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GIS based assessment of ground water for domestic and irrigation purpose in Vazhapadi Taluk, Salem, Tamil Nadu, India

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ABSTRACT

In the current scenario, application of remote sensing and GIS has been widely increased in the assessment of water quality. The main aim of this study is to investigate the nature of groundwater and its suitability for domestic and irrigation purpose in Vazhapadi Taluk, Salem district. 50 sample locations are selected in the study area and analysed for 12 basic water quality parameters. The physio-chemical properties are also compared with standard regulations and water quality index map is developed using GIS. Based on the detailed investigation, it is predicted that some sample locations are in need of primary degree of treatment for domestic usage. The studies also reveal that majority of groundwater samples are suitable for irrigation purposes.

Keywords: GIS, Groundwater, Irrigation, Water Quality Index

1 INTRODUCTION

The groundwater engineering is the basic aspect, which is tolerating to utilization for agriculture, residential, and industries. The greater part of the population on the earth relies upon groundwater for every day engagements. An ever-increasing number of researchers are focusing on hydro-geochemistry in ongoing decades, which is trying to the scientific analyst dependent on hydrology and lithology. The hydro-geochemical technique can be utilized for distinguishing the interaction among rocks and waters. Developing countries like, India, China have extensive distressing differences of topography, hydrological, meteorological, geomorphological, hydro-topographical, and geographical conditions. Groundwater source, occurrence, and relocations depend on a few elements, for example, waste disposal, gradient, topography, geomorphology, and lineament thickness. Groundwater, perfect and safe in antiquated days as opposed to current decades, indicates how speedy industrialization makes extreme ecological issues in many nations. Once the groundwater is tarnished, it is exceptionally hard to regain its quality. Environmental variables, such as land-use pattern, type of aquifer, and soil-seepage limit, influence the dimension of groundwater defilement.

Groundwater vulnerability assessment is viewed as the underlying advance in comprehension and assessing the weakness of an aquifer. Accordingly, vulnerability mapping has turned into important demand during recent years. The utilization of Geographic Information System (GIS) tools have added, all things considered, in the assurance of the groundwater vulnerability to contamination. This Novel technique emerges as it meets a few favourable circumstances, as it evaluates natural vulnerability over the whole land surface of the potential catchment region of an aquifer, it utilizes promptly accessible parameters that give enough information to nourish the model and it is implementable inside a system. GIS is an important tool for mapping the water quality and powerful to screen, which is utilized as a database framework to make maps of water quality dependent on focus estimations of different substance constituents. The point of the present examination is to outline the groundwater nature of the investigation territory utilizing geospatial and geostatistical instruments.

2 MATERIALS AND METHODS

2.1 Study area

The Vazhapadi is a highly developing taluk in Salem District, Tamilnadu, India. The Taluk is bounded by Attur to the north, by Salem city to the east, Gangavelli taluk to the south and Sankagiri to the west. The study area covers 443.90 sq.km and lies between 11°41′29″ N latitude and 78°24′29″ E longitude of Salem District (Figure 1). The study area is drained by the Carvery river and the peoples are highly depend on groundwater for their daily needs. With a view of agriculture, Coconut, Tomato plants are frequently cultivated by the farmer in this taluk. The Site visit and survey of water sources by the research team revels the unavailability of surface water in the taluk. In the study area annual rainfall is measured about 936mm.

2.2 Geology

A significant part of the study area (about 85%) is underlain by granitic gneiss and other metamorphic rocks of Precambrian age and remaining region of the study area is underlain by sandstones and shales. A thin layer of alluvial deposits occurs in along the course of the carvery river. Based on lithology, the study area was arranged into three distinctive classes: (1) consolidated rock formation in which groundwater happens under kept to semi-bound conditions; (2) semi-consolidated formation, where ground-water happens under restricted to semiconfined conditions and (3) unconsolidated arrangements where groundwater happens in unconfined aquifers.

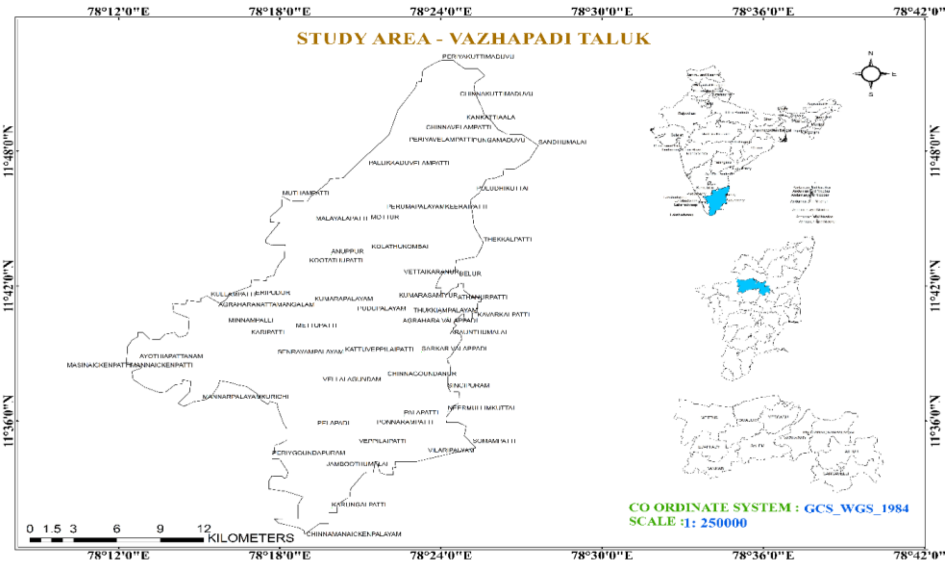

Figure 1: Sample locations and study area map

3 RESULTS AND DISCUSSION

3.1 Drinking purpose – Water Quality Index

Water quality index was determined by using the weight arithmetic method which is useful to recognize the status of the water resources (Table 1). For the WQI, a load (w_i) was chosen to every parameter based on their criticalness to the total groundwater quality. The highest weight was given to the parameter that causes a serious health effect when its value increases above the certain serious concentration limits. The weight factor (W_i) of the parameter is determined by the dividing the individual weight of each parameter by the sum of all parameter weights. Quality rating of all parameters (q_n) and unit weight of all parameter (W_n) were calculated. The WQI was calculated by the following formula:

$$WQI = \frac{\sum q_n W_n}{\sum W_n}$$

In a study area, 32.91 Sq. Km of area is Excellent, 354.21 Sq. Km of area is Good, 55.67 Sq. Km of area is Permissible and 1.24 Sq. Km of area is Doubtful for drinking purpose in Pre-monsoon period, 16.73 Km of area is Excellent, 342.62 Sq. Km of area is Good, 82.74 Sq. Km of area is Permissible and 2.04 Sq. Km of area is Doubtful for drinking purpose during Post monsoon season in study area (Figure 2).

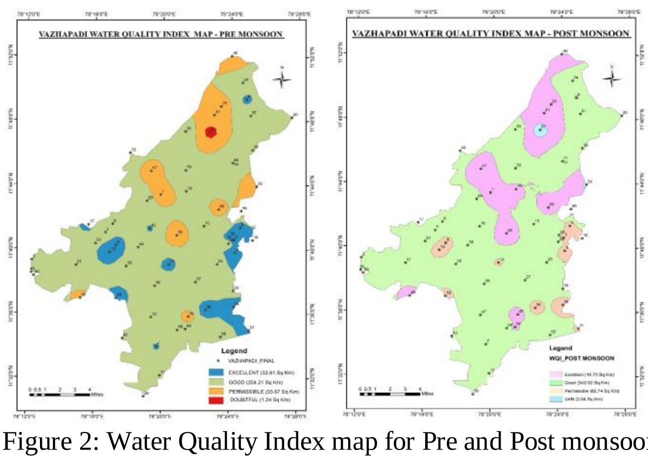

Figure 2: Water Quality Index map for Pre and Post monsoon

Table 1: Groundwater samples classified based on WQI

Sl. No	WQI	Category	% of Samples	% of Samples
1	0-25	Excellent	25	20.31
2	26-50	Good	51.5	53.12
3	51-75	Permissible	20.31	22.43
4	76-100	Doubtful	3.19	4.14
5	Above 100	Unfit	-	-

3.2 Piper Diagram

The trilinear plots and Piper (1944) diagram reveal that the groundwater of the investigation zone is the predominantly Na-Cl and Na-SO_4 type and secondarily Ca-Mg-Cl, Na-Cl type in the pre-and post-monsoon seasons, respectively. The groundwater data plot on the trilinear diagram demonstrates that the majority of the groundwater samples fall into no dominant zone in the cation facies, while the Cl type zone in the anion facies during both seasons respectively. However, few samples fall into no dominant zone in the anion facies and the Ca zone in the cation facies, individually. The plot of geochemical data of both the season on diamond shaped field uncovers that dominant part of the plotted locations fall in zone Na-Cl, Ca-Cl and Mg-Cl. A large portion of the groundwater samples fall in the zone Na-Cl, recommending Permanent hardness in the investigation region.

3.3 Irrigation purpose USSL Diagram

The United States Salinity Laboratory (1954) proposed a graph for concentrate the suitability of groundwater for irrigation purposes based Electrical Conductivity (EC) and Sodium Adsorption Ratio (SAR). High concentration of salt (EC) in water leads the arrangement of saline soil, while a high sodium concentration leads to the formation of alkaline soil. The sodium or alkali hazard expressed in terms of SAR and evaluated by the formula,

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

The SAR values in the study area ranged from 1.13 to 15.83 meq/L with the average value of 4.81 meq/L in the pre-monsoon season and from 1.52 to 15.35meq/L with the average value of 4.99 meq/L in the post-monsoon season, respectively (Table 2). Based on USSL diagram, the water quality shows that 51% and 48% of the samples fall in the C4-S2 (Very High Salinity with Medium Sodium) During the Pre and Post monsoon seasons in a study area. 14% (9 Samples) and 9% (6 Samples) of the in the study area fall in the C2-S1 Field. It indicates that, such type of water can be suitable for agriculture purpose but little danger for interchangeable of cation and anions. Based on the SAR, Suitability of groundwater for irrigation purpose in shown in Figure 3, 379.33 Sq.km of area is good, 62.24 Sq.km of area is permissible and 2.47 Sq.km of area is unfit for irrigation purpose in pre-monsoon season and 368 Sq.km of area good, 73 Sq.km of area is permissible and 2.51 Sq.km of area is unfit for irrigation purpose in post monsoon season.

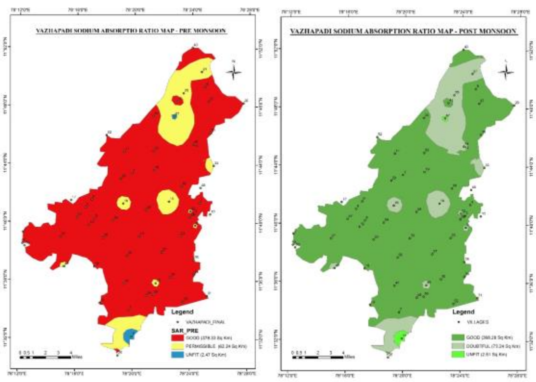

Figure 3: Sodium Absorption Ratio – Pre and post monsoon

3.4 Wilcox Diagram

The concentration of sodium is generally expressed in terms of %Na which is usually used for estimating the fitness of water for agriculture uses because sodium reacts with soil to reduce its permeability properties of the soil (Wilcox, 1955). The High concentration of sodium content can lead the exchange of Na ions in water for Ca and Mg in the soil, which causes the soil to deflocculate and can decrease the percolation rate of the soil. %Na is Classified into five categories for irrigation uses and percentage of Samples fall in each category is shown in Table 3. The following equation is used to be calculate the percentage sodium in groundwater:

$$\%Na = \frac{(Na+K)}{(Ca+Mg+Na+K)} * 100$$

In the study area, percent sodium (Na %) in the ground-water samples 13 and 7% were excellent category, 26 and 18 % of the samples were Good for irrigation, 18 and 32% of the samples were fall in the permissible for irrigation, 34 and 36% of the samples were fall in the doubtful category for irrigation uses in the pre and post monsoon season. By using GIS tool, Total area of Suitability of groundwater for irrigation purpose in shown in Figure 4, 346.23 Sq.km of area is permissible, 97.82 Sq.km of area is not permissible for irrigation purpose in pre-monsoon season and 341.49 Sq.km of area good, 102.56 Sq.km of area is not permissible for irrigation purpose in post monsoon season. Which indicates that, the groundwater highly contaminated due to presence of sodium ions in a study area.

Table 3: Classification of Groundwater based on sodium %

Sl. No	%Na Value	Category	Pre-Monsoon	Post Monsoon
1	< 20%	Excellent	13	7
2	20–40 %	Good	26	18
3	40–60 %	Permissible	18	32
4	60–80 %	Doubtful	34	36
5	> 80 %	Unsuitable	9	7

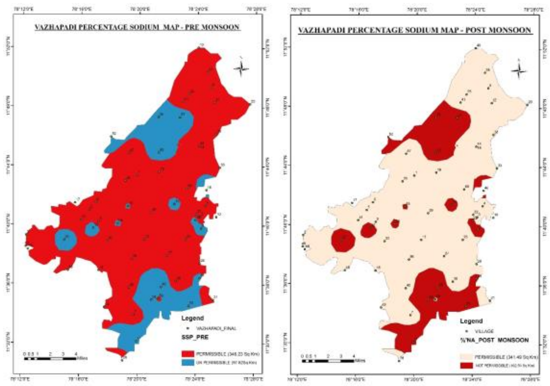

Figure 4: Percentage sodium – Pre and post monsoon

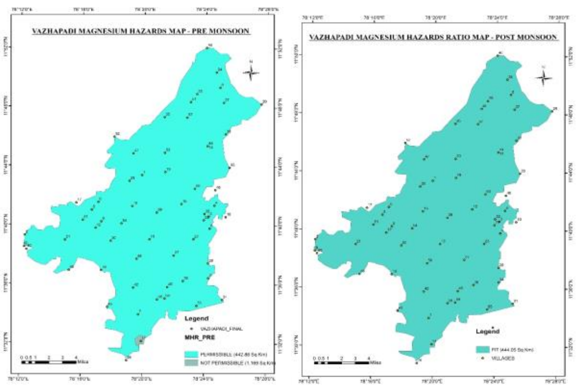

Figure 5: Magnesium Hazards ratio – Pre and post monsoon

3.5 Magnesium Hazards ratio

Szabolcs proposed a magnesium hazard (MH) value for irrigation water; below 50 meq/L magnesium ratio is suggested for safe and suitable for agricultural activity.

$$MH = \frac{Mg}{(Ca+Mg)} * 100$$

From the analytical data, the MH values ranged from 22.27 to 51.50 meq/L with an average of 41.65 meq/L and 28.25 to 57.52 meq/L with the mean value of 44.56 meq/L during the pre- and post-monsoon seasons, respectively. Based on the above criteria, approximately 12.35% of the samples in the pre-monsoon season and 18.56% of the samples in the post-monsoon season are exceed the 50meq/L and not suitable for irrigation purpose (Table 4). Total area of Magnesium contamination has been identified by using GIS and shown in Figure 5, 442.88 Sq.km of area is permissible, 1.169 Sq.km of area is not permissible for irrigation purpose in pre-monsoon season and 444.05 Sq.km of area is permissible for irrigation purpose in post monsoon season.

Table 4: Statistical Analysis of Groundwater parameters in Study area

Parameter	**Premonsoon (n=62)**					**Postmonsoon (n=62)**				
	MIN	**MAX**	**AVG**	**MEAN**	**STD**	**MIN**	**MAX**	**AVG**	**MEAN**	**STD**
pH	7.32	8.36	7.81	7.79	0.25	8.6	7.56	8.05	8.03	0.25
EC	307.00	6657.00	2072.97	1795.00	1354.98	6741	391	2156.97	1879.00	1344.35
TDS	295.00	4740.00	1538.75	1337.00	949.70	4778	333	1576.75	1375.00	942.25
TA	52.00	700.00	326.81	340.00	188.89	723	75	349.81	363.00	187.41
TH	65.00	853.00	426.88	411.00	244.14	875	87	448.88	433.00	242.22
CA	13.65	252.95	99.15	104.55	57.47	256.5	17.2	102.70	108.10	57.02
MG	4.37	111.67	44.98	40.27	28.24	113.2	5.9	46.51	41.80	28.02
NA	27.00	878.00	235.50	204.00	162.69	890	39	247.50	216.00	161.42
K	0.83	269.83	41.17	26.83	45.11	270.23	1.23	41.57	27.23	44.75
NO3	7.00	70.00	24.83	21.50	14.31	76	13	30.83	27.50	14.20
CL	60.00	1304.00	326.52	240.00	244.86	1331	87	353.52	267.00	242.94
SO4	17.00	506.00	192.75	162.50	129.26	528	39	214.75	184.50	128.25
F	0.00	1.10	0.37	0.30	0.35	1.1	0	0.37	0.30	0.35
WQI	12.70	84.04	37.78	32.83	18.10	15.61	86.95	40.69	35.74	18.10
SAR	1.13	15.33	4.81	4.67	2.26	1.52	15.35	4.99	4.84	2.20
MHR	22.27	51.50	41.65	43.08	4.74	28.25	57.52	44.56	46.42	5.68
KR	0.54	3.08	1.28	1.08	0.55	0.68	3.94	1.56	1.52	0.64

3.6 Kelly ratio

Kelly 1946 proposed a sodium value of groundwater for irrigation purpose. The value of Kelly ratio less than 1 indicates that the groundwater samples are suitable for irrigation purpose. In a study area, 0.54 to 3.08 meq/L with the mean value of 1.28meq/L and 0.68 to 3.94 meq/L with an average value of 1.56meq/L in pre and post monsoon seasons in study area (Table 4). Based on Kelly ratio, the groundwater samples of the study area are suitable for irrigation purpose in both seasons. Figure 6 shows that, 401.81Sq.km of area is permissible, 42.23 Sq.km of area is not permissible for irrigation purpose in pre-monsoon season and 444.05 Sq.km of area is permissible for irrigation purpose in post monsoon season based on Kelly ratio.

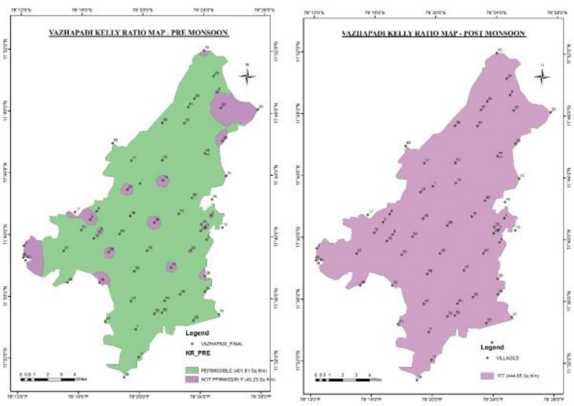

Figure 6: Kelly ratio – Pre and post monsoon

4 CONCLUSIONS

The groundwater of the vazhapdi taluk, is marginally acidic to soluble nature and it's conquered by Sodium in the cationic and chloride in the anionic abundances during pre and post monsoon respectively. The majority of the groundwater samples 78 in the pre and 87% in the post-monsoon seasons are highly soaked as for dolomite and calcite, significantly the presence of calcareous rocks in the sub-surface soil profile of the region. The conclusion of the present study is proposed that the chemical characteristics of the groundwater is primarily controlled by the rock water interaction, exchange of ions with minor contribution from anthropogenic activities of the study area. Besides, the concentration of each parameters in the water samples are higher in the pre-monsoon season than the post monsoon season, individually. The greater part of the groundwater samples of the vazhapdi taluk are good and permissible level for irrigation purpose in the both seasons. Based on Magnesium hazards ratio and Kelly ratio, some of the groundwater sample locations restrict the suitability for irrigation uses. These findings demonstrate that the groundwater of the study area is required appropriate water treatment and distinct administration plan before utilizing for household and irrigation purposes.

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