***Original Research Article***

# DELINEATION AND MAPPING OF GROUNDWATER QUALITY IN CHENGALPATTU DISTRICT OF TAMILNADU


## ABSTRACT

Groundwater is a major natural source of water supply all around the world. It's utilised for irrigation, industry, and even household purposes. The quality of groundwater is important for irrigation. Irrigation water quality plays a critical role in long-term soil productivity. To assess the quality of the groundwater, 149 samples were taken in May 2022 from the coastal blocks of the Chengalpattu district: Chithamur (42), Lathur (37), Thirukalukundram (31), and Thiruporur (39). The samples were analysed in accordance with the appropriate protocol. The study revealed that the coastline blocks pH ranges from 8.92 to 7.52 and their EC ranges from 11.50 to 0.13 dS $m^{-1}$. The Sodium Absorption Ratio (SAR) ranges from 20.00 to -6.80, while the Residual Sodium Carbonate (RSC) ranges from 14.77 to 0.26 meq/L. The Chengalpattu district has a high concentration of alkali water, according to CSSRI, Karnal classification. Among the coastal blocks, the Thiruporur block contains more alkali water compared to other coastal blocks (46%)



**Keywords**: Groundwater, Chengalpattu district, pH, EC, SAR, RSC


## INTRODUCTION

Chengalpattu district is situated on the northeast coast of Tamil Nadu. The district total area is 2944.96 square kilometers and its shoreline extends for 57 kilometers. It is situated between the longitude of 79°59' East and the latitude of 12°41' North. The major river in the Chengalpattu district is Palar which runs through the Chengalpattu district for 54 kilometres, is one of the important rivers in Tamil Nadu. It comprising of 8 taluks with 636 revenue villages and 8 blocks with 359 Village Panchayats. Acharapakkam, Chithamur, Kattankulathur, Lathur, Maduranthagam, St. Thomas Mount, Thiruporur, and Thirukalukundram are the eight blocks. Chithamur, Lathur, Thirukazhukundram, and Thiruporur are the coastal blocks in this area. Chengalpattu has a tropical wet and dry climate. The district average annual rainfall is around 1400 mm. Paddy is the most often planted crop in the area. Sugarcane is grown in several areas of the district as well. Horticulture crops like brinjal and ladies finger, watermelons and betel leaves are also grown in this area.

Water is a key component of our ecosystem without it, life on Earth cannot exist. Fresh water is a precious resource that is important for agriculture, industry, and human survival. Two-thirds of the surface of the world is covered with water. Only around 3% of the water on earth is freshwater, which is essential for all living forms; the other 97% is salt water. Groundwater is the most abundant and extensively distributed source of water in India. It is used for various purposes, including personal, commercial, and agriculture (Viveka *et al.*, 2019). Groundwater becomes polluted with a range of pollutants, including home, agricultural, and industrial pollutants, as a result of the use of fertilizers, pesticides, and other chemical products (Singh *et al.,*2020). The productivity of agriculture may be increased through irrigation. The yield is decreased when low-quality irrigation water is used for irrigation. As a result, the water's quality needs to be determined before it is used to irrigate crops (Sachin *et al.,* 2021). Groundwater intrusion and pollution are caused by extensive groundwater extraction and increasing sea levels in coastal aquifers. To prevent seawater intrusion, restrict groundwater pumping in the affected region and install water collection systems (Pramada *et al.,*

2018). The main issue in coastal locations is seawater intrusion, which has a negative impact on crop growth and yield. Increased salinity in groundwater has a direct impact on plants in numerous ways, including oxidative stress, ion toxicity, nutritional imbalance, and metabolic activity changes. Reduced plant growth, development, and yield are the results of all these issues (Sidari *et al.,* 2008). Irrigating crops with low-quality water is detrimental to crop health and can cause salt and sodicity issues in the soil over time. Utilizing saline water reduces soil productivity by having an adverse effect on its salinity, sodicity, or toxicity. In some cases, the land may even become unusable for farming. As a result, determining the quality of groundwater is critical for recognising these issues. The objective of this study is to investigate the groundwater quality in the coastal areas of the Chengalpattu district and mapping the groundwater quality using Arc GIS software.

## MATERIALS AND METHODS

In Chengalpattu district, 149 water samples were collected from the coastal blocks *viz*.Chithamur, Lathur, Thirukalukundram, and Thiruporur during May 2022. The location of the sample site was noted using a handheld GPS receiver (GPS, Garmin). A pre-clean plastic polyethene bottle was used to collect samples. A laboratory study was undertaken to evaluate the irrigation water quality. The samples were tested for pH, electrical conductivity, cations such as $Ca^{2+}$ and $Mg^{2+}$ using the versenate technique, and anions such as $CO_3^{2-}$, $HCO_3^-$, $Cl^-$ using the Titrimetric method, and K+, $Na^+$ using Flame photometry and $SO_4^{2-}$ using Turbidimetry using the standard procedure provided by (Richards, 1954). Quality indicators such as the Residual Sodium Carbonate (RSC) and Sodium Adsorption Rate (SAR) were computed using the formula shown below.

$$\mathbf{SAR= } \boldsymbol{Na^+ / \sqrt{(Ca^{2+} + Mg^{2+})/2}}$$

$$\mathbf{RSC = (CO_3^{2-} + HCO_3^-) -- (Ca^{2+} + Mg^{2+})}$$

The central soil salinity research institute (CSSRI) in Karnal uses the EC, SAR, and RSC values to assess the appropriateness of groundwater samples for irrigation. (AICRP, 1991) (Table 1.) and the Arc GIS software version 10.1 was used to create the map of various water quality metrics in the Chengalpattu district.

**Table 1: Grouping of low-quality ground waters for irrigation in India (CSSRI, Karnal classification)**

| Water quality | $EC_{iw}$ (dS/m) | $SAR_{iw}$ (m mol/L) | RSC (meq/L) |
|---|---|---|---|
| A. Good | <2 | <10 | <2.5 |
| B. Saline | | | |
| i. Marginal saline | 2-4 | <10 | <2.5 |
| ii. Saline | >4 | <10 | <2.5 |
| iii. High SAR saline | >4 | >10 | <2.5 |
| C. Alkali water | | | |
| i. Marginally alkali | <4 | <10 | 2.5-4.0 |
| ii. Alkali | <4 | <10 | >4 |
| iii. Highly alkali | Variable | >10 | >4 |
| D. Toxic water | The toxic water has variable salinity, SAR and RSC but has excess of specific ions such as chloride, sodium, nitrate, boron, fluoride or heavy metals such as selenium, cadmium, lead and arsenic etc | | |

## RESULTS AND DISCUSSION

### Electrochemical properties

The study findings indicate that the pH of the groundwater sample in the blocks of Chithamur and Lathur in the Chengalpattu district respectively, in the range of 7.69 to 8.87 with a mean of 8.22 and 7.52 to 8.73 with a mean of 8.30 and the pH range in the Thirukalukundram and Thiruporur block varies from 7.78 to 8.93 with an average of 8.32 and 7.77 to 8.78 with an average of 8.32 respectively. It shows that the majority of the samples come under slightly alkaline in nature similar results were reported by (Srinivas *et al.,* 2014).

The EC value in the Chengalpattu district coastal blocks ranges from 0.44 to 11.50 dS $m^{-1}$, 0.13 to 3.58 dS $m^{-1}$, 0.49 to 2.70 dS $m^{-1}$, and 0.39 to 3.94 dS $m^{-1}$in Chithamur, Lathur, Thirukalukundram, and Thiruporur respectively. In the Chengalapttu district, the mean EC values are 1.50, 1.19, 1.31, and 1.31 dS $m^{-1}$ respectively for the Chithamur, Lathur, Thirukalukundram, and Thiruporur blocks.

The variance in EC is greater in coastal groundwater due to man-made activities such as fertiliser misuse, mineral dissolution, and saltwater intrusion (Srinivasamoorthy *et al.,* 2011).

**Anionic constituents of groundwater**

The range of the carbonate content in the groundwater samples taken from the coastal blocks is 2.00 to 8.00 meq $L^{-1}$ (Chithamur), 0.00 to 8.00 meq $L^{-1}$ (Lathur), 2.00 to 4.13 meq $L^{-1}$ (Thirukalukundram), and 2.00 to 4.00 meq $L^{-1}$ (Thiruporur), with a mean value of 4.19, 4.22, 4.13, and 4.00 meq $L^{-1}$ respectively. Groundwater has higher bicarbonate and carbonate concentrations as a result of weathering of carbonate-bearing rocks and carbonic acid dissolution in the aquifer. Mohanty *et al.,* (2019) and Venkatasalam *et al.,* (2019) both found similar findings.

The bicarbonate content of the Chithamur, Lathur, Thirukalukundram, and Thiruporur blocks ranges from 2.00 to 18.00 meq $L^{-1}$, 0.00 to 14.00 meq $L^{-1}$, 2.00 to 16.00 meq $L^{-1}$, and 2.00 to 24.00 meq $L^{-1}$, with the mean value of these blocks being 6.81, 5.78, 6.97, and 7.54 meq $L^{-1}$ respectively. Bicarbonate is responsible for the alkalinity of groundwater. The carbonate and bicarbonates are probably derived from weathering of silicate rocks, dissolution of carbonate precipitates atmospheric and soil $CO_2$ gas (Jeong,2001). Similar results were reported by Venkatasalam *et al.,* (2019) and Manoj Kumar *et al.,* (2019).

The Chengalpattu district Chithamur, Lathur, Thirukalukundram, and Thiruporur blocks had chloride levels that varied from 0.20 to 13.20 meq $L^{-1}$, 0.40 to 20.80 meq $L^{-1}$, 0.60 to 10.40 meq $L^{-1}$, and 0.60 to 12.20 meq $L^{-1}$ with corresponding means of 1.58, 2.28, 1.89, and 1.55 meq $L^{-1}$. The chloride ion is the most common natural form of chlorine and is particularly stable in water. (Kuttimani *et al.,*2017). The high concentration of chloride in the study area is due to the mixture of seawater with groundwater (Krishnakumar *et al.,* 2012). Higher chloride concentrations might be caused by brines, wind-blown salt, seawater infiltration, industrial waste, and salt. Similar report was reported by (Manoj Kumar *et al.,*2019).

The range of sulphate content in the groundwater samples were collected is 0.04 to 2.18 meq $L^{-1}$, -0.05 to 9.58 meq $L^{-1}$, 0.01 to 1.28 meq $L^{-1}$, and 0.04 to 6.89 meq $L^{-1}$ with respective mean values of 0.62, 0.73, 0.47, and 0.68 meq $L^{-1}$ in the blocks of Chithamur, Lathur, Thirukalukundram and Thiruporur. Sulphate levels in groundwater rise as a result of leaching and anthropogenic activities (Manoj Kumar *et al.,* 2014).

**Cationic constituents of groundwater**

Calcium levels in Chithamur, Lathur, Thirukalukundram, and Thiruporur varied from 1.20 to 6.40 meq $L^{-1}$, 0.20 to 8.20 meq $L^{-1}$, 0.40 to 10.00 meq $L^{-1}$, and 0.40 to 9.20 meq $L^{-1}$, with a mean of 2.70, 2.71, 3.08, and 2.91 meq $L^{-1}$. The lower concentration of $Ca^{2+}$ in the study area, in comparison to Na2+ is due to cations exchange process that occurs naturally when seawater intrudes into the coastal aquifer system (Ahmad Zaharin *et al.,* 2006).

Magnesium levels in groundwater samples taken from the Chithamur, Lathur, Thirukalukundram, and Thiruporur blocks in the Chengalpattu district range from 0.40 to 13.80 meq $L^{-1}$, 0.20 to 14.00 meq $L^{-1}$, 0.40 to 3.21 meq $L^{-1}$, and 0.00 to 17.63 meq $L^{-1}$ with mean values of 3.78, 2.86, 3.21, and 3.63 meq $L^{-1}$. Similar results were reported by Manoj Kumar *et al.,* (2014)

The hardness of water is mostly determined by cations such as calcium and magnesium. The main sources of high calcium content are limestone, dolomite, and gypsum, and their breakdown causes an increase in calcium in groundwater. (Viveka *et al.,* 2019)

The sodium content of the groundwater in the Chithamur, Lathur, Thirukalukundram, and Thiruporur blocks respectively, ranged from 0.81 to 19.82 meq $L^{-1}$, 0.43 to 20.74 meq $L^{-1}$, 0.98 to 14.14 meq $L^{-1}$, and 0.80 to 19.74 meq $L^{-1}$, with a mean of 5.98, 6.58, 6.56, and 6.42 meq $L^{-1}$.

The weathering of minerals containing sodium tends to raise the sodium content of water in the aquifer due to the combined effects of saltwater water mixing, halite dissolution, rock-water interaction activities, and other factors (Mohanty *et al.,* 2019)

In the groundwater samples, potassium concentrations range from 0.06 to 0.63 meq $L^{-1}$, 0.05 to 0.90 meq $L^{-1}$, 0.05 to 0.55 meq $L^{-1}$, and 0.06 to 2.18 meq $L^{-1}$, with the mean value being 0.13, 0.12, 0.15 and 0.14 meq $L^{-1}$ in the blocks of Chithamur, Lathur, Thirukalukundram, and Thiruporur, respectively. In coastal aquifers, the weathering of clay minerals and potash feldspar raises the potassium content in the water. (Manoj Kumar *et al.,* 2014)

**Table 2: Mean chemical composition of groundwater in coastal blocks of Chengalpattu district**

| Name of the blocks | No. of samples | Range/ Mean | pH | EC | $Ca^{2+}$ | $Mg^{2+}$ | $Na^{+}$ | $K^{+}$ | $Co_3^{2-}$ | $HCO_3^{-}$ | $Cl^{-}$ | $SO_4^{2-}$ | SAR | RSC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (dS/m) | meq $L^{-1}$ | | | | | | | | m mol/L | meq $L^{-1}$ |
| **Chithamur** | 42 | Min | 7.69 | 0.44 | 1.20 | 0.40 | 0.81 | 0.06 | 2.00 | 2.00 | 0.20 | 0.04 | -2.40 | 0.60 |
| | | Max | 8.87 | 11.50 | 6.40 | 13.80 | 19.82 | 0.63 | 8.00 | 18.00 | 13.20 | 2.18 | 18.40 | 14.77 |
| | | Mean | 8.22 | 1.50 | 2.70 | 3.78 | 5.98 | 0.13 | 4.19 | 6.81 | 1.58 | 0.62 | 4.52 | 3.56 |
| **Lathur** | 37 | Min | 7.52 | 0.13 | 0.20 | 0.20 | 0.43 | 0.05 | 0.00 | 0.00 | 0.40 | -0.05 | -7.20 | 0.26 |
| | | Max | 8.73 | 3.58 | 8.20 | 14.00 | 20.74 | 0.90 | 8.00 | 14.00 | 20.80 | 9.58 | 15.20 | 9.88 |
| | | Mean | 8.30 | 1.19 | 2.71 | 2.86 | 6.58 | 0.12 | 4.22 | 5.78 | 2.28 | 0.73 | 4.42 | 4.10 |
| **Thirukalukundram** | 31 | Min | 7.78 | 0.49 | 0.40 | 0.40 | 0.98 | 0.05 | 2.00 | 2.00 | 0.60 | 0.01 | 1.60 | 0.83 |
| | | Max | 8.93 | 2.70 | 10.00 | 9.20 | 14.14 | 0.55 | 8.00 | 16.00 | 10.40 | 1.28 | 12.80 | 10.54 |
| | | Mean | 8.32 | 1.31 | 3.08 | 3.21 | 6.56 | 0.15 | 4.13 | 6.97 | 1.89 | 0.47 | 4.81 | 3.77 |
| **Thiruporur** | 39 | Min | 7.77 | 0.39 | 0.40 | 0.00 | 0.80 | 0.06 | 2.00 | 2.00 | 0.60 | 0.04 | -6.80 | 0.73 |
| | | Max | 8.78 | 3.94 | 9.20 | 17.60 | 19.74 | 2.18 | 8.00 | 24.00 | 12.20 | 6.89 | 20.00 | 9.87 |
| | | Mean | 8.32 | 1.31 | 2.91 | 3.63 | 6.42 | 0.14 | 4.00 | 7.54 | 1.55 | 0.68 | 5.01 | 3.63 |

**Water quality parameter**

SAR values range from -2.40 to 18.40, -7.20 to 15.20, 1.60 to 12.80, and -6.80 to 20.00 in Chengalpattu district coastal blocks, with a mean of 4.52, 4.42, 4.81, and 5.01. In the Chengalpattu district. High sodium ions in water affect the permeability of the soil and cause infiltration problems and replace calcium and magnesium ions adsorbed on the clays thus causing dispersion of soil particles (Kannan *et al.,* 2021). The rise in exchangeable sodium in the soil is caused by an increase in the SAR of irrigation water (Santhosh Kumar *et al.,* 2019).

RSC values vary from 0.60 to 14.77 meq $L^{-1}$, 0.26 to 9.88 meq $L^{-1}$, 0.83 to 10.54 meq $L^{-1}$, and 0.73 to 9.87 meq $L^{-1}$, with 3.56, 4.10, 3.77, and 3.63 meq $L^{-1}$ as the mean. (Table 2). Higher RSC values suggest that much of the calcium and some magnesium ions precipitate from the solution, increasing the amount of sodium in water and soil particles and therefore increasing the possibility for sodium hazard (Singh *et al.,* 2020). A high RSC may hinder air and water movement through the soil pore space, causing soil deterioration and rendering the soil unfit for irrigation (Kawo *et al.,* 2018)

**Water quality categorization based on CSSRI, Karnal**

CSSRI, Karnal classified the water quality based on the EC, SAR and RSC. According to the water quality classification, (Table 1) the coastal blocks of Chengalpattu district have good quality water at 17%, 11%, 13% and 15% in Chithamur, lathur, Thirukalukundram, and Thiruporur respectively. (Table 3 and Fig 1)

The marginal saline (MS) was highly present in Chithamur(7%) followed by Thirukalukundram (6%) and Chithamur, Lathur (3%) blocks. Lathur block (46%) have high marginally alkali (MA) followed by Thirukalukundram, Thiruourur(36%) and Chithamur (33%).

The alkali water highly present in Thiruporur(46%) followed by Thirukalukundram (42%), Chithamur(41%) and Lathur (40%) and highly alkali (HA) present in Chithamur (2%) and Thirukalukundram (3%) blocks.

Based on the results the groundwater quality mapping was prepared by using the ArcGIS 10.1 software. The spatial distribution of different water quality parameters is presented in Figure 2.

**Table 3. Water quality distribution (%) in coastal blocks of Chengalpattu district**

| S. No. | Block | No.of samples | Good | MS | MA | Alkali | HA |
|---|---|---|---|---|---|---|---|
| 1 | Chithamur | 42 | 17 | 7 | 33 | 41 | 2 |
| 2 | Lathur | 37 | 11 | 3 | 46 | 40 | - |
| 3 | Thirukalukundram | 31 | 13 | 6 | 36 | 42 | 3 |
| 4 | Thiruporur | 39 | 15 | 3 | 36 | 46 | - |

**Fig 1. Percentage distribution of different categories of water quality**

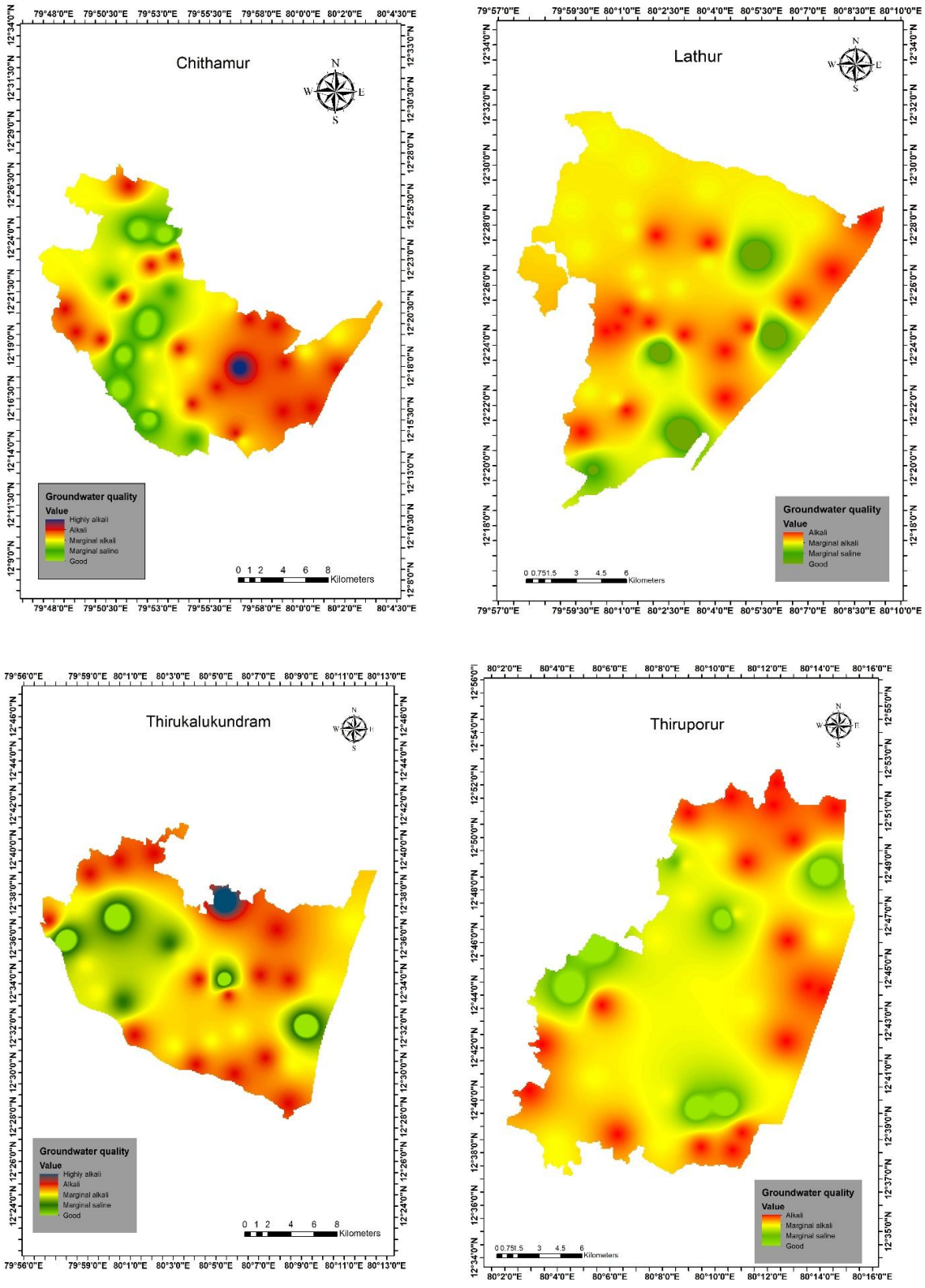


**Fig.2. Spatial distribution of different quality parameters of groundwater in coastal blocks of Chengalpattu district**

## CONCLUSION

Based on the findings of this study that the Thiruporur block have high amount of alkali water (46%) compare to other blocks. Marginal alkali accounted for 46% in Lathur block followed by Thirukalukundram, Thiruporur and Chithamur. Highly alkali water was present in Chithamur (2%) and Thirukalukundram (3%) block. Chithamur block have high amount of good quality water (17%) and marginal saline (7%). Most of the samples in the Chengalpattu district area comes under alkali water and marginal saline water and this might be due to the coastal line in these blocks.

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