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Study on Physical-Chemical Characteristics of the Ground water in Olakkur Block Villupuram District, Tamilnadu, India

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Abstract

This study sought to explore the physical-chemical Characteristics of groundwater quality in Olakkur block, which is located in Villupuram district, is water starved region for the past few years due to insufficient rainfall, led to the groundwater depletion and affect the groundwater quality. Ground water samples were collected from different localities in and around Olakkur block. Analysis result was compared with the WHO standards of drinking water quality parameters namely EC,TDS, Calcium, Magnesium, Sodium, Potassium, Nitrate, carbonate, bicarbonate, Fluoride etc. The usefulness of these parameters in predicting ground water quality characteristics is discussed. The quality of ground water in the study area is classified into fresh to brackish water and moderately hard to very hard water. From the overall evaluation of collected groundwater sample it is observed that the water from the study area is suitable for drinking purposes. Groundwater Chloro-Alkaline-Indicies (CAI) suggests that there is an exchange of water Mg^{2+} and Ca^{2+} with rock Na^{+} and K^{+}. The calculated values in RSC, SAR, Na %, show that the water is suitable for Irrigation purposes.

Key words: Groundwater, characteristics, SAR , WHO standards, Olakkur block etc

1. Introduction:

At the global level, groundwater is needed for human consumption, for ecosystem support and for the conservation of the quality of the river base flow, in addition to the use of surface water. In order to ensure the effective and healthy use of resources for drinking, agricultural and industrial purposes, and groundwater quality assessment is essential [1].There has been a tremendous raise in the demand for groundwater due to the increase in population, irrigation practices and industrial usages [2]. Quality of groundwater is similarly important to its quantity owing to the suitability of water for various purposes [3]. Groundwater quality is largely controlled by discharge and recharges patterns of aquifers, nature of host and related rocks, and contaminated actions [5]. The change in the quality of groundwater in an area is a result of physical and chemical parameters that are greatly affected by geological formations and anthropogenic activities. Several researchers have focused on groundwater quality monitoring and assessment for domestic and industrial activities [6]. Due to overwithdrawl of

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groundwater for agricultural, domestic and industrial purposes for the past few years the groundwater level has gone down it will affect the groundwater quality and quantity [7]. The value of groundwater lies not only in its vast occurrence and availability but also in its reliable quality [8]. Poor water quality will affect the plant growth and human health [9]. Groundwater resources are often over exploited to meet the increasing demand hence a heavy stress is applied to the aquifer system. The main aim of this study is to investigate the levels of Calcium, Magnesium, Sodium in the surrounding villages of Olakkur block and thereafter compare the obtained results with the WHO standards for water quality and give direction for further implementation action plan to the concerned body.

2. Materials and Methods

A 20 groundwater samples were collected in the year 2019 from open and bore wells during Postmonsoon and Premonsoon. The electrical conductivity and pH were measured in the field using portable kit. The collected samples were chemically analysed by standard analytical method APHA[11].

2. 1 Study area

The study area Olakkur block (Fig:1) is one of the blocks in Viluppuram district, Tamilnadu. The block is situated in northern part of Viluppuram district. The Olakkur block lies at latitude of 12º 10’ to 12º 25’N and longitude 79º 35’ to 79º50’E. The total area is 270.5 sq.kms. Climate of the study area is mostly hot and dry except winter season. The entire block is underlined by charnockites, homblende Biotite Gneiss (Fig.2). Charnockites is the dominant lithology of the study area, homblende biotite gneiss was observed in the NW part of study area. Samples collected from open and bore wells are labelled with details of the locations. They are 1. Pattanam (OW) 2. Ural 3. Melpakkam (OW).4. Evalur (OW) 5. Evalur (BW) 6. Evalur. 7. Purangarai (OW) 8. Purangarai (BW) 9. Olakkur(OW) 10.Saram 11.Echeri 12.Nolambur 13.Kilkudalur 14. Melpettai 15. Panjalam (OW). 16. Melpakkam (BW) 17.Pattanam (BW) 18.Olakkur(BW) 19. Venmaniathur 20. Panjalam (BW). Water sample collected in the field were analyzed in the laboratory for the major cations and anions using the standard methods as recommended by the American Public Health Association [12].

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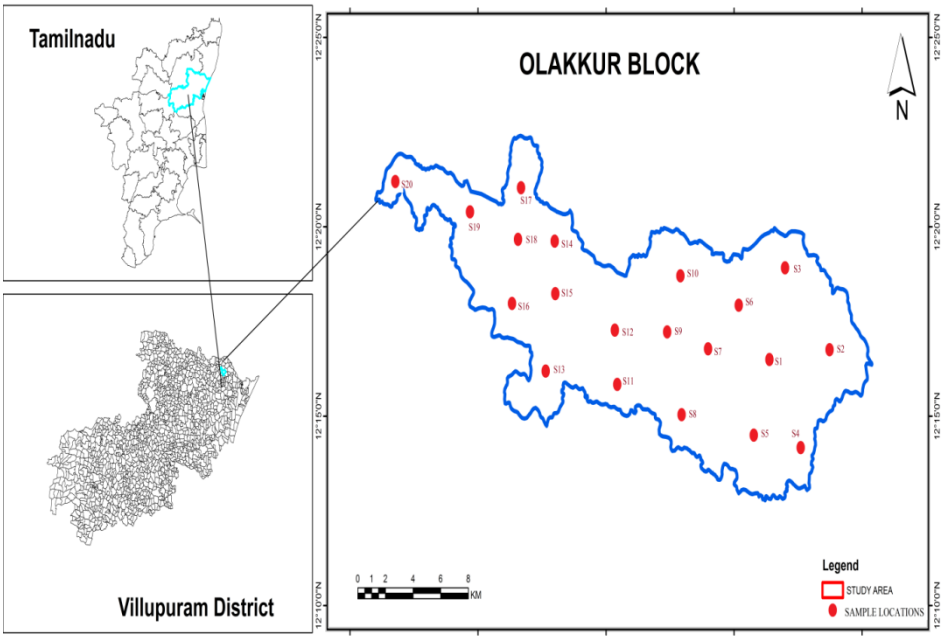

Fig.1 Location map of Study Area

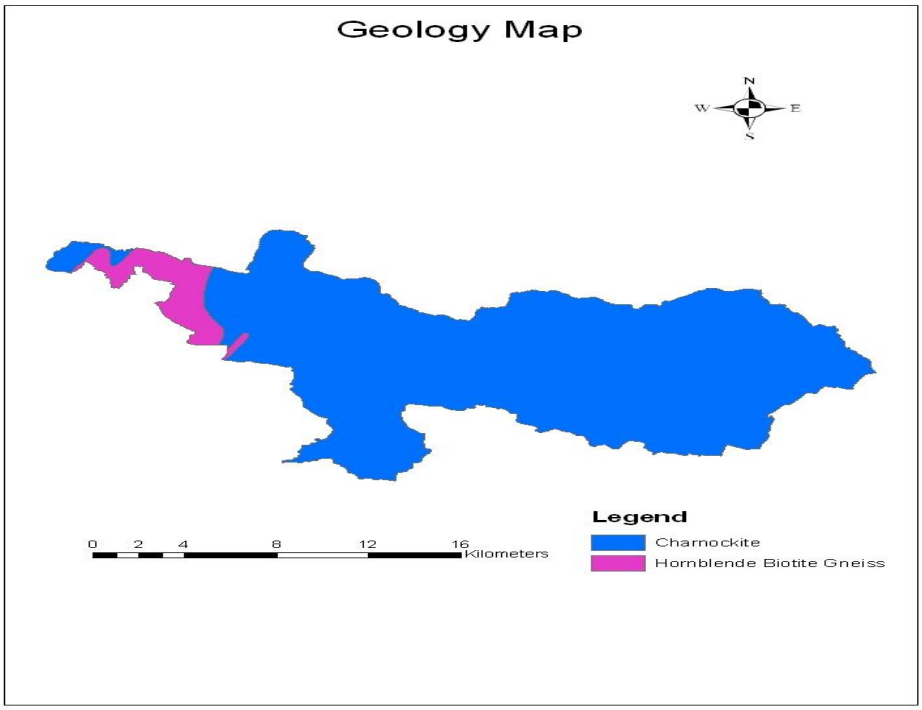

Fig:2 Geology Map of Study area

3. Results and Discussions

The physical and chemical parameters of Olakkur block is shown in Table 1. The groundwater quality data analysis for drinking water has been carried out as per guidelines

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given by [13]. The pH value of ground water samples ranges from 6.9 to 8.4 during premonsoon and postmonsoon. Almost all samples fall (6.5 to 8.5) within the recommended limits of WHO [14] for human utilization. The electrical conductivity values range from 230 to 3100 µ mhos/cm during postmonsson and 410 to 3200 µ mhos/cm during premonsoon (Table 1). The electrical conductivity (EC) of water is a function of dissolved mineral content. It is a good marker of Total Dissolved Solids (TDS) which is an indication of salinity that affects the taste of potable water. TDS concentration of study area is observed as minimum of 540 mg/l in (Nolambur) and maximum of 1676 mg/l in (Olakkur) during Premonsoon and 565 to 1348 mg/l during Postmonsoon season. TDS value of less than 1000 mg/l in groundwater can be used for consumable purpose without any risk, because it has lower content of soluble salts.

Calcium concentration in groundwater samples ranges from 11 to 81 mg/l in Postmonsoon season and 32 to 97 mg/l in Premonsoon season and. Magnesium concentration in groundwater observed between 23 to 110 mg/l in Premonsoon season and 9 to 92 mg/l in Postmonsoon. Calcium and magnesium ions present in groundwater is obtained from leaching of limestone, dolomites and gypsum. The presence of Calcium and Magnesium concentration in the water samples may be due to weathering of rocks. All the groundwater samples have sodium concentration, because most of rocks and soils contain sodium compounds from which sodium is easily dissolved. Sodium is necessary for the human body to function normally. Pollution or salt water intrusion may be demonstrated by a rise in sodium in groundwater above normal levels. The sodium concentration recorded 54 to 496 mg/l during Postmonsoon and 67 to 534 mg/l during Premonsoon season in the present study. The maximum concentration of sodium is observed in the locations Olakkur and Pattanam. 13 samples from the premonsoon and 11 samples postmonsoon from study area crossing the the permissible limit prescribed by WHO standards. Potassium concentration is good if it is less than 10 mg/l for drinking water [15]. The major source of potassium in groundwater is due to weathering of rocks which are rich in minerals like microcline, orthoclase and biotite. Potassium concentration range from 7 to 54 mg/l. It is observed that potassium concentration is low in groundwater; the reason is that potassium is resistant to decomposition. The bicarbonate concentration of the groundwater samples range from 24 to 203 mg/l. Dissolved CO_2 from rainwater is the source of bicarbonate in groundwater and dissolves more CO_2 as it enters the soil.

Table :2 Physico-chemical parameters for drinking water prescribed by WHO 2011

S.no	Water Quality Parameters	Permissible limit	No.of Samples Exceeding Permissible limit (Premonsoon)	No.of Samples Exceeding Permissible limit (Postmonsoon)

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1	pH	6.5-8.5	Nil	Nil
2	TDS(mg/l)	1000	7	5
3	Ca	200	Nil	Nil
4	Mg	150	Nil	Nil
5	Na	200	13	11
6	Cl	600	Nil	Nil
7	SO4	250	Nil	Nil
8	NO_3	45	Nil	Nil
`9	K	12	16	13

Chloride concentration noted in 54 to 320 mg/l during Premonsoon and 67 to 289 mg/l in Postmonsoon. The high chloride concentration was recorded in villages Olakkur and Melpettai. It is due to replacement of hydroxide to chloride in the hornblende biotite gneissic rocks [17]. Nitrate is one of the most common indicators of manure and inorganic fertilizer impacts. Numerous researchers indicate that nitrate is often higher in groundwater in areas of intensive agriculture. Nitrate concentration in the study area observed minimum concentration of 5 mg/l in both the season and maximum value of 19 and 29 mg/ noted in Postmonsoon and Premonsoon season. Fluoride concentration in the groundwater samples are range from 0 to 1 mg/l. Fluoride values are within the desirable limit. Physical and chemical parameters of groundwater in the study area fall within the permissible limit as per WHO [18] it show suitable for drinking purposes, except sodium concentration (table:2). The enrichment of sodium concentration in groundwater occurs may be due to long residence time of water, dissolution of minerals from lithological composition and in addition input of fertilizers with irrigation waters [19].

3.1 Suitability of Groundwater for Irrigation

The EC of the ground water in the study area ranges from 230 to 3100(ohms/m) and 410 to 3200(ohms/m) during postmonsoon and premonsoon season .70 % of samples in Premonsoon and 50 % of samples in Postmonsoon fall in permissible category (Table 3). Most of the groundwater samples from the study area shows good to permissible category, remaining 2 samples collected from the location Evalur (OW & BW), fall in doubtful category and 1 sample comes under unsuitable category from the location of Venmaniathur. The higher value of EC is attributed to geochemical processes and anthropogenic activities..

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Table.3 Ground water Quality based on Electrical conductivity

EC (µS/cm)	Category	No.of Samples(PRM)	No.of Samples(POM)
< 250	Excellent	NIL	1
250-750	Good	3	5
750-2000	Permissible	14	11
2000-3000	Doubtful	2	2
>3000	Unsuitable	1	1

3.2 Sodium Adsorption Ratio (SAR)

For determining the suitability of groundwater for irrigation purpose, Sodium Adsorption Ratio (SAR) is broadly used. If the water used for irrigation consist high concentration of Na^{2+} and low concentration of Ca^{2+} then the ion exchange complex may turn into saturated with Na^{2+}, which affects the soil structure and plants growth. Based on the categorization, 85% of samples during Premonsoon season and 90% of samples from Postmonsoon season(shown in Fig:3) observed suitable for irrigation purposes. (Table:4).15 % of samples are shows unsuitable for irrigation purposes [21].

Table.4 Ground water Suitability for Irrigation purposes based on Sodium Adsorption Ratio (SAR)

SAR Range	Categories	No.of Samples(PRM)	No.of Samples(POM)
<10	Excellent	8	10
10 to 18	Good	9	8
18 to 26	Doubtful	3	2
>26	Unsuitable	NIL	NIL

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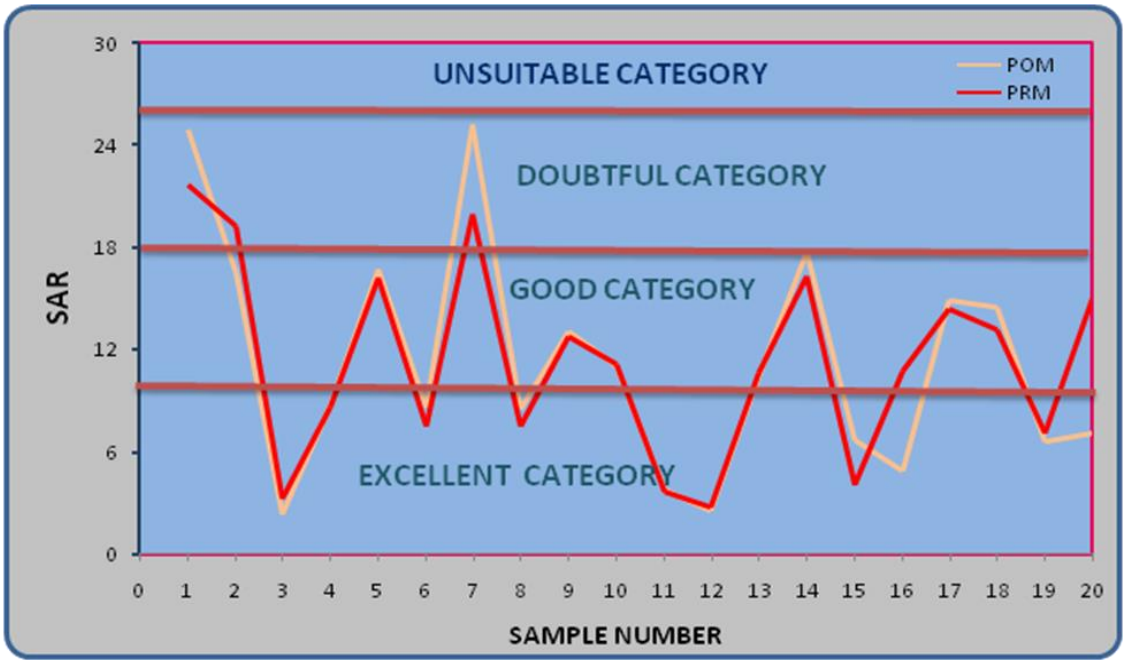

Fig: 3 Graphical chart for SAR

3.3 Sodium percentage (Na%)

Alkali soils are considered soils containing a significant amount of sodium with carbonate as the chief anion; saline soils are those with chloride or sulphate as the predominant anion. Sodium plays a major role in the classification of irrigation water due to the fact that sodium reacts with the soil and as a consequence, particle clogging occurs, thus decreasing permeability[22].The Na% is computed with respect to relative proportion of cations present in water as where, all ionic concentrations are expressed in meq/l [23]. Sodium percentage in water is a parameter computed to evaluate the suitability for irrigation [24].Based on the classification of Na% 50 % of samples (shown in Fig:4) from the study area observed doubtful category and 20 % of samples are permissible category and 30 % of samples fall in Unsuitable category both of Premonsoon and Postmonsoon season. (Table:5).

Table.5 Ground water Suitability for Irrigation purposes based on Sodium Percentage (Na%)

Range	Categories	No.of Samples(PRM)	No.of Samples(POM)
<20	Excellent	Nil	Nil
20-40	Good	Nil	Nil
40-60	Permissible	4	4
60-80	Doubtful	10	10
>80	Unsuitable	6	6

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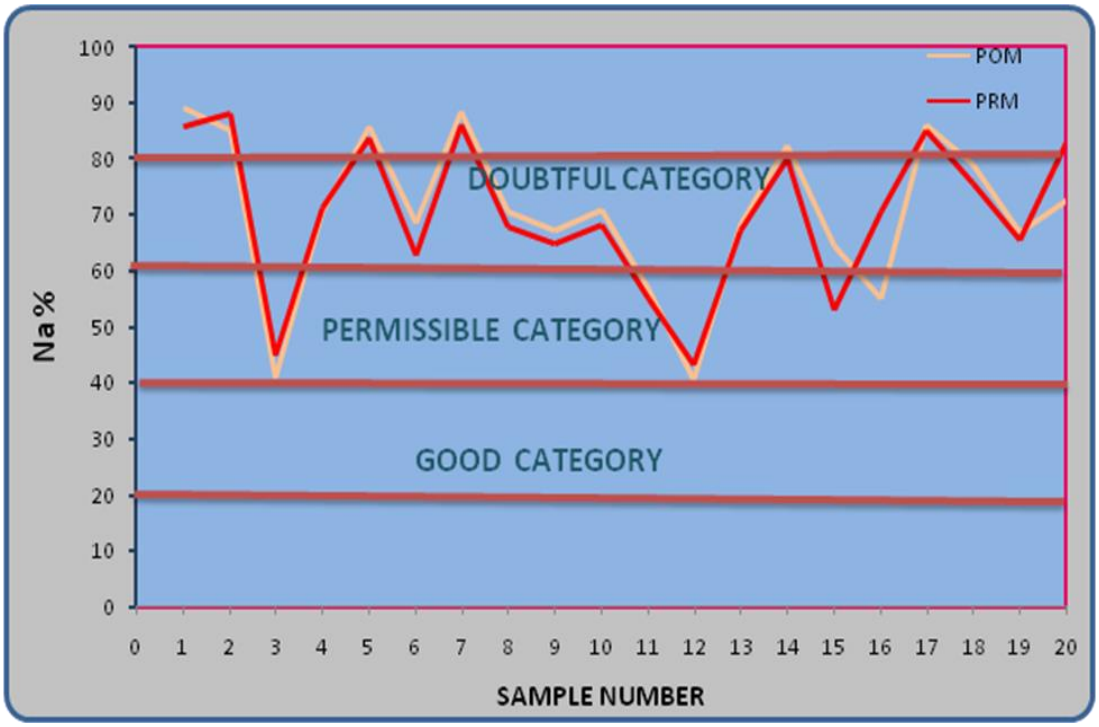

Fig: 4 Graphical chart for Na%

3.4 Residual Sodium Carbonate (RSC)

The RSC values shown in the following table is rated based on. An RSC value lesser than 1.25 meq/l is safe for irrigation, a value between 1.25 and 2.5 meq/l is of marginal quality, and a value greater than 2.5 meq/l is incompatible for irrigation, according to the US Salinity Laboratory (1954). The calculated RSC values of Premonsoon season range from -9.93 to 1.016 and -7.94 to 0.47 during Post monsoon season it reflects all the groundwater samples suitable for irrigation purposes in the study region(Table: 6).

Table.6 Ground water Suitability for Irrigation purposes based on Residual Sodium Carbonate (RSC)

RSC (meq/l)	Categories	No.of Samples(PRM)	No.of Samples(POM)
< 1.25	Safe	20	20
1.25 - 2.5	Moderate	NIL	NIL

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> 2.5	Unsuitable	NIL	NIL

3.5 Wilcox diagram

According to the sodium % and specific conductance in evaluating the suitability of the water samples are varying from very good to doubtful classes for irrigation. 70% of the waters of both premonsoon and postmonsoon fall in permissible category.

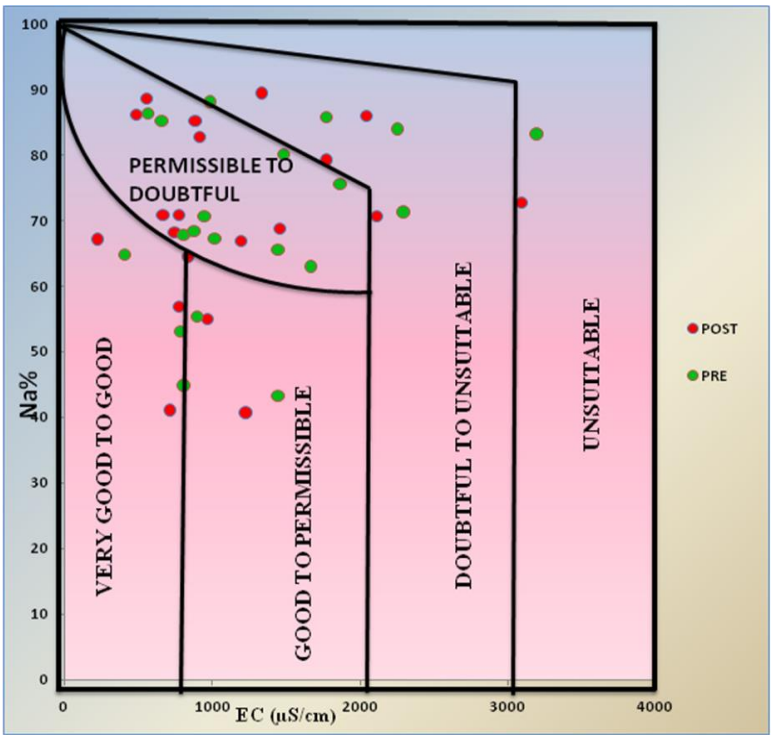

Fig 3 Specific conductance and % sodium relationship for evaluation irrigation water

3.6 Index of Base Exchange

It is essential to understand the changes in chemical composition of groundwater during its journey in the underground [25]. The CAI 1 and CAI 2 chloro-alkaline indices[26], which show the ion exchange between groundwater and its host community, are recommended. The Chloro-alkaline indices used for the Base Exchange evaluation are determined using formulas.

1. Chloro Alkaline Indices 1 = $(Cl^- – (Na^+ + K^+)) / Cl^-$
2. Chloro Alkaline Indices 2 = $(Cl^- – (Na^+ + K^+) / (SO^{2-}_4 + HCO^-_3 + CO_3^{2-} + NO^-_3)$

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The exchange is known as direct when the indices are positive, if there is an ion exchange reaction of Na+ and K+ from water with Mg and Ca in the rock. If the trade is reversed, the exchange is indirect and it is found that the indices are negative[27].

The Chloro-alkaline Indices of groundwater during Premonsoon has been observed that CAI-1 value ranges between -9.031 to 0.46, while CAI-2 values fall between -5.33 to 1.22. During the Postmonsoon season CAI-1 value ranges between -10.91 to 0.28, while CAI-2 values fall between -5.75 to 0.47. The present study shows that 90 to 95 % of groundwater samples shows negative ratios and 5 to 10 % of groundwater samples shows positive ratios both the seasons, Positive Chloro-Alkaline Indices indicate exchange of Na^+ and K^+ from the water with Mg^{2+} and Ca^{2+} of the rocks [28]. Negative Chloro-alkaline Indices of groundwater indicates there is an exchange of Mg^{2+} and Ca^{2+} of the water with Na^+ and K^+ of the rocks [29].

Conclusion

ased on the analysis of groundwater, it has been possible to understand the geochemical quality of groundwater in the study area and to evaluate its suitability for drinking and irrigation purposes. The study inferred that the groundwater in the study area is slightly alkaline in nature. Na, Ca, HCO3, and Cl are the dominant ions and 45 % of the study area exceeded the recommended limits of TDS. Total hardness reveals that the water is generally hard in nature. ased on the analysis of groundwater, it has been possible to understand the geochemical quality of groundwater in the study area and to evaluate its suitability for drinking and irrigation purposes. The study inferred that the groundwater in the study area is slightly alkaline in nat-ure. Na, Ca, HCO3, and Cl are the dominant ions and 45 % of the study area exceeded the recommended limits of TDS. Total hardness reveals that the water is generally hard in nature.

From the analysis it is inferred that the physical and chemical characteristics of groundwater in the study area are alkaline in nature. The concentration of major ions in the groundwater are within the permissible limits of WHO except Sodium concentration. The Fluoride concentration in the groundwater is within the permissible limits and overall parameters shows that the groundwater is suitable for drinking purposes. Groundwater Chloro-alkaline indices suggest an exchange of Mg^{2+} and Ca^{2+} of water with Na^+ and K^+ of the rocks. The values in EC, SAR, Na%, RSC indicates that the water is suitable for irrigation purposes.

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