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Water quality evaluation for drinking purpose of Rewa Block, district-Rewa, Madhya Pradesh, India

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Abstract
This study, deals with groundwater quality for Drinking and Irrigation purpose of Rewa Block, Ditrict-Rewa, Madhya Pradesh, India. Study area covers an area of 704.17 km^2 and lies between 81˚06'00" and 81˚30'00" E longitudes and 24˚18'00" and 24˚42'00" N latitudes. Geologically, the area is occupied by sandstone and shale of Rewa Group belonging to Vindhyan super-group. The groundwater occurs in semi-confined to confined condition. A total number of fifty ground water samples were collected in pre and post-monsoon seasons of 2018-19 from different locations of the study area and analyzed for comically analysis for various water quality parameters such as PH, electrical conductivity (EC), Total dissolved solids (TDS), Total hardness (TH), chloride (Cl), carbonate, bicarbonate, sodium (Na), Potassium (K) and calcium with magnesium (Ca+Mg). On comparing the results against water quality standards laid by World Health Organization (WHO) and BIS. It is observed that some parameters exceed the standard limits. The ground water is hard to very hard in nature. The overall study reveals that water concentration of various cations and anions suggest that the groundwater of the area is partially suitable for drinking purpose.

Keywords: Groundwater quality, Rewa block, Rewa, Madhya Pradesh, India

Introduction
Fresh water is the most precious material for survival on earth, not only human life but also for flora and fauna. Groundwater quality is one of the most important aspects in water resource studies (Ackah *et al* 2011; Sayyed and wagh, 2011) [1, 29, 30]. It is largely controlled by discharge recharge, nature of the host and associated rocks as well as contaminated activities (Raghunath, 1907; sayyed and sayadi, 2011; zhang *et al*, 2011) [29, 30, 37]. Only 2 to 3% total water on earth is fresh water. Water pollution is classified into four classes likewise-physical, chemical, biological and physiological pollution of water. Physical water pollution brings about changes in water with regard to its color, density, test, turbidity and thermal properties etc. the chemical pollution of water causes changes in acidity and alkalinity/pH. Biological pollution is caused by bacteria, alge, virus, protozoa etc. physiological pollution of water by caused by several chemical agents such as chlorine, sulphur dioxide, hydrogen sulphide ketones, phenols amines etc. according to WHO organization, about 80% of all the disease in human.

The quality of groundwater is affected by many factors such as physic-chemical characteristics of soil, weathering of rocks, and rainfall etc. (pureshotham *et al*; 2011) [25]. Groundwater quality assessment of dfferent quality parameters has been carried out by various researches (Hegde, 2006; Pandian and Shankar, 2007; Popleare and Dewalkar, 2007; Mshra, 2010) [13, 22, 24, 29]. The groundwater quality assessment for drinking and irrigation purpose in the vindhyan region has carried out by few researchers (Tiwari *et al*, 2009, 2010, Mishra *et al* 2012) [33, 32, 20].

Ground water has been used as major sources of drinking water in both rural and urban areas in the world. In India alone, nearly 80% of the rural population depends on untreated ground water. The quality of ground water in the various part of our country has been studied by various workers. Polluted water is responsible for spread of various water borne diseases. Therefore in present study an attempt has been made to evaluate the physiochemical characteristics of ground water for drinking and irrigation purpose of Rewa block, Rewa district Madhay Pradesh, India.

About Study Area

Study area covers an area of 704.17 km^2 and lies between 81˚06'00" and 81˚30'00" E longitudes and 24˚18'00" and 24˚42'00" N latitudes. Geologically, the area is occupied by sandstone and shale of Rewa Group belonging to Vindhyan super-group. The groundwater occurs in semi-confined to confined condition. A total number of fifty ground water samples were collected in the study area. Location map of the study area is shown in Fig.1; The Rewa block is bounded on the north by Semaria blockand Raipur Krachulian block, on the east and southeast by Sidhi district, and on the west by Satna district.

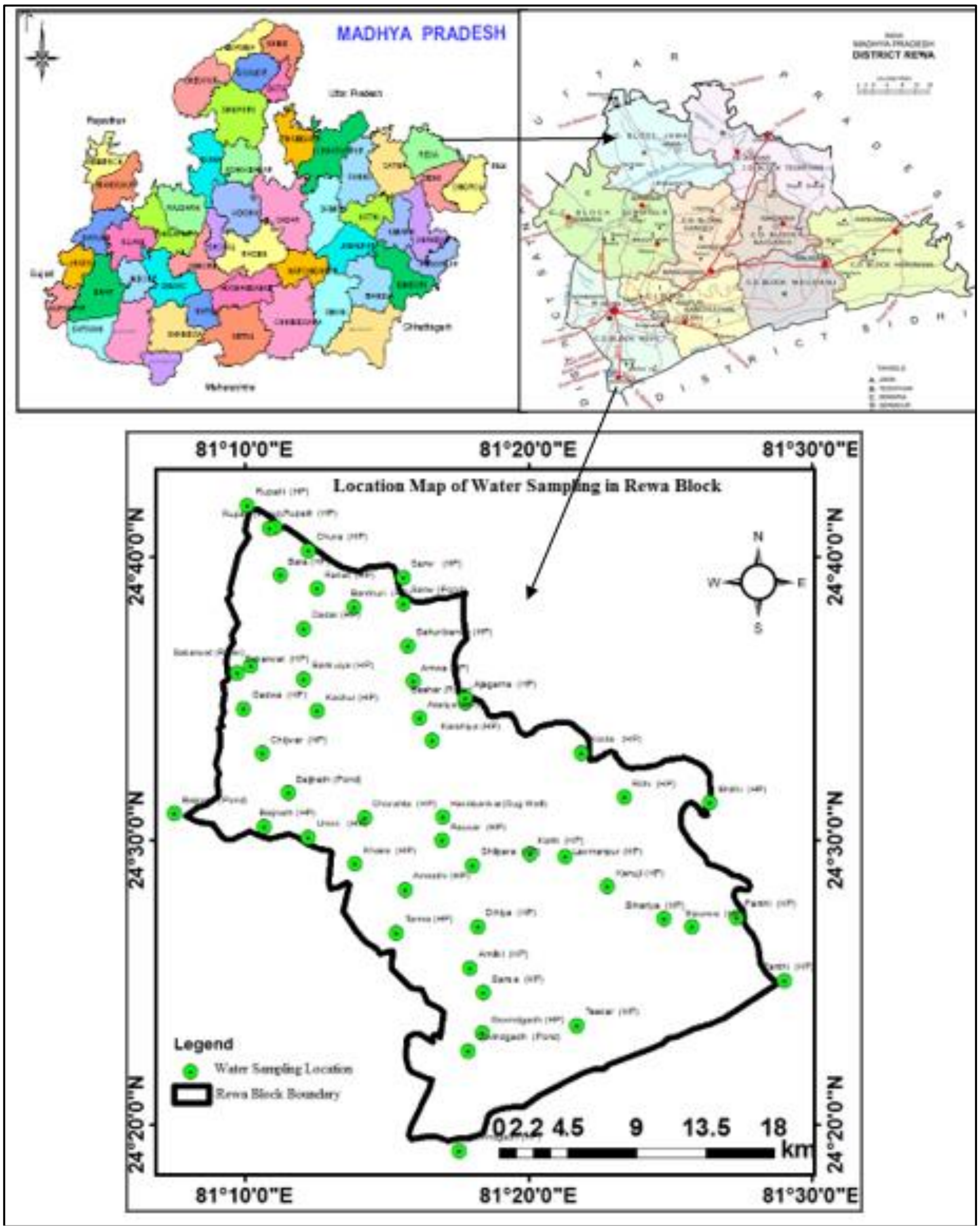


Fig 1: Location map of the water sampling points in the study area.

Material and Methods

Ground water samples were collected from hand pups/dug well and surface water (River/pond) of the different locations of the study area during pre and post monsoon seasons of year 2018. The sample was collected in plastic bottles of 500 ml capacity. The sampling bottles were thoroughly washed with 1:1 Nitric acid (HNO_3) and then cleaned and rinsed with distilled water. At the sampling site bottles were rinsed two to three times with water samples to be examined finally filling with it (Sankar Prashad Mishra, 2016) [18]. During sampling from a hand pump the water was pumped to waste for about four to five minutes and then sample was collected directly from a hand pump. The entire samples were collected from ten to fifty meter depth and lifted water through hand pump. All samples were labelled and write the GPS location latitude and longitude also mansion. Samples store were brought to laboratory and refrigerated at 4 ºC. The physicochemical analysis was done using procedure of standard methods. The methods used for determination of various physicochemical parameters are given Table-1.

Table 1: methods used for analysis of water quality parameters

S. no.	Parameters	Methods
1	pH	pH meter
2	Electrical Conductivity	Conductivity meter
3	Total Hardness	EDTA titration method
4	total Dissolved Solid	Water quality analyser instrument
5	Chloride	Argentometric titration method
6	Calcium and Magnesium	Titration method
7	Sodium, Calcium and Potassium	Flame photometer

Groundwater Quality Analysis for Drinking Purpose

Standards for quality of drinking water have been set by different agencies like APHA, WHO, AWWA and Indian drinking water specification. (Table-2)

Table 2: Standards of water quality by WHO and BIS for drinking purpose

S. no.	Water quality parameters	WHO (1991)		BIS(1991)	
		Max. Desirable	Max. Permissible	Max. Desirable	Max. Permissible
1	pH	7	8.5	6.5	8.5
2	EC	-	1400	-	-
3	TH (mg/l)	100	500	300	600
4	TDS (mg/l)	500	1500	500	1000
5	Ca (mg/l)	75	200	75	200
6	Mg (mg/l)	30	150	30	100
7	Na (mg/l)	-	200	-	200
8	K (mg/l)	-	12	-	-
9	Cl (mg/l)	200	600	250	1000
10	SO4 (mg/l)	200	400	150	400
11	F (mg/l)l	1	1.5	1	1.5
12	Turbidity (NTU)	-	-	1	5

Result and Discution

Water quality analysis

The quantity chemical analysis data of sample have been presented in Table 3, pre-monsoon and Table 4, post-monsoon Overall, the water sample in the study area of found to be alkaline and moderately hard to hard in nature. The pH reference value in drinking water is 6.5 to 8.5 according to Bureau of Indian Standard (Table 2). The all the value of pH in the study area is found ranged from 6.3 to 7.7. The seasonal variation shows the pH values fluctuating minimum during the monsoon and maximum in post-monsoon season at the different sample location. The more sample are 98% to 100% permissible limits in both seasons.

Table 3: Classification of samples according to standards specified for water quality indices for pre-monsoon seasons

S. No.	Particulars	Pre-Monsoon									
		Pre/Post Monsoon	Min	Max	Permissible Sample	Permissible Sample (%)	Not Permissible sample	Not Permissible Sample (%)	Not Acceptable Sample	Not Acceptable Sample%
1	pH (31°C)	Pre	6.3	7.7	45	98	1	2	0	0
		Post	6.3	7.6	46	100	0	0	0	0
2	EC (µs.)	Pre	54.0	3110	39	85	7	15	0	0
		Post	69.1	3401	38	83	8	17	0	0
3	Turbidity (NTU)	Pre	0.0	192	30	65	16	35	0	0
		Post	0.0	449	38	83	8	17	0	0
4	TH (mg/l)	Pre	20.0	1560	37	80	9	20	0	0
		Post	110	1760	24	52	22	48	0	0
5	TDS (mg/l)	Pre	248	2054	32	70	1	2	13	28
		Post	210	1921	24	52	1	2	21	46
6	Cl (mg/l)	Pre	123	1497	43	93	3	7	0	0
		Post	150	1298	37	80	9	20	0	0
7	Na (mg/l)	Pre	3.1	345	44	96	2	4	0	0
		Post	5.3	239	45	98	1	2	0	0
8	K (mg/l)	Pre	0.2	89	41	89	5	11	0	0
		Post	0.4	36	43	93	3	7	0	0
9	Ca (mg/l)	Pre	1.8	58	0	0	0	0	46	100
		Post	3.1	57	0	0	0	0	46	100
10	Mg (mg/l)	Pre	5.0	302	30	65	13	28	3	7
		Post	14.1	320	37	80	6	13	3	7
11	Na %	Pre	8.7	86.4	46	100	0	0	0	0
		Post	13.0	62.8	46	100	0	0	0	0
12	SO_4 (mg/l)	Pre	5.7	34.4	17	46	100	0	0	0
		Post	2.9	26.1	13	46	100	0	0	0

Note: pH = Power of Hydrogen, EC= Electrical conductivity (µs.), Turbidity (NTU), TH= Total Hardness (mg/l), TDS= Total Dissolved Solids (mg/l), HCO_3= Bi-Carbonate (mg/l), Cl= Chloride (mg/l), Na= Sodium (mg/l), K= Potassium (mg/l), Ca= Calcium (mg/l), Mg=Magnesium (mg/l), SO_4=Sulfate (mg/l), HP = Hand Pump,

Spatial representation

The simplest way of representing water quality information on a graph is to bar-chart diagram the concentrations of a particular substance of interest. Hence, an attempt has been made to infer spatial variations of crucial ions determining the quality of water.

(i) Electrical conductivity

Electrical conductivity of water may be defined as the capacity of water to conduct electrical current. This capacity is directly related to the amount of current conducting bodies (ions, radicals or solid particles). EC of water can be proportionately related to the dissolved solids in water, as the flow of current is dependent on the quantity and conducting capability of these dissolved particles.

EC is the most important parameter to demarcate salinity hazard and suitability of water for irrigation purposes. The EC varies from 54 to 3110 µs/cm and 69.1 to 3401µs/cm during pre and post-monsoon season, respectively. Higher values were noted during post-monsoon when compared with pre-monsoon season. The classification of water quality on the basis of irrigation quality (WHO 2008) shows that Table 2, the 83 to 85% water samples varies from pre and post-monsoon season within the permissible limits and 15 to 17% above permissible limits. The EC values for pre and post-monsoon season are used to create the spatial distribution graph for the study area. It is observed that conductivity values of water samples follow similar trend if both seasons.

(ii) Turbidity (NTU)

Figure III-a and III-b are the plots for turbidity values 65% samples is permissible and 35% not permissible limits for pre-monsoon season and post-monsoon season values are 83%, and 17% permissible and not permissible limits respectively. Present the spatial distribution of turbidity in the study area for both seasons and values of water samples also follow similar trends in both seasons. During post-monsoon season of the study area have more turbidity in water compared to pre-monsoon.

(iii) Total hardness (mg/l)

Total hardness during post-monsoon season of the study area has more in water compared to pre-monsoon. The higher value is mainly found owing to abundant availability of limestone rocks in the surrounding area consequently more solubility of Ca^{++} and Mg^{++} salts under anaerobic conditions. Hardness of water two types, first temporary and second permanent types water hardness. Temporary hardiness is mainly due to the presence of calcium carbonate and gets removed when water is boiled. Permanent hardness is causes by the presence of Ca^{++} and Mg^{++} which gets removed by ion exchange processes. Total hardness of water samples varies between 20 to 1560 mg/l in pre-monsoon and 110-1760 mg/l in post-monsoon season (Table 3 and Table 4). The water quality is 52% and 80% sample is under permissible limits, post and pre-monsoon season, respectively.

(iv) Total dissolved solids (TDS)

Total dissolved solids are a measure of the combine content of all inorganic and organic substances present in a liquid in molecular, ionized of micro-granular suspended form. This parameter is generally used as a manifestation of aesthetic characteristics of drinking water. High TDS levels generally indicate hard water and can thus affect the test of water.

TDS values 70% samples is permissible, 2% not permissible and 28% samples is below the permissible limits for pre-monsoon season and post-monsoon season TDS values are 52%, 2% and 46% permissible, not permissible and below permissible limits respectively. Present the spatial distribution graph of TDS in the study area for both seasons and values of water samples also follow similar trends in both seasons. During pre monsoon season of the study area have more dissolved solids in water compared to post-monsoon.

(v) Chloride (Cl^-)

Chloride is the most common toxicity in water used for irrigation purpose. It is neither adsorbed nor held back by soils; rather it moves readily with the soil-water and gets adsorbed by crop, and accumulates in the leaves (Ayers R S *et al*, 1994). Higher intake of Cl^- beyond the crop tolerance limit in plants develops symptoms like leaf bourn and drying of leaf tissues. Excessive necrosis is often accompanied by early leaf defoliation of drop (Subba Rao N 2006). The permissible limit of Cl^- in water quality range between 200 to 600 mg/l and 250 to 1000 mg/l by WHO and BOI, respectively (Table 2). Too much of chloride leads to bad taste in water and also chloride ion combines with the Na and forms NaCl, whose excess presence in water makes it salin and unfit for drinking and irrigation purposes. The concentration of chloride in the water sample collected vary from 122.8 to 1497.4 mg/l pre-monsoon and 149.7 to 1297.8 mg/l post-monsoon (Table 3 and Table 4). The maximum Cl^- content in water during pre-monsoon season in compared to post-monsoon. Present the spatial distribution graph of Cl^- in the study are for both sessions and sample 80 to 93 % under permissible limits.

(vi) Sodium (Na^+), Potassium (K), Calcium (Ca), Magnesium (mg), Bi-carbonate (HCO_3) and Sulphate (SO_4)

Sodium toxicity is recorded as a result of high sodium in water as Na% and SAR ratios. Typical toxicity symptoms to plants and trees are leaf burn and dead tissue along the outside edges of leaves. Symptoms appear first on the older leaves, starting at the outer edges and when the severity increases it moves progressively inward between the veins toward the leaf centre. The adverse effect of sodium on the soil is more closely related to the ration of sodium to the total cations in the irrigation water than to the absolute concentration of sodium. It has now been recognized that as percent of sodium increases in the soil solution larger quantities calcium and magnesium, thus resulting in alkali soil. The concentration of sodium in the water samples collected varies from 3.1 to 345 mg/l and 5.3 to 238.8 mg/l pre-monsoon and post-monsoon respectively (Table 3 and Table 4). Represent the spatial distribution of Na^+ in the study area and if is found that in both the seasons, maximum samples are within the safe category 96 to 98% sample is below 200 mg/l (WHO and BOI).

Potassium lies between 0.2 to 88.8 mg/l (pre-monsoon) and 0.4 to 35.8 mg/l (post- monsoon) seasons. The water quality is 89 to 93% sample under permissible limits (12 mg/l, WHO). The values of both constituents (Na and K) are well within permissible limits. The occurrence of clay minerals in sand stone and shale may be possible sources of sodium and potassium in ground water.

Calcium concentration varies between 1.8 to 57.7 mg/l in pre-monsoon and 3.1 to 56.9 mg/l in post-monsoon seasons. The presented for Ca values 100% samples is below permissible limits (75 – 150 mg/l, WHO).

Magnesium concentration lies between 5.0 to 302.3 and 14.1 to 320.0 mg/l during pre and post-monsoon seasons respectively. The values of both constituents (Ca and Mg) are within permissible limits. The higher concentration of magnesium makes water unpalatable and consumption of such type of water cause laxative effect in human beings. Mg^{+} values 65% samples is permissible, 28% not permissible and 7% samples is below the permissible limits for pre-monsoon season and post-monsoon season Mg^{+} values are 80%, 13% and 7% permissible, not permissible and below permissible limits respectively.

Presenting the Bi-Carbonate concentration values 89% sample is permissible, 11% not permissible limits in pre-monsoon and 91% is permissible, 2% not permissible and 7% is below permissible limits in Post-monsoon. The sulphate (SO_4) is all samples under permissible limits in both monsoon seasons.

Water quality for Drinking Purposes

In the large and specially semi urban or rural parts of our country groundwater sources in form of fug wells of bore wells are the only source of drinking water standard, the total Hardness of samples have been measured and the use of Hydro geochemical facies (Piper diagram) and Water Quality Index have been make.

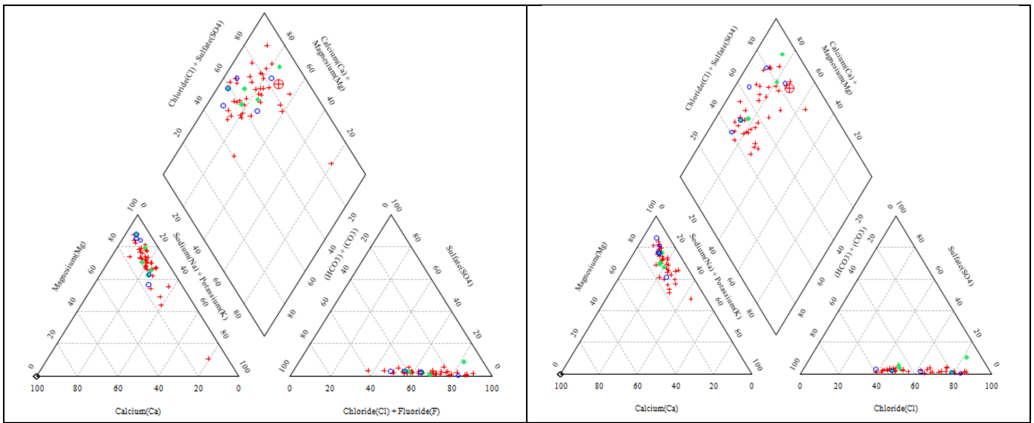
Table 5: Classification of samples according to standards specified for water quality index

Parameter	Range	Class	No. of Sample		% of Sample	
			Pre-monsoon	Post-monsoon	Pre-monsoon	Post-monsoon
WQI	0-25	Excellent	9	12	20	26
	25-50	Good	27	26	59	57
	50-75	Poor	6	4	13	9
	75-100	Very Poor	2	3	4	7
	>100	Unfit for Drinking	2	1	4	2

Note: SAR = Sodium Adsorption Ratio, SSP = Soluble Sodium Percentage, PI = Permeability Index RSC = Residual Sodium Carbonate, KR = Kelly's Ratio, All values meq/l.

(i) Hydrogeochemical facies

A Piper Trilinear diagram is a graphical representation classifying water based on the dominant presence of cations and anions and has widespread use to assess the water type. Piper diagram can predict the water type in three ways- fresh type, sulfate type and saline type. In Fig. 2-a, and 2-b it can be seen the water samples fall under $CaHCO_3$ or the bi-carbonate type during post-monsoon whereas during pre-monsoon groundwater in certain locations falls under the Ca-Mg-Cl-SO_4 types as well. Samples in the top quadrant are calcium sulphate waters, which are typical of gypsum ground water and mine drainage of pre and post monsoon season.

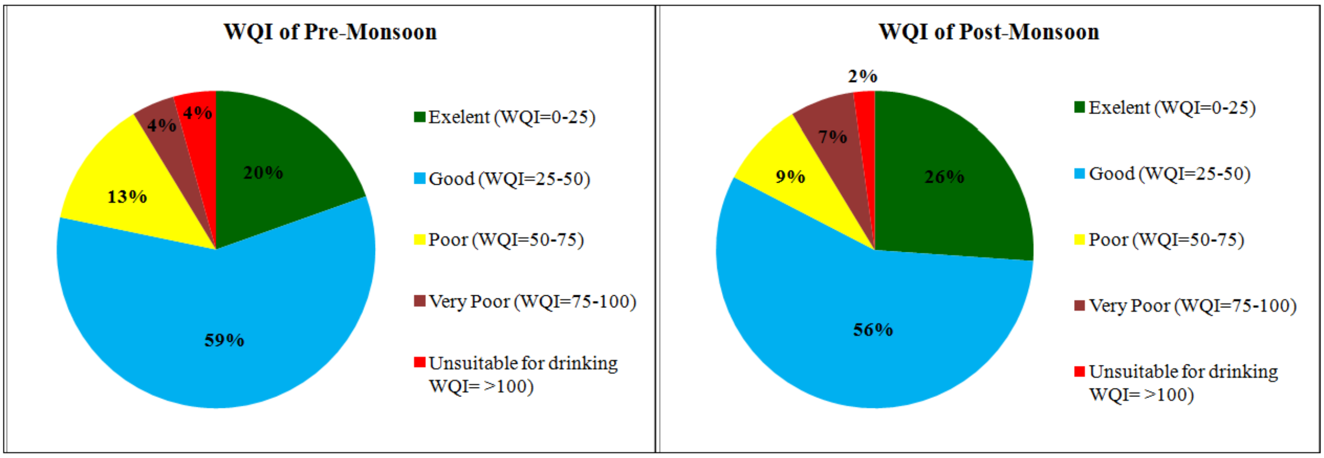


a. Pre-Monsoon Season b. Post-Monsoon Season

Fig 2: Piper Trilinear diagram (a. pre-monsoon; b. post-monsoon)

(ii) Water quality index (WQI)

Water quality index values depicted through the weighted arithmetic water quality index method were shown in Table-3 indicates range of WQI values according to which the five classes in pre and post monsoon. The pie charts presented in Fig. 3-a, and 3-b depiction clearly explains that the pre and post monsoon values are much suitable for drinking purpose in most of the station where water samples are collected. Whereas in very small sample shows that not suitability for drinking according to the Table-3. The pollution before post monsoon is more than that of pre monsoon in current study



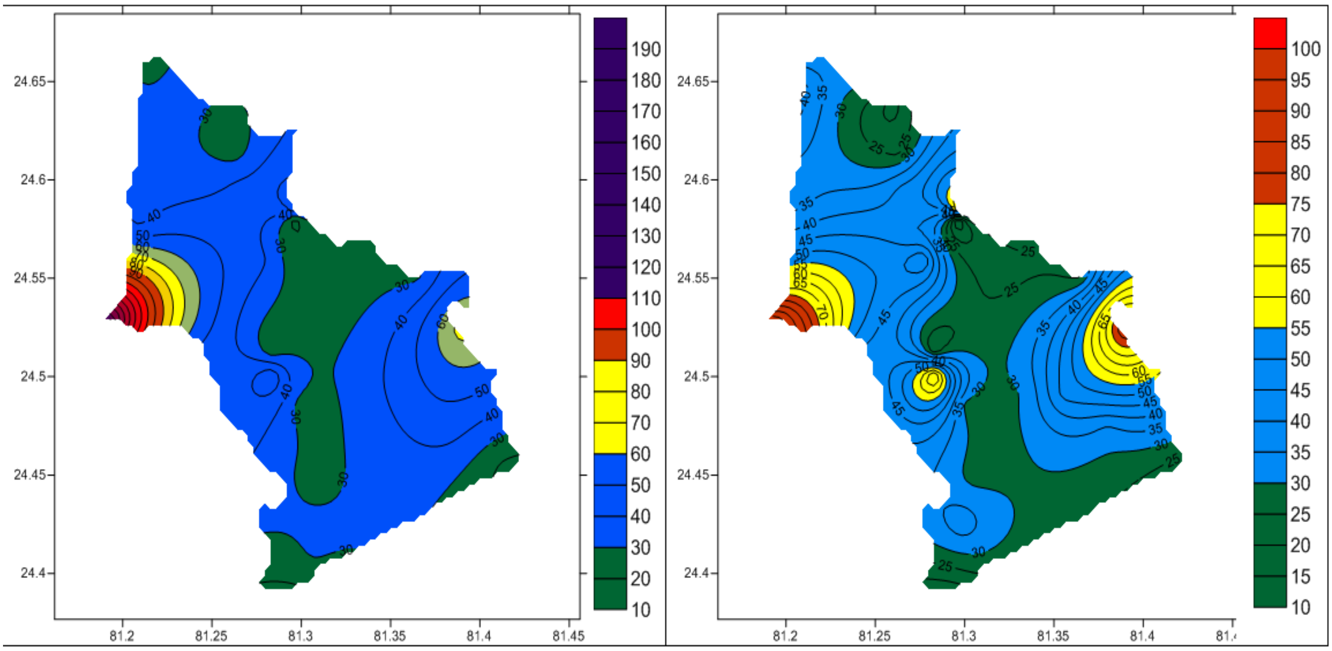
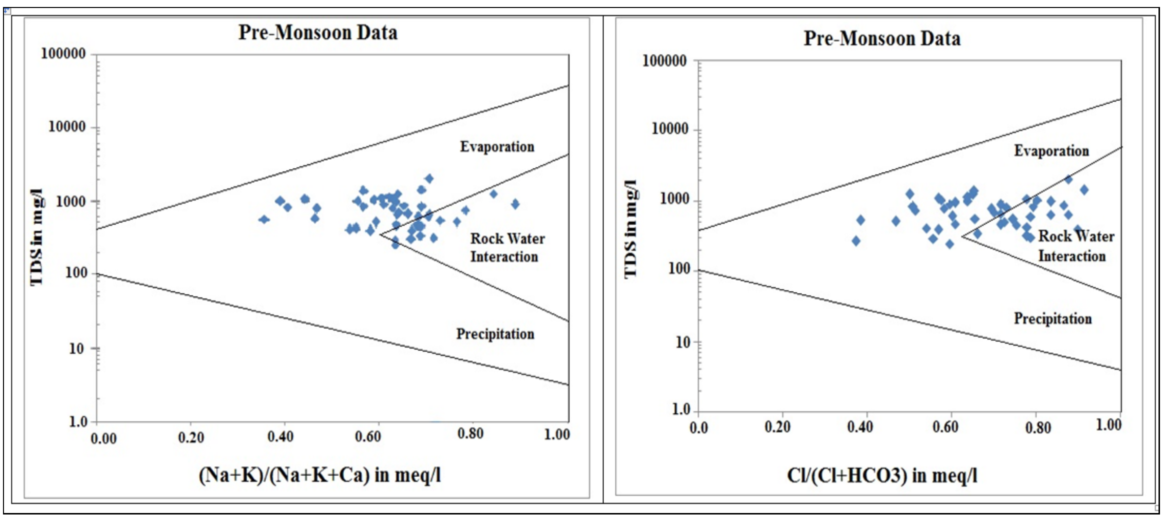


Fig 3: Categorization of groundwater WQI (a. pre-monsoon; b. post-monsoon)

(iii) Gibb's diagram

The Gibb's Diagram is prepared using TDS, Na^+, K^+, Ca^+, Cl, SO_4^- and $CHO3^-$ concentrations in groundwater. The predominant samples fall in the rock–water interaction dominance and evaporation dominance field of the Gibbs diagram (Fig. 4-a and 4-b). From these diagrams it can be interpreted that during both sampling sessions' rock- water interaction processes control the levels of all chemical constituents in groundwater of study area. The rock–water interaction dominance field indicates the interaction between rock chemistry and the chemistry of the percolated waters under the subsurface. Dissolution and displacement reactions in rocks lining the aquifers are primary reasons behind changing concentrations of major ions in solution.



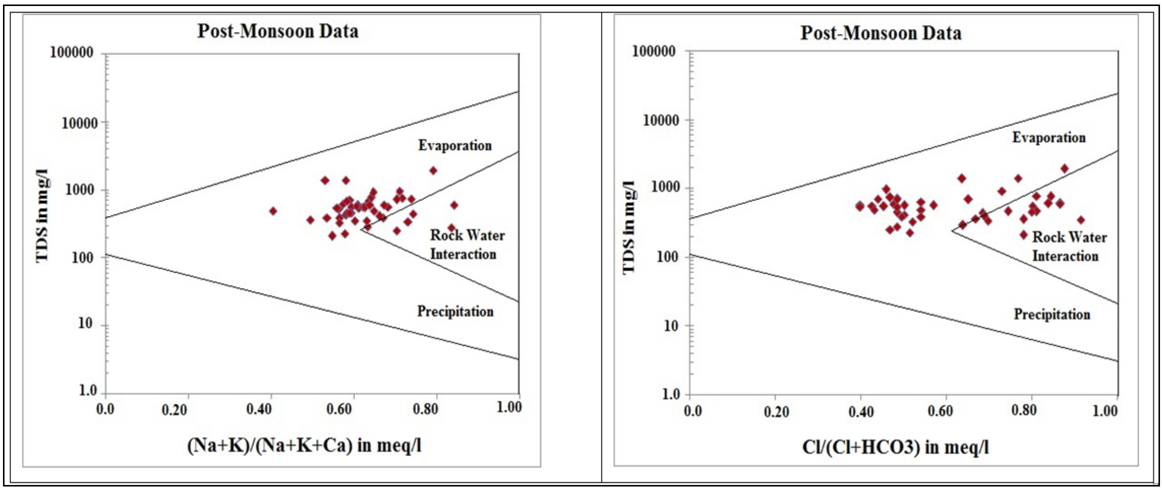


Fig 4: Gibb's Diagrams (a) pre-monsoon and (b) post-monsoon season

Conclusion

The water samples were taken from the various sites of Rewa block, Rewa district area were analyzed and the analysis that the water quality parameters like pH, Total Dissolved Solids, Total Hardness, Calcium, Magnesium, Nitrate, Chloride, and Sulfate lies within the maximum permissible limit prescribed by WHO and BIS. It is observed that some parameters exceed the standard limits. The ground water is hard to very hard in nature. The overall study reveals that water concentration of various cations and anions suggest that the groundwater of the area is partially suitable for drinking purpose.

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