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Polymer Chemistry Perspectives: Applying The Water Quality Index [WQI] For Groundwater Quality Assessment

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Abstract

Through the utilization of polymers' special qualities, such as their capacity to concentrate analytes and their affinity for particular pollutants, we establish a strong framework for assessing groundwater quality. A more thorough understanding of groundwater contamination is made possible by the integration of polymer-based techniques with the WQI, empowering stakeholders to decide on remediation and water resource management strategies with knowledge. The quality of groundwater, especially shallow groundwater, is being negatively impacted by a number of anthropogenic activities. To keep the quality of the water within a particular safe range, groundwater monitoring has therefore become essential. In the current research, the groundwater quality in Mathura district has been evaluated using the Water Quality Index [WQI]. Eight major criteria, including pH, alkalinity, total hardness, total dissolved solids, chloride, electrical conductivity, fluoride, and nitrate, were chosen to calculate WQI since they have the most impact on evaluating the quality of drinking water. The 20 samples' WQI has been calculated and determined. 90% of the water samples, according to WQI analysis, fell into "Very Bad to Bad" water category, and only 10% fall into the "Medium" category. No sample was found to fall into the "excellent to good" category, which shows that the water needs to undergo sufficient treatment before it can be used directly. The water can be used for drinking after being treated.

Keywords: Polymer toxicity, hydrochemistry, chemical pollutants, groundwater and water quality index [WQI]

INTRODUCTION

The Water Quality Index [WQI], which is used to assess groundwater quality, can be greatly influenced by polymer chemistry[1]. A thorough instrument for assessing the general quality of water resources based on physicochemical, biological, and ecological factors is the Water Quality Index [WQI]. The development of WQI frameworks is greatly aided by polymer chemistry, which offers cutting-edge materials and analytical techniques for the identification and measurement of water constituents. Polymers play a important role in augmenting the sensitivity, selectivity, and dependability of analytical methodologies utilized in Water Quality Index [WQI] computations, therefore elevating the precision of water quality evaluations. Rivers and groundwater are the main sources for human water consumption[2]. Human activities are changing the quality of groundwater, especially shallow groundwater. Water quality and climate change also has an intricate relationship between them[3]. Due to increase in global temperature and unpredictable weather conditions, there has a drastic effect on ground water quality. Since most microorganisms are screened out by the soil that ground water flows through it is less susceptible to bacterial contamination than surface water[4].

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Groundwater is a rich source of natural components and isolated minerals for a variety of purposes. Many of them are beneficial or harmless, but they only occasionally happen. Others are hazardous, and some of them might be really damaging. Large data volumes are a major issue in water quality monitoring[5]. To simplify vast amounts of data for easier comprehension and interpretation, tools are needed[6]. A key tool for condensing a lot of water quality data into simple numerical forms is the water quality list [WQI][7–9]. The indices of water quality offer a means for measuring and accessing water quality as well as a tool to evaluate thousands of environmental data sets into information that is useful and indicates the health of water resources. A crucial factor in determining the quality of drinkable water is the Water Quality Index. As a direct consequence of this fact, ongoing groundwater monitoring is required. Monitoring water quality might be complicated by the presence of large amounts of data. Tools are required in order to simplify massive volumes of data, making their comprehension and interpretation simpler.

STUDY AREA

The Mathura district of the state of Uttar Pradesh is the study's focus area. Delhi is around 162 miles away, and it is located at 27.28°N 77.41°E. It is 174 meters above sea level on average [see Figure 1]. The district's 3376 sq. km. total size makes up 4% of the state's overall area. The Yamuna River runs along the shores of the Mathura District. The Mathura district has seen fast and uncontrolled growth, which includes the establishment of multiple companies, tourism, different construction projects, and the repurposing of forest and agricultural land. Numerous development initiatives have been implemented in the area; some have been swift, while others have been unplanned. These activities include the creation of various industries, the utilization of agriculture and forest land for other types of development, pharmaceuticals, tourism, and various construction projects[10]. All these activities are directly or indirectly affects the groundwater quality of the region.

MATERIALS & METHODS

The Mathura district of the state of Uttar Pradesh is the study's focus area. Delhi is around 162 miles away, and it is located at 27.28°N 77.41°E. It is 174 meters above sea level on average [see Figure 1]. The district's 3376 sq. km. total size makes up 4% of the state's overall area. The Yamuna River runs along the shores of the Mathura District. Twenty sites were used to collect water samples. The samples were chemically analyzed using field water testing kit.

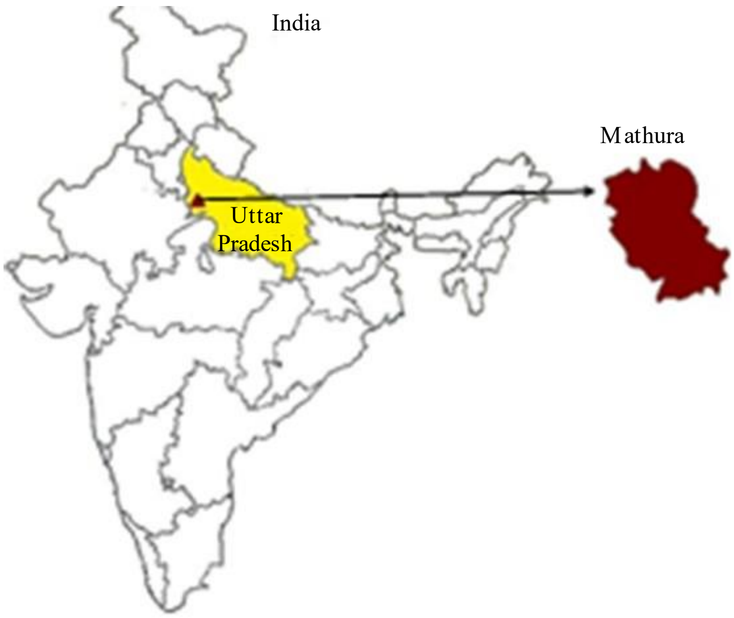

Figure 1. Study area

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In order to determine the total WQI of the Mathura district for the samples of ground water, the following formula[11],

Step01: Quality rating [Q_i] for ith parameter

$\frac{Ci-Cid}{Ci-Cid}$ Q_i = ×100

C_s-standard concentration for ith parameter [BIS, IS11624–1986]

C_{id}-ideal concentration value for ith parameter

C_i - measured concentration for ith parameter

$$\frac{\mathbf{1}}{\sum_{i=1}^{i=n} \mathbf{1/Si}}$$

K=

Where S_i: standard value for the ith parameter
Step2: Weightage of the parameter
Step3: Water quality index
Wi=K/Si

WQI= $\sum_{i=1}^{i=n}$ Wi x Qi

The determined weightage factor is also included in Table-1, together with the standard value [Si] and the ideal value [Cid] [Wi]. Table 2 provides a breakdown of the various WQI ranges along with a summary of the relevant water quality ratings.

Table1. Calculation Values of various Water Quality Parameters.

S.N.	Parameters	Standard value, S_i	Ideal value, Cid	$1/S_I$	Weightage factor, W_i
i.1	pH	8.5	7	.118	.119
i.2	Alkalinity [Ak]	120	0	.008	.008
i.3	Total Hardness [$CaCo_3$]	300	0	.003	.003
v.4	Chloride [Cl]	250	0	.004	.004
v.5	Total Dissolved Solid [TDS]	500	0	.002	.002
i.6	Electrical Conductivity [E.C]	300	0	.003	.003
i.7	Nitrate [NO_3]	45	0	.022	.022
i.8	Fluorides[F]	1.2	0	.833	.839
Total[K]			0.993		1

Table 2. Water Quality Index Score based classes of water [12]1 Bathusa, I.M and Saseetharan MK. Assessment of Water Quality Index for Groundwater of Coimbatore City North Zone. J Appl Hydrol. 2010;23[1]:1–11.

S.N.	Water quality index	Description
1	>75	Extreme Bad
2	50-75	Bad
3	30-50	Medium
4	10-30	Good
5	0- 10	Excellent

Table 2 shows five categories of water quality for human usage. Water quality index of greater than 75 shows water quality is extremely poor and may pose serious risks to human health and aquatic life. This could indicate high levels of pollution or contamination. Value in between 50-75 shows that water quality is average, but there may be some concerns or issues present. It may not meet all quality standards but may be suitable for certain uses with caution. WQI value of 10-30 Water quality is relatively high, indicating that it meets most quality standards and is suitable for various uses, including drinking and recreational activities. WQI of value in between 0 to 10 shows water quality is exceptional, with very low levels of pollution or contamination. It is safe for consumption and supports a healthy aquatic ecosystem.

RESULTS & DISCUSSION

The sample values that were observed are presented in Table 3. A total 20 samples were taken and tested at the laboratory. It was discovered that the majority of the samples have pH were very close to 8. At a number of different places, the pH value is highest close to the industry and drops with increasing distance from there. The obtained results indicate that the TDS values are comparable to or even higher than those found in industrial areas. The values of all of the WQI with their ratings are shown in Table 4, which generates and presents the total water quality index [Figure 2]. The bulk of the locations have water quality indices that are much below acceptable levels. The water that is located in the immediate vicinity of the industrial complex is unfit for human consumption. As a consequence of this, the water in the neighboring industrial area is of a low quality and should not be consumed.

Table 3. Observed water quality values for all the samples [values in mg/l, excluding pH and E.C.].

Sample N.	pH	Alkalinity	Total hardness	Cl	TDS	F	NO_3	E C [mho]
i.	8.5	350	620	250	1464	0.5	0.0	2185
ii.	8.0	600	430	200	1476	2.0	0.0	2202
iii.	8.0	450	600	350	1680	4.0	0.0	2507
iv.	8.0	300	450	320	1284	3.0	0.0	1916
v.	8.0	360	980	400	2088	1.0	20.0	3116
vi.	8.5	600	1200	990	3348	4.0	45.0	4997
vii.	8.5	400	300	260	1152	5.0	0.0	1719
viii.	8.0	470	700	660	2196	5.0	0.0	3277
ix.	8.5	50	680	280	1812	2.0	0.0	2704
x.	8.5	310	750	300	1632	3.0	0.0	2435
xi.	8.0	480	700	340	1824	5.0	0.0	2722
xii.	8.5	580	820	270	2004	4.0	0.0	2991
xiii.	8.0	390	610	350	1620	1.0	0.0	2417
xiv.	8.5	550	780	290	1944	0.5	0.0	2901
xv.	8.5	410	680	330	1704	3.0	0.0	2543
xvi.	8.5	360	440	310	1332	2.0	0.0	1988
xvii.	8.0	420	500	280	1440	0.5	0.0	2149
xviii.	8.5	630	430	250	1572	4.0	0.0	2346
xix.	8.0	300	450	320	1284	3.0	0.0	1916
xx.	8.0	600	400	400	1680	3.0	20.0	2507

Table 4. WQI [Different sample locations].

Sample N.	WQI	Rating
i.	159	Extreme Bad
ii.	122	Extreme Bad
iii.	228	Extreme Bad
iv.	222	Extreme Bad

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v.	50	Medium
vi.	85	Bad
vii.	55	Bad
viii.	363	Extreme Bad
ix.	157	Extreme Bad
x.	297	Extreme Bad
xi.	298	Extreme Bad
xii.	37	Medium
xiii.	225	Extreme Bad
xiv.	52	Bad
xv.	155	Extreme Bad
xvi.	293	Extreme Bad
xvii.	86	Bad
xviii.	222	Extreme Bad
xix.	305	Extreme Bad
xx.	364	Extreme Bad

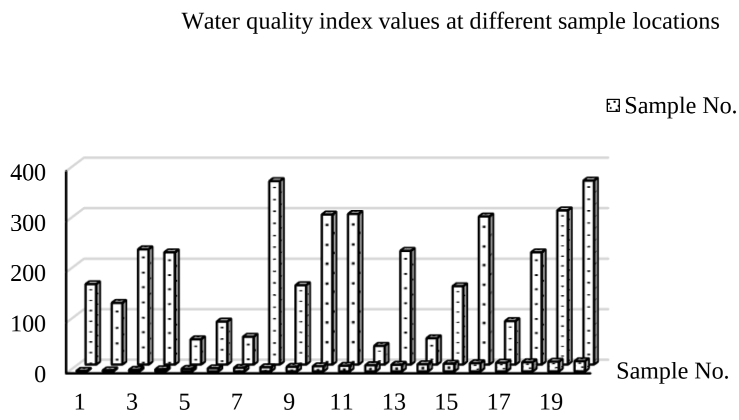

Figure 2. Values of water quality index

CONCLUSION

The Water Quality Index [WQI] assessment in Mathura presents a thorough picture of the overall water quality in the region, encompassing various parameters crucial for human health and ecological balance. Through meticulous analysis and interpretation of data collected from multiple sampling points, we have gained valuable insights into the current state of water quality in Mathura. The findings reveal a mixed scenario, with certain areas exhibiting satisfactory water quality while others raise concerns necessitating immediate attention. Factors such as industrial effluents, agricultural runoff, and domestic sewage contribute significantly to the degradation of water quality, emphasizing the urgent need for stringent regulatory measures and proactive intervention strategies

The Mathura district's Groundwater Quality Index reveals that 90% of the entire study region has water quality falls into the "Very Bad to Bad" category. The water close to the industries is not fit for human consumption. Water Quality Index tool is a highly important instrument for conveying water quality in easily understandable language for report to decision makers and the local population. One of the solutions to improve the quality is application of polymers to improve groundwater quality index in water treatment processes. Polymers can be employed to remove contaminants from groundwater, thus contributing to the improvement of its overall quality as assessed by the groundwater quality index. Polymers are added to groundwater to facilitate the aggregation of suspended particles and impurities, making them easier to remove through sedimentation or filtration.

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