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RESEARCH ARTICLE

ASSESSMENT OF WATER QUALITY IN RIVER BETWA AND PAHUJ AROUND JHANSI CITY, UTTAR PRADESH, INDIA

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ABSTRACT

Jhansi which is situated in Central part of India of Bundelkhand region of Uttar Pradesh, India having two rivers namely Betwa and Pahuj in East and West part of the city respectively. The present investigation was carried out on both of the river to find out the assessment of water quality. The sampling locations were chosen carefully in order to get maximum representation of the diverse eco-hydrological environments within the river system. Our investigation showed that the water of Betwa and Pahuj River are alkaline in nature with higher concentration of cations. Nitrate was dominant at site III followed by Site II and I and it can be attributed due to high rate of decomposition and anthropogenic pressure. In both the river Dissolved Oxygen was dominant at site I and II compare to site III due to abundance of animated life and the microbial activity, which result in the depletion of the dissolved oxygen.

INTRODUCTION

Water is the most vital resource for life. Approximately 97.2% water lies in oceans as salt water. While 2.15% in frozen ice from and the remaining 0.65% remain as fresh either on surface or ground water. Available fresh water resources are very limited. The demand for fresh water has increased day by day and will increase with the rapid growth of population, agriculture and industry. As a result the fresh water reserve depletes day by day too. The requirement of clean water per person is about 2.7 lit per day, thus the global requirement is about 5 billion cu. m. only for drinking purpose. Agriculture is also one of the major consumers of fresh water resources. Water as resource is under relentless pressure due to population growth, rapid urbanization, large scale industrialization and environmental concern (Rai and Pal, 2002). It is one of the most important commodities which man has exploited than any other resource for the substance of his life (Mathur and Maheshwari, 2005). Water pollution has now reached a crisis point specifically in developing world. Almost every water body is polluted to an alarming level. Thus, estimation of quality of water is extremely important for proper assessment of the associated hazards (Warhate *et al.,* 2006). In societies like our India with developing economics, the optimum development, efficient utilization and effective management of their water resources should be the dominant strategy for economic growth. But in recent years unscientific management and use of this resources for various purpose almost invariably has created undesirable problems in its wake, water logging and salinity in the case of agriculture use and environment pollution of various limits as a result of mining, industries and municipal use (Kumar et al., 2008).

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Bundelkhand region of Uttar Pradesh comprising of seven districts viz., Banda, Chitrakoot, Hamirpur, Jhansi, Lalitpur and Mahoba which is known as socio-economically backward region of the country. It is situated in the South West of the River Yamuna and slope South-West to North-East. The water quality of Lakes/Pond/River has deteriorated sufficiently to cause serious disturbance to the biodiversity of Lake/Pond/River environments due to lack of proper planning and negligence of regulations, an appreciable amount of environmental degradation and ecological damage to Lake/Pond/River water in this region (Kumar *et al.,* 2010). Aquatic ecosystems are getting polluted day by day due to the growth of the industrial corridor, nutrient loading and rapid anthropogenic activities especially in developing countries (Kumar and Pal, 2010). Chemical contamination of the environment is a pervasive insidious side effect of human population growth and technological development. With this background present proposed study has been undertaken for examine the water quality of river Betwa and Pahuj which are most important rivers flowing with in Jhansi city of Bundelkhand region of Uttar Paradesh with the fallowing objectives-

- For examine the water quality of Betwa and Pahuj River.
- Find out seasonal and spatial variation in water chemistry.
- To provide a base line data for the formulation of future conservational and management policies.

MATERIAL AND METHODS

Study area

Jhansi is well known district of Bundelkhand region of Uttar Pradesh with a geographical area of 502.75 thousand hectare. The district is situated in the South West corner of the region

at 24º11' - 25º57' N latitude and 78º10' - 79º23' E longitudes. Population of Jhansi is near about 4, 79,612.The western area of the district is covered with hillocks. Jhansi is located in the plateau of central Indian area dominated by rocky reliefs and minerals underneath the soil. The city has a natural slope in the north as it lies on the south western border of the vast *Tarai* plains of Uttar Pradesh. The elevation rises on the south. The region relies heavily on Monsoon rains for irrigation purposes. Under an ambitious canal project (Rajghat canal), the government is constructing a network of canals for irrigation in Jhansi and Lalitpur and some area of Madhya Pradesh.

Being on a rocky plateau, Jhansi experiences extreme temperatures. Winter begins in October with the retreat of the Southwest Monsoon (Jhansi does not experience any rainfall from the Northeast Monsoon) and peaks in mid-December.

Analytical design

Physical and chemical properties of water have been done according to standard methods (APHA, 2005) and Hi-Media (WT 023) kit and their specific range for water analysis are presented below (Table 1).

RESULTS AND DISCUSSIONS

Detail physico-chemical properties of river Betwa and Pahuj have been presented in Table – 2 and 3 respectively. It was observed that both the river water have showed slightly alkaline in nature i.e. pH ranges from 6.9 to 8.6 in Betwa river while 7.03 to 8.76 in Pahuj river. The conductivity, being the measure of total ionic potential in the water, the highest specific conductivity was obtained at site III during peak

Table 1. Methods of water analysis (Hi-Media Kit)

S.No.	Type of test	Range	Reagent Provided
01.	pH	pH test strips of range 2.0 to 10.5	
02.	Turbidity (visual comparison method)	0-25 NTU standards	5 Bottles : bottle marked sample bottle for standards of 0, 5, 10, and 25 NTU for turbidity comparison.
03.	Chloride (Titration method)	----	4 reagent bottles: marked CHL-A, CHL-B, CHL-C (2 bottles)
04.	Total hardness (Titration method)	25-600 mg/l (ppm) *CaCo3*	4 reagent bottles: marked TH-A, TH-B, TH-C (2 bottles)
05.	Fluoride (visual colour comparison method)	0-2.5 mg/l (ppm)	2 Reagent bottles: marked reagent FL-A, FL-B
06.	Nitrate (visual colour comparison method)	0-100 mg/l (ppm)	One reagent bottle : marked reagent Fe
07.	Iron (visual colour comparision method)	0-2 mg/l (ppm)	One reagent bottle: marked reagent Fe
08.	Residual free chlorine (Titration method)	0-3 mg/l (ppm)	4 Reagent bottles: marked reagent RCL-A, RCL-B, RCL-C

The mercury generally reads about 4^0C minimum and 21^0C maximum. Spring arrives by the end of February and is a short-lived phase of transition. Summer begins by April and summer temperatures can peak at 47^0C in May. The rainy season starts by the third week of June (although this is variable year to year). Monsoon rains gradually weaken in September and the season ends by the last week of September. In the rainy season, average daily high temperature around 36^0C with high humidity. The average rainfall for this city is about 900 mm per year, observed almost entirely within the three-and-a-half months of the Southwest Monsoon. Jhansi which is situated in Central part of India of Bundelkahnd region of Uttar Pradesh having two rivers namely Betwa and Pahuj in East and West part of the city respectively. The present investigation was carried out on both of the river to find out the quality of water. Betwa River is located in the east of Jhansi city. Monthly water sample have been collected from 3 different point of Betwa River around Jhansi city (About 5 Km stretch) as fallows-.

Site1. Kachcha Ghar;
Site2. Orchha Resorts and
Site3. Knot Ghat respectively.

Pahuj River is located in the west of Jhansi city. Monthly water Sample have been collected from 3 different points of Pahuj River around Jhansi city (About 5 Km stretch) as fallows –

Site1. After railway (Garia) dam;
Site2. Dhobi Ghat (Sipri) and
Site3. Pahuj Dam.

summer against the lowest at site I during winter in Betwa river. Maximum water conductivity was recorded during May at site III and minimum was recorded during January at site II in Pahuj river. Conductivity was increased downstream in both the river may be attributed to higher concentration of soluble ions and high nutrient enrichment. The conductivity mainly depends on ionic concentration or dissolved inorganic substances. Alkalinity plays an important role in buffering capacity of water (Hutchinson, 1967) where upstream sites fall under soft medium water type and downstream site fall under hard water increased catchment influences on the stream water. The natural water most of the alkalinity is due to CO_2. The free CO_2 react water partly to form carbonic acid (H_2CO_3) which further gets dissociated in to hydrogen (H^+) and bicarbonate (HCO_3) ions. The HCO_3 ions thus formed get further dissociated into H^+ and CO_3 ions.

At site III of Betwa river maximum alkalinity was recorded during May and minimum was found during January at site II whereas in Pahuj river maximum alkalinity was observed during May in site III and minimum was recorded during January at site II. In the present study total hardness increased towards the onset of summer and it was maximum (157 mg/l) in site II of Betwa river and148 mg/l in site III of Pahuj river. The hardness of water is mainly governed by the content of calcium and magnessium salt. Hardness may be due to the persence of Ca^{++} and Mg^{++} salts from detergents and soaps used for laundering on the bank of the stream precipitated as calcium carbonate.

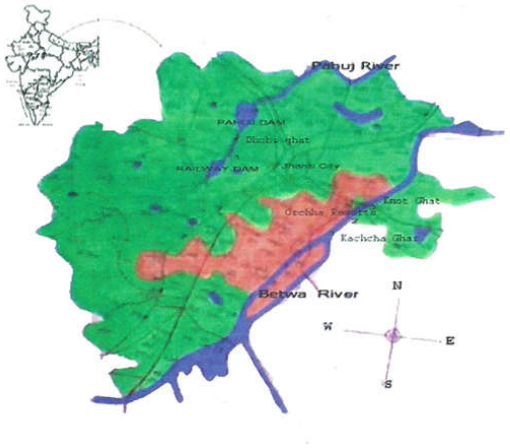

Fig. 1. Location of sampling sites in Betwa and Pahuj River
(not in scale)

contamination .During the present investigation an increase the concentration of Nitrate-nitrogen were observed in downstream of the rivers. Such increase may be due to rapid decomposition of organic matter (Kumar and Pal, 2010; Sharma, 2003; Shyamala et al., 2008). It also emphasized that when the dead organic matter decomposes in water, it forms complex proteins which get converted into nitrogenous organic matter and finally to nitrate by bacterial activity. 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 (Hutchinson, 1967). 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. In the persent study, the maxmimum concentration of dissolved oxygen was observed in January (above 7 mg/l in both the river) that could be attributed to vigorous photosynthetic activity of the autotrophs. A marked decrease in dissolved oxygen content

Table 2. Water quality of Betwa River

S. N.	Parameter	January	February	March	April	May
01.	Temperature ºC	6.96±0.12	14.66±0.88	20±0.57	23±.1.15	25.33±0.88
02.	pH	12.33±0.88	7.33±0.12	7.33±0.12	8.2±0.32	8.6±0.37
03.	Conductivity (µS/cm)	578±.26.05	599.33±.20.34	616.33±.19.42	639±.9.86	632.66±.23.95
04.	Alkalinity (mg/L)	160±.5.77	177.66±.6.48	182.33±.6.74	18.3±.7.26	196.66±.8.81
05.	Total Hardness (mg/L)	116.33±6.06	123.33±.6.76	130±.7.63	139±.7.37	156.66±.11.66
06.	Chloride (mg/L)	13.33±3.33	15±2.88	21.66± 4.41	25±5.0	28.33±6.0
07.	Nitrate (mg/L)	6.40±0.98	7.15±0.99	7.96±0.61	8.56±0.74	9.63±0.44
08.	Dissolved Oxygen (mg/L)	7.46±0.48	6.93±0.46	6.30±0.49	5.56±0.47	4.71±0.25
09.	Turbidity (NTU)	6.66±1.66	10±0.00	13.33±1.66	18.33±3.33	21.66±3.33
10.	Total solid (mg/L)	313.33±6.00	350±9.16	364±8.62	352±6.00	376±3.00
11.	Total DS (mg/L)	264.33±6.6	293±4.5	301.33±3.7	284.66±9.2	297±2.3
12.	Total SS (mg/L)	49±6.65	57±4.93	62.66±5.36	67.33±5.23	73±6.11
13.	Fluoride (mg/L)	0.73±0.12	0.6±0.05	0.73±0.12	0.6±0.10	0.63±0.60
14.	BOD (mg/L)	4.7±0.29	4.7±0.29	4.7±0.29	2.1±0.32	2.13±0.17
15.	COD (mg/L)	43.33±2.6	40±3.0	35±2.3	33±2.3	31±1.5

The concentration of chloride was comparatively lower for being very low available. Chloride is found widely distributed in nature in the form of salt of sodium, potassium and calcium. The increase in the concentration of chloride down the stream point towards the faucal pollution. Chloride 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. The persent study depicted a narrow fluctuating range in chloride content. However, there was increasing trend in its amounts from January to May in both the river. In water the most important source of Nitrate- nitrogen is biological of nitrogen organic matter both autochthonous and allochthnous origin. Domestic sewage and agriculture runoff have been regarded as the main source of allocthonous nitrogenous organic matter.Metabolic wastes of aquqtic community and dead organism add the autocthonous nitrogenous organic matter. There are nitrifying bacteria which are known to play significiant role in oxidation of such organic matter. The high concentration of nitrate in water indicates pollution load.

Nitrate is the most highly oxidized and usually the most abudant 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 towards the summer could be the result of increase in water temperature and increased rate of decomposition. Turbidity is commonly linked to total suspended solids (TSS) because water with high TSS levels typically looks murkier and have higher turbidity measurements. Common suspended solids are clay, silt, and sand from soils, phytoplankton (suspended algae), bits of decaying vegetation, industrial wastes and sewage. Measuring turbidity in streams is an important indicator of the concentration of suspended sediments in the water. Sediments are a natural part of streams and other water bodies and even the most pristine streams in undeveloped watersheds will run muddy during high flows. Typically, after rainfall, the turbidity of the river increases with higher runoff rates.

Turbidity limits light penetration and hinders photosynthesis, thereby altering the composition and distribution of aquatic plant communities. Excessive fine sediment can fill the small spaces between the river bed gravel and reduce suitable habitat for many benthic invertebrates (e.g., mayflies, stoneflies, and clams) and spawning fish. Sediment absorbs solar energy, raising water temperatures and reducing the amount of dissolved oxygen. Sediment also carries nutrients, particularly phosphorus and toxic substances, such as PCBs and mercury. These may be released in the environment after sediment settles in the river bed (Basin Information Document, 1997). In our study, the amount of

Turbidity recorded higher amount in May (18 – 22 NTU) and lower in January (6– 11NTU) respectively. Total solids are a measure of the suspended and dissolved solids in water. Suspended solids are those that can be retained on a water filter and are capable of settling out of the water

(Adhikari and Gupta, 2002). In the present study also total suspended solids were increased during summer season. The concentration of dissolved solids in River water is important because it determines the flow of water in and out of the cells of aquatic organisms. Also, some dissolved inorganic elements

Table 3. Water quality of Pahuj River

S. N.	Parameter	January	February	March	April	May
01.	Temperature ºC	10.33±0.88	15.33±0.88	22±0.57	23.16±0.6	25.66±0.9
02.	pH	7.03±0.28	7.49±0.18	8.41±0.20	8.71±0.24	8.76±0.36
03.	Conductivity (µS/cm)	315±11.93	312.33±4.91	325.66±13.48	336.33±13.29	348±8.5
04.	Alkalinity (mg/L)	92.33±10.10	109.66±9.5	119.33±7.6	125±7.7	133.66±8.2
05.	Total Hardness (mg/L)	114.33±4.9	118±5.1	123±5.5	136.66±7.05	148.33±13.64
06.	Chloride (mg/L)	13.33±3.33	21.66±4.1	25.00±5.0	28.33±6.0	35.00±7.6
07.	Nitrate (mg/L)	6.06±0.52	7.3±0.43	7.5±0.34	8.2±0.15	8.5±0.25
08.	Dissolved Oxygen (mg/L)	7.06±.53	6.5±0.40	5.73±0.24	4.33±0.24	3.8±0.15
09.	Turbidity (NTU)	11.66±1.66	11.66±1.66	13.33±1.66	16.66±4.4	18.33±3.3
10.	Total solid (mg/L)	303±20.27	318.33±16.69	315.66 ±13.37	345±4.04	360.66±6.36
11.	Total DS (mg/L)	266±18.24	270.66±21.36	262.66±13.17	286.33±4.48	294±8.02
12.	Total SS (mg/L)	37.33± 2.02	47.66±4.97	53±1.00	58.66±2.7	66.33±0.9
13.	Fluoride (mg/L)	0.56±0.06	0.76±0.08	0.8±0.05	0.56±0.06	0.6±0.05
14.	BOD (mg/L)	3.0 ±0.44	3.1±0.48	2.7±0.38	2.3±0.40	19±0.47
15.	COD (mg/L)	49.33±4.4	43.66±4.2	40.33±3.5	36.66±2.9	33.66±1.8

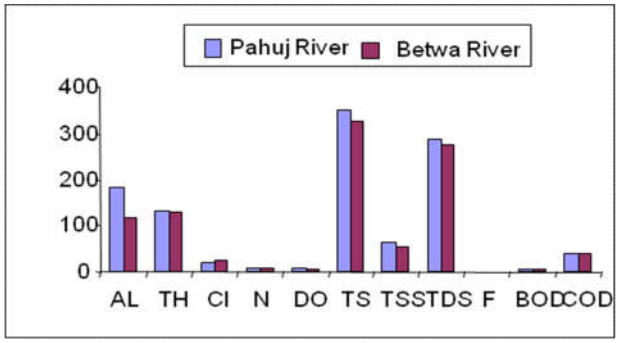

Fig. 2. Comparative analytical status of Betwa and Pahuj river (mean value)

(AL – Alkalinity; TH – Total Hardness; Cl – Chloride; N – Nitrogen; DO – Dissolve Oxygen; TS – Total solids; TSS – Total suspended solids; TDS – Total dissolved solids; F – Fluoride; BOD – Biochemical Oxygen Demand; COD – Chemical Oxygen Demand)

column into the stream bottom when stream velocities are low. They include silt, clay, plankton, organic wastes, and inorganic precipitates such as those from acid mine drainage. Dissolved solids are those that pass through a water filter. They include some organic materials, as well as salts, inorganic nutrients, and toxins. It was also found maximum with the increase in temperature (Table 2). The suspended solids determination is particularly useful in the analysis of sewage and other waste waters and is as significant as BOD determination. It is used to evaluate the strength of domestic wastewaters and efficiency of treatment units.

Suspended solids are objectionable in river for many reasons. Suspended Solids containing much organic matter may cause putrefaction and consequently the stream may be devoid of dissolved oxygen. Abbasi *et al*. (2002) in their study on Buckingham canal which passes through Chennai and carries run off water which is occasionally used for irrigation, laundry and other domestic purposes by economically weak population living near its banks, have reported lower values at summer and higher values during monsoon season. It has been observed that the lower values of total suspended solids in monsoon season and higher values in winter seasons from sewage effluent channel of Calcutta

such as nitrogen, phosphorus, and sulfur are nutrients essential for life. Fluoride level in various type of environment samples show wide variation in different river system in india. In general surface water sample in the mountain stream showed higher levels of fluoride. The mean fluoride concentration is given 245 ppb in rivers of India (Madhavan and Subramanian, 2001). The fluoride concentration of Chambal river 114 ppb, river Ganges 199 ppb, and Yamuna river 183 ppb (Saksena et al., 2008; Sarin and Krishnaswami, 1984) but in present investigation it was found quite low. The Fluoride at site I of Betwa river recorded maximum of 0.9 and minimum of 0.5 mg/l at site III. In Pahuj site II showed maximum comcentartion of Fl content (0.9 mg/l) and minimum 0.5 mg/l in same site. The mean Fl concentration observed almost same in both the river i.e. nearly 0.7 mg/l. BOD determination is still the best available single test for assessing organic pollution. BOD of water samples value was indication for entry of organic waste in the river. Ganga at Varanasi and showed that high values are indication of organic pollution (Mishra and Tripathi, 2007). Lower levels of BOD at the sampling sites indicated that the Kistobazar Nala is not polluted by sewage disposal, animal waste, etc. and this could be attributed to sparse distribution of agricultural fields in its catchment area. Higher level of BOD was observed in Ganga river may be due to sewage contamination in river Ganga at Bihar (Tiwari et al., 2005). Low level of BOD indicating less pollution status of river Cauvery (Begum and Harikrishna, 2008). High levels of BOD were found generally due to waste disposable at those sites. Low BOD at a tributary of middle Parana river (Argentina) was reported with the reference of river water quality facing pollution pressure from nearby areas (Marchese et al., 2008). Researchers observed BOD ranged between 0.60 to 5.67 mg/l in Chambal river, and suggested that this stretch of the river was free from organic pollution (Saksena et al., 2008). In the present study BOD were decreases during summer season and recorded higher in January in both the river i.e. 2.13 – 4.7 in Betwa and 1.9 – 3.0 mg/l in Pahuj respectively.

COD test is quite useful in finding out the pollution strength of industrial waste and sewage. Chemical oxygen

demand as is the amount of oxygen required for a sample to oxidize at its organic and inorganic matter. High level of COD in river Ganga at various places of Bihar mainly due to raw sewage, municipal waste, industrial effluents and anthropogenic disturbances (Tiwari *et al.,* 2005). COD from 174 – 429 mg/l showing higher pollution by sewage receiving TD-7 canal at Turkey. COD between 48 from 51 mg/l (Zaimoglu *et al.,* 2006) showing creation of pollution due to nearby industries and human disturbances through infrastructure works at Salado river (Argentina). Little abundance of COD in Kosi river, Uttrakhand indicating pristine nature and good health of river (Bhandari and Nayal, 2008). In the present study COD also increase during winter and decrease slowly during summer and ranges between 31 – 43mg/l in Betwa and 33 – 49 mg/l in Pahuj river. Pahuj river is comparatively much polluted (Figure -2) than Betwa river as it is bearing more domestic load due to its proximity to Jhansi city.

Conclusion

The present study area comes under semi arid region with low precipitation (900 mm/yr) and higher evaporation (1800 mm/yr). Therefore ground water is in small quantity and ground water table goes down during summer month (mid April to June). Surface water is Main source of water in Jhansi i.e. Betwa River, Pahuj River, Baruwa Sagar lake, Lakshmi Tal, Atiya Tal are the source of surface water . Both the quality and quantity of this resource should be maintained for betterment of the local people. Before management of the surface water bodies the physico-chemical characteristics of the water should be thoroughly studied. The temperature of all sites was found to be progressive with the advancement of summer season. With the increase in temperature of air there was automatically corresponding increase in temperature of water. Alkalinity value of site of Pahuj river II and III were high compare to Site I but in Betwa river Site III and I were high in compare to Site II which is indicative of their richness in electrolytes. In Pahuj river Site II and III have hard water compared to site I but in Betwa River site II and I have hard water compared to site III due to the presence of Ca and Mg ions. Presence of Nitrate can be attributed due to high rate of decomposition and anthropogenic pressure. After investigation it have been conclude that that both river Betwa and Pahuj is unpolluted up stream while as downstream it is polluted and the main source of pollution is the sewage disposal and agricultural runoff from the catchments areas and need to be proper treatment before uses.

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