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Water Quality Assessment of Pahuj River using Water Quality Index at Unnao Balaji, M.P., India

Krishna Kumar Yadav[a*], Neha Gupta[b], Vinit Kumar[c], Sudarshana Sharma[d], Sandeep Arya[e]

[a,b,c,d,e]*Institute of Environment and Development Studies, Bundelkhand University, Jhansi-284128, India*
[a]*Email: envirokrishna@gmail.com*
[b]*Email: nhgupta83@gmail.com*
[c]*Email: vinit_dhaka@yahoo.co.in*
[d]*Email: sudarshanasharma9@gmail.com*
[e]*Email: resanarya@yahoo.com*

Abstract

The study has been carried to assess the water quality index of Pahuj River at Unnao Balaji, Madhya Pradesh. The samples were collected from 10 different locations and analyzed for various physico-chemical parameters like Temperature, pH, Turbidity, Total Hardness, Chloride, Dissolved Oxygen, Biological Oxygen Demand, Fluoride, Iron and Nitrate. Water Quality Index serves as the basis for environment assessment of water in relation to pollution load categorization and designation of classes. The value of Water Quality Index (WQI) at almost all location indicates that water of Pahuj River at Unnao Balaji is unfit for drinking purpose due to disposal of heavy amount of sewage into the River.

Keywords*:* Pahuj River, Water Quality Index, Physico-chemical Parameters and Water Quality

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* Corresponding author.
E-mail address: envirokrishna@gmail.com.

1. Introduction

The problems associated with sewage disposal have become a major problem of the urban world due to increase in human population and urbanization. River waters are facing a variety of pressure affecting both the ecosystem and human health through sewage waste water discharge and disposal practices that may lead to introduction of high nutrient loads, hazardous chemicals and pathogens causing diseases. Sewage effluents have historically been discharged through outfall [1]. Most of the rivers have been unmindfully used for the disposal of domestic and industrial effluents far beyond their assimilative capacities and have been rendered grossly polluted [2-3]. The adverse public health, environmental, socioeconomic, food quality and security, and aesthetic impacts from sewage contamination are well documented [4-5]. The potential deleterious effects of pollutants from sewage effluents on the receiving water quality depend on the volume of the discharge, the chemical composition and concentration in the effluents. It also depends on point and non-point source pollution. Point source pollution refers to contaminants that enter a water way through a discrete conveyance such as a pipe or ditch. Example of this category includes discharge from sewage treatment plant, a factory, or a city storm drain. While Non-point source pollution refers to diffuse contamination that does not originate from single discrete source. Example of this category is leaching out of nitrogen compounds from agricultural land which has been fertilized.

River pollution in India has now reached to a point of crisis due to unplanned urbanization and rapid growth of industrialization [6-8]. Industrial activities are important source of heavy metal pollution in the environment resulting in high contamination of suspended matter [9]. Hence, the aim of this study is water quality evaluation at different sites (polluted & non-polluted site) of Pahuj River in Unnao Balaji.

2. Study Area

Pahuj River flows through the historic city of Jhansi, Uttar Pradesh. It probably originates near the hills of Jhansi or in Tikamgarh district of Madhya Pradesh. It has been referred as the Pushpavati in religious texts. This river also flows through Unnao Balaji 20km from Jhansi, famous for Sun Temple and people. It is a tributary of the Sindh River, which joins the Yamuna River in Etawah, Uttar Pradesh state, just after the Chambal River confluence with the Yamuna River. It is a small and dry river which passes through the Indian Grassland and Fodder Research Institute, Jhansi. Due to the construction of Pahuj dam near Jhansi, the river has increased its water level and the dam is an important picnic spot for Jhansi city-dwellers.

3. Sampling and Analytical Design

The water samples were collected from the Pahuj River at ten different selected stations S1, S2, S3, S4, S5, S6, S7, S8, S9 and S10 during the period of January 2014 to May 2014 (Fig 1). First five samples i.e. S1 to S5 were collected from upstream to sun temple, S6 was collected from sun temple and rest were collected from downstream. All the samples were collected at morning time between 6am-9am to retain and maintain their properties. The river water samples were collected in pre-washed polyethylene bottles. Prior to collect the sample from sampling sites, the pre-cleaned polyethylene bottles were also washed by water sample. The pH and turbidity were measured and estimated at sampling sites by using water analysis kit (systronic). The other parameters were measured by the procedures given by APHA [10] in the laboratory.

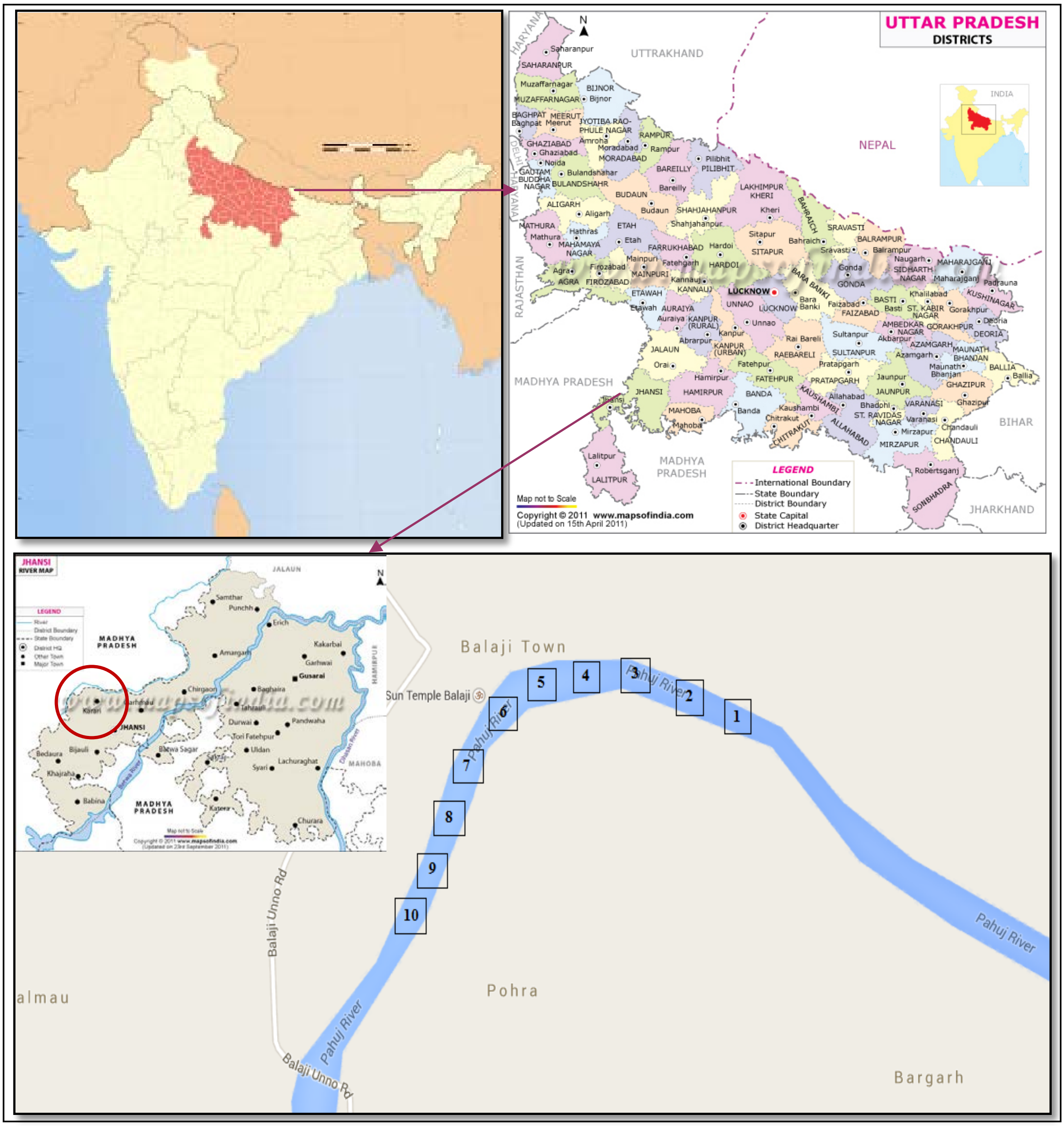

Fig 1. Map showing location of sampling sites

4. Calculation of Water Quality Index

Water Quality Index is a very useful tool for communication the information on the overall quality of water [11]. The Bureau of Indian Standard and ICMR Standards have been considered for calculation of WQI.

WQI was calculated using 3 steps:

i. In the first step, the unit weight was calculated for each chemical parameter using the below equation:

$$w_i = k/S_i$$

Where, S_i = Standard value of i^{th} water quality parameter;

k = Constant of proportionality and it was calculated by using the below equation:

$$k = [1/(\sum 1/S_{i=1,2,\ldots,i})]$$

ii. In the second step, q_i was computed using the below equation:

$$q_i = \frac{C_i}{S_i} \times 100$$

Where, q_i is the quality rating and C_i is the concentration of each chemical parameter in each water sample.

iii. In the third step, WQI is calculated by using the below equation:

$$WQI = \sum q_i \times w_i$$

Water quality for drinking purpose has been usually classified into 5 categories:

Table 1. Water Quality Rating

WQI Level	Water Quality Rating
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very Poor
> 100	Unfit for drinking purpose

Source: Joshi et al., 2009

5. Result and Discussion

The Results of the physico-chemical analysis of the samples collection from various sites is summarized in table-2. Various parameters including temperature, pH, BOD, Total hardness etc. has been studied and discussed separately below.

5.1. Temperature

Water temperature is an important factor determining the water quality in term of its physico-chemical properties and it directly regulates the characteristic like patterns of mixing and stratification water column.

Water temperature is one of the most impertinent limnological parameters that playing prominent role in regulating the water quality as well as the productivity. In the sample, value of temperature varies between 25ºC and 28ºC.

Table 2. Physico-chemical Properties of Pahuj River Water

Sampling Location	Temp (ºC)	pH	Turb (NTU)	TH (mg/l)	Cl (mg/l)	DO (mg/l)	BOD (mg/l)	Fluoride (mg/l)	Fe (mg/l)	Nitrate (mg/l)
S1	26.4	7.4	7	215	38.9	3	6.2	0.52	0.32	18.4
S2	27.2	7.2	10	197	45.7	3.6	5.8	0.58	0.35	12.2
S3	25.6	7.5	5	175	30	2.7	6.1	0.62	0.34	45
S4	25.8	7	18	237	51.8	2.5	5.5	0.65	0.30	10
S5	27.7	8.5	14	250	57.4	2	5.3	0.68	0.38	20.4
S6	26.7	8.1	22	182	58.6	1.8	6.1	0.7	0.4	16.8
S7	25	7.2	25	187	60	4	4.9	0.5	0.35	30.8
S8	25.2	7.6	6	198	57.3	2.5	5.3	0.57	0.32	28.2
S9	27.4	7.8	12	227	54.6	3.2	3.7	0.67	0.37	34.2
S10	28	8.1	16	204	59.8	3	3.3	0.56	0.4	32
IS 10500:2012	-	6.5-8.5	1-5	200-600	250-1000	-	-	1-1.5	0.3	45

*Temp= Temperature; Turb= Turbidity; TH= Total Hardness; Cl= Chloride; DO= Dissolved Oxygen; BOD= Biological Oxygen Demand and Fe= Iron

5.2. pH

pH is an important parameter in evaluating the acid base balance of water. The pH values of water at waste discharge points are usually higher than that of the river water. The pH measured at various sampling sites is presented in Table 2. Maximum pH value i.e. 8.5 was observed at S5 near Sun Temple and the minimum value i.e. 7 was observed at S4.

5.3. Turbidity

The turbidity in water is mainly caused by sand, silt, clay, phytoplankton, microorganism or organic material suspended or dissolver in it [12]. Turbidity standard is measured in Nephelometric Turbidity Unit (NTUs). Turbidity was ranges between 5-25 NTU for various samples. All the values were above the permissible limits except S3.

5.4. Total Hardness

Hardness is the property of water which prevents the lather formation with soap and increases the boiling points of water [13-14]. The hardness of water is mainly governed by the content of calcium and magnesium salt. Hardness may be due to the presence of Ca^{+2} and Mg^{+2} salts from detergents and soaps used for laundering on the bank of the stream precipitated as calcium carbonate. The value of total hardness was ranges from 175 to 200 mg/L.

5.5. Chloride

Chloride is found widely distributed in nature in the form of salt of sodium, potassium and calcium. Chlorides are least metabolically utilized because of their inert nature. Inland natural waters have low chloride concentration often less than that of bicarbonates and sulphates. In natural fresh waters high concentration of chlorides is regarded as an indicator of sewer pollution. In the present study, chloride was ranges between 30-60mg/l. A maximum value of 60 mg/l was found at S, while a minimum value of 30 mg/l was found at S3.

5.6. Dissolved Oxygen (DO)

Dissolved oxygen is of great important in all aquatic ecosystems as it regulates most of metabolic processes of organism and also the community architecture as a whole [15]. The main sources of dissolved oxygen in water are diffusion of oxygen from air and photosynthetic activity taking place in water. The diffusion of oxygen from air mainly dependent on temperature, salinity, total dissolved salt and water movements etc. Dissolved oxygen content in natural and waste water depends on physical, chemical and biological activities in the water bodies. In the present study, DO was varied between 1.8 - 3.6 mg/l.

5.7. Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand (BOD) is an empirical test to provide a measure of the level of degradable organic material in a body of water. Waters having a BOD of less than 1 mg/l can be relatively unimpacted by humans and primary candidates for conservation. If BOD exceeds 3 mg/l, it affects coagulation and rapid sand-filtration processes conventional water treatment plants, requiring expensive advanced water treatment. In the present study, BOD was ranges between 3.3 – 6.2 mg/l.

5.8. Fluoride

High fluoride intake over a period of time can lead to fluorosis. Excess fluoride intake with inadequate food supplement is responsible for dental and skeletal fluorosis, which is a serious health concern in many areas of the world. The sources of fluoride are mainly geogenic, but significant contribution from industrial effluents is also reported. The study shows less values of fluoride concentration i,e. ranges from 0.50 – 0.68 mg/l,which is the below the permissible limit given by BIS.

5.9. Iron

Iron is one of the most important constituent of blood in human and other living organism. Iron is an essential element for human nutrition and metabolism but in excess quantities results in toxic effect like hemochromatosis in tissues. The maximum permissible limit of iron in drinking water is 0.3 ppm. The iron concentration in various samples were measured and found between 0.3- 0.4mg/L. This more or less similar to the permissible limit given by BIS.

5.10. Nitrate

Table 2 represents the nitrate concentration of Pahuj River at various sites. A high nitrate gives a sufficient indication of the deteriorating quality of water due to entry of waste water in river. Nitrate is the most highly oxidized and usually the most abundant form of combined inorganic nitrogen in surface water bodies. The concentration of nitrate contained in fresh water seems to be increased agricultural waste and sewage contamination. Maximum value is 45 mg/l was observed at S3 and minimum value is 10 mg/L was found S4.

6. Statistical Analysis

The statistical analysis was done for correlation. Water quality index was calculated to check the suitability of water for human consumption.

Table 3. Correlation Coefficient between various Parameters

Parameter	Temp	pH	Turb.	TH	Cl	DO	BOD	Fluoride	Fe	Nitrate
Temp	1									
pH	0.643	1								
Turbidity	-0.002	0.065	1							
TH	0.430	0.228	-0.001	1						
Cl	0.203	0.391	0.677	0.243	1					
DO	-0.164	-0.582	0.059	-0.237	-0.089	1				
BOD	-0.444	-0.303	-0.227	-0.249	-0.555	-0.303	1			
Fluoride	0.373	0.489	0.388	0.335	0.120	-0.722	0.058	1		
Fe	0.681	0.789	0.388	-0.114	0.452	-0.181	-0.435	0.338	1	
Nitrate	-0.160	0.174	-0.259	-0.404	-0.207	0.207	-0.372	-0.153	0.189	1

7. Water Quality Index of the Study Area

The data was also used to calculate the Water Quality Index to get better understanding of overall water quality. The standards as per Bureau of Indian Standard and Indian Council of Medical Research for the drinking with its corresponding status categories of WQI are given in Table 1 and 4. The WQI in respect to individual sampling locations are provided in Table 5. The WQI ranged from 94.44 to 223.53 which indicate very poor to unfit for drinking purpose status of water quality.

Table 4. Unit Weight of parameters based on Indian drinking water standard

Parameter	Standard	Unit Weight (w_i)
pH	6.5-8.5 (BIS)	0.0248
Turbidity	5 (BIS)	0.0421
Total Hardness	300 (BIS)	0.0007
Chloride	250 (BIS)	0.0008
Dissolved Oxygen	5 (ICMR)	0.0421
Biological Oxygen Demand	5 (ICMR)	0.0421
Fluoride	1.5 (BIS)	0.1404
Iron	0.3 (BIS)	0.7022
Nitrate	45 (BIS)	0.0047

Table 5. Quality Rating, Water Quality Index and Category of water of various water samples

Sampling Site	Quality Rating = $\sum q_i$	WQI = $\sum q_i \times w_i$	Category
S1	1748.77	223.53	Unfit for drinking purpose
S2	739.10	105.98	Unfit for drinking purpose
S3	689.24	99.72	Very Poor
S4	867.63	100.43	Unfit for drinking purpose
S5	849.63	116.02	Unfit for drinking purpose
S6	994.73	127.97	Unfit for drinking purpose
S7	1067.48	117.65	Unfit for drinking purpose
S8	661.67	94.44	Very Poor
S9	811.27	111.50	Unfit for drinking purpose
S10	874.99	120.42	Unfit for drinking purpose

8. Conclusion

This study provides an informative primary data on water quality parameters and helps to understand the contamination of Pahuj River water and its possible influence on the ecological system. In the present study, an effort has been made to evaluate many physico-chemical parameters and its characteristic behavior of a river water samples at different sampling sites. Water Quality Index is a very useful tool to understand the water quality for drinking purpose. Water quality index of Pahuj River varies from 94.44 to 223.53 which indicate that the quality of Pahuj River is very poor to unfit for drinking purpose. This may be due to heavy discharge of effluent, domestic sewage and other anthropogenic activities. The study suggest immediate need to take extensive water quality monitoring studies and to find the remedial measures to protect this important natural water sources in the study area.

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