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Research Article

The Analysis of Water Quality Index with Study of the Effect of Textile Effluents on the Groundwater of Bhilwara City

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Abstract

Contamination of water is a big concern that is now existing not just in India but also all around the world. In the city of Bhilwara, which is located in India, there is a lack of well-organized drainage and sewer infrastructure, as well as poor management of solid waste. The quality of the water is decreasing as a result of the discharge of these contaminants into the Banas River, which is located nearby, through a variety of different channels. Therefore, the purpose of this study is to evaluate the existing groundwater quality in Bhilwara city by utilizing hadrochemical, multivariate statistical, and Water Quality Index (WQI) status. According to the conclusions of the study, the amount of potable water that is available in this little community is gradually decreasing. The water quality index (WQI) of the source, which can range anywhere from 62 to 74, reveals that the quality of the groundwater is deteriorating on a daily basis. There should be a comprehensive management strategy that includes monitoring cells, according to the findings of this study, in order to protect the water environment in the Bhilwara region.

Keywords

Contamination, Groundwater, Physicochemical, Water Quality Index, Correlation

1. Introduction

An rising number of contaminants are endangering the world's water resources by lowering the quality of the water in rivers, lakes, aquifers, and oceans [1]. Pollutant discharges via the sewage system are what drive it these days. Thus, the planning, development, implementation, monitoring, and auditing of water quality are all involved in water quality management [2]. Gaining further insight into the extent and consequences of issues related to water quality is essential for creating strategies and policies aimed at reducing pollution in the water supply [3]. The many and complex steps involved in evaluating the quality of the water are like a chain with around a dozen links; if one of them breaks, the assessment's overall reliability may suffer. [4]. Traditionally, aquatic environment quality evaluations have been primarily inspired by the need to verify if the observed water quality is adequate for planned usage. [5]. Water quality is now assessed by in situ measurements and the collection of water samples for additional research laboratory studies. These methods are vital for controlling and enhancing the quality of groundwaters [6]. Dissolved organic matter (DOM), oils, suspended sediments, pathogens, DOM, oils, and aquatic vascular plants alter the energy spectra of reflected solar radiation and/or thermal radiation that is emitted from surface water to the ground. These changes can be measured through the use of remote

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sensing techniques [7]. The mainstream of substances and microbes don't directly alter or modify the thermal or spectral characteristics of groundwaters [8]. They can only be identified indirectly by measurements of other water quality pointers affected by these compounds [9]. With 10.4% of the country's total land area, Rajasthan is the major state in India. It is also arguably the most magnificently architecturally designed, artistically decorative, and tribally diverse state in India. Industrialization began slowly in the 1960s, with textiles, agriculture, and minerals being the main industries [10]. Numerous villages are situated in close proximity to the textile industrial region of Bhilwara. The majority of these textile enterprises disposed of their waste in the open without any treatment, which has resulted in the ongoing degradation of the groundwater quality. Bhilwara produces more fabric than Maharashtra and Bhiwadi combined. Rajasthan is the second-largest producer of cement in India and the leader in quarrying and mining. [11]. Sambhar has abundant salt reserves, Khetri has copper mines, and Dariba-Bhilwara has zinc mines. Zinc mines at Zawar Mala and Rampura Aghucha, close to Bhilwara, are located [12, 13]. We aim to bring the attention of the policy makers to the fact that a new policy should be generated by the policy makers for the improvement of groundwater in the village. In the current study, an effort has been made to assess the impact of textile industries on the groundwater superiority of Bhilwara city.

2. Materials and Methods

2.1. Study Area

With 34.22 million hectares, or 10.5% of the nation's total size, Rajasthan is the biggest state in India, however it only shares 1.15% of its water resources [14]. 60% to 75% of the state is semi-arid or arid. With little and variable drizzle, high summer temperatures, low humidity, strong winds, a adverse water balance, and a severe water deficit, Western Rajasthan is dry to semi-arid [15]. The eastern part of the state experiences more humidity, calmer winds, and more rainfall in its semi-arid to sub-humid climate. Groundwater is overused in several parts of the state [16, 17]. The study area, which spans 76,546 km^2, comprises six districts that are centrally located in the state of Rajasthan. Atoon is located in Bhilwara. With 1616 men and 1607 women, there are 3223 individuals based on 2011 census data. With 647 homes, this community occupies 1501 hectares of the overall land area. Figure 1 depicts the research region, while Table 1 provides specifics such as physical, geological, and hydrogeological parameters.

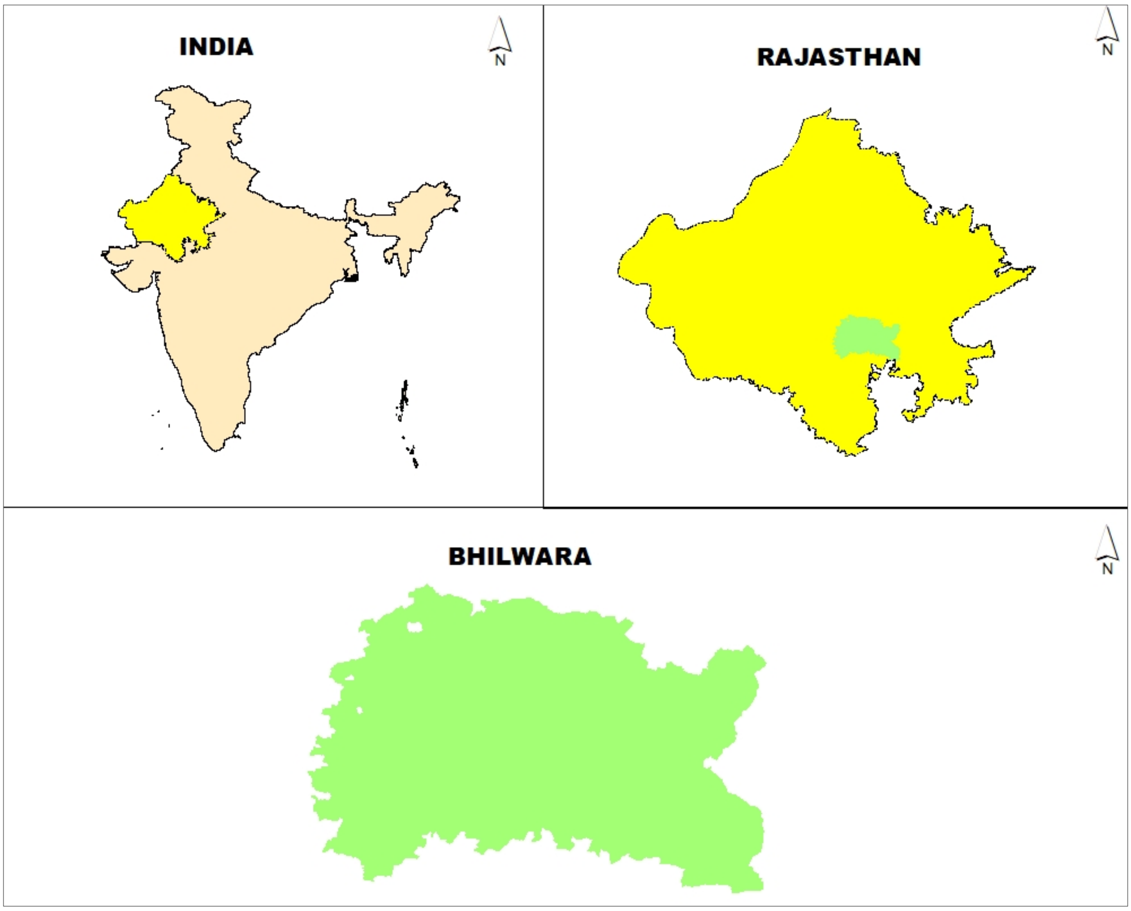

Figure 1. Study area map.

2.2. Water Sampling

Ground water samples from around Bhilwara city of Rajasthan were collected in pre-cleaned and rinsed polythene bottles of one-Liter capacity with necessary precautions [18, 19]. The samples were collected, from April 2021 to Dec. 2023 from manually operated hand pumps.

3. Physico-chemical Analysis

The following physico-chemical characteristics were examined for each sample: pH, total alkalinity (TA), total hardness (TH), calcium hardness (Ca H), magnesium hardness (Mg H), total dissolved solids (TDS), nitrate, fluoride, and electrical conductivity (EC), Water sample analyses were performed using accepted analytical procedures [20, 21]. When preparing the solutions, double-distilled water was used together with just AR-grade chemicals. Table 1 provides a summary of the analytical methodologies' specifics.

Table 1. *Parameters and methods employed in the physicochemical examination of water samples.*

S. No.	Parameters	Unit	Method Employed
1	pH		Digital pH meter
2	EC	µmhos/cm	Digital Conductivity Meter
3	Total Alkalinity	Mg/L	Titrimetric method (With HCl)
4	Total Hardness	Mg/L	Titrimetric method (with EDTA)
5	Sulphate	Mg/L	Spectrophotometric method
6	Nitrate	Mg/L	Spectrophotometric method
7	Fluoride	Mg/L	Digital Pen Fluoride Meter
8	TDS	Mg/L	Digital TDS-meter
9	Na	Mg/L	Flam photometry
10	K	Mg/L	Flam photometry

Table 2. *The value of different parameters and comparison with WHO standards.*

Parameters	2021	2022	2023	WHO limit
pH	7.5	7.6	7.9	6.5 - 8.5
EC	1380	1640	1350	1400
Total Alkalinity	323	228	140	600
Total Hardness	360	216	190	600
Sulphate	253	210	95	150
Nitrate	2.62	3.2	2.4	45
Fluoride	0.86	0.92	1.1	1.5
Total Dissolved Solid	1120	1226	894	500
Na	329	124	152	50
K	2.6	3.5	7.6	200

Table 3. The Anova analysis of selected parameters showing in table 2.

Anova: Single Factor				
SUMMARY				
Groups	***Count***	***Sum***	***Average***	***Variance***
7.5	9	3771.08	419.0089	248109.7
7.6	9	3651.62	405.7356	358652.9
7.9	9	2832.1	314.6778	227303.8
6.5 - 8.5	9	3546.5	394.0556	199938.7

ANOVA						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Groups	59428.36	3	19809.45	0.076632	0.972162	2.90112
Within Groups	8272041	32	258501.3			
Total	8331469	35				

It is evident from the Anova analysis in Table 3 that the p value is significantly less than the alpha value, we can conclude that the data we acquired during the experiment are excellent and free of any form of error.

4. Result and Discussion

Based on the findings result (Table 2) many parameters are beyond the limit shown by WHO. The water quality index of 2023 has the highest value the value of 2021, which indicates the pollution increased day by day in Bhilwara, Atoon is situated near an industrial area hence the greater the air and underground water pollution affected the water quality. The result of this is as follows:

Year-wise statistics of groundwater chemistry are presented in Table 2. pH values in the study area were within the recommended limit (6.5–8.5). The water in the area is normal to saline and Total Dissolved Solids (TDS) range from 894 to 1226 mg/L. High fluoride (up to 1.1 mg/L) is dominantly present in the study area. Nitrate is higher (up to 2.4 mg/L) may be due to leaching from plant nutrients and nitrate fertilizers. The Electric conductance was quite higher than the WHO limit in 2022. The concentration of sulphate was quite higher in 2021 and 2022. Total dissolved solids (TDS) are always higher in all three years.

4.1. Water Quality Index

The WQI of 2023 has a greater value which is unfit for drinking purposes (which is shown in Tables 4 to 6). The WQI approach is an effective instrument that makes it simple to inform the public—especially policymakers—about the quality of the water. It is a clear instrument that makes it possible to integrate the water characteristics, which are consequently thought to be significant for the water's quality [22]. The ten most widely used water quality metrics are pH, EC, TDS, TH, NItrate, Sulfurate, Sodium, and Potassium. These factors collectively represent the overall water quality of the Atoon Village that was chosen to create the water quality index. Using the "weighted arithmetic index method," the WQI has been calculated [23]. The calculated water quality Index result are as follows:

Table 4. The WQI result of 2021.

Parameters	WHO limit (Sn)	1/Sn	K= 1/∑1/Sn∑1/Sn	Wn=K/Sn	2021 Reading (Vn)	Vn/Sn	Qn= Vn/Sn*100	WnQn
pH	8.5	0.117647	1.184482942	0.13935093	7.5	0.3333	33.33	4.644567

Parameters	WHO limit (Sn)	1/Sn	K= 1/∑1/Sn∑1/Sn	Wn=K/Sn	2021 Reading (Vn)	Vn/Sn	Qn= Vn/Sn*100	WnQn
EC	1400	0.000714	1.184482942	0.00084606	1380	0.985714	98.57142857	0.083397
Total Alkalinity	600	0.001667	1.184482942	0.00197414	323	0.538333	53.83333333	0.106274
Total Hardness	600	0.001667	1.184482942	0.00197414	360	0.6	60	0.118448
Sulphate	150	0.006667	1.184482942	0.00789655	253	1.686667	168.6666667	1.331885
Nitrate	45	0.022222	1.184482942	0.02632184	2.62	0.058222	5.822222222	0.153252
Fluoride	1.5	0.666667	1.184482942	0.78965529	0.86	0.573333	57.33333333	45.27357
Total Dissolved Solid	500	0.002	1.184482942	0.00236897	1120	2.24	224	0.530648
Na	50	0.02	1.184482942	0.02368966	329	6.58	658	15.5878
K	200	0.005	1.184482942	0.00592241	2.6	0.013	1.3	0.007699
		0.84425		1				67.83754

Table 5. *WQI Result of 2022.*

Parameters	WHO limit (Sn)	1/Sn	K= 1/∑1/Sn∑1/Sn	Wn= K/Sn	2022 Reading (Vn)	Vn/Sn	Qn= Vn/Sn*100	WnQn
pH	8.5	0.117647	1.184482942	0.13935093	7.6	0.4	40	5.5740
EC	1400	0.000714	1.184482942	0.00084606	1640	1.1714	117.1428	0.09910
Total Alkalinity	600	0.001667	1.184482942	0.00197414	228	0.38	38	0.07501
Total Hardness	600	0.001667	1.184482942	0.00197414	216	0.36	36	0.07106
Sulphate	150	0.006667	1.184482942	0.00789655	210	1.4	140	1.1055
Nitrate	45	0.022222	1.184482942	0.02632184	3.2	0.07111	7.1111	0.1871
Fluoride	1.5	0.666667	1.184482942	0.78965529	0.92	0.61333	61.33333	48.4321
Total Dissolved Solid	500	0.002	1.184482942	0.00236897	1226	2.452	245.2	0.58750
Na	50	0.02	1.184482942	0.02368966	124	2.48	248	5.8750
K	200	0.005	1.184482942	0.00592241	3.5	0.0175	1.75	0.01036
		0.84425		1				62.0103

Table 6. *WQI Result of 2023.*

Parameters	WHO limit (Sn)	1/Sn	K= 1/∑1/Sn∑1/Sn	Wn= K/Sn	2023 Reading (Vn)	Vn/Sn	Qn= Vn/Sn*100	WnQn
pH	8.5	0.117647	1.184482942	0.13935093	7.9	0.6	60	8.36105
EC	1400	0.000714	1.184482942	0.00084606	1350	0.9642	96.4285	0.081584
Total Alkalinity	600	0.001667	1.184482942	0.00197414	140	0.23333	23.3333	0.046063
Total Hardness	600	0.001667	1.184482942	0.00197414	190	0.31666	31.6666	0.063514
Sulphate	150	0.006667	1.184482942	0.00789655	95	0.63333	63.3333	0.50015
Nitrate	45	0.022222	1.184482942	0.02632184	2.4	0.05333	5.3333	0.14038
Fluoride	1.5	0.666667	1.184482942	0.78965529	1.1	0.73333	73.3333	57.9080

Parameters	WHO limit (Sn)	1/Sn	K= 1/∑1/Sn∑1/Sn	Wn= K/Sn	2023 Reading (Vn)	Vn/Sn	Qn= Vn/Sn*100	WnQn
Total Dissolved Solid	500	0.002	1.184482942	0.00236897	894	1.788	178.8	0.4235
Na	50	0.02	1.184482942	0.02368966	152	3.04	304	7.2016
K	200	0.005	1.184482942	0.00592241	7.6	0.038	3.8	0.0225
		0.84425		1				74.7475

On the basis of the above tabulation result, we state that the water quality index increased day by day Table 4. Show the 2021 WQI which is 67.83 which is not suitable for drinking purposes, Table 5. Reflects the 2022 WQI is equal to 62 and table no. 6 show the 2023 WQI is 74.74 which is not good for drinking purpose.

4.2. Correlations

Table 7. *Correlation between analytical data.*

Column1	pH	EC	Total Alkalinity	Total Hardness	Sulphate	Nitrate	Fluoride	Total Dissolved Solid	Na	K
pH	1									
EC	-0.36649	1								
Total Alkalinity	-0.95441	0.072053	1							
Total Hardness	-0.78865	-0.28303	0.936223661	1						
Sulphate	-0.94154	0.031614	0.999180169	0.94968254	1					
Nitrate	-0.52307	0.984689	0.244816158	-0.111508597	0.205363	1				
Fluoride	1	-0.36649	-0.954411087	-0.788649573	-0.9415442	-0.52307	1			
Total Dissolved Solid	-0.84702	0.804994	0.649743022	0.341183131	0.6184359	0.89609	-0.847024	1		
Na	-0.5971	-0.52752	0.809322282	0.964109426	0.8324379	-0.37136	-0.5971	0.079363817	1	
K	0.997343	-0.43329	-0.93013186	-0.741766618	-0.9145024	-0.58376	0.9973433	-0.883494754	-0.53708	1

Table 7 reflects the correlation between the parameters which shows the inter-relationship of parameters which are as follows- The pH has highly positively correlated with fluoride and potassium and highly negatively correlated with total alkalinity, total hardness, sulphate, and TDS. EC is highly correlated with nitrate ion concentration and TDS. Total Alkalinity strongly correlated with TDS, Sulphate ions, and sodium ion concentration. Total hardness is strongly correlated with sulphate ions and sodium ion concentration. Sulphate is highly correlated with sodium ion concentration. These correlations make study easy to explain the effect of the particular ion concentrations.

5. Conclusion

The outcomes that most of the water quality metrics were above acceptable ranges. The present research zone's total Water Quality Index score was higher, indicating poor water quality. In the region, 70% of the criteria were deemed dangerous, and at least 50% of the test findings were unsuccessful. In this area of Bhilwara districts, none can be deemed safe for the usage of groundwater. The goal of the "National Rural Drinking Water Program" will be to supply sustainable and safe drinking water. The coverage of habitations with poor quality is given top priority.

Abbreviations

TA	Total Alkalinity
TDS	Total Dissolve Solids
EC	Electric Conductivity
WQI	Water Quality Index

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Mahesh Kumar Singh: Methodology, Resources, Writing – original draft, Writing – review & editing

Pankaj Sen: Conceptualization, Supervision, Validation

Shweta Dadheech: Formal Analysis, Writing – review & editing

Rajeev Mehta: Supervision, Visualization

Preeti Mehta: Validation, Visualization

Conflicts of Interest

The authors declare no conflicts of interest.

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