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Assessment of Groundwater Quality for Irrigation purpose in Pennagaram block, Dharmapuri District, Tamilnadu, India

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Abstract: **The suitability of groundwater for irrigation purpose was assessed in Pennagaram block located in Dharmapuri district of Tamilnadu, India. The groundwater samples form eighty villages were analyzed during rainy season in the month of September 2013 for major cations, anions and other parameters. The irrigation factors have been measured for controlling and recognizing the quality of water in the review area region for irrigation purpose. The plot of Cl^-/HCO_3^- versus Cl^- shows the exchangeable mechanism has responsible for the chemical composition of groundwater. According to %Na, RSC, KR, SAR, PI, MR, Salinity index and Sodicity index makes the groundwater has safe. Based on PS and Sodicity index makes the groundwater has nearly problem for irrigation purpose. The Gibbs diagram and Durov diagram suggested that the reverse ion-exchange process, simple dissolution or chemical weathering, evaporation and rock dominance mechanism controls the groundwater chemistry. Based on piper diagram and Schoeller diagram the mainstream of water type is Ca-Mg-Cl and Ca-Cl water type. This study result will be helpful for sustainable development of groundwater resources, and it requires a special type of irrigation method.**

Keywords: **Pennagaram, Ground water, Ion-exchanging, Irrigation, Sustainable, India.**

1. INTRODUCTION

Ground water is an essential recognized source of water for urban and rural backgrounds in developing countries. Groundwater is utilized as a most important water system for agricultural enhancement. Estimates of America and Asia only recommend that more than 1000 million entities believe upon these sources. Accessibility of protected and dependable birthplace of water is an essential for commercial improvement. Groundwater is generally considered to be much cleaner than surface water [1].

The quality of water is now varying as a consequence of growing population, discharge of industrial, agricultural and domestic water; land use practices; geological formation; rainfall patterns; and infiltration. These practices affect the groundwater quality increasing demand for irrigation in India to raise high-yielding varieties of crops [2]. Once the groundwater was contaminated in aquifers, it persists for hundreds of years because of their very slow movement.

The dissolution of geochemical practices involving the interaction of country rock with groundwater leads to the development of secondary mineral phases [3]. The hydrochemistry of water occurring from different water bodies occurring chemistry of water in very close proximity to one other. India has moving toward lack of available water and the problem will be founded by issues of water quality [4].

Irrigation is essential for agricultural production in semiarid regions where rainfall is not adequate to uphold crop growth. Irrigated agriculture consumes 60 to 80 % of the total water usage and contributes approximately 38 % of the global food production. It has played a major role in generating employment opportunities in the rural areas and providing food for low prices for downtrodden people in the urban area [5].

Hence, it is necessary to determine the suitability of groundwater for irrigation purpose based on the presence of major ions in the groundwater. The important chemical parameters for judging the degree of suitability of water for irrigation purpose has been selected. In this regard, the computations are all in the seasons of 2013-2014.

2. GEOGRAPHY OF THE STUDY AREA

Pennagaram block is situated on the western part of Dharmapuri district, Tamilnadu, India. It falls in the following co-ordinates East longitude 77°46'12 - 78°04'26 and North latitude 11°55'15 - 12°15'38 and it forms a part of the Government of India Topo sheets 57H/15. The total block areal extent is 633.67 Sq. kms and is situated at an altitude on 450 meters above mean sea level. Chinnar and Cauvery are the chief rivers that flow through the study area. The Red Sandy soil (Iron composite) is presented in the study area region. It is generally derived from crystalline rock. Nearly 33.83% of the area in this block is identified as agricultural land. The average rainfall in this area is approximately 850 mm. The Ground water level varies from 3.65 to 13.45m.

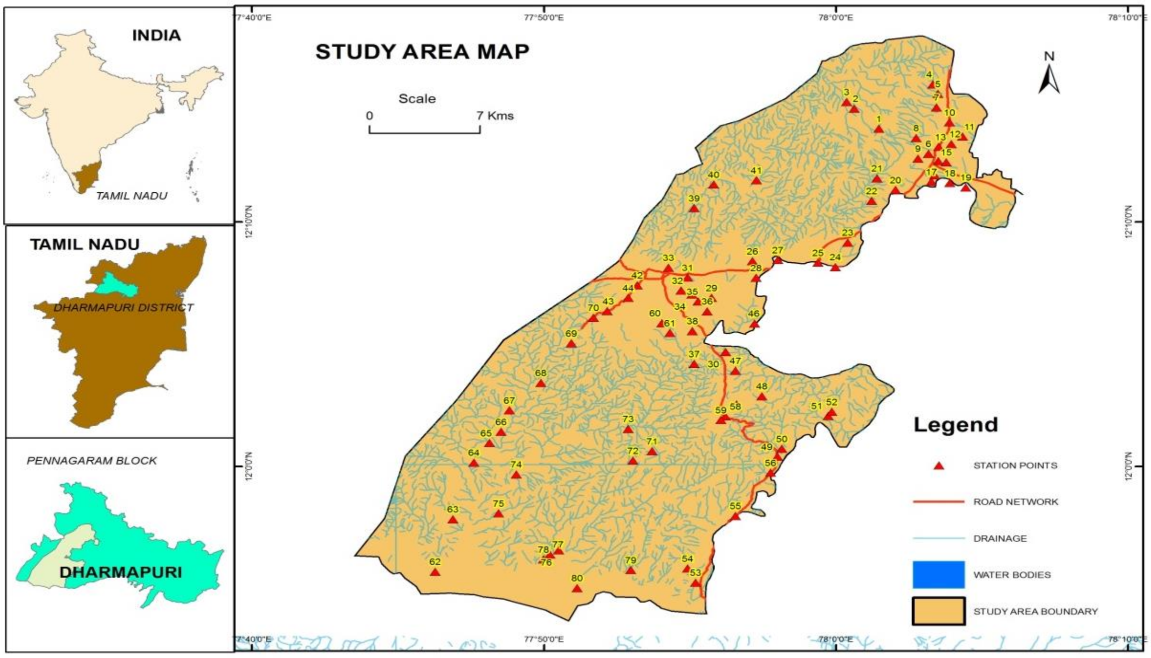

FIGURE I: STUDY AREA MAP

3. MATERIALS AND METHODS

Groundwater samples were collected during the year 2013 in post-monsoon (January) and pre-monsoon (May) from eighty different locations which are almost uniformly distributed over the study area. Groundwater samples were analyzed in the laboratory for major cations and anions according to standard techniques prescribed by APHA (2005). To assess the suitability of groundwater for irrigation uses, the following irrigational quality parameters were computed by the following equations:

TABLE I: EQUATIONS FOR CALCULATING IRRIGATION PARAMETERS

$\%Na = \frac{Na^+ + K^+}{Ca^{2+} + Mg^{2+} + Na^+ + K^+} X\ 10$	$RSC = (HCO_3^- + CO_3^{2-}) - (Ca^{2+} + Mg^{2+})$
$CAI\ I = \frac{Cl^- - (Na^+ + K^+)}{Cl^-}$	$CAI\ II = \frac{Cl^- - (Na^+ + K^+)}{(SO_4^{2-} + HCO_3^- + CO_3^{2-} + NO_3^-)}$
$KR = \frac{Na^+}{Ca^{2+} + Mg^{2+}}$	$SAR = \frac{Na^+}{\sqrt{(Ca^{2+} + Mg^{2+})/2}}$
$PI = \frac{Na^+ + \sqrt{HCO_3^-}}{Ca^{2+} + Mg^{2+} + Na^+} X\ 100$	$MR = \frac{Mg^{2+}}{Ca^{2+} + Mg^{2+}} X100$

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$PS = Cl^- + \frac{SO_4^{2-}}{2}$	$\text{Gibbs Ratio I} = \frac{Cl^-}{(Cl^- + HCO_3^-)}$
$\text{Gibbs Ratio II} = \frac{(Na^+ + K^+)}{(Na^+ + K^+ + Ca^{2+})}$	

All the ionic concentrations in the above equation are expressed in meq/L, and %Na and PI in %. Piper, Durov and Schoeller diagrams are drawn by ArcGIS software.

4. RESULTS AND DISCUSSION

A. Irrigation quality

The Cl^-/HCO_3^- ratio shows that most of the samples are affected by slightly to moderately affected category. It shows the groundwater samples in the study area strongly affected by saline water [7].Chloro Alkaline Indices CAI-I and CAI-II specifies cation exchangeable mechanism has one of the responses for the chemical composition of groundwater in the studied area. % Na, RSC, PI, KR and MR values of the groundwater samples show the study area has safe for irrigation [8, 9]. The sodium adsorption ratio (SAR) results showed that more than 85% of the groundwater samples are safe for irrigation [10]. The Potential Salinity (PS) makes nearly the groundwater has unsuitable for irrigation purpose due to the presence of chloride [11].

Salinity Index and Sodicity Index

The salinity index (figure 2) shows the majority of the groundwater samples are categorized as class II (slightly saline) and class III (moderate saline). Based on salinity index, some samples are nearly problem for irrigation. Sodicity index is calculated using SAR ranging from 0 to 3 is considered to be good for irrigation purpose. Based on Sodicity index, most of the groundwater samples are suitable for irrigation.

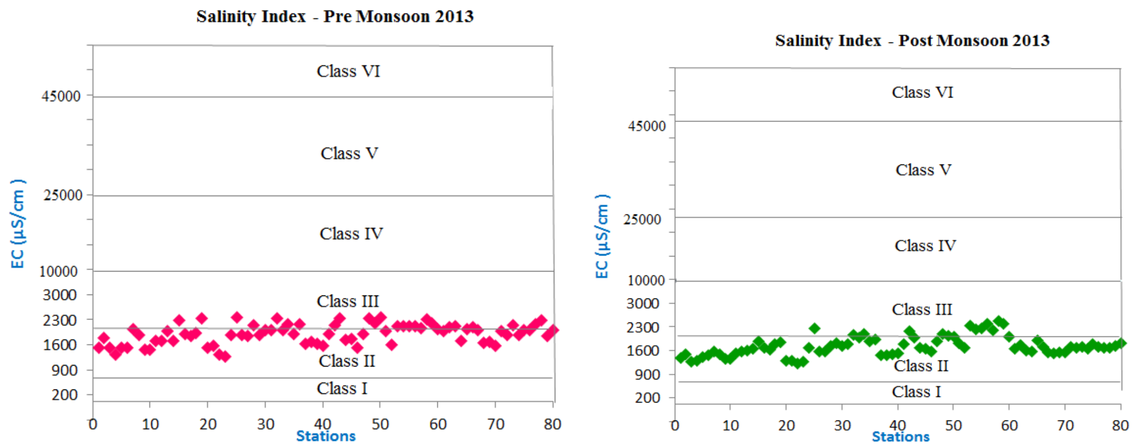

FIGURE II: SALINITY INDEX FOR THE GROUNDWATER SAMPLES

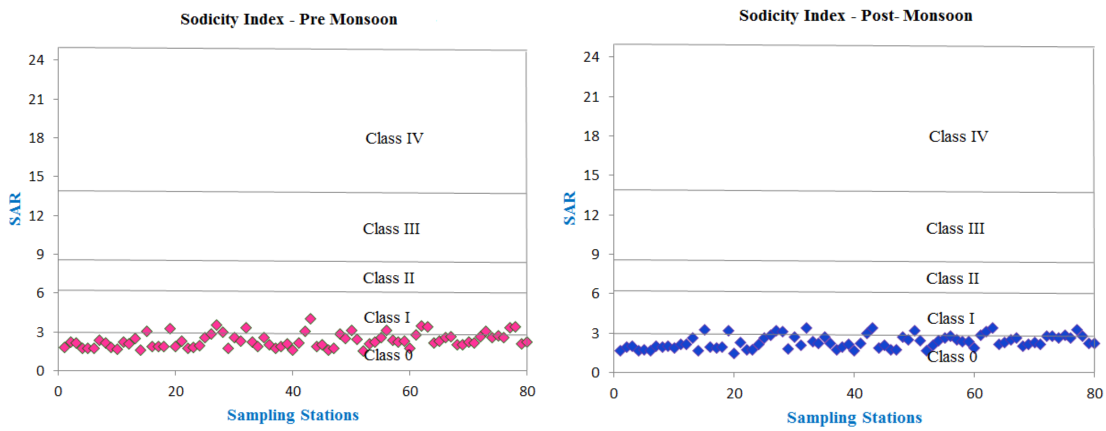

FIGURE III: SODICITY INDEX FOR THE GROUNDWATER SAMPLES

B. Groundwater Classification for Irrigation

USSL Diagram

The values of EC and SAR are related and designed on USSL diagram. It directs the indication of salinity and alkali hazards. Suitability of water for irrigation purpose has been classified as four classes (C1-C4) has is shown in figure 4. All the groundwater samples fall in under low and high salinity in both the seasons. It shows the groundwater samples are used for irrigation with proper drainage.

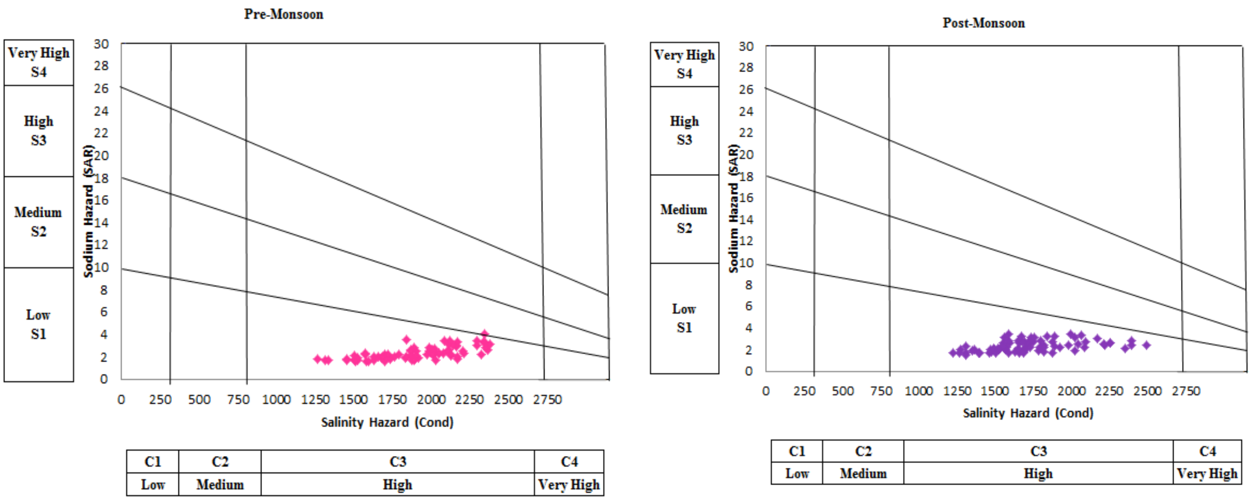

FIGURE IV: USSL CLASSIFICATION OF GROUNDWATER

Wilcox Diagram

Classification of irrigation water is based on EC and Sodium percentage [12, 13]. According to Wilcox classification, the suitability of groundwater for irrigation purpose for majority of the samples falls in good permissible and doubtful to unsuitable during both the seasons.

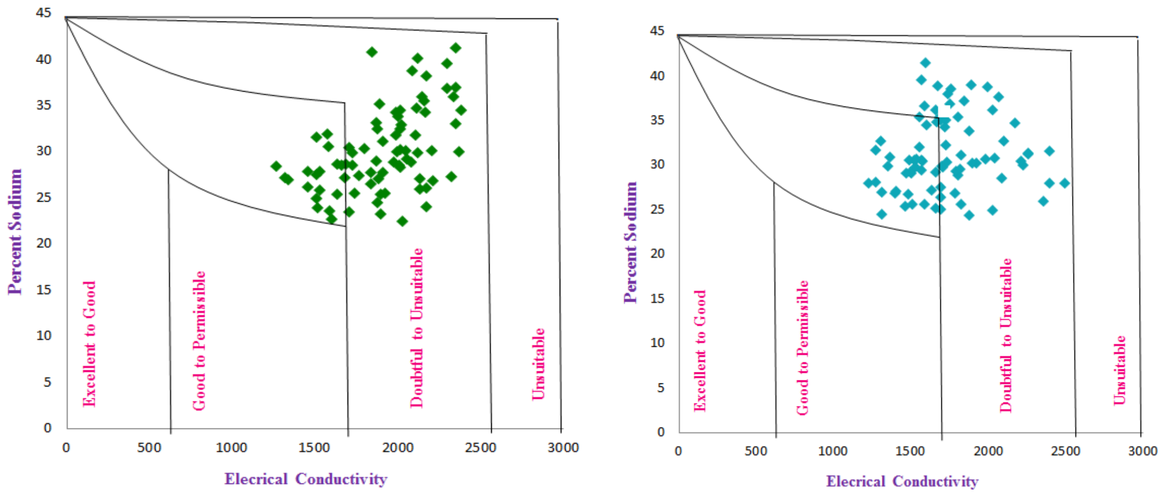

FIGURE V: WILCOX DIAGRAM OF GROUNDWATER DURING PRM AND POM

Doneen's plot:

According to Doneen's plot, the groundwater suitability for irrigation is based on Permeability Index [14]. As per figure 6, water can be classified as Class I and Class II. It indicates all the groundwater samples are good for irrigation in both seasons.

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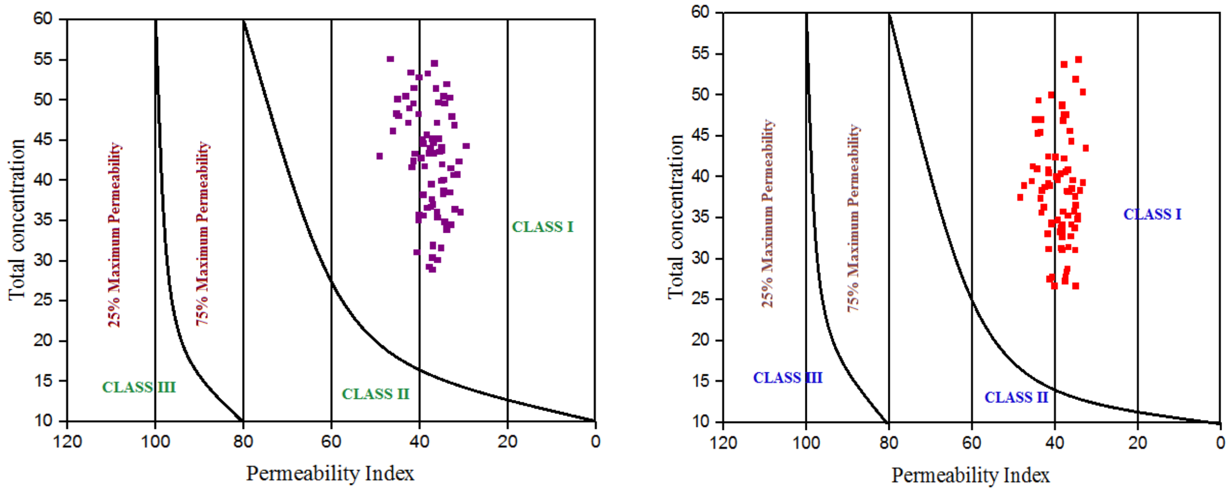

FIGURE VI: DONEEN'S CHART SHOWING CLASSIFICATION OF GROUNDWATER FOR PRM AND POM

C. Controlling the mechanism of Hydrogeochemistry

Gibbs plot

The Gibbs diagram illustrates three distinct fields, namely rainfall dominance, evaporation dominance and rock dominance that are shown figure 7 and 8 [15]. The Gibbs diagram was plotting ratios of dominant anions and TDS in Gibbs ratio I. Similarly, the Gibbs ratio II was plotted between dominant cations and TDS. It shows the most of the samples falls in the rock water interaction and evaporation fields, which suggest the chemical weathering of rock-forming minerals that are influencing the groundwater quality by dissolution of rock.

Piper plot

The Piper diagram (tri-linear) is used to graphically demonstrate the connection between the most important dissolved constituents in groundwater samples [16]. The major cations and anions are plotted individually and recognize the overall characteristics of water. The result shows CaCl water type is most predominant in the groundwater background of both the seasons. This is due to dominance of Calcium (alkaline earth metals) over Na^+ & K^+ (alkali metals) and the strong acids (Cl^- and SO_4^{2-}) dominate weak acids (HCO_3^- and CO_3^{2-}).

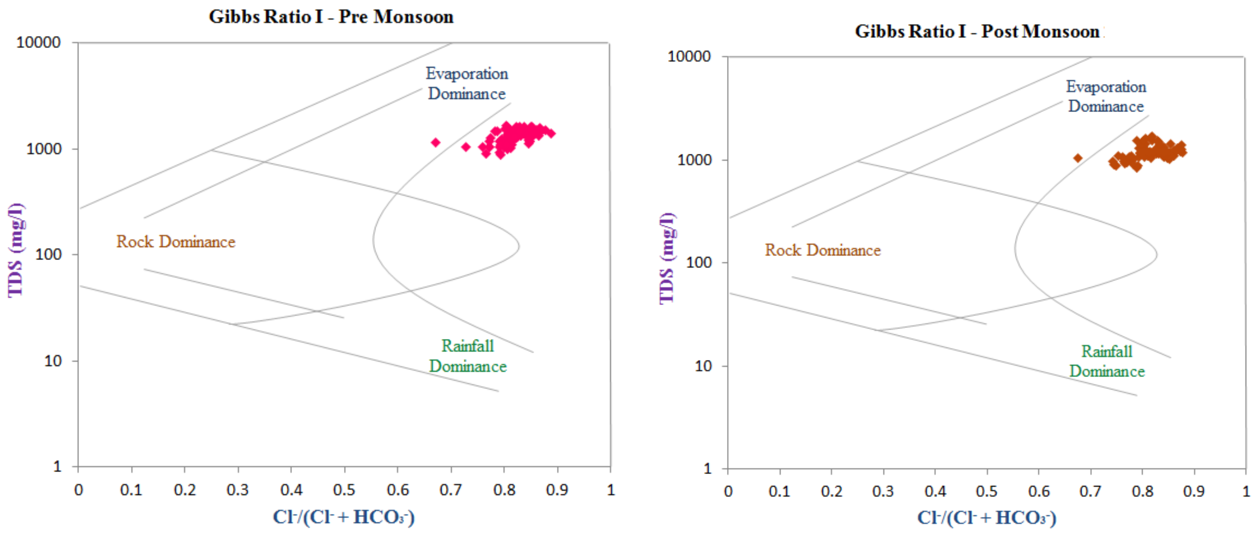

FIGURE VII: GIBBS RATIO I, SHOWS THE MECHANISM CONTROLS GROUNDWATER CHEMISTRY

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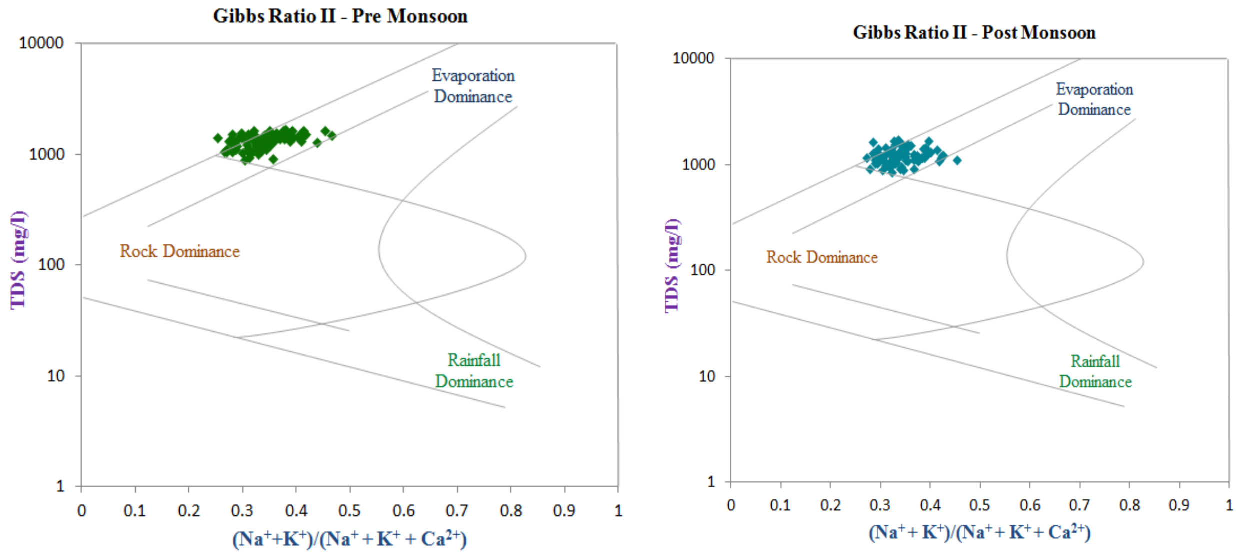

FIGURE VIII: GIBBS RATIO II, SHOWS THE MECHANISM CONTROLS GROUNDWATER CHEMISTRY

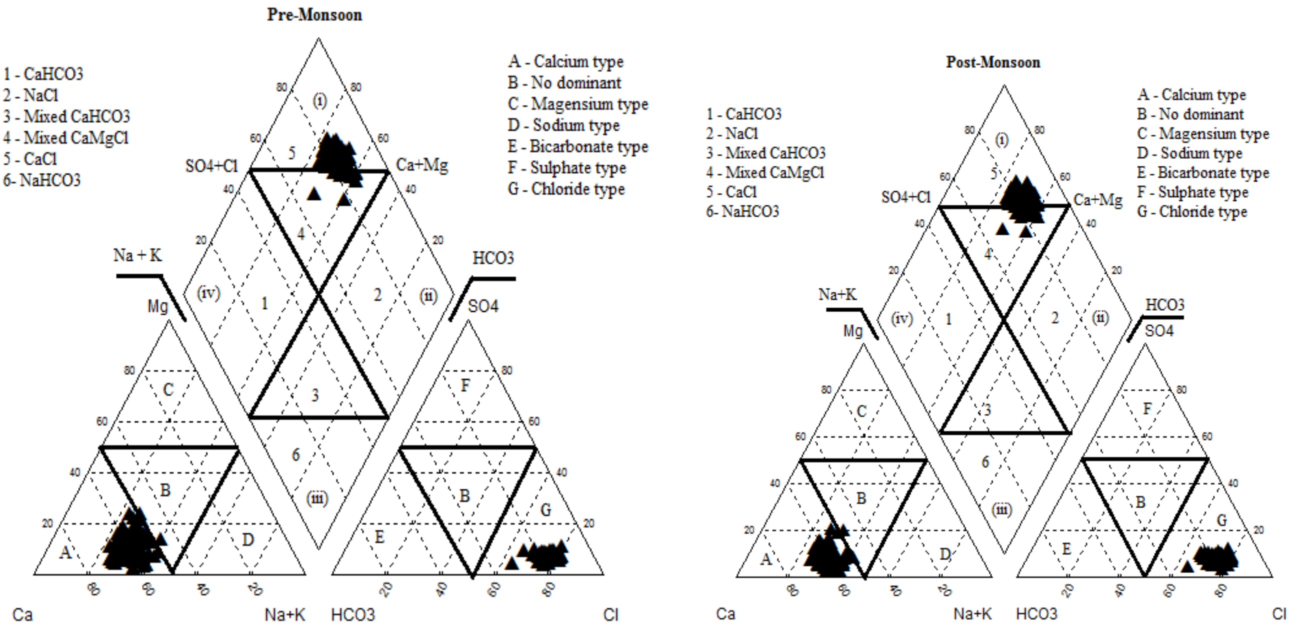

FIGURE IX: PIPER DIAGRAM SHOWING HYDRO GEOCHEMICAL FACIES

Durov Diagram

Durov diagram plots the major ions as percentages of mill equivalents in two base triangles [17]. It shows the hydro geochemical process analysis, in the middle of the diagram represents Calcium and Chloride is the dominant ions in both the seasons. Samples in field 9, where Na^+ and Cl^- are dominant, represents endpoint water [18]. The presence of water type indicates salinization, which may be attributed to reverse ion-exchange process and simple dissolution or chemical weathering process.

Schoeller Diagram

Schoeller diagram displays the role of major chemical constituents present in the groundwater. It results Chloride is the dominant ion followed by Calcium, Sodium, Magnesium and Bicarbonate. Sulphate is the least one among anions. The relative abundance of major ions follows order: $Cl^- > Ca^{2+} > Na^+ > Mg^{2+} > HCO_3^- > SO_4^{2-}$.

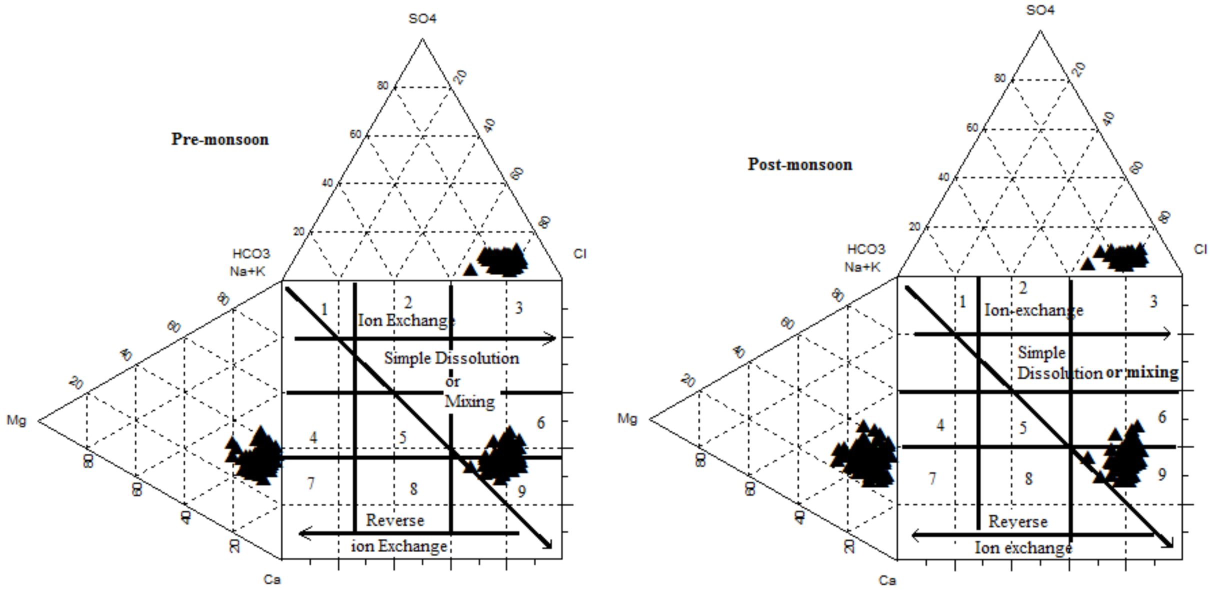

FIGURE X: DUROV DIAGRAM SHOWING HYDRO GEOCHEMICAL FACIES

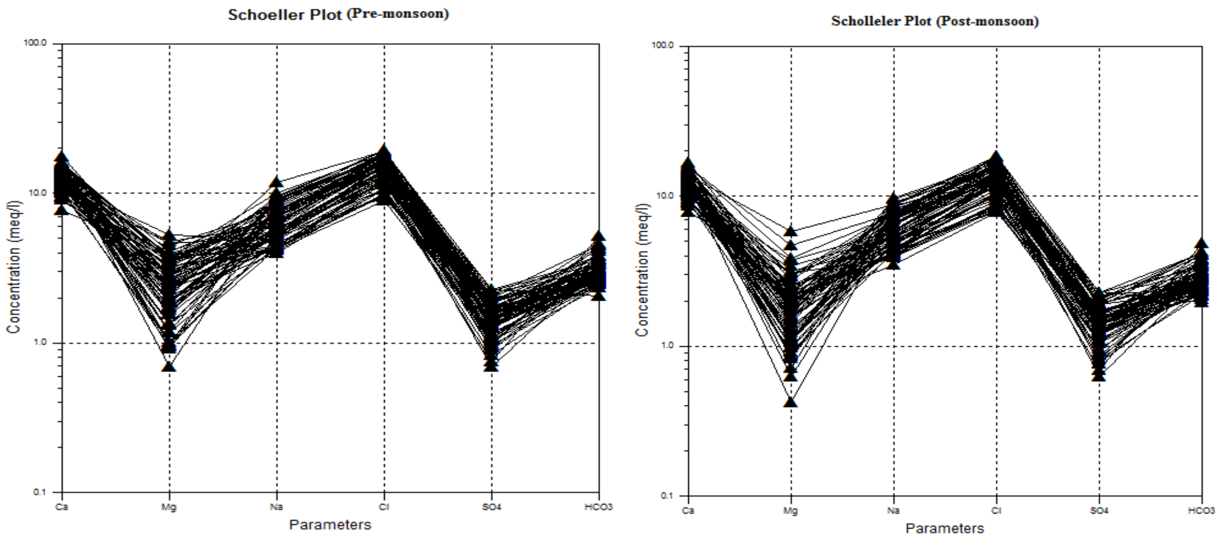

FIGURE XI: SCHOELLER DIAGRAM SHOWING HYDRO GEOCHEMICAL FACIES

5. CONCLUSION

The plot of Cl^-/HCO_3^- ratio shows the groundwater samples in the study area strongly affected by Saline water. The chloro alkaline indices illustrates the exchangeable mechanism has responsible for the chemical composition of groundwater. According to %Na, RSC, KR, SAR, PI, MR, Salinity index and Sodicity index makes the groundwater has safe for irrigation. Based on PS and Sodicity index makes the groundwater has nearly problem for irrigation purpose. The Gibbs diagram suggested that the evaporation dominance and rock dominance mechanism controls the groundwater chemistry. Based on piper and Schoeller diagram Ca-Mg-Cl and Ca-Cl controls the groundwater chemistry. Based on Durov diagram, the presence of high salinity denotes reverse ion-exchange process and simple dissolution or chemical weathering process controls the chemistry of groundwater. This study result will be helpful for sustainable development of groundwater resources, and it requires a special type of irrigation method in the study area.

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