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Evaluation of groundwater quality in Raya Block, Mathura District (Uttar Pradesh) using water quality index

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Abstract
In the present work groundwater samples were collected from twenty different locations of Raya Block, Mathura U.P. The collected groundwater samples were analysed for physiochemical parameters by using the standard methods as mentioned in Adoni *et al.,* 1985 and APHA, 2005.The obtained results were compared World Health Organization (WHO) and Bureau of Indian Standards (BIS). Results show that Total Dissolved Solids (TDS), Total Hardness (TH), Mg2+ and Cl^- are found to be higher than permissible limit when compared with the guidelines of the WHO and BIS. The WQI values in the study area ranged from 40.4 to 117.5. The overall WQI clearly indicates that the quality of groundwater in Raya Block belongs to poor categories as for as portability for human consumption is concerned.

Keywords: Groundwater, physicochemical parameters, WQI.

Introduction
Groundwater is the most important natural resource for the domestic, industrial and agricultural consumption and its contamination has been documented as one of the most severe issues around the world in recent times. Rural population living in India depends on groundwater for domestic and agricultural purposes. The available fresh water to man is hardly 0.3-0.5% of the total water available on the earth and therefore, its judicious use is imperative (Ganesh and Kale, 1995) [14]. The fresh water is a finite and limited resource (Bouwer, 2000) [15]. The utilization of water from ages has led to its over exploitation coupled with the growing population along with improved standard of living as a consequence of technological innovations (Todd, 1995) [16]. Groundwater is threatened by severe problems caused by natural/ anthropogenic factors, such as the extensive agricultural activities, the marine intrusion, the population growth, and the industrial development (Zammouri *et al.*, 2013) [17]. Contamination of groundwater also depends on the geology of the area and it is rapid in hard rock areas especially in lime stone regions where extensive cavern systems are below the water table (Singh, 1982). This is a feature common, not only in developed countries but also in developing countries like India. The changes in quality of groundwater response to variation in physical, chemical and biological environments through which it (Singh *et al*., 2003). The water quality has a strong relation with the health, for this, the water quality evaluation is very important and widely studied in many regions around the world (Asadi *et al.*, 2020). In this paper, the focus of the study is to assess the groundwater quality for Raya Block of Mathura district, Uttar Pradesh.

Material and Methodology
Study area
A Raya Block of Mathura district was selected to assess the physiochemical characteristics of groundwater. A total geographical area of the district is 3303 sq.km; and lies between North latitudes 27°13’ to 27°57’ and East longitudes 77°15’ to 77°58’. The average annual rainfall is 620 mm. The climate is sub-tropical humid and it is characterised by a hot dry summer and a pleasant cold season. About 88% of rainfall takes place from June to September. During the monsoon surplus water is available for deep percolation to ground water. Major soil types are silty, sandy and loamy soils the geology of the district is covered with the homogenous formation and does not show any significant structural complications.

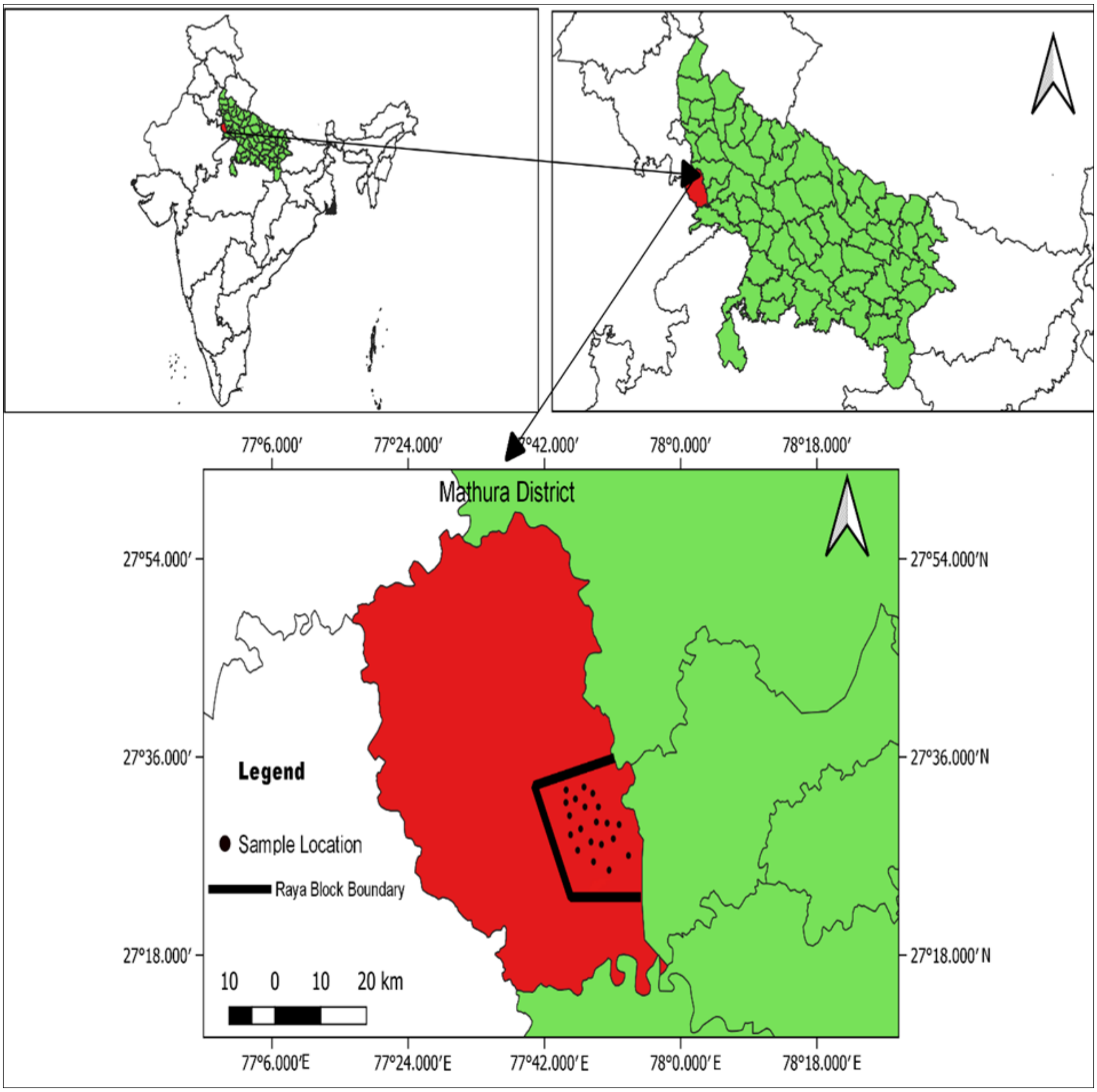

Fig 1: Location of study and sites of groundwater samples collected for analysis in Raya block of Mathura district, India

Sample Collection and Analysis

Twenty groundwater samples were collected in January 2022 in Raya Block, Mathura District, U.P. The groundwater characterization has been carried out for the parameters like pH, Electrical Conductivity (EC), total dissolved solids (TDS), total hardness (TH), calcium (Ca^{2+}), magnesium (Mg^{2+}), chloride (Cl^-), nitrate ($NO3^-$), Iron (Fe) and fluoride (F^-) by following the standard methods prescribed as per Bureau of Indian Standard 10500 (BIS 2012) and WHO (2006). Each of the analysis in the study was repeated twice until concordant values were obtained, and all the tests were carried out according to the standard methods (APHA, 2005).

Water Quality Index (WQI):

Water quality index (WQI) is an exceptionally valuable tool for evaluating the overall quality of water (Ketata *et al.*, 2012), and with its help, a large number of data can be shown in a single value and facilitates easy understanding of the information. Weighted arithmetic water quality index method classified the water quality according to the degree of purity by using the most commonly measured water quality variables and the calculation of WQI was made (Brown *et al.*, 1972) by using the following equation:

$$\mathbf{WQI} = \sum \mathbf{QnWn} / \sum \mathbf{Wn}$$

The quality rating scale (Qi) for each parameter is calculated by using this expression:

$$\mathbf{Qn} = \mathbf{100}[(\mathbf{Vn} - \mathbf{Vo}/\mathbf{Sn} - \mathbf{Vo})]$$

Vn is estimated concentration of ith parameter in the analysed water

V_o is the ideal value of this parameter in pure water

$V_o = 0$ (except pH =7.0 and DO = 14.6 mg/l)

Sn is recommended standard value of ith parameter

The unit weight (Wi) for each water quality parameter is calculated by using the following formula:

$$\mathbf{Wn} = \mathbf{K}/\mathbf{Sn}$$

K= proportional constant.

Table 1: Classification of Groundwater quality according to WQI range

S. No.	WQI range	Water Quality
1	<50	Excellent Water
2	50-100	Good water
3	100-200	Poor water
4	200-300	Very poor water
5	>300	Unsuitable for drinking purpose

Result and Discussions
The physicochemical concentrations of collected groundwater samples for the various parameters are shown in Table No.3. pH is the measure of hydrogen ion concentration value in water which indicates whether a solution is acidic, neutral or basic. The pH required has to be in the range of 6.5–8.5 for the drinking purpose (BIS, 2012). In present study pH concentration is ranges from 7.0 to 8.5 which shows that it is within the permissible limit as prescribed by BIS (2012).

Total Dissolved Solids (TDS)
Total dissolved solids, the concentration of total inorganic salts and a small amount of organic salts dissolved in the water is another important physio-chemical parameter determining the water quality. TDS in groundwater samples ranges from 610 mg/l to 5500 mg/l with a mean of 1963 mg/l. However, the desirable limit of TDS study area is higher than the permissible limit indicating severe contamination and health threat. High TDS increase density of water, decrease solubility of gases like oxygen and ultimately make the water unsuitable for drinking (WHO, 1984). High TDS level (>500mg/L) result in excessive scaling in water pipes, water heater, boilers, and household appliances (Tihansky, 1974). Similar results of TDS of groundwater at Bhanpur Bhopal were also reported by Hurra and Bhawsar, 2021.

Electrical conductivity (EC)
Electrical conductivity, the measure of water capacity to convey the electrical current is one of the important physio-chemical parameters determining the water quality. The highest desirable limit of EC in drinking water is 750 µS/cm (WHO 2016). The observed value of EC in water samples is between 900 and 10600 µS/cm with a mean of 2268µS/cm in of 20 sample. The observed value of EC represents the ability of the water to conduct electric current in which higher EC indicates enrichment of salts in the groundwater (Logeshkumaran *et al*.).

Total Hardness (TH)
Total hardness is one of the most important parameters in water quality assessment. The TH in the study area varies between 440 to 3900 with a mean value of 1437 mg/l. The WHO standards for TH is 500 mg/l. Hardness reflects the composite measure of polyvalent cations whereas calcium and magnesium are the primary constituent of hardness (Larry, 1996).

Chloride (Cl)
Chloride in excess imparts a salty taste to water, and people who are allergic to high chloride are subjected to laxative effects (Anitha *et al*. 2011; Sadat-Noori *et al*. 2014). In the study area chloride concentration ranges from 135 mg/l to 4500 mg/l. Chlorides are found in natural water due to leaching of chloride containing rocks and soils discharges of effluents from chemical industries such as sewage disposal, ice-cream plant effluent, and irrigation drainage. Higher concentration of chloride is harmful which causes disease related to heart and kidney of the people, indigestion, taste, palatability and corrosion are also affected. 70 percent samples are found to be value higher than desirable limit of Chloride prescribed by BIS, 2012) for drinking water (Table-2).

Fluoride (F)
Fluoride in drinking water is mainly due to the geogenic sources. Fluoride at low concentrations has a beneficial effect on teeth by preventing and reducing the risk of tooth decay (Arumugam 2010), higher concentration of fluoride causes dental and skeletal fluorosis, BIS and WHO standards for fluoride is 1.5 mg/l, values were found ranging between 0.9 mg/l to 1.3 mg/l in study area.

Calcium and Magnesium
Magnesium is an essential element for human being, it is important for normal bone structure in the body. Water with high levels of magnesium or calcium is considered as hard and is undesirable for domestic purposes. The values of calcium range from 170 mg/l to 1571mg/l with a mean value of 573 mg/l (Table 1). Mostly samples are above the permissible limit prescribed by WHO (200mg/l). Magnesium concentration is very high in the groundwater samples. Observed data shows most parts of the study area have value in the non-permissible category (>65 mg/l). It ranges from 65 mg/l to 566 mg/l with a mean of 221mg/l.

Nitrate
Hence, increasing nitrate contamination seriously threatens public drinking water supply and human health (Kumar *et al*. 2014). The main source of nitrate concentration in drinking water is anthropogenic activity. Nitrate concentration ranges from 0.67 mg/l to 0.94 mg/l in the study area. The study area is falling under the desirable limit as shown in Table 1. Nitrate concentration above 45 mg/l (BIS, 2009), causes methemoglobinemia (blue baby syndrome),gastric cancer, thyroid disease and diabetes (Krishna Kumar *et al*., 2011, Kumar *et al*. 2014).

Iron
The iron occurs naturally in the aquifer but levels in groundwater can be increased by dissolution of ferrous borehole and handpump components. Iron-bearing groundwater is often noticeably orange in colour, causing discoloration of laundry, and has an unpleasant taste, which is apparent in drinking and food preparation. Iron values were found ranging between 0.06 mg/l to 0.2 mg/l. BIS standard permissible limit for Iron for drinking water<0.3mg/l as well as WHO (2012) has fixed it to be <0.3 mg/l.

Table 2: Statistical groundwater quality parameter compared with BIS (2012) and WHO (2017).

S.NO.	Parameter	Minimum	Maximum	Mean	Standard Deviation	BIS (2012)		WHO (2017)
						Desirable limit	Permissible Limit	
1.	TDS	610	5500	1963	1230	500	2000	500
2.	EC	900	10600	3084	2268	-	-	750
3.	TH	440	3900	1437	893	200	600	500
4.	F^-	0.9	1.4	1.35	0.15	1	1.5	1.5
5.	Cl^-	135	4500	746	1001	250	1000	250
6.	Ca^{2+}	170	1571	573	364	75	200	75
7.	Mg^{+2}	221	566	221	134	30	100	30
8.	NO_3^{-1}	0.67	0.97	0.85	0.08	45	-	50
9.	Fe	0.06	0.2	0.10	0.18	0.3	-	0.3

Water Quality Index (WQI)

The WQI value and water type of the individual samples are presented in Table-4. The WQI values in the study area ranged from40.4 to 117.5. The overall WQI clearly indicates that the quality of groundwater in study area belongs to poor categories as for as portability for human consumption is concerned.

Table 3: Water Quality Index of the Study Area

S. No.	Sample Site Name	WQI	Water type
1	Bankebihari Restaurant (Mathura Road)	54.6	Poor
2	Shivpuri	68.1	Poor
3	Karab	57.2	Poor
4	Hanuman mani (Raya-Baldeo Road)	51.1	Poor
5	Chhikra	81.2	Very Poor
6	Kumha	54.4	Poor
7	Near P.K institute	97.9	Very Poor
8	Pirsua	56.2	Poor
9	Dixit Nursing Home (Raya Railway Station Road)	50.2	Poor
10	Koyal	45.8	Good
11	Dhaku	53.7	Poor
12	Gonga	55.5	Poor
13	Pathak Nagar near Railway Station	57.2	Poor
14	Near Graveyard (Bhankarpur Road)	40.4	Good
15	Mohalla Vyapariyan	97.6	Very Poor
16	Near Momin Mosque	59.3	Poor
17	Gainda Laal Nagar (Ganga Nagla Road)	55.1	Poor
18	Katra Bazar (Raya)	117.5	Unsuitable
19	Rifa –e- aam Public School (Nagariya)	72.11	Poor
20	Nangal Road	58.4	Poor

Conclusion

The results from the present stud showed that most of the parameters like Total Dissolved Solids (TDS), Total Hardness (TH), Mg2+ and Cl^- were found to be higher than permissible limit when compared with the guidelines of the WHO and BIS. The WQI values in the study area ranged from 40.4 to 117.5. The overall WQI clearly indicates that the quality of groundwater in Raya Block belongs to poor categories as for as portability for human consumption is concerned. Hence, the study concludes that groundwater in the study area is not fit for direct human consumption.

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