Original article

Water quality assessment of shallow aquifer based on Canadian Council of Ministers of the environment index and its impact on irrigation of Mathura District, Uttar Pradesh

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A R T I C L E   I N F O

A B S T R A C T

Sixty-five water samples were collected in July 2016 in the Mathura district and have experimentally determined the physio-chemical parameters and evaluated by comparing their values with Bureau of Indian Standards (BIS). The aim of the study is to find out the status of water quality in Mathura district. Results show that Total Hardness(TH), Total Dissolved Solids (TDS), Cl^- and Mg^{2+} are found to be very much higher than (>50%) the permissible limit. Majority of the samples have high values NO_3^- and Cl^-. The sources of Ca^{2+}, Mg^{2+}, Na^+ and K^+ are from the weathering process. In general, water chemistry is governed by complicated weathering procedure, ion exchange, impact of horticultural and sewage. CCME WQI values ranged from 1.862 to 82.254 and shows that the quality of water is good to poor. Agriculture indices like Gibbs Plot, Percent sodium (Na%), Residual Sodium Carbonate (RSC), Sodium Adsorption Ratio (SAR), Permeability Index (PI) Potential salinity and Magnesium hazard has values 0.50 to 0.99, 8.37% to 86.66%, −90.59 to 7.71 $meql^{-1}$, 9.59 to 96.34, 1.82 to 21.82, 4.58 to 112.83 $meql^{-1}$, and 45.57 to 8221.03 respectively. These values show that the quality of water is poor and moderately suitable for irrigation purpose. It also indicates that an anthropogenic effect on groundwater quality needs water management strategy according to their regional demand for humans.

1. Introduction

Natural water assets are directed for countless purposes including farming, drinking, household purposes, commercial production, environmental activities and so forth. Groundwater is one of the world's most essential driving force of freshwater everywhere (Bear, 1979). Around 33% of the total population of the world is anticipated to utilize groundwater mainly for drinking purpose (Nickson et al., 2005). The two noteworthy factors for variation in provincial hydrology and water assets incorporate human affairs and natural ecological changes (Li, 2014, Al-Janabi et al. 2012). The effect of human practices on nature, especially on water reserves, unavoidably intensifies with the quick improvement of the economy and booming population of the world. Babiker et al., 2007, stated that the change in the chemistry of groundwater isn't just identified with the region's lithology and residence time but also the water which influence with rock constituents, yet additionally noticeable contributions from the air, soil and climate, as well as from contaminated sources. The transfer of untreated discharge and excessive utilization of synthetic fertilizers has concluded that the freshwater is inadmissible for both household and agricultural purposes (Bruce and McMahon, 1996). The injurious impacts on health of different toxic wastes (M. Naushad, et al 2019) have been revealed from numerous researches like fluoride(Chandrawanshi and Patel, 1999), pesticides, nitrate, arsenic (Bruce and McMahon, 1996), Fe and total hardness, etc. in water (Soltan, 1998). But scientist developing techniques to remove contamination of heavy metals such as Cd(II), Co(II), Cu(II), and Pb(II) (M.

Naushad, 2014; Naushad, et al, 2015) With just 4% of the world's freshwater assets, India reinforces over 16% of the earth's population (Singh, 2003). The maximum cultivated field utilizing groundwater in India spread from 6.5 million hectares in the year 1951 to 35.38 million hectares in 1993 (GWREC, 1997). Around half of the irrigated land relies on the groundwater (CWC 2006) and 60% of the cereals and other foods are irrigated from groundwater wells (Shah et al., 2000). Human health and plant growth were adversely affected by the poor quality of water (Thorne and Peterson, 1954) Groundwater exploitation has increased substantially, principally for agricultural purposes. As major areas of the nation suffers annually from low rainfall and variable surface water sources flow.

The Canadian Council of Ministers of the Environment additionally built up a WQI to rearrange the revealing of intricate and massive scale water quality information (CCME 2001). The final product of the WQI calculation is a solitary unit-less number that lies between 0 and 100. (Glozier et al., 2004; 2006) and classification is shown in Table 1.

The CCME WQI is calculated as follows.

$$WQI = 100 - \left(\sqrt{\frac{F_1^2 + F_2^2 + F_3^2}{1.732}} \right)$$

The constant, 1.732, is a scaling factor (square root of three) to ensure that the index varies between 0 and 100.where:

F1 represents Scope: this expresses the degree of water quality guidelines non-compliance all through intrigue.

$$F1 = \left(\frac{\text{No. of failed variables}}{\text{Total no.of variables}} \right) X100$$

F2 represents Frequency: This expresses the level of individual tests that doesn't meet the objectives.

$$F2 = \left(\frac{\text{No. of failed tests}}{\text{Total no .of test}} \right) X100$$

F3 represents Amplitude: This expresses the sum by which failed test don't meet their objectives This is determined in three stages.

Step 1 - Calculation of Excursion

The excursion includes several times concentration of an individual sample which is more important than the purpose.

When the test value must not exceed the objective

$$Excursion = \left(\frac{\text{Failed test value}}{\text{Objective}} \right) - 1$$

When the test value must not fall below the objective:

$$Excursion = \left(\frac{\text{Objective}}{\text{Failed test value}} \right) - 1$$

Step 2 - Calculation of Normalized Sum of Excursions

The standardized entirety of excursions, nse, is the aggregate sum by which individual tests are out of consistence. This is determined by summing the outings of their tests from their goals and dividing by the total number of criteria (meeting objectives and those not meeting objectives).

$$nse = \frac{\sum_i^n excursion}{\text{Number of tests}}$$

Step 3 - Calculation of F3

F3 is calculated by an asymptotic function that scales the normalized sum of the excursions from objectives to yield a range from 0 to 100.

$$F3 = \left(\frac{nse}{0.01nse + 0.01} \right)$$

Though the CCME WQI is broadly acknowledged, it experiences a few restrictions. The constraints incorporate the loss of data by consolidating a few factors to a solitary index value, the loss of data among factors, the absence of convenience of the index to various biological system types and the affectability of the outcomes to the formulation of the index (Zandbergen and Hall, 1988).

2. Study area

Mathura district is located about 130 km from south-east of Delhi in the semi-desert or gray steppe soil region of south-eastern Uttar Pradesh bordering Aligarh district on the north-eastern side. The population of Mathura district is 25.47 Lakhs. The investigated area lies within latitudes 27° 14′ and 27° 17′ and longitudes 77° 17′ and 78° 12′ and covers about 3303 sq.km (shown in Fig. 1).The mean the average monthly temperature is about 42 °C in summer and 7 °C to 26 °C in winter season (Sant Lal, 2012). The only drainage in the area is the Yamuna river which enters the city from the north and after following a meandering course is passed out of the area in the SSE direction in the Agra district.

3. Geology

Study area covers geological strata with the homogenous formation and does not show any significant structural complications. Quaternary alluvial tract covers most of the part in Mathura district except for few NE- SW trending ridges, which expose Delhi Super Group of rocks in the west. Heron carried out hard rock mapping (Heron, 1922); in the region, Quaternary geological and geomorphological mapping in the alluvial tract of Mathura district shown in Table 2**.** The Mathura Older Alluvial Plains are flat to gently undulating alluvial tract covering most of the area. In the marginal tracts of Yamuna in the southern region, badlands and ravinous tracts are developed (District & Pradesh, 2006).

4. Methodology

Geochemical data was gathered to identify the industrial impact in the Mathura district. Sixty-five water samples were taken from the piezometer borehole by the Central Ground Water Board (CGWB) from various parts of the Mathura city in July 2017. After the evacuation of this stale water, the samples were stored in prewashed high-thickness polypropylene (HDPP) bottles following the standard strategy. The groundwater samples were analyzed for pH, electric conductivity (EC), total hardness (TH) as $CaCO_3$, calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), potassium (K^+), bicarbonate (HCO_3^-), chloride (Cl^-), sulphate (SO_4^{2-}), nitrate (NO_3^-) and fluoride (F^-), following the standard methods (APHA-AWWA-WEF 2005). Whereas EC is specified in terms of μS/cm at 25 °C. For analytical study, software's like AquaChem and Microsoft Excel are employed by using charge-balance error for major ionic contents, did not exceed 10%.The obtained final results of major ion concentration have been compared by the Bureau of Indian Standard (BIS, 2012) and the World Health Organization (WHO, 2011)

Table 1
WQI Categorization on the basis of CCME.

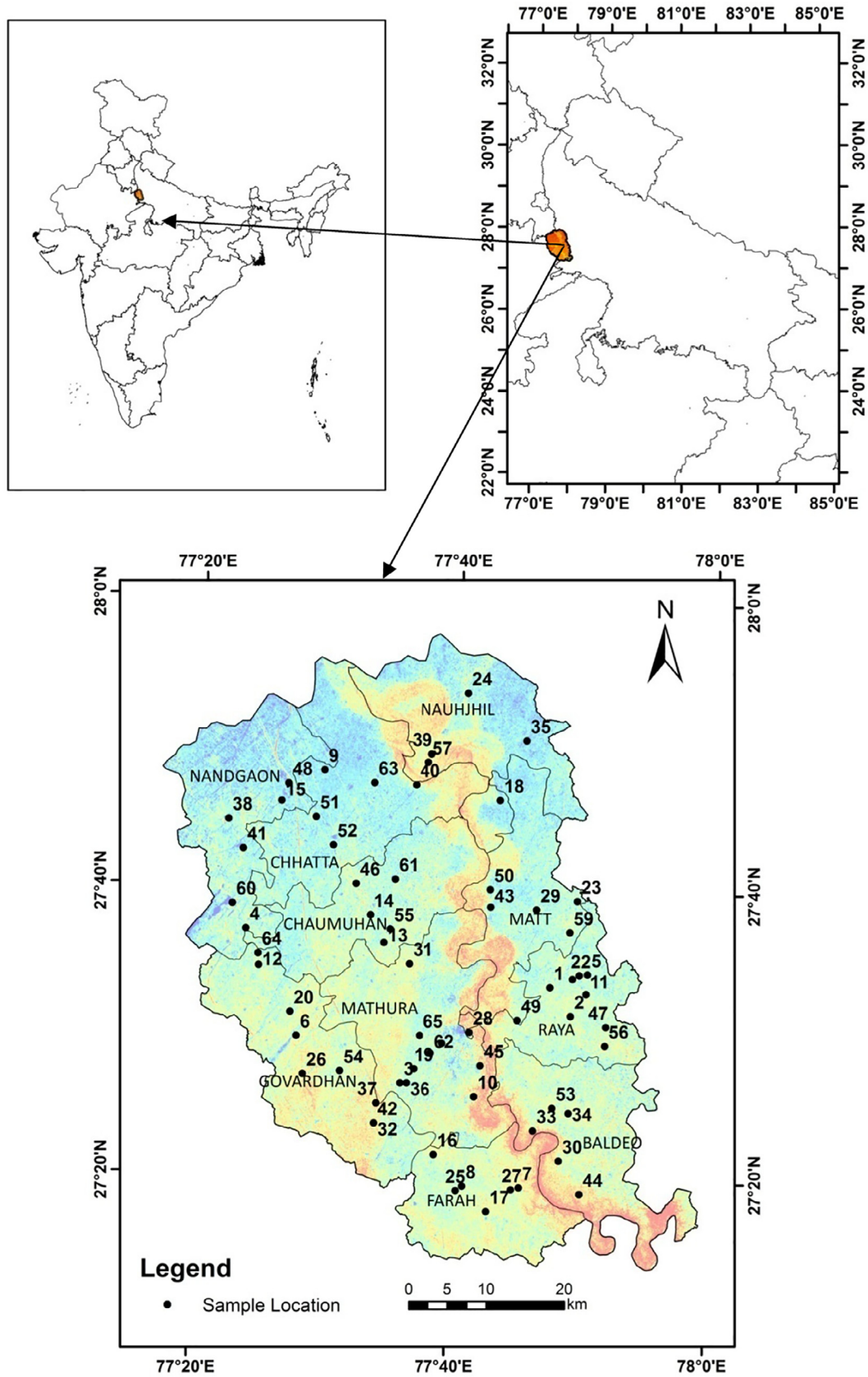| S.no	Rank	Value
1	Excellent	95–100
2	Good	80–94
3	Fair	65–79
4	Marginal	45–64
5	Poor	0–44

Fig. 1. Base map area with sample location.

Table 2
Geological succession of the Mathura district (GSI, 2006).

Group	Age	Formation	Lithology
Quaternary	Holocene	Yamuna Recent Alluvium Yamuna Terrace Alluvium Mathura Older Alluvium	Coarse-grained, quartzo-feldspathic sand reddish in color, occurs in patches in the western part and micaceous grey sand. It is composed of grey micaceous sand, clay and over bank silt. It is composed of a multicyclic sequence of clay, silt, and sand with calcrete.
	Middle to Late Pleistocene	Older Alluvium (Varanasi Alluvium)	Oxidized silt changes Khaki to brownish yellow, clay with kankar disseminations, and sand varies from grey to brown fine to medium-grained.
		Unconformity	
Proterozoic-III	Vindhyan Supergroup		Upper Bhander sandstone, Quartzite, Phyllite and shale Group.

5. Results and discussion

The vital water quality characteristics as laid down in the BIS Standards are given in Table 3 and the geochemical results are compared as illustrated in shown in Table 4.The chemical analysis of data is further analyzed for various irrigational water classification system shown in Table 5.

The variation in pH from 6.5 to 8.5is noticed in water samples. They were observed to be well within the prescribed limit. Electrical Conductivity is an estimation of the capability of fluid to convey an electrical flow. The electrical conductivity of the samples varied from 901.0 μS/cm to 14400.0 μS/cm at 25 °C. 67% of the samples show>2250 μS/cm which was above EC allowable limit. The enormous variation in EC value is associated with geochemical methods like particle exchange, reverse interaction and exchange, silicate weathering, evaporation, oxidation and sulfate reduction. (Ramesh, 2008). An increased concentration of sodium, magnesium, calcium and some other salts which result in high measures of TDS. Agrochemicals are mainly responsible and are a source for TDS as and occur as a mineral in the soil. 500 mg/L as the acceptable limit and 2000 mg/L as the permissible limit given by BIS for TDS in the absence of an alternate source of drinking water. TDS ranged from 848.0 mg/L to 17170.0 mg/L for the water samples. 78% of the water samples exceeded the 2000 mg/L permissible limit of TDS.Provenance that provides calcium incorporate feldspars from igneous and metamorphosed rocks, gypsum & carbonates (Kovalevsky et al. 2004). The value of calcium for the water samples ranged from 4.8 mg/L to 881.2 mg/L. Only 9% of the water samples exceeded the BIS permissible limit of 200 mg/L. Daily intake of sodium in excess can affect people with hypertension while pregnant ladies experience toxemia. The value of sodium varied from 45 mg/L to 2200 mg/L for the samples. A large portion of the groundwater contains generally low measures of magne-

sium; in any case, dolomitic rock or Mg-rich evaporitic rocks come in contact with water cause rise in value of magnesium. The value of magnesium ranged from 31.2 mg/L to 1013.0 mg/L. The permissible limit of magnesium 100 mg/L was exceeded by 84% in the water samples.The hardness of water depends upon the dissolved mineral, mostly magnesium and calcium. It does not possess a health risk. But hard water can be problematic on plumbing stopcocks, poor soap leather and detergent performance. Hardness ranged from 180 mg/L to 4720 mg/L. The allowable limit of 600 mg/L was exceeded by 69% of the samples. The value of bicarbonate varied from 39 mg/L to 1027 mg/L. 24% of the water samples exceeded this allowable limit given by BIS. It is the most widely recognized type of sulfur in extremely oxygenated water. BIS has recommended 200 mg/L as acceptable limit and 400 mg/L as the prescribed limit for sulfate. Sulfate changed from 5.1 mg/L to 2237.7 mg/L for the samples. 42% of the standards surpassed as far as possible. Youngsters, teenagers and the old are at a conceivably high danger of dehydration from diarrhea that might be caused by abnormal amounts of sulfate in drinking water (US EPA, 1999a,b). Nitrate (NO3) is found naturally in the earth and is significant for the plant as a supplement. Methemoglobinemia (blue infant disorder) in babies and is also the cause of cyanosis in infants (Young et al., 1976). The nitrate content of the samples varied from 0.01 mg/L to 149.32 mg/L. Only 12% of the samples exceeded the allowable BIS limit i.e 45 mg/L Fluoride is found in every single normal water at some concentration. Abundance in fluoride admission causes various kinds of fluorosis, basically dental fluorosis. BIS has recommended 1 mg/L as far as possible and 1.5 mg/L as permissible. All the examined samples were within the recommended limit by BIS.Taste limits for the chloride anion rely upon the related cations and are in the scope of 200–300 mg/L for sodium, potassium and calcium chloride. Given at edge, BIS has endorsed 250 mg/L as allowable limit and 1000 mg/L as the permissible limit. Chloride content for the water

Table 3
Drinking water – Specification (Second Revision of IS 10500:2012).

S.No.	Characteristics	Acceptable Limit	Permissible Limit
Physical Parameters			
1	pH	6.5 to 8.5	No Relaxation
2	EC, 25 °C (μmhos/cm) (Max)	2250	
3	TDS (mg/L)	500	2000
General Parameters Concerning Substances Undesirable in Excessive Amounts			
4	Calcium (as Ca) , mg/L, Max	75	200
5	Chlorides (as Cl) mg/L, Max	250	1000
6	Fluoride (as F), mg/L, Max	1	1.5
7	Magnesium (as Mg), mg/L, Max	30	100
8	Nitrate (as NO_3), mg/L, Max	45	No Relaxation
9	Sulphate (as SO_4), mg/L, Max	200	400
10	Total Alkalinity (as $CaCO_3$), mg/L, Max	200	600
11	Total Hardness (as $CaCO_3$), mg/L, Max	200	600

Table 4
Physicochemical parameters and analyzed results of the study area (mg/l).

S.no	Parameters	Min	Max	Mean	Skewness	Std. Dev.
1	pH	6.5	8.6	7.34	0.49	0.44
2	Ec (μS/cm)	901	14,400	3943	1.51	2855
3	TH	180	4720	1306	1.3	985
4	TDS	848	17,170	4963	1.34	3785
5	Mg	31.2	1013	268.1	1.43	197
6	Na	45	2200	562	1.83	437.6
7	Ca	4.8	881.2	82.5	3.8	147.2
8	HCO_3	39	1027	465.8	0.27	201.6
9	CO3	0	104	17.64	1.67	32.04
10	F	0.81	1.41	0.72	0.0	0.33
11	Cl	156.20	3905	1083	1.48	972
12	NO_3	0.01	149.32	19.85	2.81	35.09
13	SO_4	5.1	2237.7	437.1	1.94	410.8

Table 5
Suitability indexes for industrial & irrigation purposes of the study region.

S.no	Parameters	The formula used for calculation	Min	Max	Mean	Std. Dev.
1	Sodium percentage	$Na\% = \frac{(Na+K)}{(Ca+Mg+Na+K)} \times 100$	8.37	86.66	54.84	15.41
2	Sodium Absorption Ratio	$SAR = \frac{Na}{\sqrt{\frac{Ca^{2+}+Mg^{2+}}{2}}}$	0.67	21.82	7.304	4.169
3	Kelly Ratio	$KR = \frac{Na}{Ca+Mg}$	0.06	6.26	1.381	1.147
4	Residual Sodium carbonate	$RSC = (CO_3^{2-} + HCO_3^-) - (Ca^{2+} + Mg^{2+})$	−90.59	7.71	−17.96	20.97
5	Permeability index	$PI = \frac{Na+\sqrt{HCO3}}{Ca+Mg+Na} \times 100$	9.59	98.0	58.54	18.23
6	Magnesium hazard	$MAR = \frac{Mg}{Ca+Mg} \times 100$	45.6	8221	1307	1333
7	Potential salinity	$PS = Cl^- + \frac{1}{2SO_4^{2-}}$	4.58	112.83	35.11	27.21
8	Gibbs ratio	Gibbs ratio I for Anion $= \frac{Cl^-}{Cl^-+HCO3}$	0.5	0.99	0.89	0.1055
		Gibbs II for Cation $= \frac{Na^++K^+}{Na^++K^++Ca^{2+}}$	0.28	0.98	0.71	0.1973

samples varied from 156.20 mg/L to 3905.00 mg/L. 43% of the samples exceeded the acceptable limit.

6. Water quality for irrigation

A noteworthy connection between SAR values of irrigated water and the degree to which sodium is soaked by soil. If groundwater utilized for agriculture is high in sodium concentration and low in calcium value, the cation-interchange complex may end up with sodium saturation. A low SAR of 2 to 10 demonstrates little risk from sodium; the medium risk is within 10 to 18; the great danger lies between 18 and 26 and exceptionally great danger is over 26. The lower the ionic stability of the aqueous solution, the more prominent is the sodium hazard for a given SAR value of the samples. The sodium absorption ratio for the water samples varied from 0.67 to 21.82. The sodium concentration is viewed as a crucial aspect in deciding the groundwater suitability for irrigation because soil permeability deteriorates by destroying its complex structure (Todd1980). The movement of sodium from the upper horizon to lower horizon results in hardening of the soil and prevents aeration to the roots of the plant (Wilcox, 1948). Sodium

percentage for the analyzed samples varied from 8.37% to 86.66%. EC and Na % relation shown in Fig. 2.

Kelley's ratio (Kelly, 1940) is obtained by sodium value divided by the Ca^{2+} and Mg^{2+} value. Excess of sodium level in waters lead to KR value more than one. Henceforth, water with a Kelley proportion under 1 are appropriate for agricultural activities, while those with a percentage more than one are unacceptable for irrigation. The values vary from 0.06 to 6.26 for the water samples. Permeability index (Doneen, 1964) has been utilized for the assurance of appropriateness for groundwater for agriculture. A continuing horticulture process will ruin the soil permeability because of Na^+, Ca^+, Mg^{2+} and HCO_3^- precipitation in soil. Permeability Index (PI) is an appropriate criteria for the evaluation of ions (Subramani et al., 2005). Permeability index varies from 9.59 to 98.0 for the analyzed water samples (Fig. 3). The quality of the soil is antagonistically influenced by the high magnesium content in agriculture. For this type of cases, the soil is turned out to be alkaline, bringing about diminished farming yield. The significant genesis of magnesium in the groundwater is because of ion exchange of minerals in rocks and soils by water. Magnesium hazard ranged from 45.57 to 8221.0 for the water samples. Gibbs diagram is used to illustrate factors controlling the chemistry of water. In the study
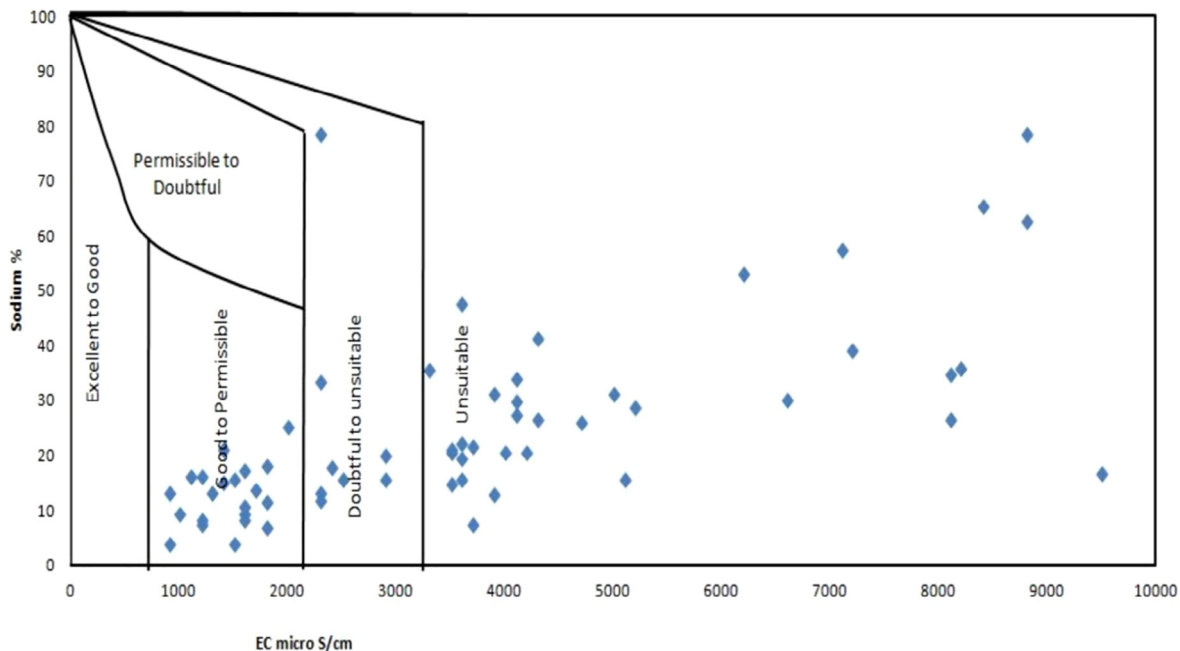

Fig. 2. Relation between EC and Na % to understand water quality (Wilcox diagram).
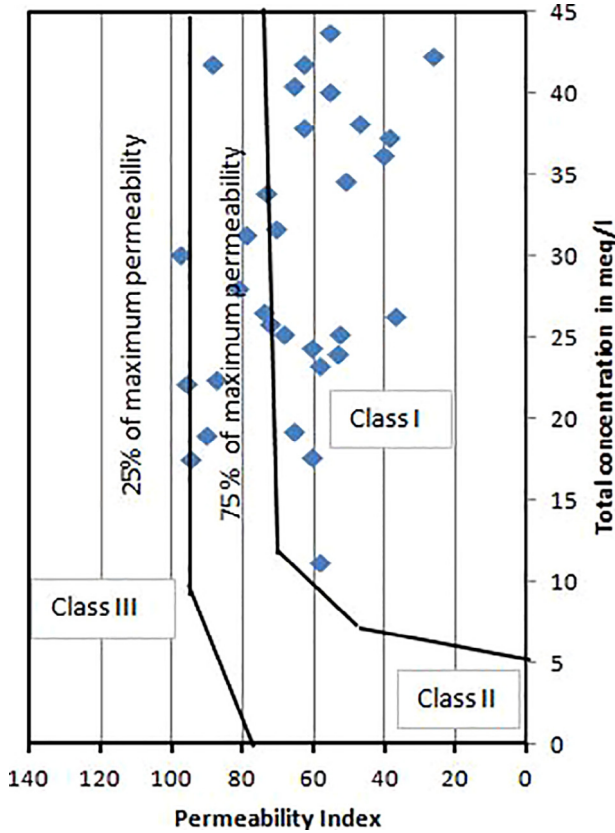
Fig. 3. Evaluation of the quality of the groundwater for irrigation purposes based on PI and total ions.

area, Gibbs ratio I varies from 0.50 to 0.99 with a mean of 0.89 while Gibbs ratio II ranges from 0.28 to 0.98 with an average value of 0.71. The Gibbs ratios plotted against TDS and it is revealed that the aquifer in the study area is predominately influenced by evaporation shown in Fig. 4.

The felicity of water for farming isn't liable only on dissolvable salts is explained by Doneen (1964). Since the low dissolvability salts assemble in the soil with every continuous irrigation cycle, the dissolvable salts cause to increase the salinity in the soil. The PS of the water specimens extends from 4.58 to 112.83 meql^{-1} with a normal of 35.11 meql^{-1}. It prescribes that the PS in the groundwater of the study area is nearly outrageous and water is unsatisfactory for utilization in farming. High sulfate content is directly proportional to the potential salinity. The overabundance entirety of carbonate and bicarbonate content in groundwater over the aggregate of calcium and magnesium substance impacts the appropriateness of water for irrigation. It very well may be deciphered that the groundwater in the investigation region indicates RSC estimation of − 90.59 to 7.71 meql^{-1} with a standard estimation of 18.96 meql^{-1}. In light of the US Salinity Laboratory (1954), more than sixteen samples have values < 1.25 meql^{-1} and are fine for agriculture; eleven specimens have values somewhere in the range of 1.25–2.5 meql^{-1} are doubtful in quality and thirteen samples have RSC values > 2.5 meql^{-1} and are inadmissible for different activities of irrigation. Sodium carbonate accumulation is being accelerated by the water which has high RSC values and results in low fertility of soil. (Eaton 1950).

7. Water quality index

A water quality index gives beneficial techniques for complex water quality information into data that is justifiable and useable by the general population. It is prescribed that at the very least, four factors are examined, in any event, multiple times be utilized in the computation of index values. It is likewise expected that the elements and objectives picked will give applicable data about a specific site. To evaluate the appropriateness of water for different uses, there is a need to revert indices like the air quality model that will order the nature of water. WQI ranged from 1.86 to 82.25 (Table 6) for the analyzed water samples of different sample sites. The WQI map was prepared in the GIS environment using the IDW method; this map was classified on the basis CCME categorization according to their values (Fig. 5). The map having red color shows
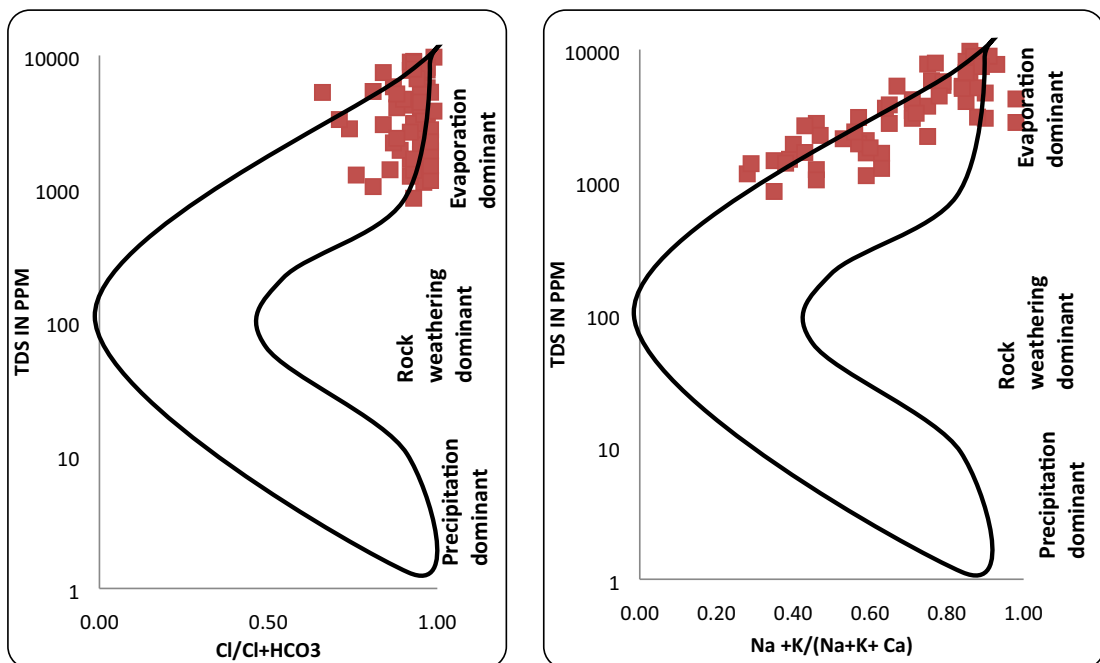

**Fig. 4.** Gibbs's diagram for the water samples.

Table 6
Different sites showing water Quality Index.

.no	Locations	WQI	Sno	Locations	WQI
1	RAYA 2	18.99	36	USFAR 2	8.54
2	NAURANGIA JAGATIYA	15.91	37	LALPUR	18.00
3	USFAR	37.91	38	GIDOH	31.57
4	NAGLA JHARELA	18.65	39	MAKDOOMPUR	19.67
5	KHUMA	82.25	40	SHERGARH 1	17.77
6	GOVERDHAN2	38.24	41	NANDGAON	15.23
7	FARAH B.D.O	36.00	42	SON	51.62
8	BERI	46.98	43	MATT 1	29.48
9	FALAIN	53.22	44	CHARMARPUR	62.01
10	SIMANA	1.86	45	MATHURA B.D.O	79.09
11	MATHURA REFINERY	53.39	46	NARISEMRI	6.96
12	PALSON	58.97	47	NUNERA	21.18
13	AAJAI KHURD	81.01	48	KOSHI	26.52
14	AKBARPUR	76.11	49	SHAHPUR	69.88
15	HARIPUR	65.82	50	BIJAULI	81.87
16	SERSHA	39.76	51	GOHARI	53.66
17	JAMALPUR	29.02	52	CHHATTA	26.73
18	SURIR KALAN	69.27	53	HOTHODA	40.16
19	MUKDMPUR	71.15	54	PAIGAON	52.12
20	NEEMGAON	6.68	55	CHAUMAUHAN B.D.O	2.10
21	PIRSUA	71.96	56	NAGLA BHARAU	62.17
22	BEHRANA	52.18	57	CHHINPARI	61.86
23	NEEMGAON	31.89	58	SABJI MANDI	26.39
24	BAZZNA	79.83	59	ANDUA	22.10
25	NAGLA SAJNA	5.76	60	BARSANA	63.47
26	PAINTHA	15.73	61	TARAULI JANVI	7.88
27	RAHEEMPUR	45.91	62	PALIKHERA	25.27
28	YAMUNA Mathura City	73.07	63	HUSSAINEE	71.49
29	JABRA	37.62	64	SHEHI	40.23
30	DAULATPUR	38.23	65	SATOHA	36.61
31	JAIT	17.10			
32	SONKH1	11.55			
33	HABEEBPUR	26.10			
34	BALDEO B.D.O	80.84			
35	HASANPUR	81.91			

Fig. 5. Water Quality Map based on CCME of the study region.

the quality of water is poor in the study region and covers the maximum area in the central part and western part of the district. A patch of blue color rises from the northern part and passes through the central part and ends at the southern area of the region shows the marginal quality of water. Yellow spots covered small area through the region and show intermediate at the northeastern part. A tiny patch of good quality water has been noticed and denotes with pink color.

8. Conclusion

From the results of the WQI of 65 water specimens, the quality of water in the study region lies in between poor and marginal index. Analytical techniques combined with GIS methodologies have been utilized to distinguish suitability and quality of water sites in the Mathura area for affordable drinking and agricultural purposes. The outcome of analysis demonstrate that water quality in many parts of the investigation region is unsatisfactory for household and agriculture activities. The results of physico-chemical parameters like EC, Cl⁻, TDS, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_3^- and Hardness lies above the maximum permissible limit in maximum number of samples prescribed by WHO and BIS. The suitable sites identified on the basis of the spatial distribution characteristics are located at north-east and some small area of central part of the Mathura district. The main reason for the high concentration of various water quality parameters is geogenic. Khuma, Ajai Khurd, Bazzna, Baldeo, Hasanpur, Mathura B.D.O and Bijauli are the places in the study region where the water quality was found good. Different irrigation indices show the water is not suitable for irrigation. It is proposed that appropriate treatment strategies and measures ought to be actualized before the utilization of the water
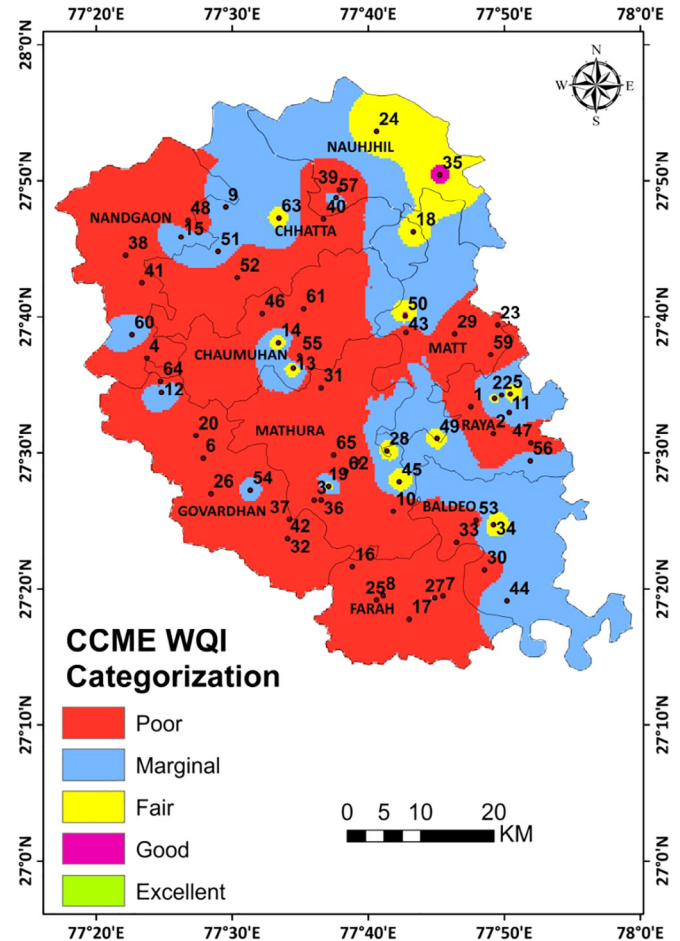
for drinking and irrigation. Besides, to handle the groundwater consumption in the area, it is prescribed to adjust sprinkling irrigation for relevant usage of assets and to conquer the water scarcity faced in the future.

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