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Assessment of Groundwater Quality using GISbased WAWQI Method for Chittorgarh district, Rajasthan, India

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ABSTRACT
Groundwater is a good source of drinking and irrigation water. Its depth and chemical composition varies place to place. A survey was led during pre-monsoon season, to assess the groundwater status as well as quality in Chittorgarh district of Rajasthan and it was found that, there is much variation in groundwater level during pre-monsoon season. Various physico-chemical analyses were performed to check the suitability of water sample. Various irrigation water quality parameters like residual sodium carbonate, sodium absorption ratio, soluble sodium percentage, Kelly's ratio and permeability indexare showing a positive sign towards quality of irrigation water. The status of groundwater quality was determined by calculating WQI index. The computed WQI index showed that 77 % and 23 % area of sampling site comes under good and poor water status, respectively during pre-monsoon. Majority of samplesof study areawas showing suitability of irrigation water use. Finally, it can be concluded that groundwater available in study area is quite suitable for irrigation as well as drinking purpose. Anthropogenic activities are indirectly affecting the quality of ground water in the study area.
(Key words: Groundwater quality, water quality index, irrigation water, drinking water)

I. INTRODUCTION

The importance of groundwater for the existence of human society cannot be overemphasized and without it, we cannot imagine our life.Earths ¾ part covered by water but we are unable to use this water. Groundwater is the major source of drinking water and irrigation. Around 95 % of human population in both rural and urban areas of India is mainly depending on groundwater for drinking purpose (Dahiphaleet al, 2014). Besides, it is an important source of water for the agricultural and the industrial sector (Johnny and Sashikumar, 2014).Groundwater is a major source of irrigation water. At global level 40% groundwater use in irrigation but in India it more than 50% of irrigation demand(CGWB, 2014). Groundwater cover more than 50% area of total irrigated area (Oza, 2007). Groundwater is a significant source of irrigation in many parts of India, especially in semiarid and arid regions. Poor quality of water adversely affects the plant growth and human health. Hence, the demarcation of groundwater quality is of vital importance to augment groundwater resources (Johnny and Sashikumar, 2014).

If water used in irrigationhas poor quality thenit will affect the crop production and deteriorate the soil quality and health.So it is required that available water which is used in irrigation should be of good quality and it is mainly depended on the amount and type of dissolved material in the water.So this study may be of great help in understanding the groundwater quality status in Chittorgarh district.

II. MATERIALS AND METHODS

Collection of Groundwater samples

The whole Chittorgarh district was divided into 7x7 km square grids and from each grid one open dug well was randomly selectedwhich is used in irrigation. Dug well locations were recorded with the help of Global Positioning System (GPS). Sampling device were used to drawn the groundwater samples and then collected in properly cleaned and wall labelled plastic bottles and brought to the laboratory for analysis. Total 134 groundwater sample were collected during pre-monsoon season (June, 2017).

Analysis of water sample

Collected water sample analysed for 11 parameters like pH, EC, TDS, cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) and anions(HCO_3^{-}, SO_4^{2-}, Cl^{-}, CO_3^{2-}).For determination of pH, EC, cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) and anions (CO_3^{2-}, HCO_3^{-} and Cl^{-}) standard method is provided by Richards, 1954. The water pH is determined using glass electrode pH meter and EC is evaluated by conductivity meter. Ca^{2+} and Mg^{2+}both are determinate by versenate titration method. Na^+ and $K^+$are analysed using flame photometer. Titration method with standard $H_2SO_4$was used for calculating $CO_3^{2-}$and $HCO3^-$. Cl^- evaluated by titration carried with standard $AgNO_3$. Chesnin and Yien, 1957 method (Tuirbidometeric Method) was used for SO_4^{2-} estimation.

Classifications of irrigation water

Water is classified in various classes on the bases of various criteria.

Residual Sodium Carbonate (RSC) or bicarbonate hazard: It is an approach, which is empirical in nature. It is also describessodicity of the water (Eaton, 1950). It is based on the equation.

$$RSC=(CO_3^{2-} + HCO_3^-) - (Ca^{2+} + Mg^{2+})$$

Sodium Adsorption Ratio (SAR) or sodium hazard: It is the ratio of sodium concentration to calcium and magnesium concentration.

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

High SAR value of water shows that water is not suitable for irrigation. It expressed that high concentration of sodium are undesirable in irrigation water.

Soluble sodium percentage (SSP): Classification of water used in agriculture based on SSP was suggested by Wilcox (1955).The formula for SSP calculation given below:

$$\text{Soluble sodium percentage (SSP)} = \frac{Na}{Ca+Mg+Na} \times 100$$

The Value of SSP less than 50 shows the good quality and suitable for agricultural purpose but the value of SSP greater than 50 shows the poor quality and not suitable for agricultural purpose. All the parameters are signified in meq/L.

Kelly's ratio (KR): The formula for Kelly's ratiocalculation given below:

$$\text{Kelly's ratio (KR)} = \frac{Na^+}{Ca^{2+}+Mg^{2+}}$$

The Value of KR <1 or =1 shows the good quality and suitable for agricultural purpose.All the parameters are signified in meq/L.

Permeability Index (PI): Permeability index is influenced by different water quality parameters like Ca^{2+}, Mg^{2+}, K^+, $Na^+$and HCO_3^-.Based on Permeability Index irrigation water can be classified as 3 categories. The permeability index for groundwater measures the total concentration of Na and HCO_3 to the cationscontent. Doneen (1964) has categorized quality of irrigation water in to three classes. On the basis of quality, irrigation water can be classified in class I (>75 %), class II (25-75%) and class III (<25%).

The formula for Permeability Index (PI)calculation given below:

$$\text{Permeability Index (PI)} = \frac{(Na+K)+\sqrt{HCO_3}}{Ca+Mg+Na+K} \times 100$$

All the parameters are signified in meq/L.

Water Quality Index (WQI)

This indexing is suitable for drinking as well as irrigation water quality determination. Brown et al. (1973) has represented calculation ofwater quality indexusing weighted arithmetic indexing (WAI) method. The following equation is used to calculate WQI is:

$$WQI = \frac{\sum_{i=1}^{n} qiWi)}{(\sum_{i=1}^{n} Wi)}$$

Where,

q_i=quality rating (sub index) of i^{th} water quality parameter

w_i= unit weight of i^{th} water quality parameter

The unit weight (W_i) values in the current study are taken from Krishnan et al.(1995) and according to Mishra and Patel (2001) the following WQI values are the consumption of humans are rated as follows:

WQI range	Usage
<50	Excellent
50-100	Good
100-200	Poor
200-300	Very Poor
300& above	Unfit

III. RESULTS AND DISCUSSION

The Residual Sodium Carbonate (RSC) indicates the excess of carbonate and bicarbonate over calcium and magnesium in groundwater. The data presented in table 1 and showed in figure 1 and 2 revealed that RSC values of groundwater of Chittorgarh district varied from nil to 5.20meL^{-1} with an average value of 1.48 meL^{-1}. Sodium absorption ratio (SAR) varied from 0.18 to 12.92 with a mean value of 3.37. Similar results were also reported byGurjeret al. (2015), Bhangeet al. (2016) and Yadav and Singh (2018) in their studies at different locations.

Table 1.Residual Sodium Carbonate (RSC) (meL^{-1}) and Sodium Adsorption Ratio (SAR)of groundwater of study area

Block	Residual Sodium Carbonate (RSC)		Sodium Adsorption Ratio (SAR)	
	Range	Mean	Range	Mean
Bari Sadri	Nil -Nil	Nil	0.44-5.64	2.30
Begun	Nil -0.40	0.30	1.34-5.55	3.02
Bhadesar	Nil -0.80	0.80	1.68-4.52	3.63
Chittorgarh	Nil -Nil	Nil	0.32-3.83	2.36
Dungla	Nil -2.40	2.40	1.15-9.19	3.48
Gangrar	Nil -1.40	1.40	1.25-4.68	3.06
Kapasan	Nil -5.20	2.11	0.68-12.81	5.15
Nimbahera	Nil -1.40	1.10	1.84-9.08	3.91
Rashmi	Nil -3.80	1.23	2.65-12.92	6.42
Rawatbhata	Nil -1.20	1.00	0.18-4.96	1.85
District	Nil **-5.20**	**1.48**	**0.18-12.92**	**3.37**

The SSP (soluble sodium percentage) values should not be greater than 50 for irrigation water, fortunately all the samples are falling under the safe category in the study area. The SSP values varies from 6.49-42.09 with average value of 24.36 (Table 2), which shows quite suitable groundwater for irrigation. The suggested values of Kelly's ratio is ≤1 for irrigation. The Kelly's Ratio values for the study area ranges from 0.07-0.73 with the average values of 0.32.All the samples are comes under the suitable category for irrigation in the study area.PI values for the study area ranges from 7.31 to 126.26 with average value of 48.72.About 20% of samples comes under the class I (>75) and rest 80 % samples belong to the class II (25-75%).This indicates the available water in the study area is moderate to good for agriculture with some symptom of poor water quality.

Table 2.Soluble sodium percentage (SSP),Kelly's Ratio (KR) andPermeability Index (PI) of groundwater

Block	Soluble sodium percentage (SSP)		Kelly's Ratio(KR)		Permeability Index(PI)	
	Range	Mean	Range	Mean	Range	Mean
Bari Sadri	8.77-17.50	20.40	0.10-0.21	0.26	9.61-46.29	40.29
Begun	20.0-25.69	20.74	0.25-0.36	0.26	90.98-72.67	39.89
Bhadesar	6.49-25.32	21.97	0.07-0.34	0.28	9.18-59.91	41.68
Chittorgarh	8.77-23.81	24.09	0.10-0.31	0.32	12.41-54.29	46.96
Dungla	14.02-25.90	26.79	0.16-0.35	0.37	25.08-68.52	59.89
Gangrar	16.13-29.41	25.33	0.19-0.42	0.34	25.00-72.04	51.91
Kapasan	16.13-42.09	30.58	0.19-0.73	0.44	27.94-126.26	70.00
Nimbahera	7.69-31.43	23.00	0.08-0.46	0.30	13.32-73.03	44.81
Rashmi	7.70-28.62	23.14	0.08-0.40	0.30	13.32-77.85	52.76
Rawatbhata	9.43-32.79	18.33	0.10-0.49	0.23	7.31-82.94	33.16
District	**6.49-42.09**	**24.36**	**0.07-0.73**	**0.32**	**7.31-126.26**	**48.72**

Water Quality Index (WQI)

WQI index is calculated to determine the suitability of water for drinking.All the 11 parameters are considered for calculation of water quality index (Table 3). Identification of these indexes may help to monitor water quality check-up process and also saves time without compromising test results.Water quality index revealed that out of 10 blocks, 8 blocks have suitability of water for drinking.The computed WQI index showed that 77 % and 23 % area of sampling site comes under good and poor water status, respectively during pre-monsoon (Table 4).

Table3. Water quality parameters with BIS standards and the their assigned weight

Parameters	BIS Standard (s_i)	Weight (w_i)	Relative weight (Wi)
pH	8.5	4	0.154
Ca	75	2	0.077
Mg	50	2	0.077
Na	200	2	0.077
K	12	2	0.077
HCO_3	250	3	0.115
Cl	250	3	0.115
TDS	500	4	0.154
SO_4	200	4	0.154
		$\sum w_i=26$	$\sum W_i=1$

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Table 4. Classification of water quality based on WQI index for pre-monsoon season

Class	WQI values	Water quality status	Pre-monsoon (%)
I	<50	Excellent	-
II	50-100	Good	77.54
III	100-200	Poor	22.46
IV	200-300	Very Poor	-
V	300 & above	Unfit	-

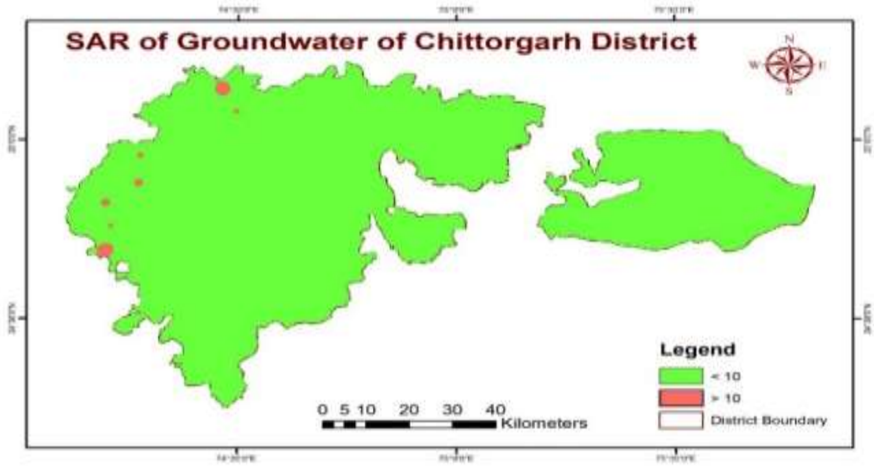

Fig.1. SAR of Groundwater of Chittorgarh district

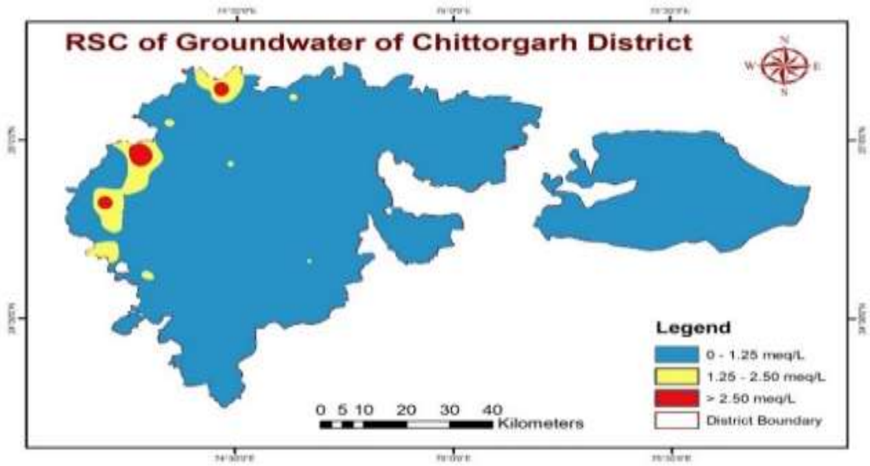

Fig.2. RSC of Groundwater of Chittorgarh district

IV. CONCLUSIONS

The study discloses the change in groundwater level during pre-monsoon season. Irrigation parametersbased on RSC, SAR and KR value indicates that pre monsoon are good.Further it was found that the quality of groundwater in Kapasan block was worst affected followed by Dungla,Rashmi and Gangrar blocks. The overall water quality index for study area had goodto poor status and it is suitable for drinking and irrigation purpose.

REFERENCES

[1]. Bhange, H.N., Singh, P.K., Purohit, R.C., Yadav, K.K., Jain, H.K. and Jain, S. 2016. Assessment of Groundwater quality through

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GIS for Khed Taluka, District Ratnagiri, India. International Research Journal of Environment Sciences, **5(11)**: 8-14.

[2]. Brown, R.M., McClelland, N.I., Deininger, R.A., and Landwehr, J.M. 1973. Validating the WQI, presented at the National Meeting on Water Resources Engineering of the American Society for Civil Engineers, Washington, D. C.

[3]. CGWB 2014.Central Ground Water Board, Ministry of Water Resources, River Development & Ganga Rejuvenation Government of India. Dynamic ground water resources of India, (as on 31st March 2011).

[4]. Chesnin, L. and Yien, C.H. 1957. Turbidimetric determination of available sulphates.Proceedings of Soil Science Society of Agriculture,**14**: 149-151.

[5]. Dahiphale, P., Singh, P. K. and Yadav, K.K. 2014.Morphometric Analysis of Sub-Basin in Jaisamand Catchment Using Geographical Information System.International Journal of Research in Engineering &Technology**2**(6): 189-202.

[6]. Dahiphale, Pravin, Singh, P.K. and Yadav, K.K. 2019.Assessment of groundwater quality for irrigation and drinking purpose in Jaisamand catchment using geographical information system.Indian Journal of Soil Conservation, **47**(3): 213-221.

[7]. Dhawan, V. 2017.Water and agriculture in India.Background paper for the South Asia expert panel during the Global Forum for Food and Agriculture (GFFA).Federal Ministry of Food and Agriculture.

[8]. Doneen L. D. 1964. Notes on water quality in agriculture, Water Science and Engineering.Department of Water Sciences and Engineering, University of California, Davis.

[9]. Eaton, F.M. 1950. Significance of carbonate in irrigation waters.Soil Science, **69**: 123-133.

[10]. Gurjer, K.L., Yadav, K.K., Verma, S.N. and Singh, P.K. 2015.Assessment of Groundwater Quality of Bhilwara District of Rajasthan.Annals of Plant and Soil Research, **17** (Special Issue): 203-205.

[11]. Johnny, J.C. and Sashikumar, M.C. 2014. Groundwater quality assessment in Dindigul District, Tamil Nadu Using GIS.Nature, Environment and Pollution Technology, An International Quarterly Scientific Journal, **13**(1): 49-56.

[12]. Krishnan, J.S.R., Rambabu, K. and Rambabu, C. 1995. Studies on water quality parameters of bore waters of ReddigudumMandal. Indian Journal of Environmental Protection,**18**(4), 91-98.

[13]. Mishra, P.C. and Patel, R.K. 2001.Study of the pollution load in the drinking water of Rairangpur.Indian Journal of Environment and Ecoplanning, **5**(2): 293-298.

[14]. Oza, A. 2007. Irrigation: Achievements and Challenges. Irrigation and water resources Part –I.

[15]. Richards, L.A. 1954. Diagnosis and improvement of saline-alkali soils.USDA, Agricultural Handbook No. 60.

[16]. Savita, R.S., Mittal, H.K., Satishkumar, U., Singh, P.K., Yadav, K.K., Jain, H.K., Mathur, S.M. and Davande, Sham 2018. Delineation of Groundwater Potential Zones using Remote Sensing and GIS Techniques in Kanakanala Reservoir Subwatershed, Karnataka, India. International Journal of Current Microbiology and Applied Sciences, **7**(1): 273-288

[17]. Wilcox L.V. 1955. Classification and use of irrigation waters.US Department of Agriculture Circular 969, Washington, DC, p.19.

[18]. Yadav K.K., Singh P.K. 2018. Prioritization for Management of Groundwater Quality-Related Problems of Rajsamand District of Rajasthan. In: Singh V., Yadav S., Yadava R. (eds) Groundwater. Water Science and Technology Library, vol**76**. Springer, Singapore. https://doi.org/10.1007/978-981-10-5789-2_16