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Evaluation of the Water Quality Status of Water Bodies of Industrial Area in Barrackpore, West Bengal, India by Using Water Quality Index

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Abstract: Water bodies become contaminated as a result of agricultural, urban, and industrial growth, as effluent is either directly or indirectly released into the environment. The current study intends to evaluate the pre- and post-monsoon water quality of water bodies in and around the Barrackpore industrial area, West Bengal, India in the years 2021–2022. Using established techniques as directed by the APHA, biological parameters such as DO, BOD, Total Coliform, Faecal Coliform, and COD, as well as physico-chemical parameters including pH, EC, TDS, Bicarbonates, Chlorides, Sulphates, Total Hardness, Calcium, Magnesium, etc., and heavy metals were analysed. The criteria that were analysed were contrasted with the BIS-mandated norms. With the exception of the pond at Jafffarpur Panchanantala Lake (P-3), all of the water bodies had BOD readings that were higher than the recommended acceptable limit during the pre-monsoon season. It has also been noted that the water quality varies seasonally. According to the Water Quality Index values, 40% of surface water samples were of good quality and 60% of samples were of poor quality during both seasons. According to this study, the surface water in these water bodies must be properly treated before being consumed and shielded from industrial and domestic pollution.

Keywords: Urban, Faecal Coliform, Total Hardness, Bicarbonates, Water Quality Index, Physico-chemical parameters, Heavy metals, Biological parameters

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Introduction

Freshwater is necessary for the growth of the entire living organisms. The lotic (rivers and streams) and lentic (ponds and lakes) water bodies are the primary sources of freshwater. Freshwater quality changes as a result of urbanization, industrialization, and population growth. Lack of public knowledge, and a lack of a legal and institutional framework are all contributing to the steady degradation of natural resources (Pavan and Banerjee, 2015; Gulia *et al.*, 2017). Even though the water bodies, particularly ponds, are often tiny in size, they are important sources of water for residential use, irrigation, fishing, etc. in rural areas. One of the primary sources of water for such village ponds is rainfall. Pollutants from residential areas, sewage outlets, detergents, car oil waste, and industrial wastewater are the main sources of pond water pollution (Ancy and Shaji, 2016). Due to the discharge of domestic sewage and industrial effluents into freshwater bodies, around 70% of the water in India is contaminated (Sheetal and Sudan, 2017). Knowing the water's quality before consuming it is crucial since consuming water that contains contaminants can result in a number of water-borne illnesses. Barrackpore industrial belts' surrounding freshwater bodies do not have any water quality reports, according to the literature review. The purpose of the current study was to evaluate the status and water quality of a few selected ponds.

Materials and Methods

Study Area:

The Barrackpore sub-district is renowned for its industrial assets. The jute industry in this region is noteworthy. Hessian, sacking bags and twill, sacking and ornamental fabrics, fine scale yarn, carpet backing cloth, carpet and wobbling, D.W tarpaulins, etc. are among the jute products manufactured. The SSI industry is also robust in the subdivision. Conch shell, leather bags, terracotta, kanta stitch, cane furniture, soft dolls, clay modelling, and handloom are among the main cottage and small scale items. Barrackpore is a northern suburban town of Kolkata Metropolitan Area, approximately 23 km from the main city by railway distance, extending from 88°28'51''E to 88°30'E and 22°48'30''N to 22°50'N. The total municipal area is of 13.63 sq. km. Barrackpore is essentially a part of the great Ganga Delta, having fairly porous alluvial soils. Here, highest rainfall (60 cm) period roughly coincides with the late summer months. Total annual rainfall amounts to nearly 155 cm. Within this industrial cluster, we principally focused on 5 sizable water bodies. Table 1 and Figure 1 show specifics about sampling sites and site location.

In the current study, sampling took place between 8 and 9 a.m. in the mornings of the months of April through May (pre-monsoon) and October through November (post-monsoon) in the years 2021 and 2022. 1.5 L rigid polyethene bottles with stoppers were used to collect the water samples. Three times of distilled water were used to rinse each bottle after it had been cleaned with 2% nitric acid (Khwaja and Aggarwal, 2016). An integrated sample was created by combining the samples that were taken from the three distinct locations. The quality of the water sample may change after sample collection as a result of physical and chemical processes; therefore, to reduce this change, samples were analysed as soon as possible after sample collection. The water samples were maintained by reducing the temperature and adding chemical preservatives (Kumar *et al*., 2014). A thermometer that was submerged right into the body of water was used to measure the temperature. The portable HI 98130 Combo pH/ EC/ TDS meter (Hanna Instruments) was used to measure *in situ* the parameters pH, Electrical Conductivity (EC), and Total Dissolved Solids (TDS). The Dissolved Oxygen was promptly fixed on the spot and examined as per Winkler's method with Azide modification. A BOD container was incubated for five days at 21°C after the BOD was determined. The potassium dichromate open reflex method was utilized to determine the COD level. We used the Multiple Test Tube technique to measure Total Coliform and Faecal Coliform. We used a Nepthalo turbidity meter to test the turbidity. Total hardness, calcium (Ca), magnesium (Mg), and fluoride (F^-) were analysed calorimetrically. Chloride (Cl^-) was measured using an argentometric analysis, while phosphate and sulphate (SO_4^{2-}) were quantified using a spectrophotometer (Thermo Fisher: Evolution 201). The Perkin Elmer AAS 700 atomic absorption spectrophotometer was used to analyze heavy metals. The other parameters were analyzed following the APHA-recommended standard procedures (APHA, 2005).

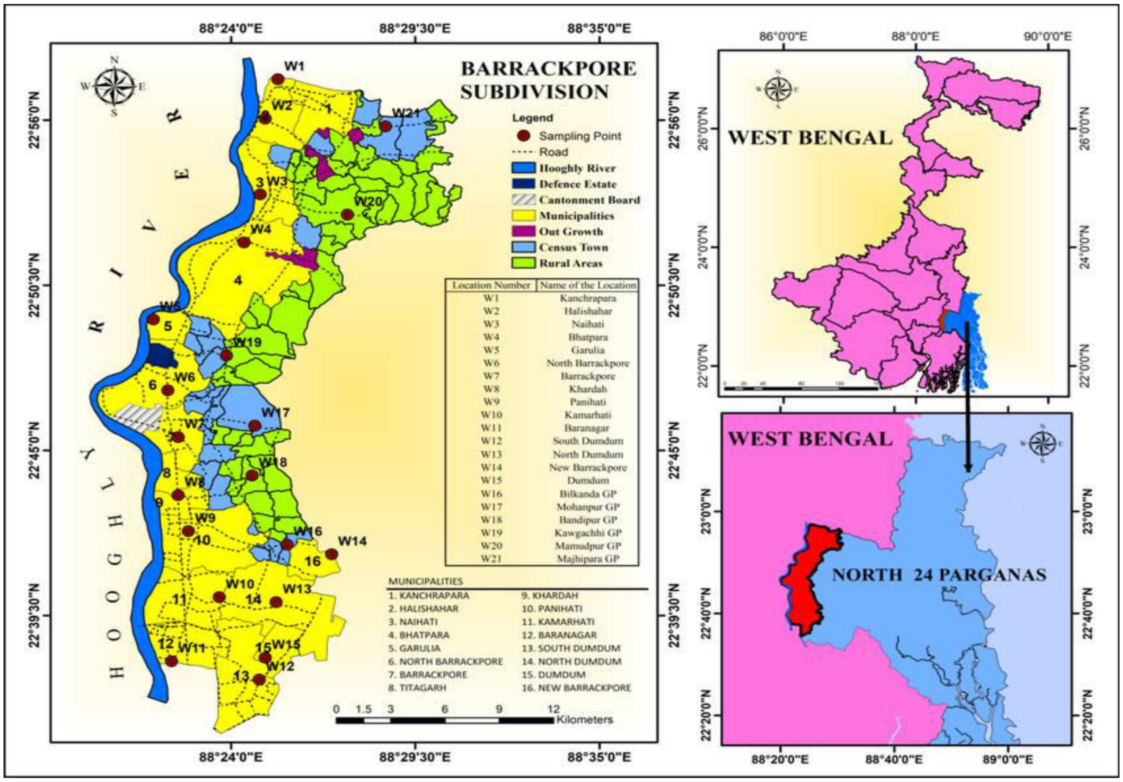

Fig 1: Study area: Barrackpore Sub Division.

Table 1: Details of sampling locations in and around Barrackpore Industrial Belt

Sample No.	Location	Coordinates
P-1	NewbarrackporeJheel	22.684470, 88.442280
P-2	Panihati Water Reservoir	22.692921, 88.398851
P-3	JafffarpurPanchanantala Lake	22.771862, 88.384249
P-4	BarrackpurNilmoni Pond	22.766148, 88.365530
P-5	Talpukur	22.753315, 88.370807

Table 2 displays the quantitative analytical data. To evaluate the drinking water quality, water quality indices have been computed for each study area location that has been chosen.

Water Quality Index:

The Water Quality Index (WQI) condenses a lot of information about water quality into a single figure. It represents the combined impact of multiple water quality factors on the overall water quality (Ramakrishnaiah *et al*., 2009). The water quality index for this study was determined by taking into account a few key variables. The drinking water quality requirements recommended by the BIS (BIS, 1991) were used to determine the WQI. The WQI has been calculated using three steps. First, a weight (wi) has been allocated to specific indicators based on their relative importance in the evaluation of drinking water quality. The parameters have been assigned a weight based on their significance in the evaluation of water quality.

The following equation was used to calculate the relative weight (Wi) in the second step:

$$W_i = w_i / \sum_{i=1}^{n} w_i$$

Where, n is the number of parameters, Wi is the relative weight, and wi is the weight of each parameter.

Table 2: Physico-chemical characteristics of pond water in and around Barrackpore Industrial Belt. Units of all the parameter are in mg/l except pH, EC (μScm-1) and Turbidity (NTU)

	Pre-Monsoon				Post-Monsoon			
Parameters	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**
Temperature	30	32	31	±1	27	29	27.6	±0.89
pH	6.27	7.48	6.79	±0.56	6.01	7.12	6.34	±0.45
EC	80.65	198	143.01	±51.28	101.5	167.4	142.38	±29.64
TSS	17	38	26.6	±9.76	20	43	33.2	±9.58
TDS	37	130	99.4	±25.64	70	132	104.2	±22.16
Turbidity	32.5	187.2	110.32	±63.92	35.3	197.3	118.42	±61.67
DO	5.67	6.82	6.19	±0.49	5.31	6.54	5.92	±0.44
BOD	3.65	4.87	4.26	±0.49	3.78	4.9	4.35	±0.47
COD	23.87	35.67	29.56	±4.54	27.98	35	31.30	±2.84
TC	370.8	510	440.57	±58.88	420.7	538.2	481.87	±45.30
TH	37.06	55.43	46.53	±7.70	45.34	62.23	54.69	±6.97
FC	218	280.6	242.52	±24.01	251.7	350.7	305.28	±39.17
HCo3	24.9	103.2	66.2	±30.85	31.1	90.23	54.87	±24.26
Cl	12.9	21.89	17.76	±3.84	14.98	24.34	20.26	±3.8
SO4	11.1	29.21	19.86	±7.33	14.02	30.20	20.44	±7.76
PO4	0.13	0.74	0.37	±0.21	0.21	1.2	0.48	±0.41
NO3	0.24	2.12	1.09	±0.77	0.25	2.56	1.20	±0.9
Na	1.83	23.76	8.91	±8.93	2.1	30.12	9.64	±11.63
K	0.6	14.82	4.16	±6.06	0.65	18.1	4.99	±7.43
Ca	6.98	8.95	7.91	±0.93	8.12	11.1	9.46	±1.14
Mg	3.78	6.95	5.49	±1.32	4.9	8.00	6.18	±1.33
F	0.17	0.38	0.28	±0.08	0.19	0.41	0.3	±0.11
Mn	0.2	0.76	0.34	±0.24	0.18	0.81	0.36	±0.26
Pb	0.018	0.031	0.024	±0.005	0.01	0.028	0.019	±0.006
Cd	0.002	0.006	0.004	±0.001	0.001	0.009	0.005	±0.003
Cu	0.023	0.056	0.038	±0.014	0.02	0.05	0.036	±0.011

The following equation was used to determine a quality rating scale (qi) for each parameter in the third step:

$$qi = (Ci / Si) \times 100$$

Where, Si is the Indian drinking water standard for each chemical parameter in mg/l and Ci is the concentration of each chemical parameter in each water sample in mg/l and Si is the Indian drinking water standard for each chemical parameter in mg/l.

The SI values for each parameter were computed using the relative weight and quality rating scale values. Thus, WQI is determined using the following equation:

$$SIi = Wi \cdot qi \text{ ....(1)}$$

$$WQI = \sum SIi \text{ ....(2)}$$

Results

Table 2 depicts the seasonal minimum, maximum, mean, and standard deviation values for the water quality metrics. The outcomes were evaluated in comparison to drinking water standards (BIS). During the pre-monsoon and post-monsoon seasons, the pH values ranged from 6.27 to 7.48 with a mean of 6.79, and from 6.01 to 7.12 with a mean of 6.34, respectively. Pre-monsoon seasons have EC levels in the range of 80.65 to 198.0 μScm^{-1} with a mean of 143.01 μScm^{-1} while post-monsoon seasons have EC values in the range of 101.5 to 167.4 μScm^{-1} with a mean of 142.38 μScm^{-1}. The amount of light scattered by suspended particles is referred to as turbidity. Turbidity in pond water is brought on by clay, silt, organic materials, phytoplankton, and other

Table 3: Relative weight of selected parameters

Parameters	Standard (BIS)	Weight (wi)	Relative Weight (Wi)
TDS	500	5	0.0625
Cl^-	250	5	0.0625
SO_4^{-2}	200	5	0.0625
NO_3^{-1}	45	5	0.0625
Mn	0.1	5	0.0625
Cd	0.003	5	0.0625
Pb	0.05	5	0.0625
F	1.0	5	0.0625
FC	-	5	0.0625
Na	-	4	0.05
pH	6.5-8.5	4	0.05
DO	5.0	4	0.05
Ca	75	3	0.0375
Mg	30	3	0.0375
TH	300	3	0.0375
BOD	3.0	3	0.0375
K	-	2	0.025
Cu	0.05	2	0.025
COD	-	2	0.025
EC	300	1	0.0125
Temp.	40	1	0.0125
Turbidity	1	1	0.0125
PO_4	-	1	0.0125
HCO_3^{-1}	200	1	0.0125
		80	1

Table 4: WQI classification and results (Paul et al. 2016)

WQI Value	Water Quality
<50	Excellent
50-100	Good
100-200	Poor
200-300	Very Poor
>300	Unsuitable

microscopic creatures. During the pre-monsoon and post-monsoon seasons, the turbidity varied from 32.5 to 187.2 NTU and 35.3 to 197.3 NTU, respectively. In the pre-monsoon season, the lowest and maximum dissolved oxygen readings were 5.67 mg/l and 6.82 mg/l, respectively, whereas in the post-monsoon season, these were 5.31 and 6.45 mg/l. The oxygen that the microbe uses to carry out the aerobic oxidation of organic materials is referred to as BOD. Consequently, the BOD rises as the amount of organic matter in the water does. During the pre-monsoon and post-monsoon seasons, the BOD value ranged from 3.65 mg/l to 4.87 mg/l and 3.78 mg/l to 4.90 mg/l, respectively. The range of Total Coliform counts per 100 millilitres of water during pre-monsoon and post-monsoon was 370.8 to 510 and 420.7 to 538.2, respectively. The range of total hardness values observed during pre-monsoon was 37.06 to 55.43 mg/l, whereas during post-monsoon it was 45.34 to 62.23 mg/l. The considerable content of manganese was recorded in both seasons. The

Table 5: Water quality status based on WQI

Location No.	WQI			
	Pre Monsoon	Water Quality Status	Post-Monsoon	Water Quality Status
P-1	128.32	Poor	126.76	Poor
P-2	97.25	Good	92.98	Good
P-3	189.43	Poor	196.41	Poor
P-4	120.12	Poor	135.67	Poor
P-5	75.23	Good	85.12	Good

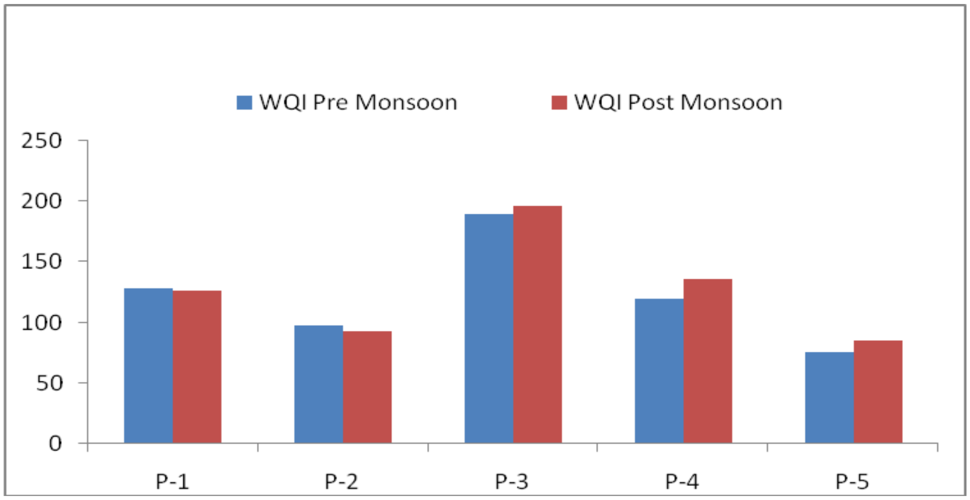

Fig. 2: Seasonal variation of WQI.

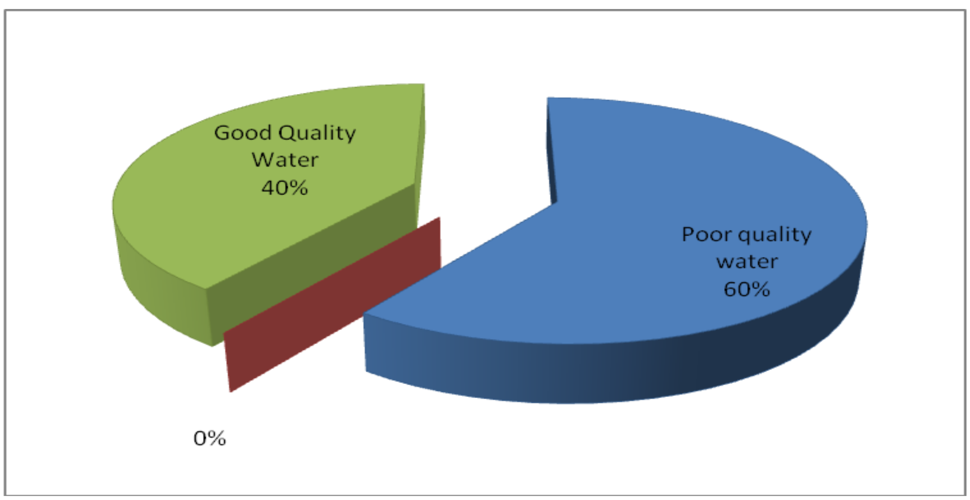

Fig. 3: Pie diagram of overall WQI.

post-monsoon season was found to have higher levels of calcium (9.46 mg/l) and magnesium (6.18 mg/l) than the pre-monsoon season 7.91 mg/l and 5.49 mg/l, respectively. Both seasons have a notable amount of manganese content. Lead, cadmium, and copper concentrations, among other heavy metals, were all within the BIS regulatory levels in both seasons.

Water Quality Index:

Table 3 illustrates the relative and assigned weights for each parameter. Tables 4 and 5, show the classification of the Water Quality Index and its values, respectively. Figures 2 and 3, display the seasonal variation of the WQI and the pie diagram of the total WQI, respectively at the sampling locations.

Discussion

From pre-monsoon to post-monsoon, the pH value decreased, which may be related to rainfall dilution (Rashmi, 2016). An aqueous solution's electrical conductivity—a property that depends on ions, their overall concentration, mobility, and temperature-- is what allows electric current to flow through it. No significant difference in EC level in pre and post monsoon was recorded. According to Bajpai *et al*. (2012), a high EC value implies the presence of salts and ions in higher concentration. The amount of light scattered by suspended particles is referred to as turbidity. Turbidity in pond water is brought on by clay, silt, organic materials, phytoplankton, and other microscopic creatures. The post-monsoon season show the highest levels of water turbidity, which may have been caused by the build-up of sand, clay, silt, manure, and other pollutants in addition to rains from the local area (Kumar *et al*., 2014). The oxygen can be created by photosynthetic organisms like algae and aquatic plants or it can be dissolved in water from the air. In water, oxygen is a poorly soluble gas, and the temperature and partial pressure of the water affect how soluble it is. A slight increase in oxygen content was recorded in pre-monsoon period. In both seasons, the BOD levels in all the water samples were higher than the recommended level (BIS: 3 mg/l). Due to the existence of many microorganisms in water bodies, which accelerate their metabolic activities with an increase in concentration, the BOD value of the post-monsoon season was higher than that of the pre-monsoon season (Kumar *et al*., 2014).

The pre-monsoon to post-monsoon total coliform count rose. Both industrial activity and residential population may be contributing factors to the high concentration of organic materials of faecal origin. With regard to the presence of ferrous iron, bicarbonates, sulphates, chloride, and nitrate of calcium and magnesium, TH is used to characterize the impact of dissolved minerals (mostly calcium and magnesium) on determining the acceptability of water for household, industrial, and drinking purposes. High levels of hardness are most likely the result of frequent additions of significant amounts of detergents from the surrounding residential areas that run off into the bodies of water. According to Deepa *et al*. (2016), hard water can lead to digestive issues and increase the risk of calcium oxalate crystals accumulating in the urinary system. The post-monsoon season was found to have higher levels of calcium and magnesium than the pre-monsoon season. Both seasons have a notable. amount of manganese content. Lead, cadmium, and copper concentrations, among other heavy metals, were all within the BIS regulatory levels in both seasons. Although seasonal changes were noted, the remaining metrics were all within the BIS standard limit.

Water Quality Index:

The WQI values showed that nearly every sampling location in both seasons fell into the low category for surface water quality. According to Jena *et al*. (2013), anthropogenic activities like the release of wastewater from home, industrial, and agricultural uses, overexploitation, and ionic leaching could be to blame. It has been shown that 60% of the sampling areas' surface water is of poor quality, whereas 40% is of high grade. This suggests that the study sites' water samples are heavily contaminated. They are unfit for consumption and other practical human endeavours. According to the water quality index (WQI), sample site P-5 is much more contaminated than the rest.

Conclusion

The water sample analytical data demonstrate that there are minor seasonal fluctuations in every parameter. The study area's surface quality metrics have been found to have higher values during the post-monsoon period, which is indicative of a distinct seasonal change and the impact of the monsoon. 60% of the surface water at the sampling location is of low quality, and 40% is of acceptable quality, according to the water quality indices (WQI), which ranged from 75.23 to 196.41. The primary cause of the water bodies' low water quality was the bacteriological load there. It has been discovered that the Water Quality Index (WQI) is highly helpful tool for evaluating the general quality of water in this study. This study shows that certain water body areas' surface water need adequate treatment before consumption. These water bodies must be shielded from industrial and residential pollution. To ensure that the water quality remains high, industry owners and the surrounding community must support an awareness campaign. Water body preservation, renewal, and protection need to be viewed as significant national and global issues. The baseline data on surface water quality in the industrial areas of the Barrackpore Industrial Belt provided by this study may be used by government policy makers and industrial entrepreneurs to implement pollution control measures.

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