Assessment of Groundwater Using Water Quality Index (WQI) at Saharanpur City, Uttar Pradesh (West), India

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Abstract Groundwater is a natural resource and plays a vital role in our life. The study was carried out to access the groundwater quality of Saharanpur district, Uttar Pradesh. The assessment study was formulated in WQI to understand more about groundwater quality in a single term. Water Quality Index (WQI) summarizes numerical equations in a single term to understand better the quality of water. It is also helpful in determining the valuable rating of water quality and appropriate technique for its treatment. It also communicates information about water quality to the public and legislative decision-makers. In the present study, groundwater samples were collected from different locations, and WQI has been computed using seven parameters viz., pH, Total Hardness, Total Alkalinity, Electrical Conductivity, Calcium, Magnesium and Chloride. The result shows that WQI for all the locations were higher than 100 and in some locations, it was more than 200, which means the water quality is extremely poor and not drinkable.

Keywords Water quality index · Groundwater quality · Water analysis

1 Introduction

Groundwater is a natural dynamic renewable resource with consideration of all others [1]. Its availability in adequate quantity is very important for human life and other purposes. Human life depends, in direct (for drinking) and indirect ways (like cooking, washing, bathing, etc.), on fresh water. Groundwater is the most crucial source of potable water throughout the world [2]. It is generally consumed

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by drinking, washing, preparing food and so forth. Groundwater defilement due to anthropogenic exercises is a worldwide issue for domain researchers and policymakers. Among the anthropogenic exercises, industrialization, urbanization, solid waste unloading, present-day rural and so forth assume a huge part in tainting of freshwater aquifers [3–8]. But presently due to a lack of discipline and weak legislations toward conservation, the quality and quantity of water became polluted and spoiled. Consequently, the number of water-borne diseases which cause health hazards has increased [9]. Nonetheless, the greater part of the investigations connected with groundwater quality examinations have been completed in the eastern or focal district of Uttar Pradesh, and there is an earnest need to lead such a review in the western locale. Saharanpur district falls under the Hindon River catchment [2]. That's why it is necessary to monitor the quality of groundwater regularly to observe the demand and level of pollution in it.

The present study mainly focused on the physiochemical analysis of groundwater samples of different locations and formulated the results in the WQI to conclude the exact quality of groundwater whether drinkable or not.

2 Materials and Methods

2.1 Study Area

As shown in Fig. 1, the study was carried out at Saharanpur city, Uttar Pradesh. The Saharanpur district is very near to the Shivalik hills range and lies under the upper Ganga-Yamuna region of northern India [10]. The mean sea level of Saharanpur district is ~269 m, and the annual mean rainfall is approximately 1150 mm [11]. Due to the deposition of alluvium soil across the district by the tributaries of two rivers, the soil is fertile. The population of the district is 3,464,228 out of which 69% lives in rural locations [12]. Thus, mostly the population depends on agriculture for their livelihood. The important industries in Saharanpur include the tobacco industry, cotton industry, paper mill, sugar industry and woodwork industry. The majority of the population depends on hand pumps and bore wells for water requirements. The samples for the study were collected from 18 different sites as shown in Fig. 2.

2.2 Sample Collection

Groundwater samples from hand pumps and bore wells of different locations were collected in bottles (polyethylene) which were prewashed by diluted acid and soaked with deionized water. Before sampling, hand pumps and bore wells were pumped for 10 min to remove standing water from the sources to get a representative sample. The samples were properly preserved and carried to the laboratory of Environmental

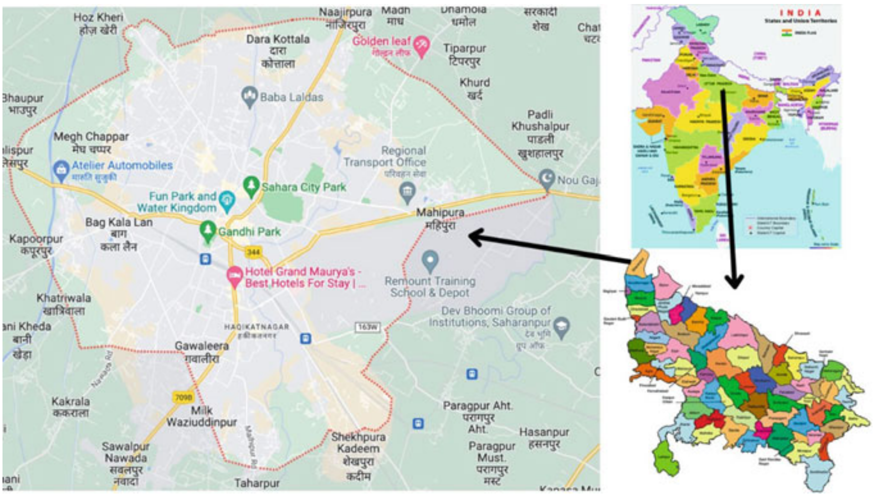

Fig. 1 Image showing study area

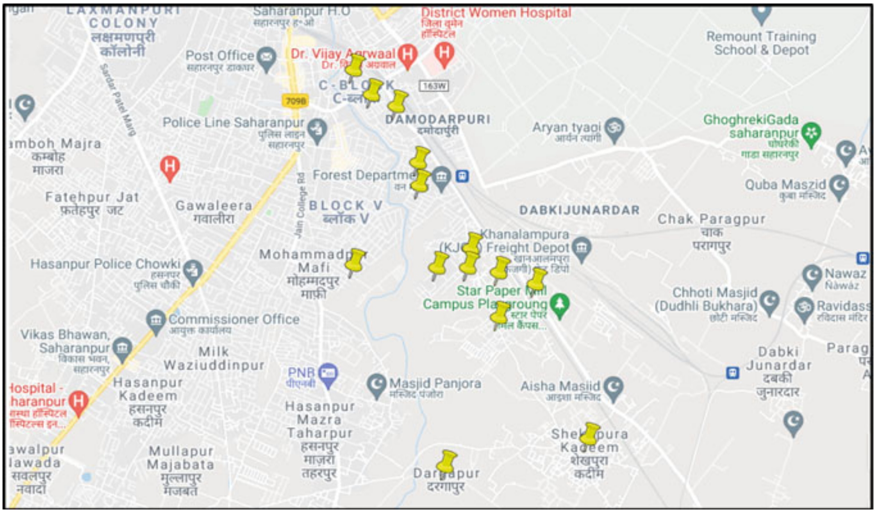

Fig. 2 Image showing sites of sample collected

Management Division, Central Pulp & Paper Research Institute, Saharanpur, India, for further analysis. The analyses were carried out as per standard [13]. All the samples were analyzed in duplicate to ensure more accuracy and less error.

In the present study, seven important parameters were chosen for the calculation of WQI. The standards for drinking water quality recommended by World Health Organization (WHO) [14], Bureau of Indian Standards (BIS) [15] and Indian Council for Medical Research (ICMR) were taken to compute Water Quality Index (WQI).

Table 1 Drinking water standards as per recommended agency [14, 15]

S. No	Parameter	Standard (Sn)	Recommended agency	Relative weight (Wn)
1	pH	6.5–8.5	ICMR/BIS	0.219
2	Electrical conductivity (EC)	300	ICMR	0.371
3	Total alkalinity	120	ICMR	0.0155
4	Total hardness	300	ICMR/BIS	0.0062
5	Chloride	250	ICMR	0.0074
6	Calcium	75	ICMR/BIS	0.025
7	Magnesium	30	ICMR/BIS	0.061
				$\sum$**Wn = 0.7051**

Note All values are in mg/l except pH and EC (μS/cm)

The weighted arithmetic index method [16] was adopted to calculate the WQI (Table 1)

$$WQI = \frac{\sum qnWn}{\sum Wn}$$

where

qn = Quality rating (nth water quality parameter) and n = 1, 2, ……0.6.

Wn = Relative weight of nth parameters.

Now,

$$qn = \frac{100(Vn - Vio)}{(Sn - Vio)}$$

where

Vn = Estimated value (nth parameter).

Sn = Permissible value (nth parameter).

Vio = Ideal value (nth parameter for pure water).

Vio = 7.0 (for pH) and, 0 (for all other parameters).

And,

$$Wn = \frac{K}{Sn}$$

where

K = Proportionality Constant.

$$\text{Now } \mathbf{K} = \mathbf{1} / \sum (\mathbf{1}/\mathbf{Sn})$$

Table 2 Degree of water quality based on the value of WQI

WQI ranges	Degree of water quality
0–25	Excellent
26–50	Good
51–75	Poor
76–100	Very poor
>100	Unsuitable

The water quality index describes the quality of water as per Chatterji et al., 2002, given in Table 2.

3 Results and Discussion

The results of the physiochemical analysis of groundwater samples of different locations are presented in Tables 3 and 4 and Fig. 3.

The analysis results of different parameters of groundwater samples as presented in Table 3 reveal that only pH and Chloride concentrations meet the permissible limits as per the recommended agency. All other parameters were not meeting the prescribed standard permissible limits, except one or two locations for a specific parameter. The EC levels in all samples were found to be high in all locations. Only three sites were found to be ≤0.5 mS/cm, which was close to the permissible limit, i.e., 0.3 mS/cm. Out of 18 locations, only one location was found to meet the permissible limit of Total Alkalinity. For Total Hardness and Calcium, only 8 locations were found to meet the standard limit. Nine locations were found to meet the permissible of magnesium.

The possible impacts on groundwater quality may be likely due to the discharge of untreated sewage water and industries' effluent into river streams, as the city is an industrial hub of all kinds of large- and medium-scale industries. A seasonal river named Dhamola is also flowing on the side of the selected locations carrying municipal, household and industrial wastewater. The wastewater and waste are dumped into the river without any treatment. This may also degrade the groundwater quality by contaminating the groundwater aquifers through sediment percolation.

4 Conclusion

Among all the sampling locations, the value of different parameters varies significantly due to various anthropogenic means. Understanding the groundwater quality is important because it decides the suitability of water for different purposes like drinking, bathing, cooking, etc. It is difficult to understand the suitability of specific parameter results because all the parameters are not under permissible limits. Thus,

Table 3 Physiochemical analysis of different samples

Locations	pH	EC (mS/cm)	Total alkalinity (mg/l)	Total hardness (mg/l)	Chloride (mg/l)	Calcium (mg/l)	Magnesium (mg/l)
Himmatnagar	7.12	1.12	436	440	86.37	99	47
IPT campus	7.57	0.5	285	226	17	51	24
Indra Gandhi Colony-I	7.13	0.51	420	250	27.19	57	26
Indra Gandhi Colony-II	7.05	0.56	340	225	28.4	58	22
Near paper mill	7.01	0.93	450	357	50.18	79	39
Rajvihar	7	1.18	506	542	71	145	43
Anjani Vihar	7.39	0.75	352	352	58.39	82	29
Kapil Vihar-I	7.35	1.1	650	532	117	117	58
Kapil Vihar-II	7.25	0.93	458	384	56.38	88	39
Brahmpuri Colony	7.1	0.71	416	239	50.18	56	24
Brijesh nagar	7.6	0.7	398	225	95.17	58	22
Shastrinagar-I	7.54	0.96	512	408	79	112	31
Shastrinagar-II	7.42	0.9	470	435	70.4	102	44
Vinay vihar	7.54	0.64	400	294	37.38	68	30
Dargapur	7.29	1.01	588	388	69	95	37
Shekhpura-I	7.14	0.5	608	228	51	61	18
Shekhpura-II	7.18	1.71	614	500	151	146	33
CPPRI colony	8.24	0.45	55	210	8	48.1	22.1

WQI is formulated for the water with seven different water quality parameters to understand the quality of water in a single term. The study reveals that the WQI of all the locations was greater than 100. And in some locations, it was found to be more than 200. It means that the quality of water in these locations is extremely poor and not suitable for drinking purposes. The study provides useful information to plan and execute suitable practices to combat groundwater pollution in the study area.

Table 4 Calculation of water quality index (WQI) for different locations

Sample location	pH	qn (pH)	EC (mS)	qn (EC)	Calcium (mg/l)	qn (Ca)	Total hardness (mg/l)	qn (TH)	Chloride (mg/l)	qn (Chloride)	Total alkalinity (mg/L)	qn (TA)	Magnesium (mg/l)	qn (Mg)	WQI
Himmatnagar	7.12	24	1.12	373.33	99	132	440	146.67	86.37	34.548	436	363.33	47	156.67	231.76
IPT campus	7.57	114	0.5	166.67	51	68	226	75.333	17	6.8	285	237.5	24	80.00	138.39
Indra Gandhi Colony-I	7.13	26	0.51	170	57	76	250	83.333	27.19	10.876	420	350	26	86.67	116.26
Indra Gandhi Colony-II	7.05	10	0.56	186.67	58	77.333	225	75	28.4	11.36	340	283.33	22	73.33	117.42
Near paper mill	7.01	2	0.93	310	79	105.33	357	119	50.18	20.072	450	375	39	130.00	188.21
Rajvihar	7	0	1.18	393.33	145	193.33	542	180.67	71	28.4	506	421.67	43	143.33	237.37
Anjani Vihar	7.39	78	0.75	250	82	109.33	325	108.33	58.39	23.356	352	293.33	29	96.67	175.65
Kapil Vihar-I	7.35	70	1.1	366.67	117	156	532	177.33	117	46.8	650	541.67	58	193.33	250.88
Kapil Vihar-II	7.25	50	0.93	310	88	117.33	384	128	56.38	22.552	458	381.67	39	130.00	203.80
Brahmpuri Colony	7.1	20	0.71	236.67	56	74.667	239	79.667	50.18	20.072	416	346.67	24	80.00	148.84
Brijesh Nagar	7.6	120	0.7	233.33	58	77.333	225	75	95.17	38.068	398	331.67	22	73.33	177.48
Shastrinagar-I	7.54	108	0.96	320	112	149.33	408	136	79	31.6	512	426.67	31	103.33	227.06
Shastrinagar-II	7.42	84	0.9	300	102	136	435	145	70.4	28.16	470	391.67	44	146.67	211.63

(continued)

Table 4 (continued)

Sample location	pH	qn (pH)	EC (mS)	qn (EC)	Calcium (mg/l)	qn (Ca)	Total hardness (mg/l)	qn (TH)	Chloride (mg/l)	qn (Chloride)	Total alkalinity (mg/L)	qn (TA)	Magnesium (mg/l)	qn (Mg)	WQI
Vinay vihar	7.54	108	0.64	213.33	68	90.667	294	98	37.38	14.952	400	333.33	30	100.00	166.01
Dargapur	7.29	58	1.01	336.67	95	126.67	388	129.33	69	27.6	588	490	37	123.33	222.52
Shekhpura-I	7.14	28	0.5	166.67	61	81.333	228	76	51	20.4	608	506.67	18	60.00	116.49
Shekhpura-II	7.18	36	1.71	570	146	194.67	500	166.67	151	60.4	614	511.67	33	110.00	340.86
CPPRI colony	8.24	248	0.45	150	48.1	64.133	210	70	8	3.2	54.5	45.417	22.1	73.67	166.25

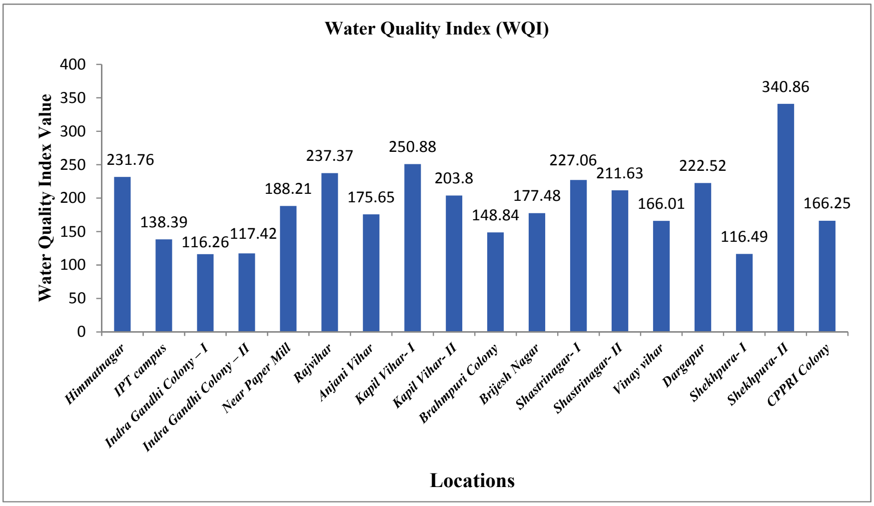

Fig. 3 Water quality index (WQI) for different locations

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