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RESEARCH ARTICLE

GROUNDWATER QUALITY DOMAINS FOR DRINKING AND IRRIGATIONAL PURPOSES USING GISIN SWETA NADI, VELLAR RIVER, TAMILNADU, INDIA

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ABSTRACT

Groundwater samples from 47 locations have been collected from various location of the Sweta Nadi, Vellar River, Tamil Nadu, India and these samples were used to assess the groundwater quality for drinking and irrigation purposes. The study area of about 602.07km^2 in a part of the Vellar River basin. The physical and chemical parameters of groundwater such as pH, electrical conductivity (EC), total dissolved solids (TDS), total hardness(TH), Na^+, Ca^{2+}, Mg^{2+}, Cl^-, HCO_3^-, CO_3^{2-}, SO_4^{2-}, NO_3^-, F^- and Fe^{2+}were determined. The values were analyzed and compared with World Health Organization (WHO 1996) water quality standards. Suitable groundwater quality zones for drinking and irrigational purposes were identified through spatial distribution maps using GIS. Kelley's ratio, sodium absorption ratio (SAR), Magnesium hazards, residual sodium carbonate (RSC) and permeability index (PI) were used to assess the suitability of the groundwater for irrigational purposes. The graphical interpretation of irrigational water quality was made through Wilcox diagram, Doneen diagram, USSL diagrams and Gibbs plots.

INTRODUCTION

The environmental impact of human activity on the groundwater is considered as one of the major hazards in the modern days. With the increases in population, the demand for water, for industrial, domestic and agricultural uses, also increases. When these demands exceed the naturally renewable supply, water shortage occurs in the area (Janshidzadeh 2011). The Rapid urbanization and increased agricultural activities have resulted in the degradation of the water quality. Unused fertilizers, pesticides, effluents discharged from industries and sewage water are the main contaminants of the groundwater in Sweta Nadi, Tamil Nadu, and India. The chemical budget of major irons and heavy metals are important in determining the quality of groundwater. Shahmayur (2008) have compared the groundwater quality in GandhinagarTaluk, India with the standard values priscribed by WHOM. They reported that the groundwater with low pH value can cause gastrointestinal disorder and this water cannot be used for the drinking purposes.

The TDS values are important in determining the suitability of groundwater and high values of TDS are not suitable for both irrigation and drinking purposes (Davis and DeWiest 1966; Fetter 1990; Freeze and Cherry 1979). The Study of chemical budget of the major ions gains importance since it explains the origin of the ions in groundwater and the level of the contamination by natural as well as anthropogenic sources (Woo 2000; Jalali 2005; Subba Rao 2006). The contamination of water resources with fluoride beyond acceptable limits causes health problem in many areas of South Asia and other regions of the world because the earth's crust in those regions has fluoride bearing minerals (Susheela 1985; Karthikeyan 1996). The Presence of Fluoride in the groundwater above 1.5mg/l can cause fluoros is. (Woo *et al.* 2000). The surface run-off from the agricultural field is the main source of nutrients in the groundwater. The presence of nitrate, nitrite and phosphate in the groundwater above the permissible limit is not conducive for the drinking purposes (Rajmohan and Elango 2005). Anbazhagan and Nair (2004) have used the Geographical Information System (GIS) to represent and understand the spatial variation of various geochemical elements in Panval Basin, Maharastra, India. The GIS has emerged as a powerful tool for instruction of research and for building the stature of programs (Openshaw 1991; Longley 2000; Sui and Morrill 2004; Baker and Case 2000).Saraf *et al.*, (1994) have conducted a GIS based study and interpretation techniques of groundwater quality data. Durbude *et al.*, (2002) mapped the ground water quality parameters in Ghataprabha command area in GIS environment. In the present study, groundwater samples in the proximity of EroteTaluk, TamilNadu, India have been analyze in order to determine the effect of the industrial waste water disposal and anthropogenic activities. The suitability of groundwater for Drinking and Irrigation purpose have been carried out.

Study Area

The study area falls in part of Salem and Namakkal and small portion of the Trichy and Perambalur Districts is situated on the bank of River SwetaNadi between 11°19'36.51" and 11°31'27.135" N latitudes and 78°18'0.451" and 78°48'32.351" E longitudes. The study area extends over an

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area of 602.08 km^2 with groundwater sample locations (Fig.1). The hot weather begins early in March, the highest temperature is reached in April and May and reaching 40^0C. The SwetaNadi has dry weather except during the monsoon season. The average annual rainfall of the district is 660.10 mm from four distinct seasonsviz., Winter, Summer, South West monsoon, North East monsoon. The average annual rainfall in the study area is about 852mm.

METHODOLOGY

The Groundwater samples from 47 locations have been collected during pre-monsoon season (May 2013) from dug wells and bore wells of various locations which are extensively used for drinking and also irrigation purpose in the Sweta Nadi. The locations of groundwater sampling stations are shown in the Fig. 1.The physical and chemical parameters of ground water such as pH and electrical conductivity were measured within a few hours of collection by using Elico pH meter and conductivity meter. The Ca and Mg were determined titrimetrically using standard EDTA, and chloride was determined by silver nitrate titration (Volgel 1968). The Carbonate and bicarbonate were estimated with standard sulphuric acid and sulphate was determined gravimetrically by precipitating $BaSO_4$ from $BaCl_2$. The Na and K were determinedby Elico flame photometer (APHA 1996). To determine the of suitability for irrigation use, parameters like SAR, %Naand PI were calculated and plotted on USSL diagram(Richards 1954; Hem 1985), Wilcox diagram (1955) and Doneen diagram (1948)respectively. The base map was prepared using Taluk map on 1:75,000 scale. Their attributes are added and analyzed in ArcGIS software and the spatial analysis tools were used for the preparation of interpolation map. The maps were interpolated by using inverse distance methods to generate the spatial distribution map.

RESULTS AND DISCUSSION

The Physical and chemical parameters including statistical measures such as minimum, maximum, average, median and mode are given in Table.1. Understanding the groundwater quality for drinking, domestic and agricultural purposes study about Suresh *et al*., 2010.

The pre-monsoon pH values are in the range of 6.8 to 8.7 indicating an acidic to alkaline nature with an average value of 7.63. As per the (WHO 1996) standards, all the samples fall within the permissible limit (6.5 to 8.5) for human consumption. The electrical conductivity value of the samples varies from 300 to 5880µScm^{-1} with an average value of 1359µScm^{-1}. The TDS value varies from 152 to 3362 mg/l during the pre-monsoon season. The TDS values of the total stations (Table 1) 14 are found to be very high are classified as Brackish water. The presence of carbonates, bicarbonates and hydroxides are the most common source of alkalinity in natural water. Bicarbonates represent the major form since they are formed in considerable amounts from the action of carbonates upon the basic materials in the soil.

The sodium concentration in the groundwater of the study area varies between 14 to 136 mg/l. It can be observed from table 1 that the sodium concentration in the groundwater from some of the wells in pre-monsoon season is very high and unsuitable for drinking purposes (WHO1996). At these stations, it is found that the concentrations of 7 samples are high concentration because these areas are found in agricultural activates.

The calcium, magnesium, chloride, sulphate, nitrate, iron and total hardness in the groundwater are inter-related. Most of the samples show that normal values of calcium, magnesium and total hardness well within permissible limits (WHO 1996) and thus the groundwater is not much hard. The Fluorides varied from 0.06 to 1.42 mg/l with a mean of 0.89 mg/l in pre-monsoon all the samples falls within the permissible limit for drinking purposes (WHO1996).

Groundwater quality analysis for drinking purpose

It is an analytical technique associated with the study of location specific geographic phenomena together with their spatial dimensions and their associated attributes (like table analysis, classification, polygon classification and weight classification).

The calcium, magnesium, sodium, iron, chloride, sulphate, nitrate, fluoride and TDS thematic maps described above have been converted into raster form considering 30m as cell size to get considerable accuracy. These were then reclassified and assigned suitable weight ages for the spatial distribution map preparation and the results are given (Table. 3). Each thematic map such as calcium spatial distribution map (Fig. 2) reveals that more or less the entire study area falls in most desirable and maximum allowable limiting zones. The high concentration of calcium noticed in lower portion of the study area, but occurs in small patches nearby river bank because of the rate of

Table 1 Minimum and maximum values of physical and chemical parameters of groundwater with statistical parameter

Parameters	Units	Minimum	Maximum	Average
pH	-	6.80	9.50	8.42
EC*	µS/cm	330.00	3870.00	1594.26
TDS	mg/l	191	2271	905.98
Na+	mg/l	10	598.00	155.15
K+	mg/l	1.0	196.00	10.03
Ca2+	mg/l	14.00	136.00	173.71
Mg2+	mg/l	19.00	258.00	82.79
Cl-	mg/l	4.00	1035.00	284.77
HCO3-	mg/l	73.00	573.00	277.74
CO32-	mg/l	0.00	72.00	16.77
SO42-	mg/l	10.00	528.00	84.72
NO3-	mg/l	1.00	77.00	15.04
F-	mg/l	0.06	1.42	0.89
K. Ratio	meq/l	0.05	2.03	0.76
Mg- Hazard	meq/l	54.22	93.76	76.41
RSC*	meq/l	-18.81	3.14	-3.70
SAR*	-	0.21	9.98	3.12
% Na	%	7.77	68.50	41.18

decomposition of feldspar group of minerals (Hem, 1985). The desirable limit of calcium in drinking water is 75 mg/l. If the presence of calcium is more in drinking water, it will cause formation of renal calculi (Kidney stone).

Table 2 Groundwater samples of the study area exceeding the permissible limits prescribed by WHO for drinking purpose

Parameters	WHO International standard (1996)		Wells exceeding permissible limits	Total No. of samples	Undesirable effect
	Most desirable limits	Maximum allowable limits			
pH	6.5 – 8.5	9.2	1,15,16,17,23,25,27,28,32,33 ,38,40,42,43,44,45	Taste effects mucus membrane and water supply system	Taste effects mucus membrane and water supply system
TDS (mg/l)	500	1500	1,3,14,18,24,44	Gastrointestinal	Gastrointestinal Irritation
Na+ (mg/l)	-	200	1,14,18,24,33,35,44	Irritation	-
K+ (mg/l)	-	12	4,5,9,11,15,16,17,18,19,20,2 1,23,25,26,27,28,29,30,31,32 ,40,45,46,47	-	Bitter taste
Ca2+ (mg/l)	75	200	-	Bitter taste	Scale formation
Mg2+ (mg/l)	50	150	3,9,24	Scale formation	Scale formation
Cl- (mg/l)	200	600	1,3,14,18,24,33,35	Scale formation	Salty taste indicates pollution
SO42- (mg/l)	200	400	44	Salty taste indicates pollution	Laxative effective, Cause gastrointestinal irritation when Mg and Na sulfate
NO3- (mg/l)	45	-	3	Laxative effective, Cause gastrointestinal irritation when Mg and Na sulfate	Blue baby diseases in children
Fe2+ (mg/l)	-	0.3	-	Blue baby diseases in children	-
F- (mg/l)	-	1.5	-	-	Fluorosis

The Magnesium is the third dominating ion in the groundwater of the study area. The results of magnesium for pre-monsoon season spatial distribution maps (Fig. 3). It shows that the maximumarea falls in the desirable limit. The high concentration was noticed in center part of the study area. The sodium spatial distribution maps (Fig. 4) reveals that the high concentration due to the decomposition of feldspar group of minerals. The Small portion of the study area falls under not permissible for drinking purposes with sodium concentration.
Chlorite is found to be the most abundant in the groundwater of the study area. The result of Chloride (Cl) in spatial distribution map (Fig. 5) shows that around 25 km^2 area falls in not potable zone. The high concentration was noticed in small patches nearby river bank of the study area. The Results of sulphate for pre-monsoon season spatial distribution map (Fig.6) demonstrates the quality of drinking purposes. It shows that a small area falls in bad quality for drinking purposes. The Sulphate spatial distribution map (Fig. 6) displays as the more or less entire study area falling under potable category with respect to WHOM 1996.

Table 3 Aerial extent of feasible groundwater quality zones for drinking based on various chemical parameters

Class	Area in km2 pH	TDS	Ca	Mg	Na	Cl	SO_4	NO_3	F
Most desirable limit	319.93	40.69	573.12	39.96	537.37	203.62	203.62	593.76	602.08
Maximum allowable limit	-	528.57	28.95	549.00	-	373.61	373.61	-	-
Not Suitable	282.14	32.81	Nil	13.10	64.70	24.83	24.83	8.31	Nil

The Nitrate as per the spatial distribution map (Fig. 7) shows that 8.31 km^2 of the study area falling under not potable zones for drinking purposes. *The fluoride in water is considered as the optimum level to prevent both dental and bone caries and various forms of fluorosis. The* Results of fluoride for pre-monsoon season spatial distribution map (Fig. 8) shows that the entire study is fall in desirable zone. While TDS are not considered primary pollutants, high TDS levels typically indicate hard water and may lead to scales and aesthetic problems such as bitter or salty taste. The TDS spatial distribution maps (Fig. 9) reveal that most of the area falls under allowable category.

Ground Water Quality Analysis for Irrigation Purpose Durbude Classification

Groundwater always contains measurable quantities of dissolved substances, which are called salts. The salts present in the water, besides affecting the growth of the plants directly, also affect the soil structure, permeability and aeration, which indirectly saffect the plant growth. The total concentration of

Table 4 Category of irrigation water based on electrical conductivity - Durbude Classification

Sl. No.	E C (μScm^{-1})	Class	Representing samples	Total No. of samples
1	< 250	Low salinity	Nil	Nil
2	250-750	Medium salinity	2,4,12,22,26,27,32,45	**8**
3	750-2250	High salinity	5,6,7,8,9,10,11,13,15,16,17,19, 20,21,23,25,28,29,30,31,34,36, 37,38,39,40,41,42,43,47	**30**
4	2250-5000	Very high salinity	1,3,14,18,24,33,3544,46	**9**

soluble salts in irrigation water can thus be expressed for the purpose of classification of irrigation water (Table 4) as follows. Based on the Durbude classification, 30 samples fall under high salinity zone and 9 samples in very high salinity zone and 8 samples fall under medium salinity zone.

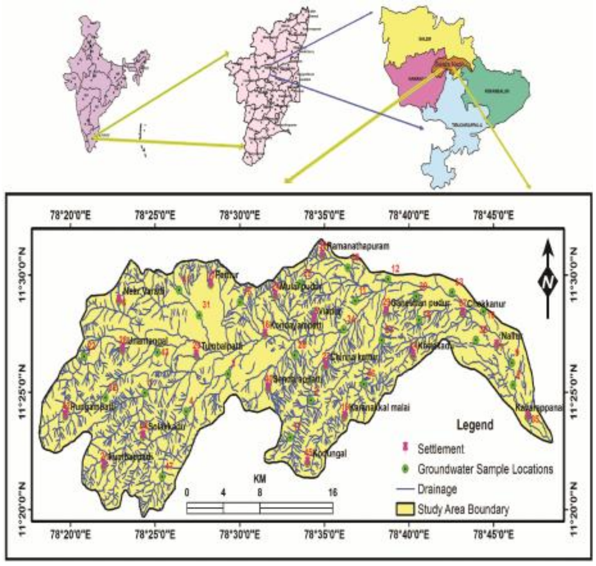


Fig. 1 Drainage of study area with location of groundwater sample wells

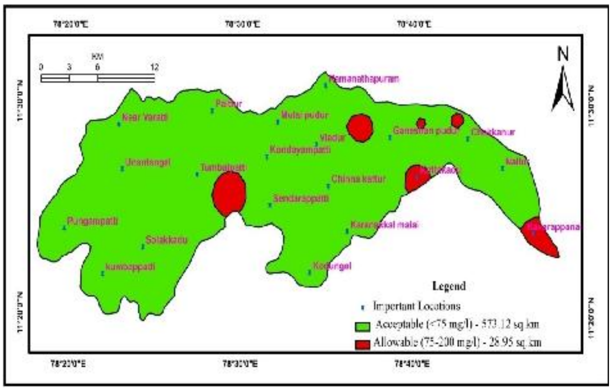


Fig. 2 Feasible groundwater zones for drinking based on Calcium

$$SAR = \frac{Na}{\sqrt{\frac{Ca+Mg}{2}}} \dots\dots\dots\dots \quad (1)$$

(Ragunath., 1987)

A simple method of evaluating high sodium water is the SAR and calculation of SAR for given water provides a useful index of the sodium hazard of that water for soils and crops. A very low SAR (less than 2) indicates no danger from sodium, low SAR (2 to 10) indicates little danger from sodium, medium hazards are indicated between 10 to 18, high hazards between 18 to 26 and very high hazards more than that. The lower the ionic strength of the solution, the greater the sodium hazards for a given SAR. The value of SAR in the groundwater samples of the study area ranges from 0.21 to 9.98 during pre-monsoon seasons (Table 1). Based on the table, the groundwater of the study area falls under the category of low sodium hazards except one sample. But there is little danger from sodium hazard in pre-monsoon season. High sodium water may produce harmful levels of exchangeable sodium in most soils and will require special soil management like good drainage, high leaching, and organic matter additions.

The sodium percentage is calculated as,

$$Na\% = \frac{Na+K}{Ca+Mg+Na+K} \times 100 \dots\dots\dots\dots (2)$$

(Ragunath., 1987)

Where all the ionic concentrations are expressed in Millieqivalent per litre.

The sodium percentage in the study area varies from 2.77 to 79.7 (Table 1 and 2), as per the WHO (1996). The sodium percentage of 68.50 is the maximum permissible limit for irrigation water. The high sodium saturation in the water samples directly causes calcium deficiency in human beings. The 10 samples fall in not potable for irrigational uses and rest of the samples falls in potable zone.

Table 5 Irrigation water quality based on residual sodium carbonate

S. No	RSC (meg/l)	Category	Representing wells	Total No. of samples	Percentage of samples
1	<1.25	Safe	All samples except below	40	85.11
2	1.25 – 2.5	Marginal	1,14,16,17,18,23,44	7	14.89
3	>2.50	Unsuitable	Nil	Nil	Nil

The sodium or alkali hazard limit for irrigation is determined by the absolute and relative concentration of cations and is expressed in terms of Sodium Absorption Ratio (SAR). There is a significant relationship between SAR values of irrigation water and the extent to which sodium is absorbed by the soil. If the groundwater used for irrigation is high in sodium and low in calcium, the cation-exchange complex may become saturated with sodium. This can destroy the soil structure owing to dispersion of the clay particles.

Table 6 Classification of groundwater samples based on Gibb's diagram

Field	Cations	Anions
	((Na+ + K+) / (Na+ + K+ + Ca2+))	
Evaporation - crystallization dominance	Nil	Nil
Rock-water interaction dominance	All samples	All samples
Precipitation dominance	Nil	Nil

Kelley's Ratio

Kelley *et al*., (1940) have suggested that the sodium problem in irrigational water could very conveniently be worked out on the basis of the values of Kelley's ratio. Groundwater having Kelley's ratio more than one is generally considered as unfit for irrigation. The Kelley's ratio has been calculated for all the water samples of the study area. It varies from 0.01 to 3.52epm (Table 1). The formula used in the estimation of this ratio is expressed as,

$$\text{Kelley's Ratio} = \frac{Na}{Ca+Mg} \longrightarrow \quad (3)$$

Where all the ionic concentrations are expressed in epm.

The 24 samples fall in not potable for irrigational uses and rest of the samples falls in potable zone.

Magnesium Ratio

$$Magnesium\,Ratio = \frac{Mg \times 100}{Ca+Mg} \text{ -------------} \quad (4)$$

Where all the ionic concentrations are expressed in epm.

The Excess of magnesium in groundwater samples affects the quality of soils, which causes poor yield of crops. The magnesium ratio in some groundwater samples varies from 14.61 to 98.20epm (Table 1). From the above table, the Magnesium ratios were found to be more than the permissible limit in all water sample locations, except in a few locations. High Mg ratio in the groundwater samples leads to surface and subsurface water interact with country rock (Suresh et. al., 2010). The study area occupies mostly fissile hornblende biotite gneiss and hornblende biotite gneiss as country rock.

Gibbs ratio

The source of the dissolved ions in the groundwater can be understood by Gibbs diagram (Gibbs 1970). It is plot of $(Na^+ + K^+)/(Na^+ + K^+ + Ca^{2+})$ vs TDS and $Cl^- /Cl^- + HCO^-_3)$ vs TDS. Fig.10a and 10b show that all the samples of pre-monsoon season falls in the rock dominance and evaporation crystallization dominance area. The Gibbs diagrams suggest that chemical weathering of the rock forming minerals and evaporation are the main processes which contribute the ions to the water. It is interesting to note that during pre-monsoon, precipitation has no dominating effect and no points fall on the precipitation dominating area. The Anthropogenic activities may also increase the TDS value (Hem 1991; Karanth 1997) and the samples tend to fall on evaporation dominance area in the pre-monsoon. The variation of Gibb's ratio with pre-monsoon was given in Table 6.

Table 7 Classification of groundwater samples based on USSL diagram

Sl. No.	Class	Irrigation Water Class	Number of Samples	Total number of samples and Percentage	
			Pre-monsoon	Pre-monsoon	
1	C1-S1	Good	Nil	Nil	Nil
2	C2-S1	Good	1,4,12,22,26,27,32,45	8	17.02%
3	C3-S1	Good	5,6,7,8,9,10,11,13.15.17.19,20,21,25,29,30,34,36,37,38,39, 40,41,42,43,47	26	55.32%
4	C3-S2	Moderate	16,23,31	3	6.38%
5	C4-S1	Moderate	3,24,46	3	6.38%
6	C4-S3	Bad	14,18	2	4.26%
7	C4-S2	Moderate	2,28,33,35,44	5	10.64%

Residual Sodium Carbonate

Residual Sodium Carbonate is given by the formula,

$$RSC = (CO_3 + HCO_3) - (Ca + Mg) \text{ -------------} \qquad (5)$$

Where all the ionic concentrations are expressed in epm.

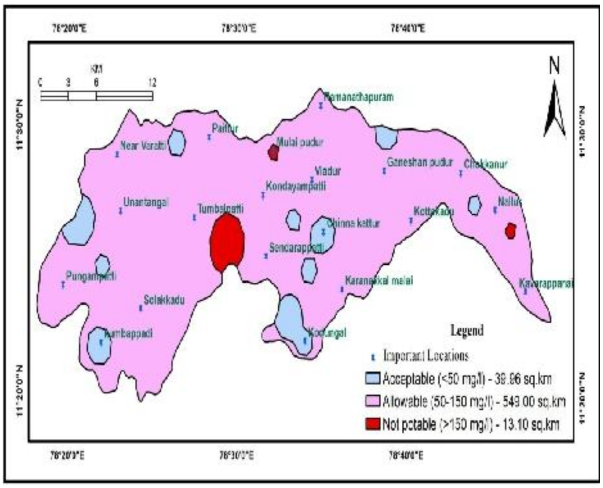


Fig. 3 Feasible groundwater zones for drinking based on Magnesium

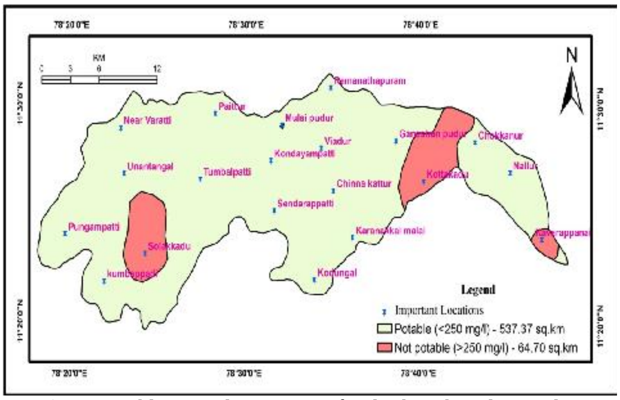


Fig. 4 Feasible groundwater zones for drinking based on Sodium

USSL Diagram

The plotting of SAR values in USSL diagram indicates that all the samples have low SAR value. Out of 8 samples, twenty four samples lie in C_2-S_1 field, each 3 sample in C_3-S_2, two samples in C_4-S_3 and three samples C_4-S_1, 5 samples fall in C_4-S_2 and 26 samples in C_3-S_1, field (Fig. 11 and Table 7). The C_2-S_1 field in USSL diagram is considered as good water category for irrigation use. This implies that no alkali hazard is

Table 8 Classification of groundwater samples based on Wilcox's diagram

Season	Irrigation water class	Representing samples	Total No. of samples	Percentage of samples
	Excellent to Good	2,4,12,22,26,27,32,45	8	17.02%
	Good to Permissible	5,6,7,8,9,10,11,13,15,20,21,34,36,37,38,39,40,41	18	38.30%
	Permissible to Doubtful	16,17,19,23,25,29,31,42,43	9	19.15%
Pre-	Doubtful to Unsuitable	24,28,30,33,35,46,47	7	14.89%
monsoon	Unsuitable	1,3,14,18,44	5	10.64%

In general the high concentration of CO_3 and HCO_3 represents alkaline nature, for this area is unfavorable for agriculture uses (Eaton 1950 and Richards 1954). Table 5 shows that 85.11 percent of samples are safe for agriculture purposes.

anticipated to the crops. The 26 Location (55.32%) samples occurred within C_3–S_1 category. This category is suitable for irrigational purposes. This class could be used for all types of crops. If the SAR value is greater than 6 to 9, the irrigation water will cause permeability problems on shrinking and swelling types of clayey soils (Saleh *et al*. 1999).

Permeability Index

The soil permeability is affected by long term use of irrigation water. It is influenced by sodium, calcium, magnesium and bicarbonate contents of soil. Doneen (1964) has evolved a criterion for assessing the suitability of water for irrigation

Table 9 Classification of groundwater samples based on Permeability Index

Season	Category of irrigation water	Representing samples	Total No. of samples	Percentage of samples
Pre-monsoon	Class – I	All samples, except below said samples	38	80.85%
	Class – II	1,12,14,17,18,22,23, 27,44	9	19.15%
	Class – III	Nil	Nil	0%

Wilcox's Diagram

Another method for determination of suitability for agricultural use in groundwater is by calculating Na^+ percentage (Wilcox, 1955), because Na^+ concentration reacts with soil to reduce its permeability (Todd, 1980). The Percentage of sodium values of groundwater samples indicate that most of the groundwater samples show excellent to good and good to permissible category for irrigation use, except a few samples which are under permissible to doubtful, doubtful to unsuitable and Unsuitable category (Fig.12 and Table 8). The Percentage of sodium plotted on Wilcox diagram indicates that out of 47 samples, 8 samples belong to Excellent to Good category, 18 samples belong to Good to Permissible category, 9 samples belong to Permissible to Doubtful category, 7 samples belong to Doubtful to Unsuitable and 5 samples belong to unsuitable category (Fig.12).

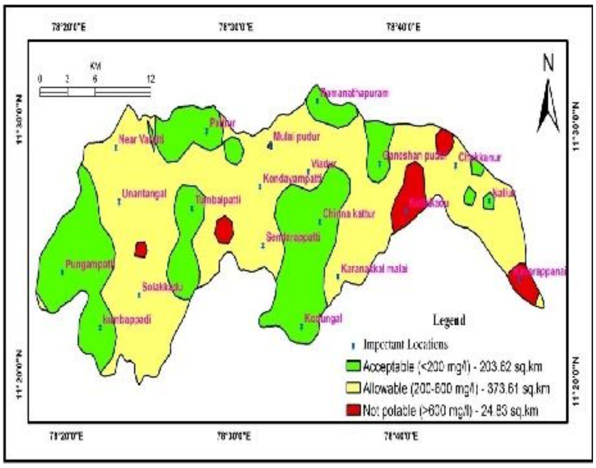


Fig. 5 Feasible groundwater zones for drinking based on Chloride

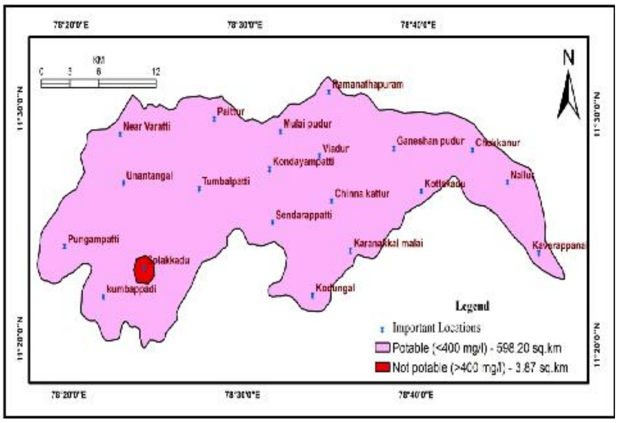


Fig. 6 Feasible groundwater zones for drinking based on Sulphate

based on Permeability Index,

$$PI = \frac{Na + \sqrt{HCO_3}}{Ca + Mg + Na} \times 100 \qquad \text{------------} \quad (6)$$

Na, Ca etc. values in epm

PI values of groundwater samples range from 7.18% to 95.77% with an average value of 56.23% (Table 9). Analytical data of PI values plotted on Doneen diagram revealed that 80.85% of the groundwater samples fall in Class I, 19.15% fall under Class II (Fig. 13). The water samples which fall under, Classes I and II in the Doneen diagram are generally good for irrigation purposes.

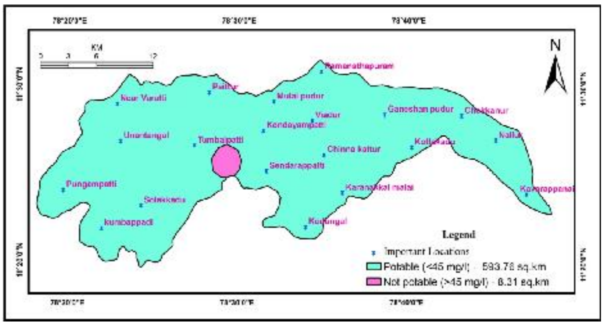


Fig. 7 Feasible groundwater zones for drinking based on Nitrate

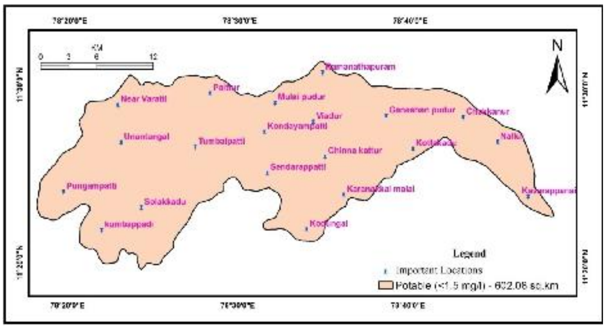


Fig.8 Feasible groundwater zones for drinking based on Fluoride

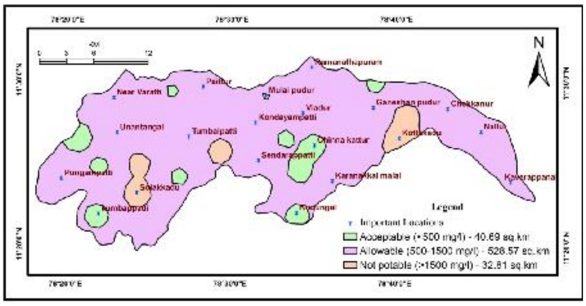
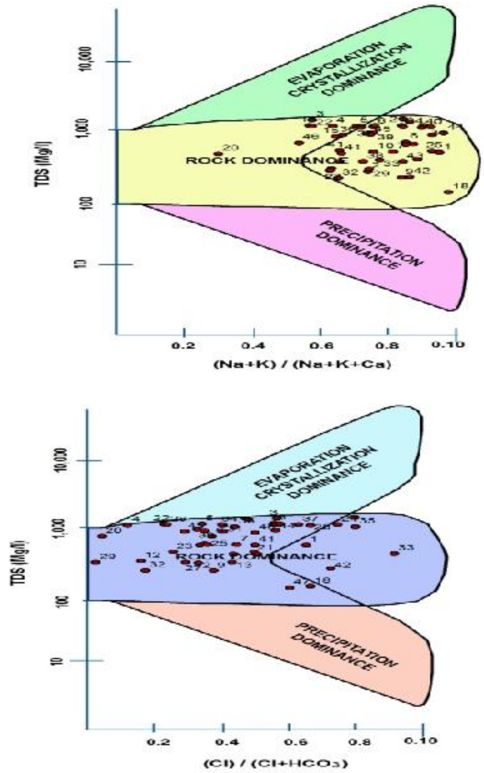


Fig. 9 Feasible groundwater zones for drinking based on TDS

CONCLUSIONS

The groundwater quality parameters in the study area with reference to the WHO 1996 standards were used to prepare the spatial distribution map. The pre-monsoon pH values are indicating an acidic to alkaline nature.



Gibbs plots illustrate the hydrochemical process in the study region
(10a. Cation 10b. Anion)

The TDS spatial distribution map reveals that most of the most of the area falls under allowable category. All the elements in the spatial distribution maps show that most of the study area falls under potable category except Nitrate. The high concentration of all elements in an area is due to the geology.

The assessment of groundwater quality for irrigational uses has been evaluated on the basis of various guidelines.

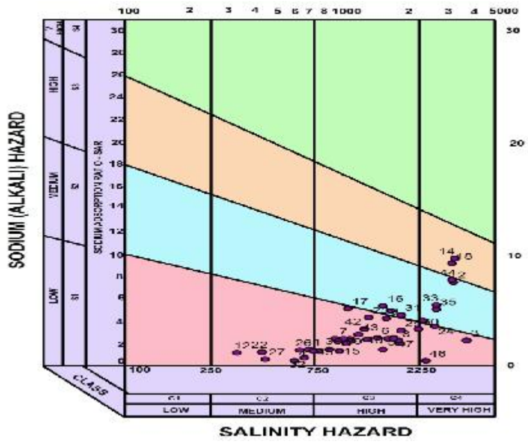


Fig. 11 Salinity and alkalinity hazard of irrigation water in US salinity diagram

The Durbude classification shows most of the samples falling under high salinity zone and 10 samples in very high salinity zone, while the rest of the samples fall under medium salinity zone. Another classification with respect to SAR and sodium percentage, more than 99% of the samples are within the permissible limit and the groundwater is suitable for irrigation purpose. The Mg ratios were found to be more than the permissible limit in all water sample locations, except in few locations. The residual sodium carbonate values of groundwater samples showed 75% of samples under "Safe" category. The high sodium saturation in the water samples directly causes calcium deficiency in human beings. 10 samples fall in not potable for irrigational uses and rest of the samples fall in potable zone. Based on Kelley's Ratio 6 samples fall in not potable for irrigational uses and rest of the samples fall in potable zone.

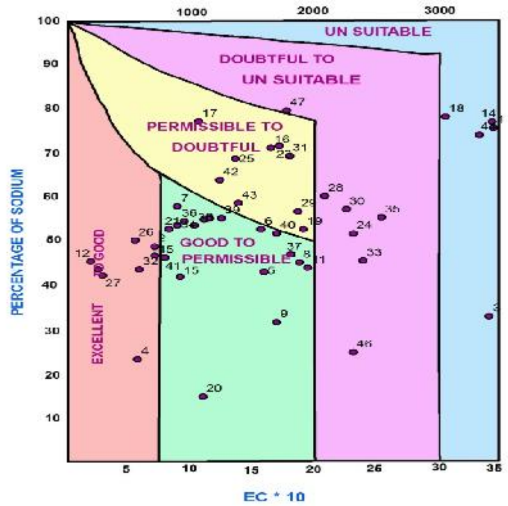


Fig. 12 Suitability of groundwater for irrigation in Wilcox's diagram

The bicarbonate concentration under "Increasing Problem" zone was found in 86.41% of the total samples in the study area. The Gibbs diagrams suggest that chemical weathering of the rock forming minerals and evaporation are the main processes which contribute the ions to the water. It is interesting to note that during pre-monsoon, precipitation has no dominating effect and no points fall on the precipitation dominating area U.S.S.L diagram, the 26 Location (55.32%) samples occurred within C_3–S_1 category. This category is suitable for irrigational purposes. This class are could be used for all types of crops. The groundwater falls under class-I for 80.85% of samples as per the classification of Donnen's Permeability Index, and could be treated as good for irrigation.

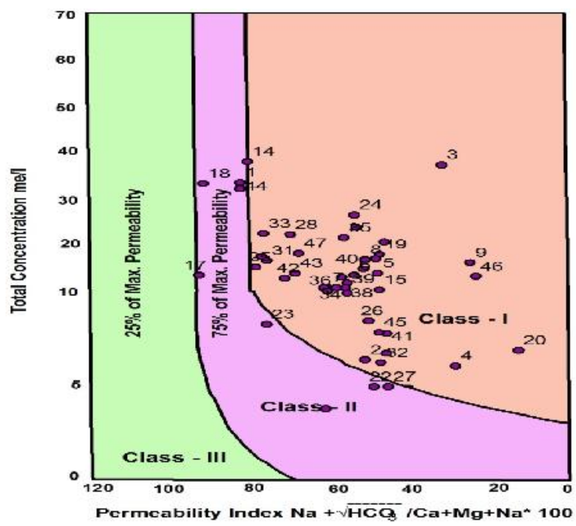


Fig. 13 Suitability of groundwater for irrigation based on Permeability Index

The Wilcox classification has shown 10.64% of groundwater under “Unsuitable” zone. Thus, the overall groundwater quality in the basin is fresh and suitable for irrigational use. According to the present study, it is evident that high salinity of groundwater persists at majority of sites. The ground water samples lead to surface and subsurface water interact with country rock. Hence, for high to very high salinity of waters, soil must be permeable with adequate drainage facilities for satisfactory crop growth.

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