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Groundwater quality assessment and mapping in coastal blocks of Viluppuram district, Tamil Nadu

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Abstract
Groundwater quality is important as it is the main factor for determining its suitability for drinking, domestic, agricultural and industrial purpose. In April 2021, a block wise categorization of groundwater quality in the Viluppuram district's coastal region was taken to ensure its optimal use. A number of 23 water samples were obtained for this study, representing the different blocks *viz*., Marakkanam (11), Vanur (12) and analyzed for quality parameter and categorized into different water quality as per the standard procedure. The investigation revealed that groundwater samples with respect to pH ranged from 7.0 to 8.4 with mean of 7.7 and EC ranged from 0.27 to 4.35 dSm^{-1} with mean of 1.14 dSm^{-1} respectively. Residual Sodium Carbonate (RSC) varied from nil to 11.10 meq L^{-1} and Sodium Absorption Ratio (SAR) ranged from 0.26 to 20.31 with a mean SAR of 0.93. In the coastal blocks surveyed, the frequency of good quality water was more in Marakkanam block based on the CSSRI, Karnal water quality classification. The Vanur blocks have the highest alkalinity (75%) and the lowest alkalinity was found in Marakkanam block (63.63%).

Keywords: groundwater quality, Viluppuram district, pH, EC, SAR, RSC

Introduction
Viluppuram District lies between 11 38' 25" N and 12 20' 44" S: 78 15' 00" W and 79 42' 55" E with an area of 3725.54 sq.km. It was carved out from the South Arcot District on 30.09.1993 and was rechristened as Viluppuram District. The residual part of the erstwhile South Arcot district was named as Cuddalore District. It is surrounded on East and South by Cuddalore District. The West by Salem and Dharmapuri District and on the North by Thiruvannamalai and Kanchipuram District. Viluppuram district in Tamilnadu has a coastal length of 40.7 km. There are seasonal rivers named as Gadilam River, Pennar River, Sankaraparani, The Rivers are only seasonal, mostly carrying flood waters and none of them are perennial. These rivers cannot be used for irrigation purpose to the expected level because of low precipitation. In Villupuram district the major crops grown are paddy, groundnut, sugarcane, cumbu, gingelly and tapioca. Paddy is the main food crop cultivated in more than 45% of net sown area (Central Ground Water Board, 2009) [2].
Groundwater plays a vital role in supplying water all over the world. According to Gupta, (2008) [3], Groundwater rather than surface water, contributes 70 to 80 percent of India's agriculture and domestic water sources. The quality of groundwater has been impacted by fast urbanization, excessive groundwater extraction, and poor disposal. As groundwater is regularly exploited, there is always the risk of seawater ingress in the country's coastal regions (Nair *et al*., 2013) [6]. Ifatimehin and Musa, (2008) [4] and Arshid *et al*. (2011) [1] reported that the assessment of water quality is required to assess the suitability of water for varied purposes. Hence, the present study was carried out to assess the mapping of ground water quality in coastal region of Viluppuram district which was undertaken during April 2021 for its optimal usage.

Materials and Methods
During April 2021, a total of 23 groundwater samples were taken based on a GPS grid survey that covered the two coastal blocks of the Viluppuram district. The samples were stored in airtight bottles which were pre-cleaned. A laboratory study was undertaken at the Department of Soil Science and Agricultural Chemistry in ADAC & RI, Trichy, in order to evolve irrigation water quality. The samples were analyzed for pH, Electrical conductivity, cations *viz*., Ca^{2+}, Mg^{2+} by Versenate method and anions like CO_3^{2-}, HCO_3^-, Cl^- by Titrimetric and K^+, Na^+ by Flame photometry, SO_4^{2-} by Turbidimetry as per standard procedure outlined by (Richards, 1954) [8]. Quality parameters like Sodium Adsorption Rate (SAR) and Residual Sodium Carbonate (RSC) were calculated as per the formula depicted as under.

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

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

Screening of groundwater samples for their suitability to irrigation is done on the basis of EC, SAR and RSC values as suggested by Central Soil Salinity Research Institute, Karnal (AICRP, 1991) (Table 1.) and the map of different water quality parameters in Viluppuram district was prepared by using Arc GIS software 10.1

Table 1: Grouping of low-quality ground waters for irrigation in India

Water quality	EC_{iw} (dS/m)	SAR_{iw} (m mol/L)	RSC (me/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	>4.0
iii. Highly alkali	Variable	>10	>4.0
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

Electro chemical properties

According to the findings of the study (Table 3.), the pH of groundwater collected from coastal blocks of Viluppuram district ranged between 7.0 to 8.4 with mean of 7.7 and demonstrating that there is no risk of alkali contamination while using this subsurface water for irrigation. Electrical conductivity (EC) is a popular easy indication to identify an increase in salinity, according to Singhal and Gupta, (2010) [9]. The electric conductivity of water in Viluppuram district's coastal blocks varies from 0.27 to 4.35 dS m^{-1} with mean of 1.14 dSm^{-1}. Out of 23 samples, 43.47, 39.3, 4.34, 13.04 percent samples had EC 0-1, 1-2, 2-3 and >3 dSm^{-1}, respectively.

Anionic constituents of groundwater

The relative concentration of anions followed by the order of Cl^{-} > HCO_3^{2-}> CO_3^{-}> SO_4^{2}. Groundwater carbonate concentrations ranged from 2.0 to 4 meq L^{-1} with a mean of 4.0 meq L^{-1}. The average bicarbonate content was 6.0 meq L^{-1}, with a range of 1.0 to 11 meq L^{-1}. The dominating anion was chloride which varied from 3 to 88 meq L^{-1} with a mean value of 8 meq L^{-1}. Rathi, Ramprakash, and Satyavan 2018 [7] reported that Chloride was the main anion in irrigation water. The concentration of sulphate in the water ranged from 0.20 to 5.56 meq L^{-1}, with a mean value of 0.43 meq L^{-1}.

Cationic constituents of groundwater

In terms of cationic concentration in groundwater of coastal blocks, sodium was determined to be the most abundant cationic ingredient, followed by Mg^{2+} > Ca^{2+}> K^{+}. Calcium levels ranged from 0.6 to 8.2 meq L^{-1} with an average of 1.7 meq L^{-1}. Magnesium levels ranged from 0.7 to 10.7 meq L^{-1} with a mean of 2.30 meq L^{-1}. The concentration of sodium in water ranged from 0.28 to 50.17 meq L^{-1} with a mean of 1.46 meq L^{-1}. Potassium concentrations ranged from 0.01 to 1.70 meq L^{-1} with a mean of 0.04 meq L^{-1} (Table 3.).

Water quality parameter

The RSC in water varied from zero to 11.10 meq L^{-1} and the SAR varied from 0.26 to 20.31 with a mean SAR of 0.93. However, in Viluppuram coastal blocks, the mean SAR and RSC values were less than 10 and greater than 4 meq L^{-1}, respectively, indicating that are harmful in view of alkalinity development in soil upon irrigation (Table 3.).

The spatial distribution of key groundwater quality parameters in coastal blocks of Viluppuram district are depicts in Figure 2. The distribution of water samples in different water quality classes suggests that good quality under groundwater samples were obtained in Marakkanam (9.09%) blocks. The highest levels of saline water were also found in the Marakkanam (9.09%) blocks. In the Viluppuram district, highest marginal saline was discovered in Marakkanam blocks (9.09%) followed by Vanur (8.33%). Vanur blocks (75.0) were found to have a high alkali content, followed by Marakkanam blocks (63.6) and the marginal alkali water was found highest in Vanur blocks (16.66%) (Table 2. and Figure 1.).

Manchand (1976) [5] examined water quality and found that water categorized as "good" can be safely used for almost all crops, whereas water categorized as "marginally saline" can be used for pearl millet and mustard crops in areas with coarse grained soil. Ground water that is moderately alkali (RSC 2.5 - 4.0) can also be used efficiently for mustard and pearl millet crops when gypsum is applied. Groundwater that is classified as saline, high SAR saline, alkali or extremely alkali water is unsuitable for irrigation, and its widespread use will result in secondary salinization. Low rainfall, extended drought and overexploitation of groundwater may be to blame for the increased levels of various types of saline/sodic problems in coastal blocks of Viluppuram district.

Table 2: Water quality distribution (%) in coastal blocks of Viluppuram district

S. No.	Block	No. of samples	Good	MS	HSS	MA	Alkali
1	Marakkanam	11	9.090	9.090	9.090	9.090	63.63
2	Vanur	12	0	8.33	0	16.66	75.0
	Average	23	4.545	8.71	4.545	12.87	69.31

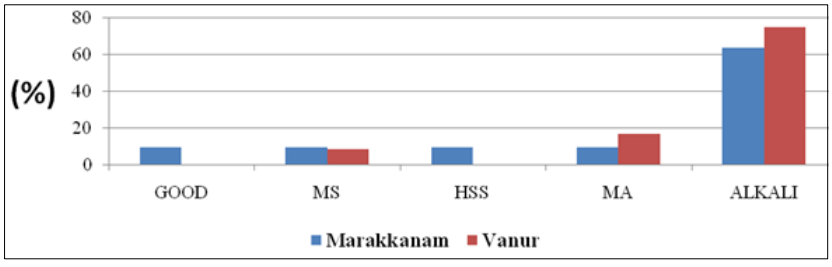

Fig 1: Percentage distribution of different categories of water quality

Table 3: Mean chemical composition of groundwater in coastal blocks of Viluppuram district

Blocks	No. of samples	Range/ mean/SD	pH	EC (dS/m)	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	SAR ($mmol^{1/2}L^{-1/2}$)	RSC ($meqL^{-1}$)
					$meqL^{-1}$									
Marakkanam	11	Min	7.0	0.27	0.6	0.7	0.28	0.01	2.0	1.0	3.0	0.20	0.28	0.0
		Max	8.4	4.35	4.3	10.7	50.17	1.70	6.0	11.0	88.0	5.56	20.31	11.10
		Mean	7.9	1.49	1.8	2.0	1.16	0.02	4.0	5.0	8.0	0.44	1.0	4.60
Vanur	12	Min	7.1	0.4	0.8	0.7	0.36	0.03	2.0	1.0	4.0	0.24	0.26	0.0
		Max	8.4	3.9	8.2	3.3	3.71	0.51	6.0	9.0	41.0	3.02	1.80	8.20
		Mean	7.5	1.05	1.6	2.4	0.88	0.06	4.0	6.0	6.5	0.43	0.66	6.20

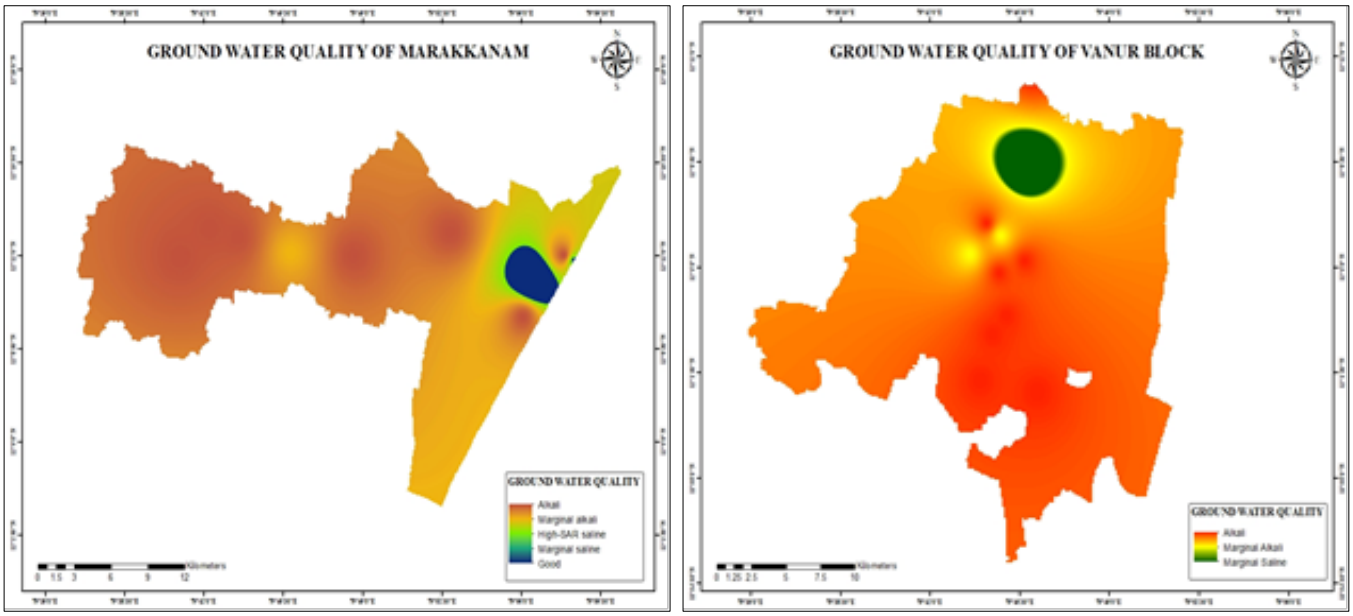

Fig 2: Spatial distribution of different quality parameter of groundwater in coastal blocks of Viluppuram district

Conclusion

Based on the results of this investigation, only 9.09 percent of samples were of good quality, Viluppuram district of the coastal blocks. Alkali accounted for 69.3% among all samples, with 12.87 percent (marginal Alkali), 8.71 percent (marginal saline) and 4.54 percent (marginal saline) following closely behind (high SAR saline). The largest percentage of alkali water samples were found in Vanur. In the Marakkanam blocks, there was an equal percentage of good water, marginal saline, high SAR saline and marginal alkali. 95.455 percent of samples in Viluppuram district's coastline blocks had varying salinity levels, which could be related to the district's wide coastal line and the district's prolonged drought.

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Conflict of interest

The author declare there is no conflict of interest

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