Cuddalore district. In pre-monsoon data revealed that the sulphate value is ranged from 58 to 231 ppm and the average of the sulphate value found as 131 ppm. In post-monsoon data revealed that the sulphate value is ranged from 134 to 269 ppm and the average of the sulphate value found as 189 ppm. The highest concentration is noted during post monsoon. Spatial distribution of $SO_4$ illustrates that the Northern part of the study area shows values higher than the permissible limit during both seasons (Figure 8). A similar result found in the study conducted in the groundwater samples near an Industrial vicinity of Cuddalore District, Tamilnadu, India (Devi et al., 2012) where the values were reported in the range 18 to 80mg/L. Bacterial fixation, fertilizer effects, tanneries, and other human-caused sources might be the other sources of this ion in the aquifer (Chidambaram et al., 2012).

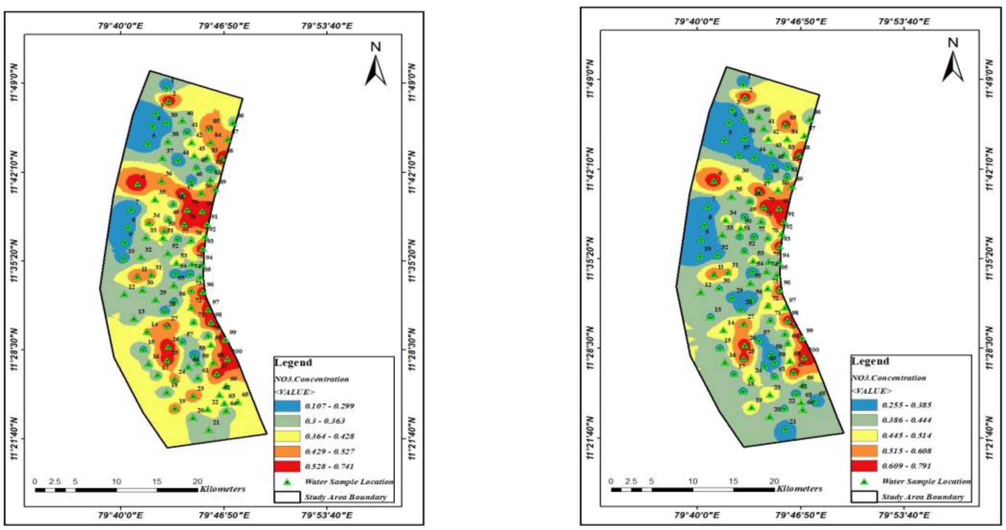



**Pre monsoon** **Post monsoon**

**Figure 8: Spatial distribution of $SO_4$ during pre and post monsoon**

**Nitrate ($NO_3$)**

Groundwater that contains more nitrate and nitrite than is safe to drink is not suitable for human consumption (Rajmohan and Elango 2005). Nitrate results mostly from surface contamination sources. Nitrate (>300 mg/l) poisoning may result in the death of livestock consuming water (Canter 1997). Nitrate contamination is strongly related to land use pattern and reported in several studies throughout the world (Sujatha and Reddy, 2006; Rajmohan *et al.*, 2009; Jing Fang and Yong-jian, 2010). During the pre-monsoon concentration of nitrate ranged varies from 0.11 to 0.74 with an average 0.40 during pre-monsoon, and during the post monsoon, it ranged between 0.25 and 0.79 with a mean value 0.45. The spatial variation observed was quite high, as nitrate concentration was found to be influenced by several waste disposal measures adjacent to the wells (Figure 9). The high values of nitrate found in the study area reveal the extent of contamination caused by the improper waste disposal measures. During the postmonsoon period of nitrate concentration decreased in several wells, however, it is found to increase in few wells. This could be due to the leaching of nitrate from the open sewerage lines.

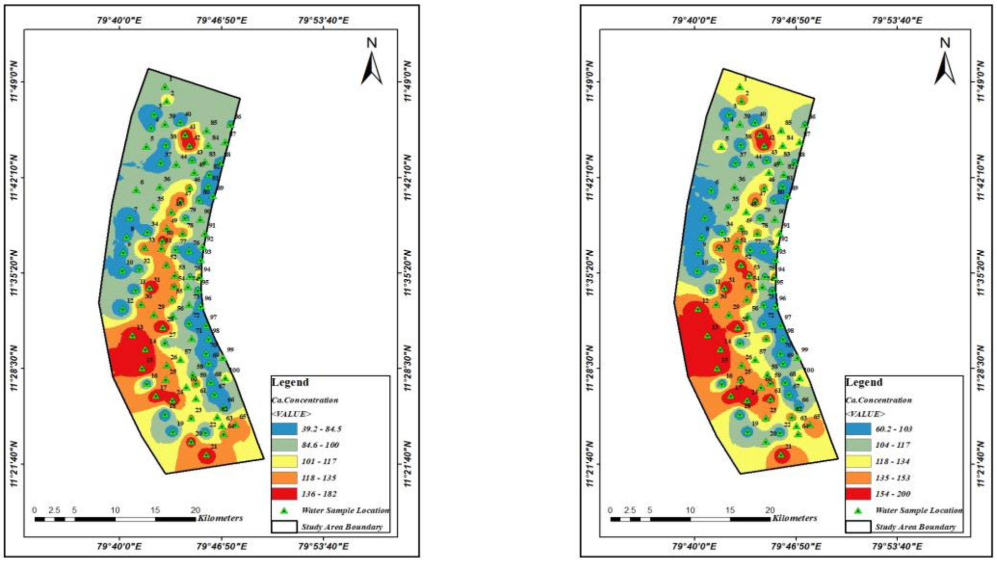



**Pre monsoon** **Post monsoon**

**Figure 9: Spatial distribution of $NO_3$ during pre and post monsoon**

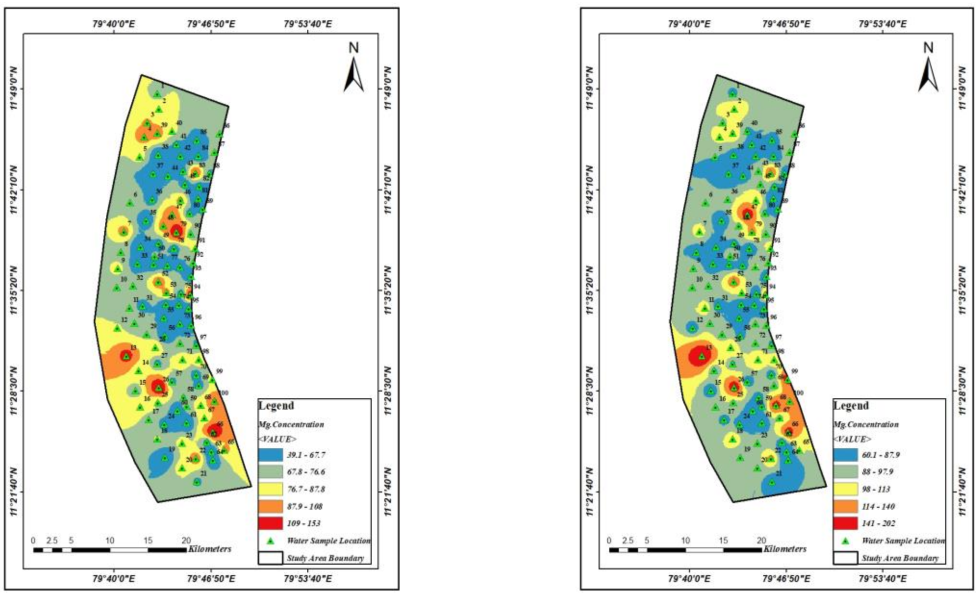
**Calcium and magnesium (Ca and Mg)**

In pre-monsoon data revealed that the calcium value is ranged from 39 to 212 and 196 while the average of the calcium. In the study area, the $Ca^{2+}$ value ranges from 60 to 236 ppm with a mean value of 210 ppm during the post monsoon. The dissolution of $CaCO_3$ and CaMg $(CO_3)_2$ precipitates during recharge may have been the source of the calcium ion in the research area's ground water. During pre-monsoon the Calcium concentration is found to be above the permissible limit in the Northern part of the study area (Figure 10). The concentration of Magnesium in the study area ranges from 84.6 to 105.2 ppm with a mean value of 36.8 ppm during the pre-monsoon and from 101.7 to125.3 ppm with a mean value of 38.4 ppm during post-monsoon. The Magnesium higher concentration is found in the Northern and middle part of the study area during pre-monsoon (Figure 11). The calcium and magnesium in waters are generally used to classify the suitability of water. Calcium and magnesium are directly related to hardness of the water and these ions are the most abundant elements in the surface and groundwater and exist mainly as bicarbonates and to a lesser degree in the form of sulphate and chloride. The desirable limit of calcium in drinking water is 75mg/L (ISI, 1996). Calcium is directly related to hardness of the water and these ions are the most abundant elements in the surface and groundwater and exist mainly as bicarbonates and to a lesser degree in the form of sulphate and chloride. Magnesium would have originated from the dissolution of magnesium calcite, gypsum, and/or dolomite, as reported by Garrels (1976).




**Pre monsoon** **Post monsoon**

**Figure 10: Spatial distribution of Ca during pre and post monsoon**

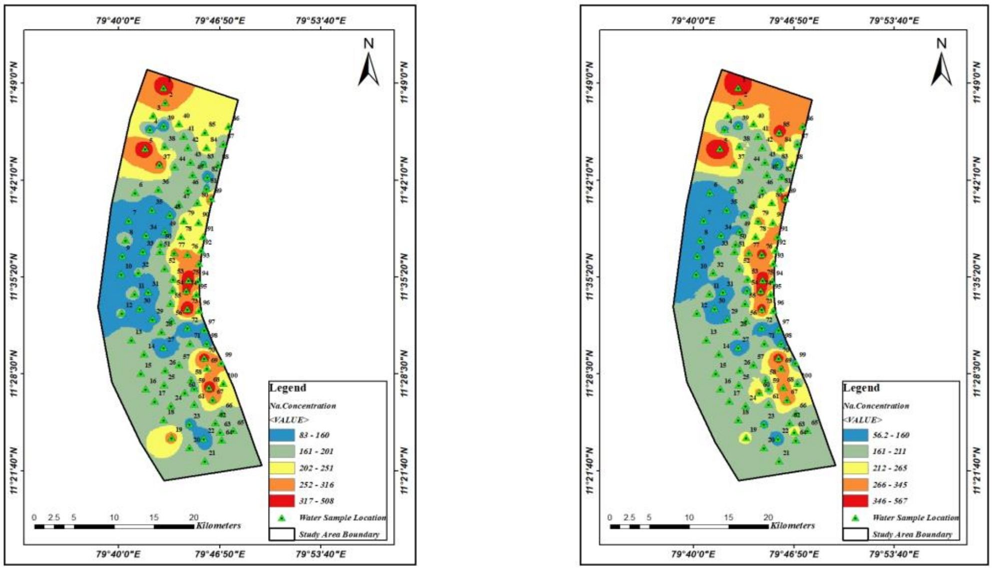



**Pre monsoon** **Post monsoon**

**Figure 11: Spatial distribution of Mg during pre and post monsoon**

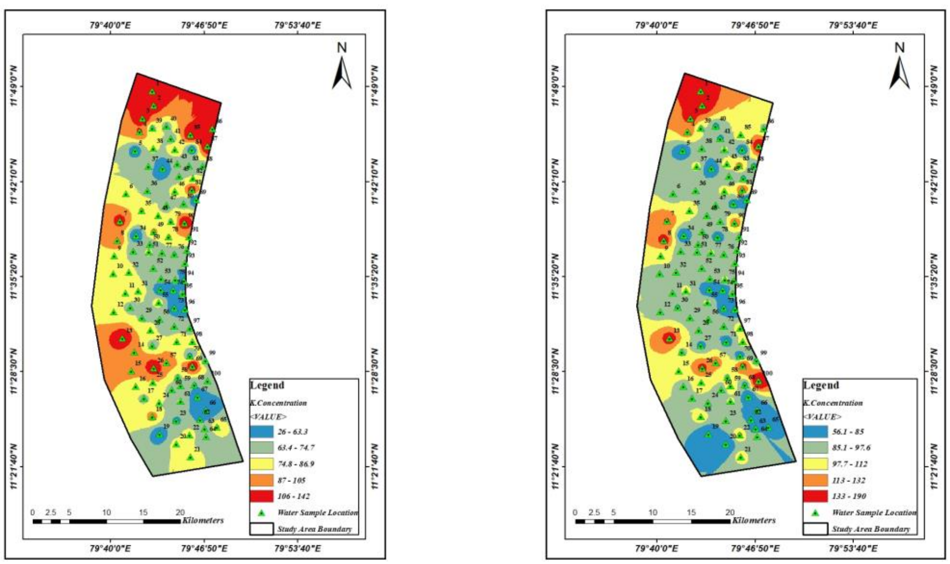
**Sodium and potassium (Na and K)**

Sodium occurs naturally in groundwater. However, sources such as road salt storage and application, industrial wastes, sewage, fertilizers, water softener discharge, and proximity to saltwater are usually the cause of elevated levels in drinking water supplies. Concentration of sodium ranged between 83 and 510 ppm, with mean value of 202 ppm in pre monsoon and 56 and 568 ppm with mean value of 214 ppm during postmonsoon respectively. The spatial distribution pattern of both the seasons shows that the higher concentrations fall in the western part of the study area (Figure 12). Concentration of potassium ranged between 26 and 142 ppm, with mean value of 78 ppm in pre monsoon and 56 and 190 ppm with mean value of 97 ppm during post-monsoon respectively. During the post-monsoon period concentration of potassium has increases in few of the wells respectively. The spatial distribution pattern of both the seasons shows that the higher concentrations fall in the western part of the study area (Figure 13). Potassium in groundwater originates from the weathering of feldspar minerals and also due to anthropogenic sources of pollution. Unlike sodium, potassium feldspars are resistant to attack by water, hence it is always present at lower concentration than sodium (Hem, 1985).




**Pre monsoon** **Post monsoon**

**Figure 12: Spatial distribution of Na during pre and post monsoon**




**Pre monsoon** **Post monsoon**

**Figure 13: Spatial distribution of K during pre and post monsoon**

## CONCLUSIONS

The research area is constantly under stress because of the growing population and increased demand for water supplies. The ground water is fresh to brackish and moderately high to hard, according to the study's hydrogeochemical analysis. Research has been done on the geochemical properties of drinking water and groundwater. The Cuddalore district collected and examined 100 groundwater samples. In the Cuddalore region of Tamil Nadu, there have been significant physicochemical changes to the groundwater. The primary sources of pollution are industrial waste, seawater intrusion in coastal areas, and intensive farming practices. The government and non-governmental groups should encourage young people, particularly aspiring civil engineers, to create rainwater harvesting structures and artificial recharge techniques in order to improve water quality.

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