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STUDIES ON HYDROGEOCHEMISTRY AND EVALUATION OF WATER QUALITY FOR DRINKING AND IRRIGATION OF GROUNDWATER NEAR RIVER CHITTAR BASIN, SOUTHERN TAMILNADU

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ABSTRACT

A comprehensive study has been made to understand the hydro geochemical and physicochemical parameters to develop water quality index in the groundwater samples, which were collected from the bore wells of ten different sites near the Chittar River during dry and wet season. The index checks the potable ability of the water samples. The index values reveals that the water samples from sites 4, 8, 9 and 10 were incompatible for consumption. Major ion chemistry of the ground water samples was interpreted to check the quality of water for meeting the irrigational requirements. The influence of Electrical conductivity affecting the water quality was also specified. The Lithological characteristics of the aquifer were examined by the Gibbs diagram. Weathering and dissolution of minerals were also identified by studying the interrelationship of the ions.

Keywords: Water quality index, Irrigational criteria, Wilcox diagram, Gibbs diagram, Hydrogeochemistry.

1. INTRODUCTION

Groundwater is virtually found all over below the earth surface. It seals the slit between the porous soil particles, rocks. In general, the groundwater is not as much as susceptible to contamination when related with surface water. Moreover the groundwater is usually mineralized in its natural state. The gentle movement of water through the porous subsurface makes it exchangable with the mineral deposits existing in the soil, bedrock and the water saturates the solids by dissolution. The quality of groundwater in which the minerals are dissolved should be assessed for appropriate and sustainable usage of the resource. The most essential reasons of groundwater effluences are due to unexpected urban expansion without inadequate consideration to sewage and waste disposal. Water pollution causes a negative impact on the entire environment which includes deterioration of human health, living organisms depending on that source, setback of economic development [1]. Water quality index is the tool to measure the quality of the water by computing the physicochemical parameters [2]. The conceivable changes in the quality of the ground water can be evaluated by the geochemical studies, which provide the apt knowledge of suitable usage of groundwater. The present study emphases on the development of water quality index of groundwater for drinking purpose, in examining the irrigational suitability of water and on study on the hydrogeochemistry interpreting the quality of groundwater.

2. STUDY AREA

The Chittar river basin is located in south (Tenkasi District) of Tamil Nadu. The river arises from Courtallalm hills of South Western Ghats and confluences with the river Tamirabarani in Sevalaperi. The river holds 17 anicuts and waters around 8,903.27 hectares. The sampling station covers the area from Courtallam to Sevalaperi. Ten study regions were carefully chosen depending of the enormous usage by the people. Most of the agricultural activities in this area are influenced by the source of groundwater only. The location of the study area is from N 08°55.230' E 077°17.721' to N 08°47.880' E 077°48.427'. The locations of the selected site were given in the table 1.

Table 1: Geographical coordinates of the sampling stations

Sample number	Sampling Station	Geographical coordinates
GW1	Near downstream of Old falls	N 08°55.230' E 077°17.721'
GW2	Near downstream Main falls	N 08°56.870' E 077°16.371'
GW3	Gundar	N 08°56.843' E 077°12.947'
GW4	Yaanai Palam (location in Tenkasi city)	N 08°57.396' E 077°18.248'
GW 5	Haumanadhi	N 09°04.076' E 077°13.833'
GW6	Karuppa nadhi	N 08°41.155' E 077°23.409'
GW 7	Thayar Thoppu	N 08°56.3780' E 077°24.453'
GW8	Ukkirankottai	N 08°54.202' E 077°36.274'
GW9	Gangaikondan	N 08°47.880' E 077°48.427'
GW 10	Sevalaperi	N 08°46.870' E 077°48.611'

3. MATERIAL AND METHOD

For the assessment of the physicochemical parameters, the water samples were collected from the bore wells of the selected sampling stations during dry (from March to May) and wet season (during the course of North East monsoon including October to December) in 2019. The samples were collected from the bore wells in a 1L polyethylene bottles which were properly washed and rinsed with distilled water. The pH and EC (μs/cm) were measured *in-situ* by the time of sample collection and the samples were stored in the refrigerators for further analysis of TDS, total alkalinity, total hardness, calcium, magnesium, sodium, potassium, iron, nitrate, nitrite, ammonia, chloride, fluoride, sulphate and phosphate using the standard procedures [3]. By interpreting the results of physicochemical parameters water quality index, Sodium absorption ratio, Kelly ratio, Residual sodium carbonate, Soluble sodium percentage, Permeability index, Magnesium hazard, Potential salinity, Chloroalkaline index, Gibbs diagram determining hydrogeochemistry of the groundwater, Electrical conductivity influencing the groundwater salinity, weathering and dissolution of ions were determined.

4. RESULTS AND DISCUSSION

4.1. Physicochemical Analysis

The readings of the physicochemical parameters of dry and wet season were tabulated in the table 2 and 3.

4.2. Correlation analyses

The parameters were also further interpreted by Pearson correlation (table 4 and 5). A high correlation coefficient means a satisfactory relationship between two variables, and a correlation coefficient around zero means no relationship. Positive values of "r" indicate a positive relationship while negative values indicate an inverse relationship. The observed correlation reveals that during dry and wet season, the Total dissolved solids (TDS) exhibit a positive correlation with total alkalinity (TA), total hardness (TH), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), chlorine (Cl^{-}), Electrical conductivity (EC) and sulphate (SO_4^{2-}); total alkalinity exhibit a positive association with Ca, Mg, Na, K, Chloride ion (Cl^{-}) and SO_4 ; TH shows a constructive correlation Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-} and SO_4^{2-}; Ca^{2+} with Mg^{2+}, Na^{+}, K^{+}, Cl^{-} and $SO^{2-}{}_4$; Mg^{2+} with Na^{+}, K^{+}, Cl^{-}, EC and SO_4^{2-}; Na^{+} with K^{+}, Cl^{-}, EC and SO_4^{2-} ; K^{+} with Cl^{-}, EC and SO_4^{2-} ; Cl^{-} with Fluoride ion (F^{-}), EC and SO_4^{2-} and EC with Sulphate ion.

Table 2: Physicochemical parameters for dry season

Physicochemical parameters	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8	GW9	GW10	Mean
pH	7.1	7.1	7.4	7.35	6.44	7.5	7.47	8.2	8.1	8.2	7.486
TDS (mg/L)	52	49	811	765	352	57	87	1820	1908	1901	780.2
Total alkalinity (mg/L)	45.5	45	198	376	144	30	40	580	680	671	280.95
Total Hardness (mg/L)	33	29	64	328	180	24	40	475	480	491	214.4
Calcium (mg/L)	4	5	43	85	46	7	10	109	124	120	55.3
Magnesium (mg/L)	3	3	17	28	15	2	3	36	41	39	18.7
Sodium (mg/L)	7	7	33	104	35	8	10	333	368	371	127.6
Potassium (mg/L)	3	4	11	28	10	2	3	84	90	92	32.7
Iron (mg/L)	0.0	0.0	0.1	0.20	0.13	0.0	0.12	0.1	0.0	0.0	0.065
Nitrite (mg/L)	0.02	0.02	0.03	0.23	0.02	0.02	0.04	0.04	0.02	0.04	0.048

Nitrate (mg/L)	5	5	6	6	5	3	3	6	3	4	4.6
Ammonia (mg/L)	0.0	0.0	0.50	0.48	0.16	0.46	0.48	0.45	0.0	0.0	0.253
Chloride (mg/L)	7	7	10	116	74	9	14	271	425	420	135.3
Fluoride (mg/L)	0	0	0	0.3	0.6	0	0.2	0.5	1.2	1.2	0.41
Electrical conductivity (µs/cm)	67	65	73	1125	518	84	128	998	2765	2756	857.9
Sulphate (mg/L)	0	0	3	12	6	0	2	76	111	101	31.1
Phosphate (mg/L)	0.05	0.05	0.10	0.48	0.10	0.06	0.68	0.78	0.10	0.12	0.252

Table 3: Physicochemical parameters for wet season

Physicochemical parameters	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8	GW9	GW10	Mean
p^H	7.2	7.3	7.5	7.4	6.8	7.8	7.6	8.3	8.2	8.2	7.63
TDS (mg/L)	49	42	797	736	322	50	73	1785	1888	1894	763.6
Total alkalinity (mg/L)	40.5	40	176	352	123	25	33	540	650	624	260.35
Total Hardness (mg/L)	27	25	60	305	125	20	30	455	418	461	192.6
Calcium (mg/L)	3	4	40	80	41	6	9	101	120	115	51.9
Magnesium (mg/L)	2	2	15	26	13	1	2	35	41	39	17.6
Sodium (mg/L)	6	6	31	100	34	7	10	321	354	359	122.8
Potassium (mg/L)	3	4	10	27	10	2	3	85	93	94	33.1
Iron (mg/L)	0.0	0.0	0.1	0.19	0.14	0.0	0.13	0.08	0.0	0.0	0.064
Nitrite (mg/L)	0.01	0.01	0.02	0.2	0.01	0.01	0.02	0.02	0.01	0.02	0.033
Nitrate (mg/L)	3	3	4	4	3	2	2	4	2	2	2.9
Ammonia (mg/L)	0.0	0.0	0.48	0.45	0.13	0.40	0.45	0.40	0.0	0.0	0.231
Chloride (mg/L)	6	6	9	110	73	8	12	269	420	410	132.3
Fluoride (mg/L)	0	0	0	0.2	0.5	0	0.2	0.5	1.2	1.1	0.39
Electrical conductivity (µs/cm)	60	62	69	985	490	80	110	949	2440	2555	780
Sulphate (mg/L)	0	0	2	10	5	0	2	70	102	91	28.2
Phosphate (mg/L)	0.05	0.05	0.10	0.5	0.11	0.06	0.60	0.80	0.10	0.12	0.249

Table 4: Pearson Correlation Dry season

	pH	TDS	TA	TH	Ca	Mg	Na	K	Fe	Nitrite	NO3	NH3	Cl	F	EC	SO4	PO_4
p^H	1																
TDS	0.799	1															
Total alkalinity	0.771	0.983*	1														
Total Hardness	0.693	0.941*	0.978*	1													
Calcium	0.687	0.963*	0.987*	0.982*	1												
Magnesium	0.684	0.968*	0.986*	0.973*	0.998*	1											
Sodium	0.824	0.971*	0.975*	0.954*	0.937*	0.931*	1										
Potassium	0.822	0.975*	0.977*	0.957*	0.941*	0.936*	0.999*	1									
Iron	-0.275	-0.065	-0.034	0.061	0.103	0.099	-0.184	-0.172	1								
Nitrite	-0.003	0.056	0.177	0.246	0.261	0.254	0.007	0.018	0.680	1							
Nitrate	-0.227	0.055	0.034	0.062	0.098	0.135	-0.088	-0.063	0.499	0.397	1						
Ammonia	0.037	-0.149	-0.196	-0.181	-0.123	-0.128	-0.268	-0.261	0.663	0.387	0.207	1					
Chloride	0.755	0.937*	0.961*	0.942*	0.927*	0.918*	0.979*	0.976*	-0.221	0.007	-0.193	-0.371	1				
Fluoride	0.544	0.818	0.855	0.857	0.846	0.829	0.867	0.861	-0.166	-0.041	-0.296	-0.451	0.940*	1			
Electrical conductivity	0.668	0.864*	0.918*	0.893	0.839	0.883*	0.906*	0.901*	-0.199	0.119	-0.251	-0.416	0.967*	0.953	1		
Sulphate	0.809	0.943*	0.946*	0.911*	0.896*	0.889*	0.986*	0.983*	-0.293	-0.097	-0.214	-0.360	0.988*	0.899	0.928*	1	
Phosphate	0.335	0.206	0.204	0.286	0.235	0.216	0.205	0.212	0.611	0.382	0.176	0.600	0.087	-0.022	-0.029	0.104	1

**correlation is significant at $P \leq 0.05$*

Table 5: Pearson Correlation for Wet season

	pH	TDS	TA	TH	Ca	Mg	Na	K	Fe	Nitrite	NO3	NH3	Cl	F	EC	SO4	PO_4
p^H	1																
TDS	0.782	1															
Total alkalinity	0.747	0.981*	1														
Total Hardness	0.707	0.944*	0.977*	1													
Calcium	0.669	0.962*	0.988*	0.976*	1												
Magnesium	0.674	0.972*	0.991*	0.973*	0.998*	1											
Sodium	0.814	0.972*	0.975*	0.957*	0.940*	0.944*	1										
Potassium	0.811	0.973*	0.976*	0.957*	0.940*	0.945*	0.999*	1									
Iron	-0.381	-0.136	-0.103	-0.012	0.031	0.0052	-0.241	-0.243	1								
Nitrite	-0.126	0.023	0.151	0.231	0.233	0.208	-0.025	-0.026	0.632	1							
Nitrate	-0.250	0.028	-0.002	0.054	0.061	0.082	-0.126	-0.115	0.528	0.459	1						
Ammonia	0.0497	-0.151	0.198	-0.153	-0.131	-0.146	-0.270	-0.274	0.649	0.390	0.409	1					
Chloride	0.748	0.940*	0.962*	0.932*	0.933*	0.933*	0.981*	0.9796*	-0.265	-0.0281	-0.246	-0.374	1				
Fluoride	0.592	0.832	0.859	0.821	0.845	0.838	0.884	0.881	-0.233	-0.121	-0.414	-0.465	0.950*	1			
Electrical conductivity	0.650	0.880*/	0.924*	0.883	0.910*	0.900*	0.921*	0.910*	-0.229	0.0863	-0.313	-0.414	0.969*	0.959*	1		
Sulphate	0.809	0.943*	0.946*	0.904*	0.899	0.904*	0.985*	0.985*	0.341	-0.132	-0.257	-0.362	0.988*	0.918*	0.928*	1	
Phosphate	0.324	0.239	0.243	0.365	0.268	0.255	0.241	0.239	0.568	0.369	0.354	0.595	0.117	-0.016	-0.001	0.133	1

**correlation is significant at $P \leq 0.05$*

4.3. Water Quality index for consumption

After physicochemical analysis, the water quality index was evaluated by attributing the weightage to the parameters depending on their effect over the quality of the water [4]. The Bureau of Indian Standards (BIS) permissible limits and the weightage for the parameters are represented in Table 6.

Table 6: Relative weight assumption for the parameters

Parameters	BIS	w_i	Relative weight (W_i)
p^H	6.5-8.5	4	0.0909
TDS	500 mg/L	5	0.1136
Total alkalinity	200 mg/L	3	0.0682
Calcium	75 mg/L	3	0.0682
Magnesium	30 mg/L	2	0.0454
Sodium	200 mg/L	4	0.0909
Nitrate	45 mg/L	4	0.0909
Chloride	250 mg/L	5	0.1136
Fluoride	1.0 mg/L	5	0.1136
Electrical Conductivity	300µS/cm	5	0.1136
Sulphate	200 mg/L	4	0.0909

Chloride ion concentration and Electrical conductivity were designated as pollution indicators. The study area possessing higher concentration of Cl^- ion and EC expresses the elevated value of water quality index signifying the poor quality of water. The water quality index is evaluated by the given formula.

The relative weight (W_i) is calculated by the equation,

$$Wi = wi/\sum wi$$

where, W_i - relative weight comprising w_i,

w_i - individual weight of each parameter.

$$Qi = (Ci/Si) * 100$$

where, Qi= Quality rating

C_i - concentration of each parameter in mg/L,

S_i -standard limits (BIS) mg/L.

The sub index (SI) is the product of relative weight and quality rating [5],

$$SIi = Wi * Q_i$$

The summation of the sub index values gives the assessed WQI. The assessed index values are characterized into consequent classes: less than 50 means Excellent water, 50-100 states that the quality of water is Good, 100-200 discloses that the quality of water is Poor, 200-300-Very poor water, greater than 300 indicating the fact that the water is not appropriate for drinking [6]. The water quality indexes of each individual site during dry and wet season are given in table 7. By analysing the results, we can conclude that site 4, 8, 9 and 10 are unsuitable for drinking purposes.

Table 7: Water Quality index of the study sites

Sampling Station	Dry Season	Wet Season
GW 1	15.327	14.193
GW 2	15.257	14.290
GW 3	45.641	43.367
GW 4	107.793	98.225
GW 5	58.915	54.408
GW 6	15.837	15.142
GW 7	21.599	19.964
GW 8	160.843	154.749
GW 9	252.702	237.187
GW 10	250.993	240.228

4.4. Natural Geochemical process

4.4.1. Gibbs diagram

The Gibbs plot signifies some specific progressions governing the surface water chemistry by relating the composition of water and lithological features of the aquifer [7]. The governing geochemical process includes evaporation, precipitation, and water-rock interaction. The influence of these processes is clear on the scatter plot: where Na/Ca+Na ratios (x-axis) are plotted against total dissolved solids (salinity) on the y-axis (fig. 1). The predominant samples for both the dry and wet season fall above the rock dominance area of the Gibbs plot. Here most of the values fall near the tip of the boomerang due to evaporation (evapoconcentrates indicating salinity Figure 1). According to the Gibbs diagram, here evaporation is the most prevailing process that governing the hydro geochemistry in the study area.

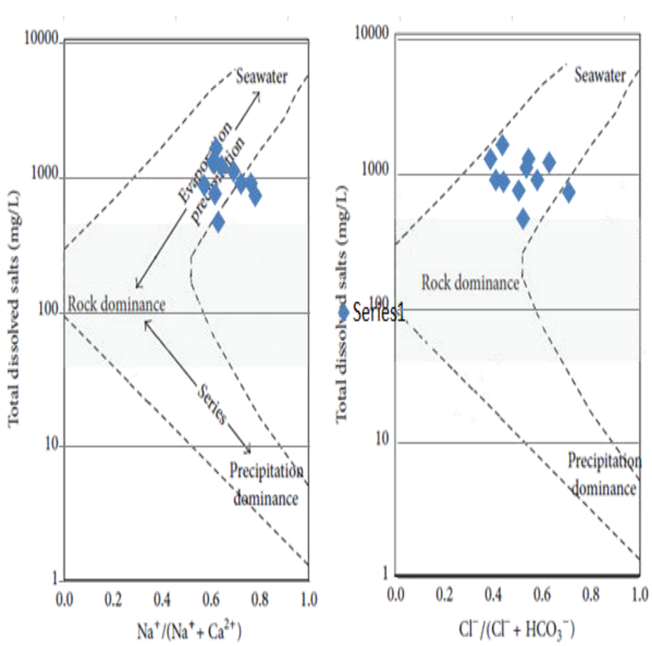

Fig. 1: Gibbs plot

4.5. Criteria for irrigational water quality

Water quality for irrigation symbolizes its potential for agricultural usage. The dissolved solids concentration in water will determine the quality for irrigational use. Salinity and alkalinity of the water are the chief concern for irrigation [8]. Good excellence of soil and efficient water management can stimulate maximal crop yield.

Sodium Absorption Ratio (SAR) is one of the most vital irrigational water classifying tools because it depends on the management of sodium affected soils [9]. Since the sodium concentration can affect the permeability of soil. The water having SAR value <10 - excellent, 10-18 - good, 18-26 - fair, above 26- unsuitable for irrigation. In the current study, sample 8,9,10 in both the seasons possesses high SAR values.

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

4.5.1. Kelly's Ratio (KR)

The Kelly's proportion of 1 or less than 1 is suggestive of noble character of water for irrigation whereas above one is indicative of unacceptable for agricultural purpose due to alkali hazards. In this present study sample 8,9,10 in both the seasons will fall under unsuitable for irrigation.

$$KR = \frac{Na}{Ca + Mg}$$

4.5.2. Soluble sodium percentage (SSP)

The SSP < 50, specify excellent quality of water and greater values (that is above 50) show that the water is insecure for irrigation [10].

$$SSP = \frac{Na}{Ca + Mg + Na} * 100$$

4.5.3. Categorization of groundwater based on salinity (Electrical Conductivity)

Irrigation is generally unified with the property of salinization. Salinization is one of the adverse effects affecting the irrigation. Saline condition harshly confines the selectivity of crop, unfavourably disturb crop germination and yields and can make soils tough to work. In semi-arid areas, the irrigational water will hold surplus quantity of salts due to maximum vaporisation of water. Salinity problem come across in irrigated agriculture are most probable to raise anywhere drainage is poor. The surface evaporation of water will be followed by the capillary raising of the groundwater, which comes close to the root zones of plants and causes the accretion of sodium salts in soils. The higher the EC, the water seems to be less available to plants, as plants can only transpire ''pure''. Increase in electrical conductivity will decrease the water availability for plants. The extent of water transpired by a crop is directly linked to harvest yield; therefore, high EC in irrigation water reduces yield potential. During dry season the electrical conductivity (EC) of the groundwater in the study area differs from 67 to 2,765µS/cm and during wet season it ranges from 60-2555µS/cm (Tables 2, 3). Based on the groundwater can be classified groundwater into four classes (Table 8) [11, 12].

High EC concentration (higher salt concentration) in water indicates the development of saline soil and a high sodium concentration leads to the formation of an alkaline soil [13]. In Wilcox diagram (Fig. 2,3), the Electrical conductivity is taken as salinity hazard and Sodium absorption ratio as alkalinity hazard, displays low alkalinity hazard (S1) and Medium-high salinity hazard (C2-C3) for majority of groundwater samples from both dry and wet seasons. Three samples from both the seasons fall in S4-C4, represents very high alkalinity hazards. Most of the samples fall I S1- C2, S1-C3 low to medium alkalinity (Table 6). The variation in alkalinity from dry to wet season is due to rock water interaction

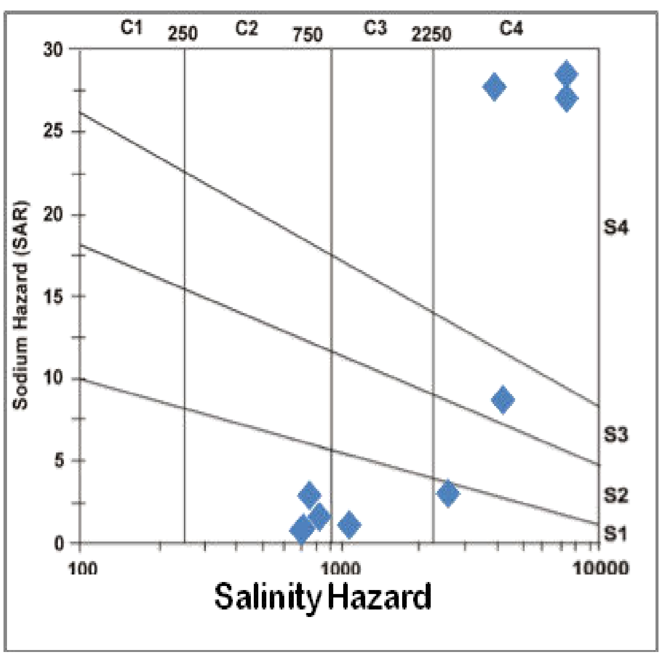

Fig. 2: Wilcox diagram for Dry Season

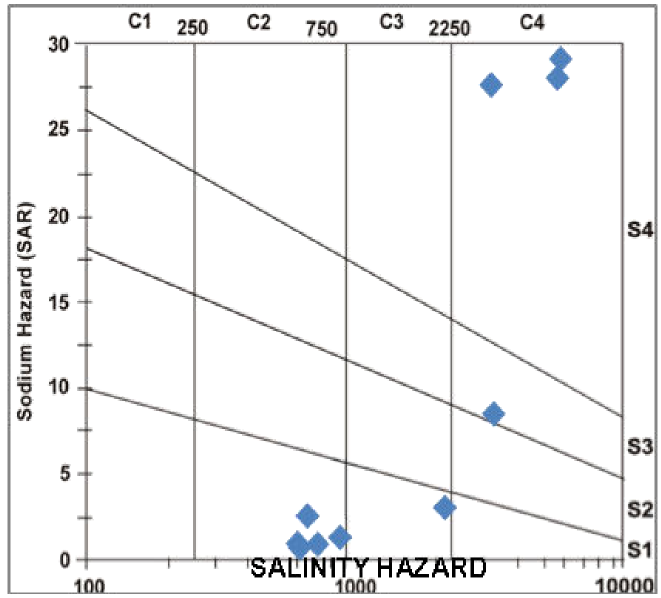

Fig. 3: Wilcox diagram for Wet Season

Table 8: Water classes based on Electrical conductivity

Electrical conductivity range (µS/cm) (Concentration of total soluble salts)	Water class	Salinity zones
250	Excellent	C1
251-750	Good	C2
751-2250	Permissible	C3
2251-6000	Doubtful	C4

4.5.4. *Magnesium Hazard (MH)*

In most of the ground water,s Ca^{2+} and Mg^{2+}ions exist to be in equilibrium. In equilibrium, Mg^{2+} in water disturbs the soil by making it alkaline and results in decrease of crop yield. If MH >50- non acceptable, MH<50 acceptable. In this study all the samples are free from magnesium hazard.

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

4.5.5. *Permeability index (PI)*

Extensive use of irrigational water disturbs soil permeability. It is influenced by several components like total soluble salt, sodium, calcium, magnesium, and bicarbonate composition of the water. Doneen (1964) categorized irrigation waters into three classes based on the PI [14].

$$PI = \frac{Na + K + \sqrt{HCO3}}{Ca + Mg + Na + K} * 100$$

PI expressed in meq/L. As per PI evaluation, all the samples fall in Class I and II, this pronounced to possess excellent to good permeability.

4.5.6. Potential Salinity (PS)

Doneen pointed out that the partially soluble salts gets precipitated in the topsoil and gathered with each succeeding irrigation, whereas the concentrations of highly soluble salts improves the salinity of the soil, which is termed as Potential salinity (meq/L).

$$PS = [Cl] + \frac{1}{2} * [SO4]$$

PS <5 Excellent to good;
PS 5-10 Good to injurious;
PS >10 Injurious to unsatisfactory;
In this present study sample 8,9,10 in both the seasons will fall under unsuitable for irrigation.

4.5.7. Residual Sodium Carbonate (RSC)

If the water with higher concentration of bicarbonate, then it has an affinity for calcium and magnesium to precipitate as carbonate. This is termed experimentally as Residual Sodium Carbonate [15], whose formula is given as,

$$RSC = (HCO3 + CO3) - (Ca + Mg)$$

If RSC is more than 2.5 meq/L, the water is mostly unsuitable for irrigation. If the value of RSC is in-between 1.25 and 2.5 meq/L, the water is suitable to some extent; while a value < 1.25 meq/L specifies good water quality.

4.5.8. Chloroalkaline Index (CAI)

Chloroalkaline index (CAI I and CAI II) was calculated by the formula given.

$$CAI\ I = Cl - \frac{Na + K}{Cl}$$

$$CAI\ II = Cl - \frac{Na + K}{(SO4 + HCO3 + NO3 + CO3)}$$

The chloralkaline index is the study of chemical reaction which involves the exchange of ion between the groundwater and aquifier. Schoeller (1977) identified the differencein the chemical composition of groundwater, and its flow can be signified by chloroalkaline indices, CAI I and CAI II [16]. Positive value of chloroalkaline index indicates the direct ion exchange among Na+ and K^+ from water and Ca^{2+} and Mg^{2+} with the rocks. When the value of CAI is negative, ion exchange concerning Mg^{2+} and Ca^{2+} from water and Na^+ and K^+ with rocks happens. The calculated values indicate that 50% of the study area falls in positive and rest of 50% lies in negative zone. The outcomes clearly specified that exchangeable cations can also be used to point out the chemical structure of groundwater. The irrigational criteria of the sampling stations are given in the tables 9 and 10.

4.5.9. Dissolution of ions by Weathering

Calcium, Magnesium, Sodium and Potassium are the major positive ions present in the water samples. While considering chloride and sulphate ions, chloride is the predominant anion present in all the study area whereas sulphates are in meagre amount in certain samples. Weathering and leaching of rocks leads to the mixing and dissolution of ions from the sources to the groundwater [17]. The fig. 4 provides information regarding the mineralization process of groundwater. In fig. 4 (Ca^{2+}+Mg^{2+} vs SO_4^{2-} + HCO_3^-), the pointing on the equiline shows that the ions have acquired from weathering of carbonate and silicate hydro geochemical process. The samples present below the line represents that the weathering process of calcite as a major one. Samples near the 1:1 line (equiline, $Ca^{2+}+Mg^{2+} = SO_4^{2-} + HCO_3^-$) reveals information about the dolomite dissolution.

Table 9: Irrigational criterions for Dry Season

Sampling Station	SAR	KR	SSP	MH	PI	PS	RSC	CAI I	CAI II
G1	3.77124	0.88889	47.0588	44.4444	77.6246	0.22675	0.422625	-1.73374	-0.40998
G2	3.57771	0.8	44.4444	40	79.1137	0.25495	0.364531	-1.8633	-0.41606
G3	6.39263	0.55224	35.5769	29.8507	53.9769	0.35185	0.399685	-5.80346	-0.22242
G4	14.0257	0.89431	47.2103	26.0163	58.6577	3.50255	0.768371	1.670886	2.074394
G5	6.54561	0.5493	35.4545	26.7606	53.9778	2.1707	-0.55268	1.235548	0.680304
G6	4.6902	1	50	27.2727	112.991	0.25495	0.060053	-1.31809	-0.86063
G7	4.01663	0.73333	42.3077	26.6667	69.4365	0.45435	0.033089	-0.90087	-0.71826
G8	39.0518	2.23082	68.7873	26.7516	75.7302	10.4657	2.584782	5.468958	5.666074
G9	38.1664	1.95789	66.1922	27.3684	73.2732	13.1438	3.269367	10.46165	9.918032
G10	40.0555	2.11111	67.8571	25	74.8728	12.899	3.403763	10.28703	9.72333

Table 10: Irrigational criterions for wet Season

Sampling Station	SAR	KR	SSP	MH	PI	PS	RSC	CAI I	CAI II
G1	3.79473	1.2	54.5455	40	109.743	0.1693	0.360465	-1.82544	-0.43494
G2	3.4641	1	50	33.3333	102.028	0.1693	0.302235	-1.97651	-0.44198
G3	5.91147	0.56364	36.0465	27.2727	56.5276	0.2746	-0.29822	-6.06679	-0.28198
G4	13.7361	0.9434	48.5437	24.5283	62.5587	3.2068	-0.26722	1.478226	1.869125
G5	6.5433	0.62963	38.6364	24.0741	56.2148	2.11125	-1.06655	1.216806	0.427399
G6	3.74166	1	50	14.2857	87.5	0.2257	0.034822	-1.34998	-0.97391
G7	4.26401	0.90909	47.619	18.1818	78.1023	0.3593	-0.06389	-1.17316	-0.91986
G8	38.927	2.36029	70.2407	25.7353	79.1952	8.3169	1.076422	5.461674	5.510309
G9	39.4553	2.19876	68.7379	25.4658	77.713	12.9096	1.467214	10.34728	9.720493
G10	40.9118	2.33117	69.9805	25.3247	78.7446	12.5129	1.448135	10.00757	9.329028

The fig. 5 (Calcium magnesium ration to the sample number) of the study area exposes that the significant process is the carbonate dissolution. Samples falling on the Ca/Mg = 1 specifies the dissolution of dolomite, Ca/Mg>2 indicates the dissolution of silicate minerals, which is responsible for the influence of calcium and magnesium in the groundwater. The samples falling below 1 ratio insists about calcite weathering process. Near 1 ratio says about dolomite weathering process and above the ratio line 2 specifically indicates the effect of silicate minerals. Carbonates and silicates existing in the sand deposits favour the weathering process. Calcium and sulphate are emerged from the dissolution of gypsum and anhydride whereas the calcium and bicarbonate derived by calcite weathering. In fig. 6 (Ca^{2+}vs HCO_3^-) most of the samples fall on the 1:2 equiline, which exposes the effect of calcite weathering in groundwater. Similarly in fig. 7 (Ca^{2+}vs SO_4^{2-}), samples fall below the equiline specifies silicate weathering rather than carbonate weathering. The fig. 8 (Na^+ + Mg^{2+} vs Total cations) give support for the silicate weathering as a result mixing of sodium and potassium in ground water prevails.

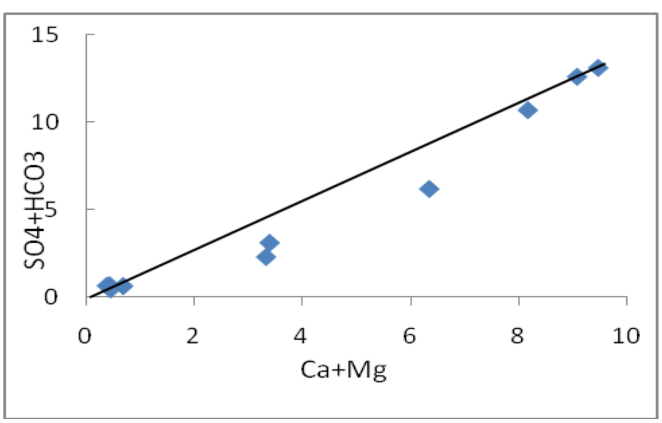

Fig. 4: Ca^{2+}+Mg^{2+} vs SO_4^{2-} + HCO_3^-

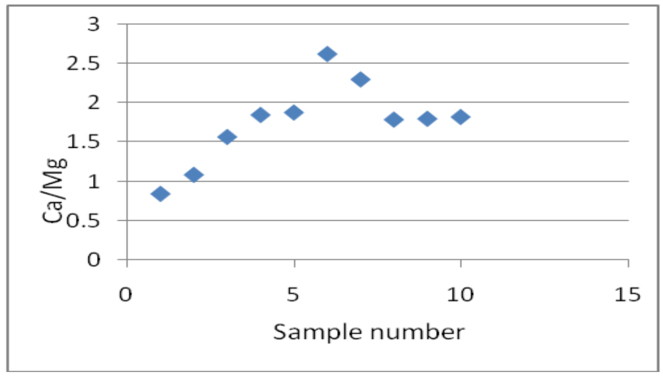

Fig. 5: Sample number Vs Ca^{2+}/Mg^{2+}

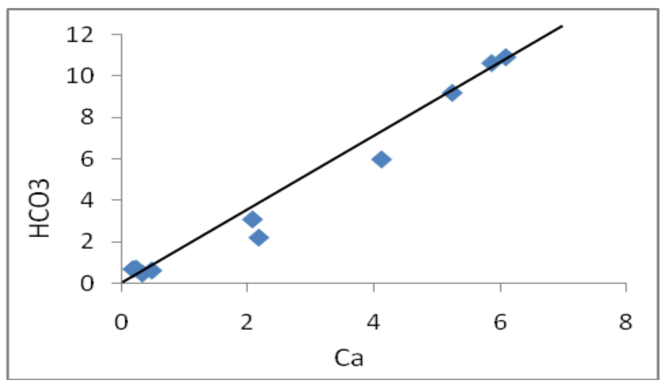

Fig. 6: Ca^{2+} vs HCO_3^-

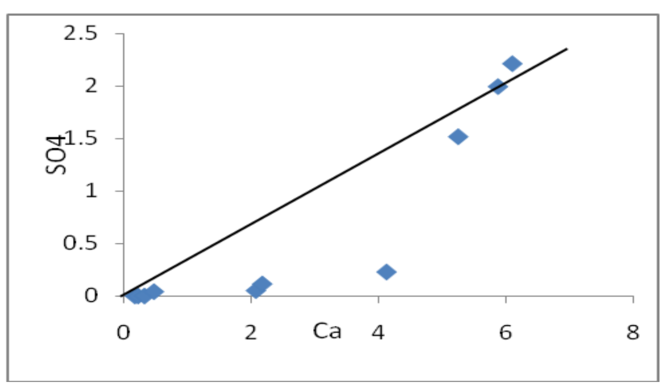

Fig. 7: Ca^{2+} vs SO_4^{2-}

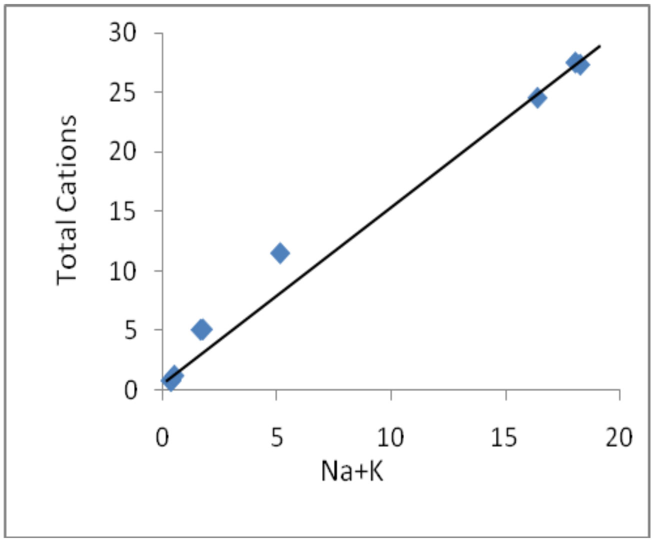

Fig. 8: $Na^{+} + K^{+}$ vs Total cations

5. CONCLUSION

The concentrations of cations were under allowable limits in the water sample. The appropriateness of water for consumption purpose was estimated using water quality index. The higher values of electrical conductivity make the water unsuitable for drinking purpose. In this study, the samples from Yanai palam (in Tenkasi city), Ukkirankottai, Gangaikondan, Sevalaperi (confluence of Chittar river with Tamiraparani river) shows higher values of electrical conductivity, which is far above than permissible limit. The concentrations of total dissolved solids are the dominant reason for the elevation in electrical conductivity. The correlation coefficient between TDS with TA/TH/cations; TA with TH/ cations/chloride; TH with cations/SO_4/Cl; Ca with Mg/Na/K/Cl/EC; Mg with Na/K/Cl/EC; Na with K/Cl/EC; K with Cl/EC/SO_4; Cl with F/EC and EC with SO_4 shows strong positive correlation. Similarly the adaptability for irrigational quality was evaluated by SAR, KR, RSC, MH, and SSP. Few samples are exceeding the irrigational limits is observed. The foremost reasons for exceeding the limits are due to anthropogenic accomplishments like land use activities, agricultural run-off, dumping the waste into the land, usage of the synthetic manures. The Gibbs diagram expresses that the evaporation is the most governing process that administers the hydro geochemistry of the study areas. By interpreting the results of cations, bicarbonates and sulphates we can accomplish that the study areas are susceptible to calcite and silicate weathering.

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Conflict of intersest

The Authors did not declare any conflict of interest.

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