Original Research Article

Delineation and mapping of groundwater quality in coastal blocks of

Tiruvallur district of Tamil Nadu using GIS

Abstract:

An investigation was carried out to assess the quality of groundwater in coastal blocks of Tiruvallur district, Tamil Nadu. Approximately fifty groundwater samples were obtained from the coastline blocks in May 2022, particularly Minjur (25 Nos), Puzhal (7 Nos,) and Gummidipoondi (18 Nos). The groundwater samples were tested for physio-chemical (pH and EC) and chemical characteristics like cations-Ca^{2+}, Mg^{2+}, Na^{+}, K^{+} and anions- CO_3^{2-}, HCO_3^{-}, Cl^{-}, and SO_4^{2-} ; and the resultant properties were computed (SAR and RSC). The pH of Minjur, Puzhal, Gummidipoondi ranged from 7.66 to 8.78 ,7.77 to 8.36, 7.35 to 8.76 respectively.The EC of Minjur ,Puzhal,Gummidipoondi were 0.3 to 3.56 dS m^{-1},0.76 to 2.91 dS m^{-1} and 0.2 to 2.07 dS m^{-1} respectively. The SAR of Minjur, Puzhal, and Gummidipoondi ranged from 1.60 to 11.73 ,1.67-10.01, 0.6 to 6.87 respectively. . The RSC of Minjur ,Puzhal, Gummidipoondi ranged from -4 to 8.4 meq l^{-1} ,-0.8 to 3.4 meq l^{-1}, -4.4 to 4.8 meq l^{-1} respectively. In the Minjur block, the majority quality of groundwater was characterized as good quality water (32 per cent), salty water (24 per cent), and alkali water (36 per cent) . While in the Puzhal block, the majority quality of groundwater was characterized as good quality water (28.57 per cent), saline water (14.28 per cent), and alkali water (57.14 per cent) . In Gummidipoondi block, the majority quality of groundwater was assessed as good quality water (38.8 percent), and alkali water (50 per cent) .

Keywords: coastal block, groundwater quality, Tiruvallur district, SAR and RSC.

Introduction:

For the development of any activity in the country, water plays a vital role. Water is used for domestic purposes, irrigation and agricultural purpose, industrial purposes and for power development. Earth is 70 per cent water. However only 3 per cent of this water is fresh water.

Much of this freshwater is frozen in glaciers, some in rivers and streams, and almost 30 per cent of this freshwater is groundwater. Groundwater is the water present beneath the earth's surface in soil pores and in the fractures. Water that seeps into the ground and finds its way into an aquifer. More than 90 per cent of groundwater in India is used for irrigated agriculture. Roughly 80 per cent of India's population depend on ground water for both drinking and irrigation. Groundwater and surface water are the two major sources of water. Groundwater's efficiency was high when compared to the surface water. For the management of various natural resources, GIS and remote sensing tools are widely used.

Tiruvallur district is the northernmost coastal district of Tamil Nadu. district is bounded by the Bay of Bengal in the East, Vellore district of Tamil Nadu and Chittoor district of Andhra Pradesh on the North and on the South by Kancheepuram district. It is between 12□55' N to 13□34' N latitude to 80□21' E longitude and has an area of 3550 sq.km. There are 14 blocks in Tiruvallur district, viz., Ellapuram, Gummidipoondi, Kadambathur, Minjur, Pallipattu, Poonamallee, Poondi, Puzhal, R.K.Pet, Sholavaram, Tiruvallur, Tirutani, Thiruvalangadu, Ambathur in which Puzhal, Minjur and Gummidipoondi comes under coastal line.

Groundwater quality assessment is important for identifying the salt and sodicity problems in the soil. Geographical Information System (GIS)is the best option to assess the groundwater quality using water quality parameter overlay analysis . Hence the present investigation was envisaged to assess the ground water quality of coastal blocks of Tiruvallur district.

Materials and Methods:

50 water samples were collected in the Tiruvallur district's coastal blocks of Minjur(25 samples), Puzhal(7 samples), and Gummidipoondi(18 samples) during May 2022. The coordinates of the sample site were recorded using a portable GPS receiver (GPS, Garmin). A pre-cleaned plastic polyethylene bottle was used to collect samples. Prior to sampling, all sample containers were thoroughly cleaned and washed with groundwater. The water samples were analyzed for pH, Electrical Conductivity, cations-Ca^{2+}, Mg^{2+}, Na^{+}, K^{+} and anions- CO_3^{2-}, HCO_3^{-}, Cl^{-}, and SO_4^{2-} .pH and EC was determined by pH meter and EC meter respectively. The cations such as Ca^{2+}, Mg^{2+} was determined by vesrsanate technique, while Flame Photometry was used to determine Na^{+}, K^{+}. Titrimetric determination of anions such as CO_3^{2-}, HCO_3^{-}, Cl^{-}, and SO_4^{2-} was determined using Richards' (1954) standard method. Other quality indicators, such

as the Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC), were calculated using the formula below:

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

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

The Central Soil Salinity Research Institute (CSSRI), Karnal uses the EC, SAR, and RSC values to determine whether groundwater samples are suitable for irrigation (Table 1). Arc GIS 10.1 software was used to create thematic maps of groundwater quality in the Tiruvallur area.

Table 1 : EC, SAR, and RSC values for determination of groundwater samples

Water quality	EC (dS/m)	SAR (meq/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	>4.0
iii. Highly alkali	Variable	>10	>4.0
D. Toxic water	Although the salinity, SAR, and RSC of the hazardous water are different, it contains excessive amounts of certain ions, including chloride, sodium, nitrate, boron, fluoride, and heavy metals including selenium, cadmium, lead, and arsenic, among others.		

Results and Discussion:

Physio-Chemical Properties:

Minjur, Puzhal, and Gummidipoondi had pH values ranging from 7.66 to 8.78, 7.77 to 8.36, and 7.35 to 8.76, respectively.The EC of the Minjur, Puzhal, and Gumidipoondi blocks ranges from 0.3 to 3.56 dS m^{-1}, 0.76 to 2.91 dS m^{-1}, and 0.2 to 2.07 dS m^{-1} respectively. SAR of Minjur, Puzhal, and Gummidipoondi ranged from 1.60 to 11.73, 1.67-10.01, and 0.6 to 6.87 respectively. RSC of Minjur, Puzhal, and Gummidipoondi ranged from -4 to 8.4 meq l^{-1}, -0.8 to 3.4 meq l^{-1}, and -4.4 to 4.8 meq l^{-1} respectively. Good quality water (32%), salty water (24%), and alkali water (36%), were discovered in the Minjur block, while good quality water (28.57%), saline water (14.28%), and alkali water (57.14%) were discovered in the Puzhal block. Good quality water (38.8 percent) and alkali water (50 percent) were discovered in Gummidipoondi block.

Cationic Concentration:

Calcium, magnesium, potassium, and sodium concentrations in Minjur block ranged from 1.2 to 14.4, 0.8 to 9.6, 0.1 to 2.105, 4.676 to 25.72 meq l^{-1} respectively. The cationic concentrations viz calcium, magnesium, potassium, and sodium in the Puzhal block ranged from 2.2 to 5.2, 0.4 to 6.4, 0.076 to 0.0369, 3.74 to 18.01 meq l^{-1}. At Gummidipoondi block the cationic concentrations of calcium, magnesium, potassium, and sodium ranged from 1.2 to 7.3, 0.8 to 9.6 , 0.092 to 0.546, 1.263 to 11.1 meq l^{-1}. Sodium, magnesium, calcium, and potassium is the order of the highest relative cationic concentrations. According to Mohanty *et al*. (2019) [2] , the presence of Na and Cl ions in coastal groundwater indicates that seawater interacts with groundwater. Mg is frequently greater than Ca in various sites, according to Mondal *et al*. (2008) [3], which could be due to the effect of the sea in that area.

Anionic Concentration:

Carbonate, Bicarbonate, Sulphate, and Chloride concentrations in Minjur block ranged from 0 to 8, 2 to 18, 0.152 to 2.756 and 2.0 to 22.1 meq l^{-1} respectively. The cationic concentrations of calcium, magnesium, potassium, and sodium in the Puzhal block ranged from 4 to 8 , 2 to 8, 0.141 to 6.386, and 1.6 to 17.4 meq l^{-1}. At Gummidipoondi block cationic concentrations of calcium, magnesium, potassium, and sodium ranged from 2 to 8, 2 to 8, 0.004 to 1.007, and 1.2

to 15.2 meq l^{-1}. The order of relative anionic concentration was chloride, bicarbonate, carbonate, and sulphate. The chloride, which is formed by rain or saline water intrusion along the seashore, is actively circulating in groundwater at relatively shallow depths.

Water quality parameters:

SAR of Minjur, Puzhal, and Gummidipoondi ranged from 2.38 to 15.1, 1.67 to 11.8, and 0.6 to 5.22, respectively. RSC of Minjur, Puzhal, and Gummidipoondi ranged from 4.4 to 8.4 meq l^{-1}, -0.8 to 3.4 meq l^{-1}, and -4.4 to 4.8 meq l^{-1}, respectively.The high sodium level in the water sample reduces permeability,reducing the amount of water available to the plant (Ahamed *et al*., 2013) [1].

At Minjur block,good quality water was around 32 per cent; Marginally saline water was around 24%; Marginally alkali water was 20%; Highly alkali water was 8%; and alkali water was 8%.At Puzhal block, good quality water was around 28.57 per cent; Marginally saline water was around 14.28%; Marginally alkali water was 57.14%. At Gummidipoondi block, good quality water was around 38.8 per cent; Marginally alkali water was 44.4% ; and alkali water was 11.11%.Marginally saline water was highest in Minjur block (24 per cent).The marginally and highly alkali water was highest in Puzhal block (57.14 per cent & 8 per cent).The alkali water was highest in Gummidipoondi block (11.11 per cent).

Sodium in the water can displace calcium and magnesium, irrigation with high SAR water may necessitate soil additives to prevent long-term soil damage.This will also result in a decrease in soil infiltration and permeability to water, as well as loss in soil structure. It causes problems in agricultural production (Prasanth *et al*., 2012; Sreekala *et al*., 2015) [4,5]. Saline irrigation has a negative impact on plant growth, owing to osmotic pressures in the soil, which tend to reduce the amount of nutrient taken up by the plant. Adopting various irrigation management techniques such as drip, sprinkler, and pitcher irrigation is a critical strategy for overcoming this problem (Monisha *et al*., 2021) [7]. The addition of organic manures such as FYM and compost also helps to reduce the negative effects of salinity caused by the release of organic acid during decomposition. In addition, green manure crops should be planted to reduce alkalinity risks. Then, modify in-situ rainwater conservation for the leaching of salts collected in soil from saline and alkali water irrigation. Low rainfall, extended drought and overexploitation of groundwater may increase the levels of various types of saline/sodic problems (Vishnu *et al*., 2021) [8].

Groundwater quality map using GIS:

The groundwater samples were classified based on their EC, SAR, and RSC values (Table1). Arc Map 10.1 was used to create a groundwater quality map for Avudaiyarkoil and Manamelkudi blocks in Pudukkottai district (Fig. 2). It demonstrates that inverse distance weighted (IDW) interpolation in a GIS tool is especially useful for comparing the spatial distribution of water quality parameters (Yuvaraj 2020) [6]. The map shows that groundwater quality is deteriorating in coastal blocks due to anthropogenic activities such as groundwater pumping near the coastal side area, which causes seawater intrusion, and waste discharged from industrial / agricultural activities, which reduces groundwater quality.

Conclusion:

The marginally and highly alkali water was highest in Puzhal block(57.14 per cent & 8 per cent).The alkali water was highest in Gummidipoondi block(11.11 per cent). The groundwater samples near the coastal area were saline and alkaline, but the groundwater samples far away from the coastal area were of good quality. So that any salinity or alkalinity issues do not harm the good-quality samples.

Table 2 : Quality of groundwater in coastal blocks of Tiruvallur district.

Minjur:

Sample No	Village name	pH	EC	SAR	RSC	Water Quality Categories(CSSRI)
1	Nallur	7.66	3.25	3.19	1.6	Good
2	Mettupalayam	7.76	2.67	2.99	0.4	Marginally saline
3	Vannipakkam	8.01	1.3	2.54	2.8	Marginally alkali
4	Elayampedu	7.85	2.06	3.90	2.2	Good
5	Athreyamangalam	7.89	1.72	3.54	1.2	Good
6	Thadamperumbakkam	8.21	1.55	3.84	1.2	Good
7	Ponneri I	8.09	1.3	3.16	1.2	Good
8	Chinnakavanam I	8.42	0.86	2.05	4.2	Marginally alkali
9	Chinnakavanam II	8.2	1.01	1.60	0.4	Good

10	Arasur	8.37	0.65	4.70	4.1	Alkali
11	Guduvanchery	8.35	0.88	4.06	3.2	Marginally alkali
12	Knagavalipuram	8.24	1.74	4.56	4	Marginally alkali
13	Katavoor	8.01	2.96	6.45	-3.6	Marginally saline
14	Arasur	8.39	0.38	6.82	4.8	Alkali
15	Medur	7.86	3.15	7.37	-4.4	Marginally saline
16	Thirupalaivenam	8.09	2.95	6.26	-4	Marginally saline
17	Pralayampalayam	8.15	2.27	7.91	2.4	Marginally saline
18	Pazhaverkadu	8.09	0.3	3.90	1.9	Good
19	Thathaimanjai	8.4	1.4	5.35	3.2	Marginally alkali
20	Kattur	8.78	3.56	11.73	8.4	Highly alkali
21	Vayalur	8.15	2.19	10.1	5.2	Highly alkali
22	Minjur-I	7.81	2.79	4.53	0.4	Marginal Saline
23	Velliyal chavadi	7.75	1.66	7.10	0.2	Good
24	Edayan chavadi	8.34	3.05	11.45	3.9	Highly alkali
25	Enoor	8.1	2.49	15.1	2.2	Highly alkali

Table 3 : Puzhal:

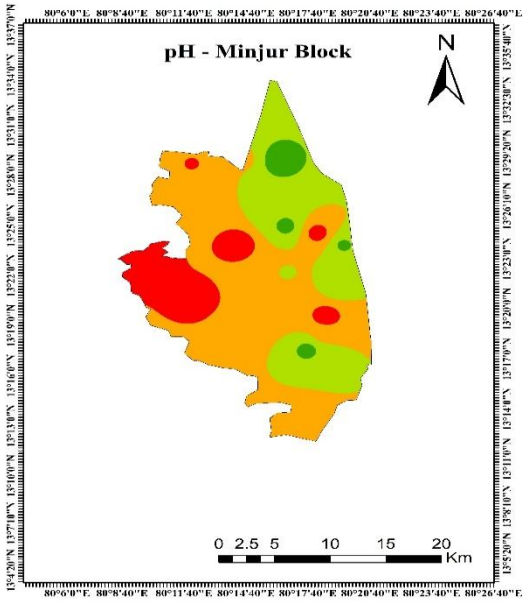
Sample No	Village name	pH	EC	SAR	RSC	Water Quality Categories(CSSRI)
1	aandar kuppam	8.35	1.6	10.01	3.4	Marginal Alkali
2	Kadapaakkam	7.84	2.91	6.76	0.8	Marginal Saline
3	Kosapur	7.77	1.44	3.53	-0.8	Good
4	Vadaperumbaakkam	8.11	1.74	5.76	2.6	Marginally alkali
5	Manjampakkam	8.25	1.47	3.81	2.5	Marginally alkali
6	Kavanangkarai	8.36	1.94	8.36	3.2	Marginally alkali
7	Puzhal	8.11	0.76	1.67	2	Good

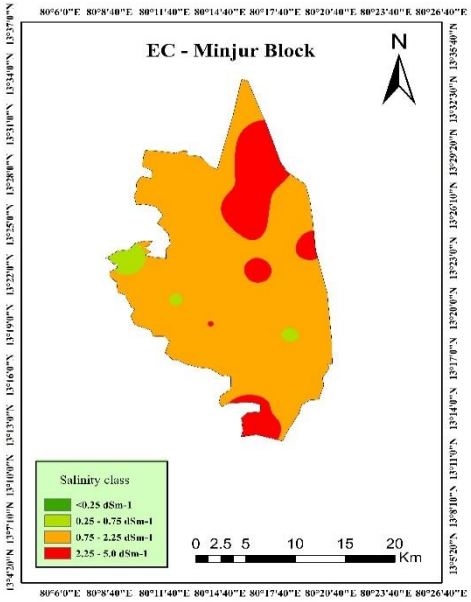
Table 4 : Gummidipoondi:

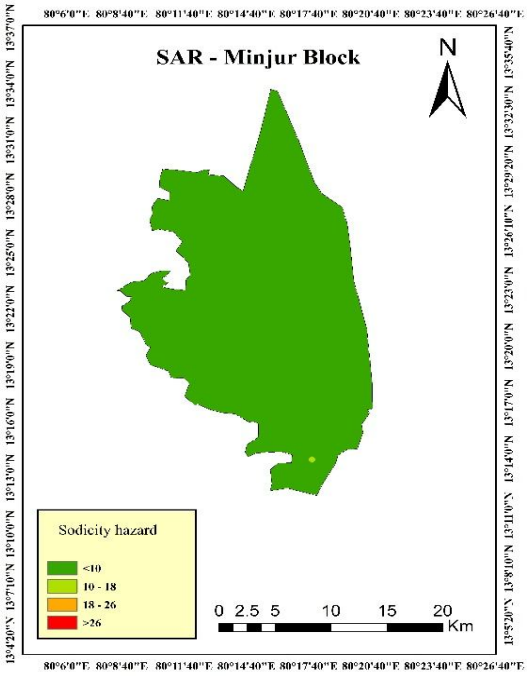
Sample No	Village name	pH	EC	SAR	RSC	Water Quality Categories(CSSRI)
1	Puthuvayal	8.76	0.8	5.22	3.6	Marginally alkali
2	Keelmudalambedu	8.11	2.07	5.58	2.6	Marginally alkali
3	Kavaraipettai	8.21	0.6	3.7	3.2	Marginally alkali
4	Verkadu	8.04	2.03	6.31	2.6	Marginally alkali
5	Old Gummidipoondi	8.27	0.49	1.64	2.5	Marginally alkali
6	Chinobulapuram	7.35	0.48	1.73	0.4	Good
7	Thurapallam	7.39	0.8	3.63	-0.3	Good
8	Panangad	7.81	0.2	0.93	0.4	Good
9	Elavur	7.73	0.66	1.02	-3.6	Good
10	Pedhikuppam	8.3	0.66	2.15	2.6	Marginally alkali
11	New gummidipoondi	7.95	1.6	0.6	-2.8	Good
12	Kuruvattucheri	8.27	0.98	2.21	2.8	Marginally alkali
13	Enathimelpakkam	8.29	0.66	3.87	4.2	Alkali
14	Ayanallur	8.46	0.45	3.25	3.2	Marginally alkali
15	Rettambedu	7.99	1.03	3.25	-2	Marginally alkali
16	Kuruviagaram	7.77	2.15	4.76	-4.4	Good
17	Vazhuthalambedu	7.98	0.79	5.87	-0.8	Good
18	Athupakkam	8.4	0.55	6.87	4.8	Alkali

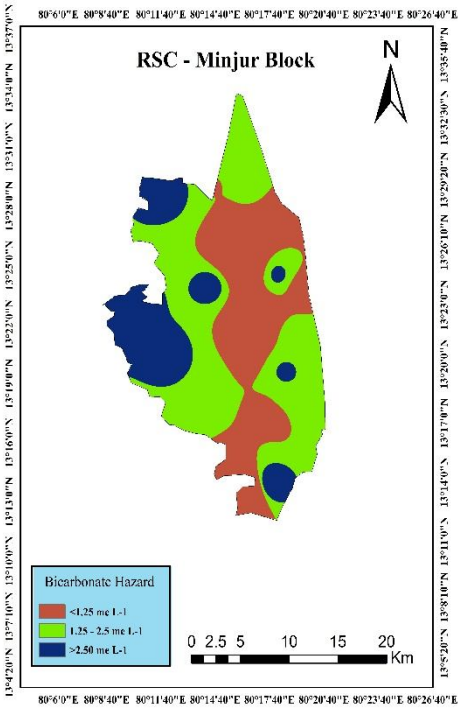
Figure 1 : **Mapping of pH,EC,SAR,RSC for all the coastal blocks of Tamil Nadu:**

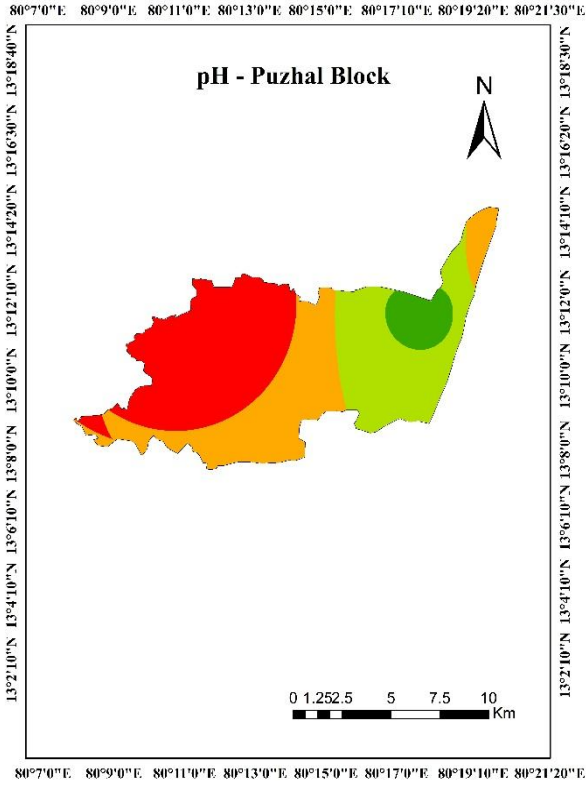
Minjur Block:

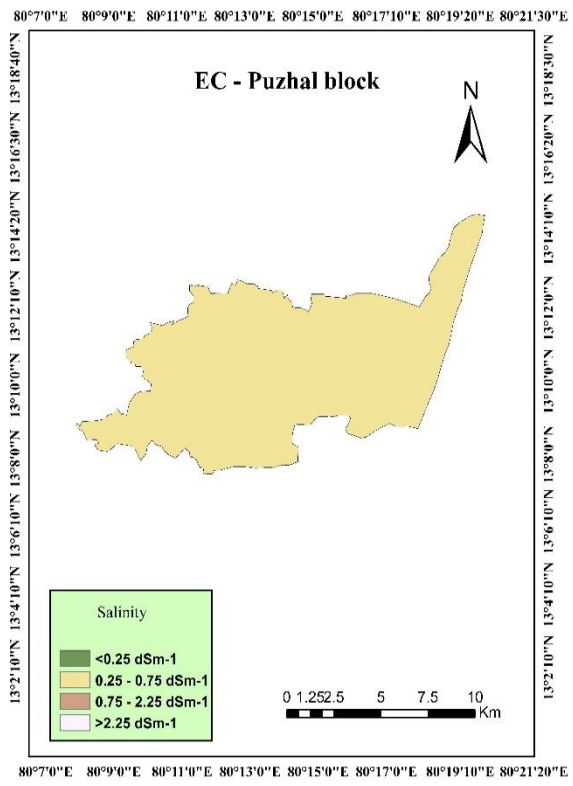

pH - Minjur Block
N
0 2.5 5 10 15 20
Km

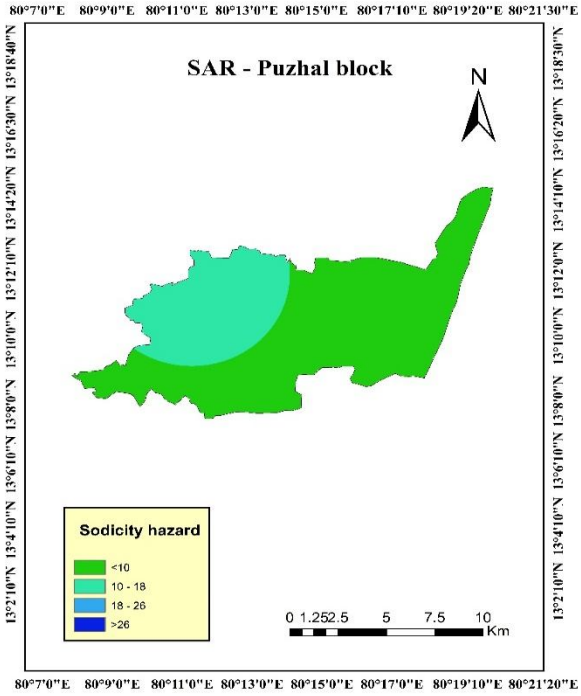

EC - Minjur Block
N
Salinity class
<0.25 dSm-1
0.25 - 0.75 dSm-1
0.75 - 2.25 dSm-1
2.25 - 5.0 dSm-1
0 2.5 5 10 15 20
Km


SAR - Minjur Block
N
Sodicity hazard
<10
10 - 18
18 - 26
>26
0 2.5 5 10 15 20
Km


RSC - Minjur Block
N
Bicarbonate Hazard
<1.25 me L-1
1.25 - 2.5 me L-1
>2.50 me L-1
0 2.5 5 10 15 20
Km
80°6'0"E 80°8'40"E 80°11'40"E 80°14'40"E 80°17'40"E 80°20'40"E 80°23'40"E 80°26'40"E


pH - Puzhal Block
N
0 1.252.5 5 7.5 10
Km


EC - Puzhal block
N
Salinity
<0.25 dSm-1
0.25 - 0.75 dSm-1
0.75 - 2.25 dSm-1
>2.25 dSm-1
0 1.252.5 5 7.5 10
Km


SAR - Puzhal block
N
Sodicity hazard
<10
10 - 18
18 - 26
>26
0 1.252.5 5 7.5 10
Km

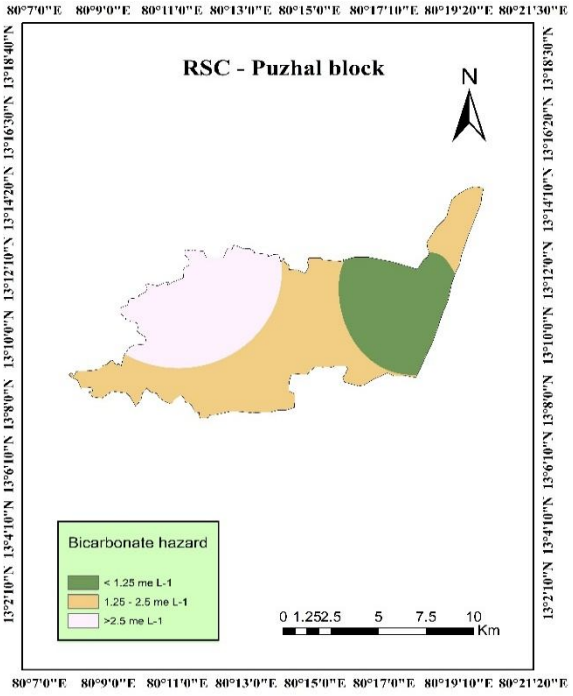
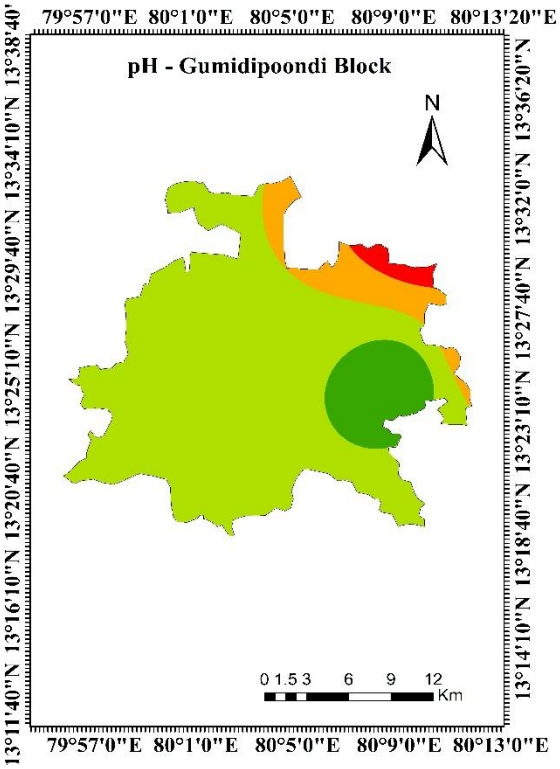
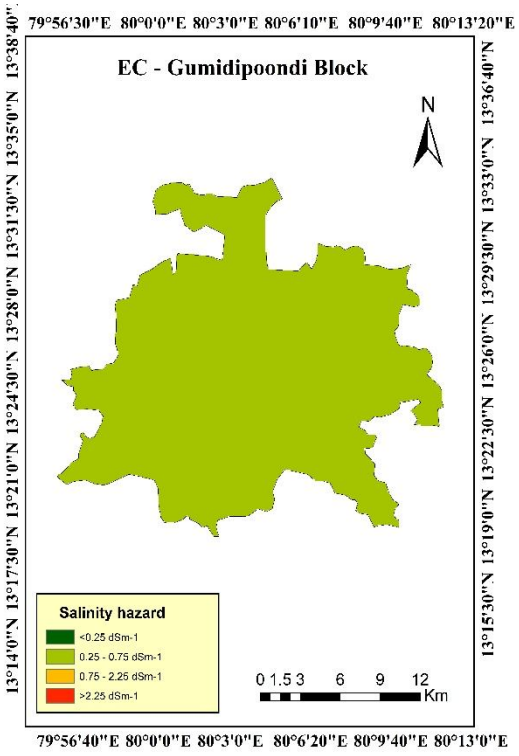
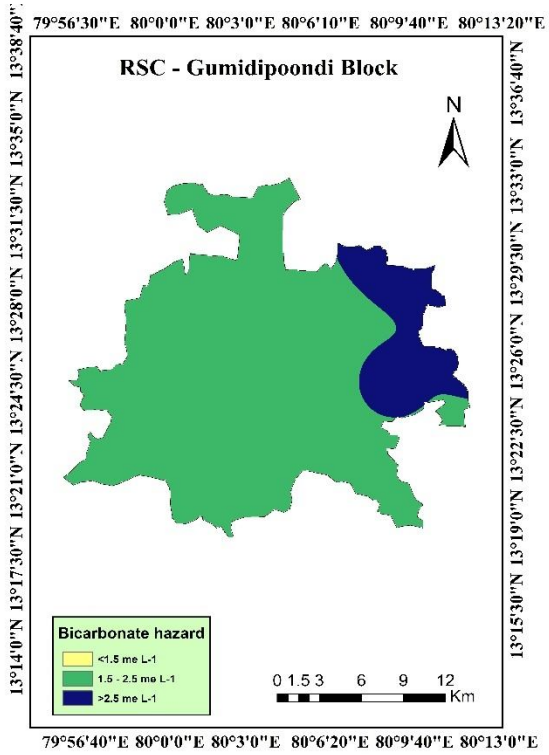

RSC - Puzhal block
N
Bicarbonate hazard
< 1.25 me L-1
1.25 - 2.5 me L-1
>2.5 me L-1
0 1.252.5 5 7.5 10
Km

Figure 2 : Gummidipoondi block:







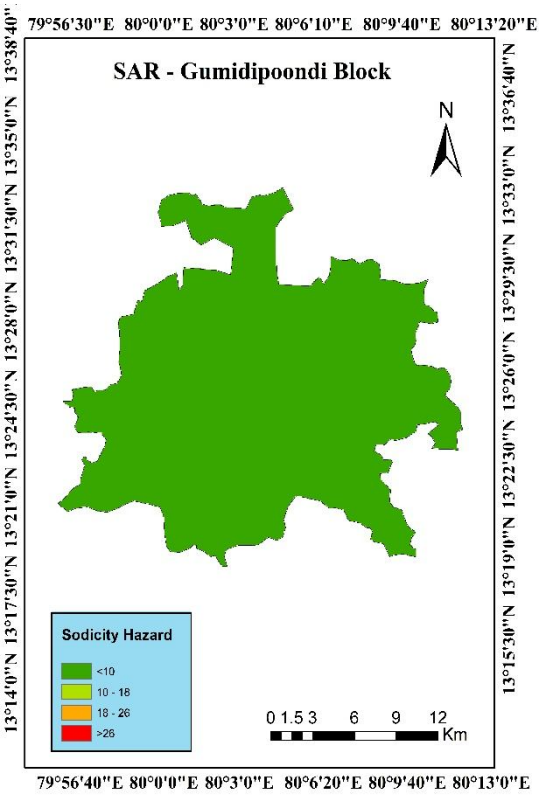
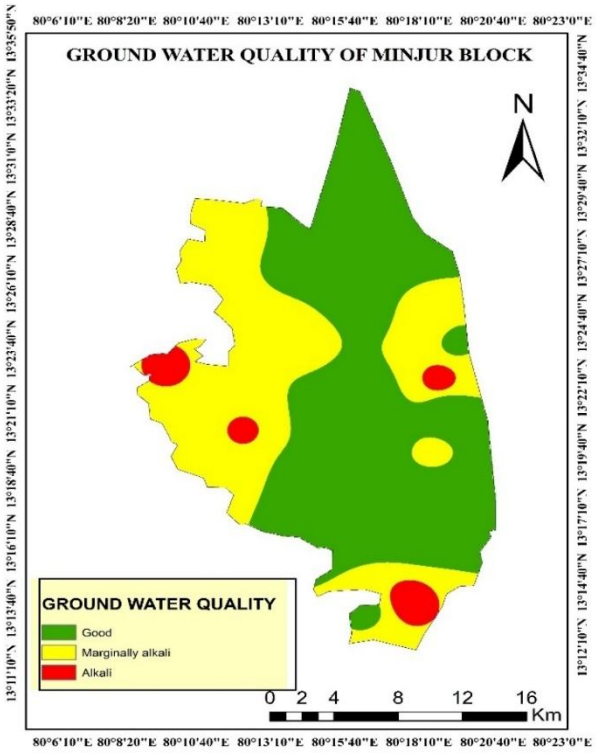
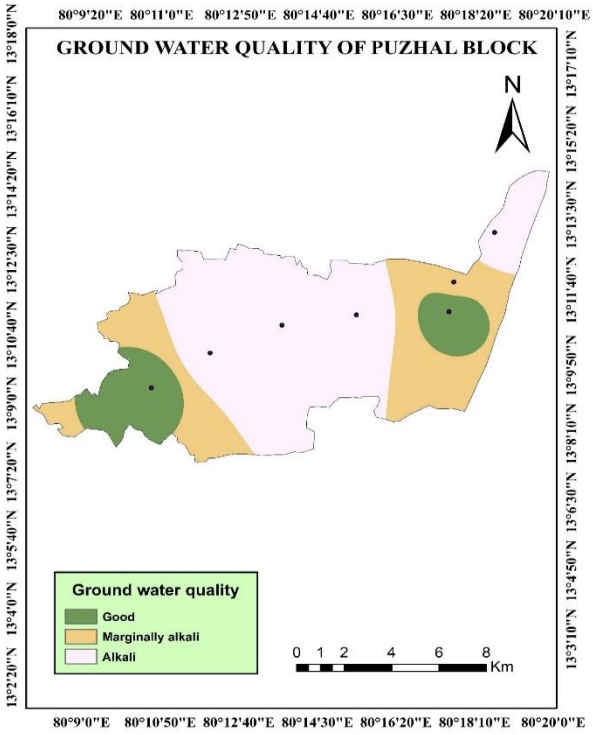
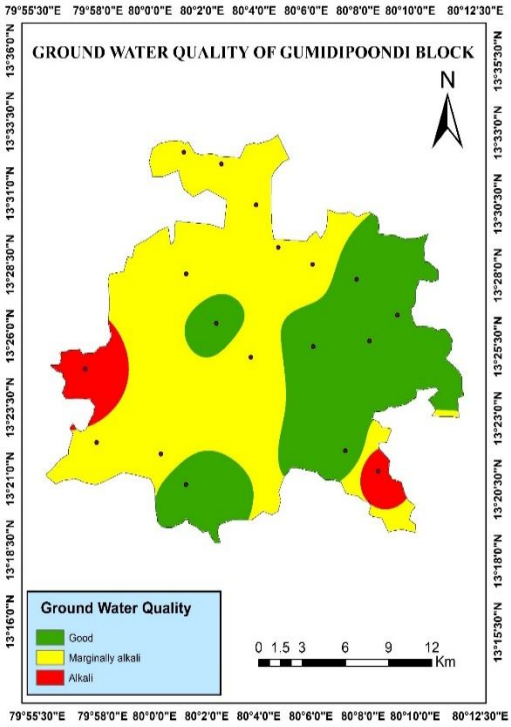


Figure 3 : Spatial distribution of different quality parameters of groundwater in coastal blocks of Tiruvallur district:


GROUND WATER QUALITY OF MINJUR BLOCK
N
GROUND WATER QUALITY
Good
Marginally alkali
Alkali
0 2 4 8 12 16
Km
80°6'10"E 80°8'20"E 80°10'40"E 80°13'10"E 80°15'40"E 80°18'10"E 80°20'40"E 80°23'0"E
13°35'50"N 13°33'20"N 13°31'0"N 13°28'40"N 13°26'10"N 13°23'40"N 13°21'10"N 13°18'40"N 13°16'10"N 13°13'40"N 13°11'10"N


GROUND WATER QUALITY OF PUZHAL BLOCK
N
Ground water quality
Good
Marginally alkali
Alkali
0 1 2 4 6 8
Km
80°9'20"E 80°11'0"E 80°12'50"E 80°14'40"E 80°16'30"E 80°18'20"E 80°20'10"E
13°18'0"N 13°16'10"N 13°14'20"N 13°12'30"N 13°10'40"N 13°9'0"N 13°7'20"N 13°5'40"N 13°4'0"N 13°2'20"N
80°9'0"E 80°10'50"E 80°12'40"E 80°14'30"E 80°16'20"E 80°18'10"E 80°20'0"E
13°17'10"N 13°15'20"N 13°13'30"N 13°11'40"N 13°9'50"N 13°8'10"N 13°6'30"N 13°4'50"N 13°3'10"N



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