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Impact of Industrial effluents on Water Quality of Betwa River near Mandideep, Raisen

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Abstract

Betwa an important river in central part of state of Madhya Pradesh originates from village Jhiri of Raisen District and travels through the industrial belt of Mandideep and Bhojpur. After flowing through several cities of Madhya Pradesh it enters the neighboring state Uttar Pradesh at Hamirpur and finally joins in Yamuna River. However the quality of river water deteriorates at several places due to inflow of sewage, industrial effluents, agricultural residues etc. from its adjacent catchment at many places. The major problem of Betwa River is the discharge of industrial effluents and sewage from the Mandideep Town besides other cities. The accrual of toxic elements from the discharge of effluent and nutrients from the eroded river banks, agricultural field has resulted in increasing level of nutrients as well as certain heavy metals like Cr, Cd, Zn & Cr. Most of the water-spread area of the riverbed has also become shallow and subsequently almost three forth part of the bed near the industrial area is covered with infestation of weeds the making the water unfit for domestic uses.

The present paper deals with the seasonal variation of limnochemical and toxicological characteristics of river Betwa during the winter months (October 2016 to December, 2016). For the present study four sampling stations were selected viz. Station- I Jhiri, Station- II, Mandideep, Station- III; Bhojpur, Station- IV; Vidisha.

The outcome of the studies revealed high values of certain parameters like BOD and COD at Station III Mandideep. The paper highlights the impact of the Industrial effluents on Water Quality of the River near Mandideep region.

Keywords: Betwa River, Mandideep, Pollution, limnochemical, BOD, COD

Introduction

Water is the basic and primary need of all vital life processes. Even today it is the major consideration for all socio-economic cultural, industrial and technological developments. Besides drinking, water is also used for fish and aquaculture, irrigation, hydropower generation etc. but these days water, the elixir of life is becoming more and more unfit and dearer to mankind due to over exploitation, unwise use, neglect and mismanagement. Today water resources have been the most exploited natural systems. Pollution of water bodies is increasing steadily due to rapid population growth, industrial proliferation, urbanization, increasing living standard and wide share of human activities. The rapid urbanization and industrialization have caused the generation of huge quantum of wastes both liquid and

solid. Unfortunately the pace of development of waste disposal schemes as expected could not match with the rapid rate of urbanization during last few decades. As a result the waste not properly disposed, reaches the water sources and thereby the water sources like river, lakes and reservoirs that are in close proximity of the urban centers are highly polluted (Pande and Sharma, 1998).

In India like other south Asian countries, most of the cities developed without proper development plan. Consequently sewage systems of the cities are not well planned. Hence wastes of homes and industries ultimately reach to the water bodies through the ill developed sewage system. One of the most significant examples is river Betwa, which is considered to be lifeline of Madhya-Pradesh along with river Narmada, is highly polluted these days due to discharge of effluents from the adjacent Mandideep Industrial clusters (Vishwakarma,2013).

Hence keeping the above scenario in mind the present study has been undertaken to assess the impact of Industrial effluents from Mandideep Industrial hubs of District Raisen on water quality of river Betwa.

Materials and Methods

Sample Collection:

A meticulous survey was conducted to identify the pollution prone zones of the river before initiation of the study. On the basis of the survey conducted and literature available, four stations were selected for collection of water samples. The sites were selected mostly on the basis of various activities occurring on surrounding area of the river. Samples were taken at the following points at monthly intervals during winter season of 2016.

Description of sampling stations:

Station- 1 Jhirri (Origin of Betwa River)
Station -2 Near Mandi deep
Station- 3 Mandi deep (Down stream of the Bridge)
Station- 4 Bhojpur (Down stream of the Bridge)

Water samples from the River were directly collected from the above four stations in one liter plastic cans. The water samples were collected from a depth of 30cm using Ruttner Water Sampler. Sampling and analytical procedures were followed as per the Standard Methods (APHA, 2005).

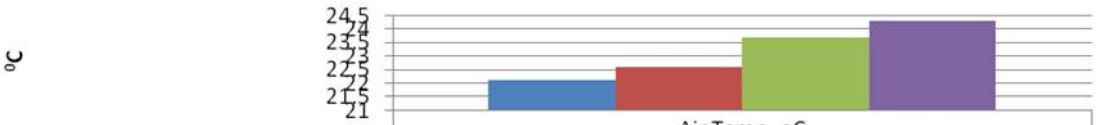
Results and Discussion

Results of various physico-chemical parameters in water samples of Betwa river is summarized below

Temperature:

During the period of investigation, the minimum value of air temperature (22.1 ^{0}C) was recorded at station-1, i.e. Jhiri, the place of origin of the river, while maximum value of air temperature (24.3 ^{0}C) was recorded at the station-4, i.e. near Bhojpur temple (Fig-1).

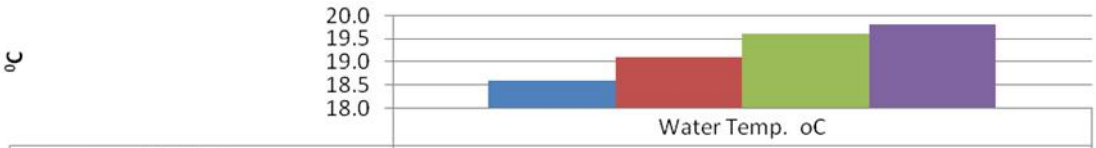
Fig- 1 Air temperature at various stations of Betwa River



	Air Temp. oC
Station-1 Jhiri, Origin	22.1
Station-2 Mandideep near Bridge	22.6
Station-3 Mandideep, Downstream	23.7
Station-4 Bhojpur	24.3

The water temperature on the other hand during the period of investigation varied from 18.6 ^{0}C to 19.8 ^{0}C. The minimum value was recorded at station-1, i.e. Jhiri, the place of origin of the river, while the maximum value of water temperature was recorded at the station-4, i.e. near Bhojpur temple (Fig-2).

Fig- 2 Water temperature at various stations of Betwa River



	Water Temp. oC
Station-1 Jhiri, Origin	18.6
Station-2 Mandideep near Bridge	19.1
Station-3 Mandideep, Downstream	19.6
Station-4 Bhojpur	19.8

The variation in water temperature during present investigation may be due to difference in timing of collection and the influence of season. Temperature controls behavioral characteristics of organisms, solubility of gases and salts in water. No other factor has so much influence as temperature. The variation is mainly related with the temperature of atmospheric and weather condition (Adebowale et. al., 2008).

pH

The value of pH was recorded from mild acidic range to alkaline range during the period of investigation. The lowest value of pH (6.4) was recorded at sampling station located in the downstream of Betwa River near Mandideep, while the highest value of pH (7.8) was recorded at the sampling located near Bhojpur. The reduction in the pH of river Betwa could have been due to the discharged industrial effluents. This result agrees with the reports by previous scientist (Edema et.al. 2006; Rim- Rukeh et.al. 2006).

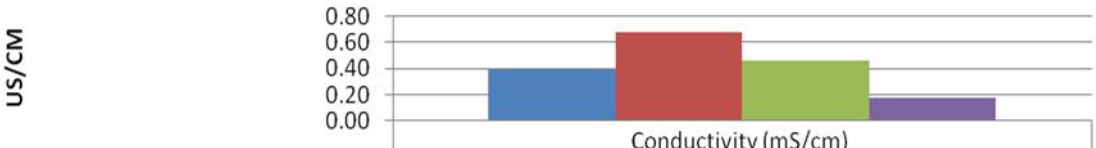
Fig-3 pH at various stations of Betwa River

	pH
Station-1 Jhiri, Origin	7.4
Station-2 Mandideep near Bridge	6.6
Station-3 Mandideep, Downstream	6.4
Station-4 Bhojpur	7.8

Conductivity:

Conductivity of the River water fluctuated between 0.18mS/cm to 0.68 mS/cm. The minimum conductivity value was recorded at the station-4 and the maximum conductivity was recorded at the station-2 which was generally higher which indicate that the significant amount of precipitation or erosion that may have an impact on water quality.

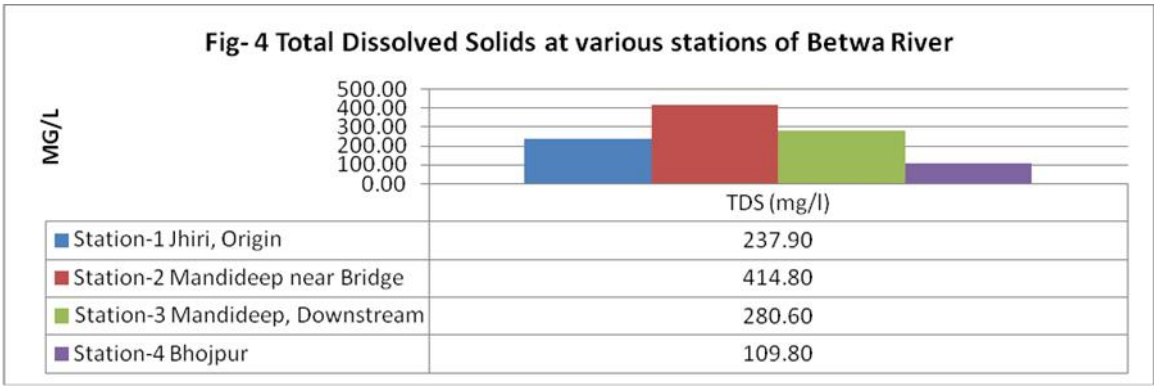
Fig- 5 Conductivity at various stations of Betwa River



	Conductivity (mS/cm)
Station-1 Jhiri, Origin	0.39
Station-2 Mandideep near Bridge	0.68
Station-3 Mandideep, Downstream	0.46
Station-4 Bhojpur	0.18

Total Dissolved Solid (TDS)

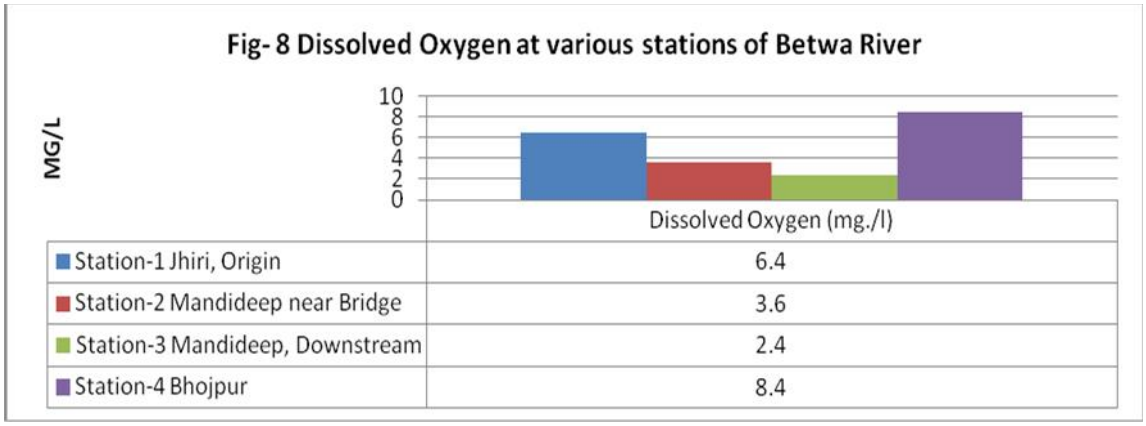
Total Dissolved Solid in the present study fluctuated in the range of 109.80 mg/liter to 414.80 mg/l. TDS was recorded in minimum range at the station-4 while it was maximum at station-2.



Total dissolved solids are a measure of the solid materials dissolved in the river water. This includes salts, some organic materials, and a wide range of other things from nutrients to toxic materials. The amount and nature of dissolved and un-dissolved matter occurring in liquid materials vary greatly. Waters with higher solids content have laxative and sometimes the reverse effect upon people whose bodies are not adjusted to them.

Dissolved Oxygen (D.O)

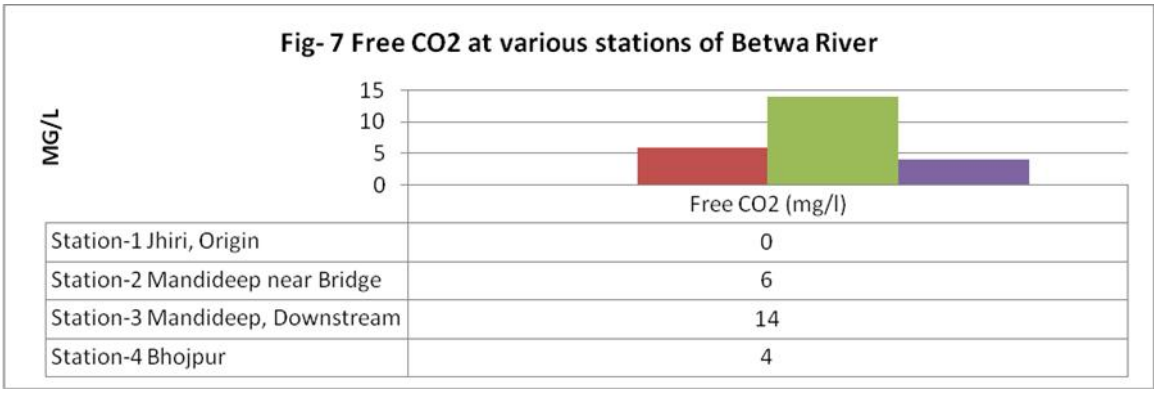
In the present study dissolved oxygen was recorded in the range of 2.4 to 8.4 mg/l. The minimum value of DO was found at station-3 while the maximum value of DO was observed at station-4.



Dissolved oxygen is very crucial for the survival of aquatic organism, Yakub and Ugwvmba, (2009). The DO ranged from 2.4 to 8.4 mg/l. Minimum dissolved oxygen was due to effluents discharge, Emongor et. al., 2005, also suggested that the industries releasing some organic substances that were high oxygen demanding wastes could be responsible for depletion of DO.

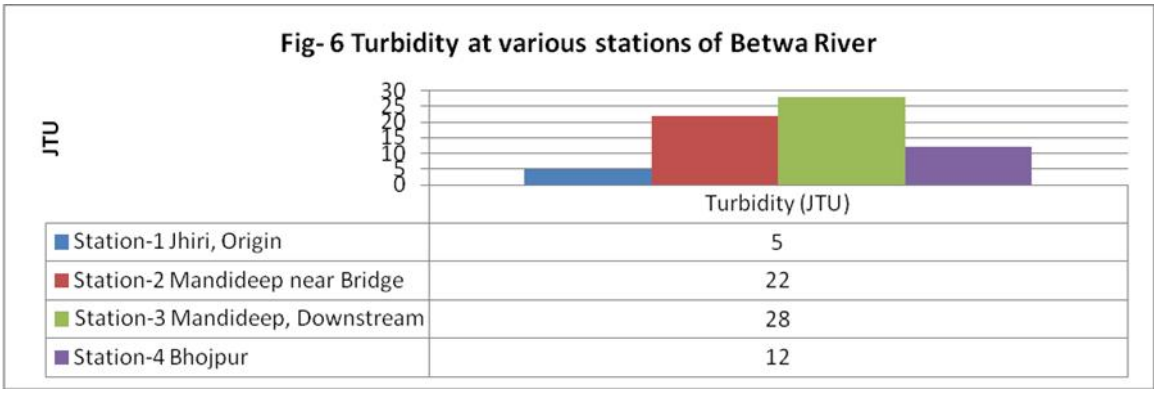
Free CO_2

In the present study Free CO_2 was found in the range of Nil to 14 mg/l. CO_2 was absent at the station-1 while it was maximum at station-3.



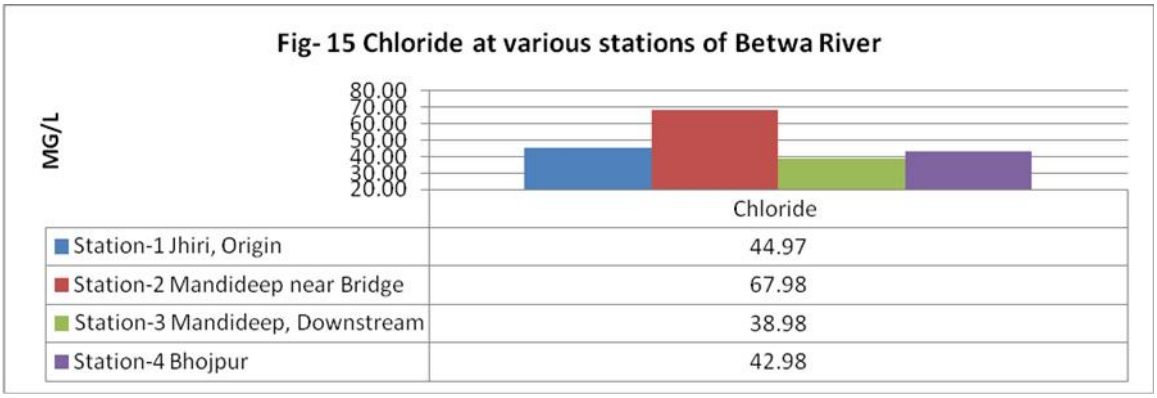
Turbidity

In the present study turbidity was found in the range of 5 to 28 mg/l. minimum value of turbidity was found in station-1 and the maximum value of turbidity was found at station-3.



Chloride

Chloride concentration was found in the range of 38.98 mg/l to 67.98 mg/l. The minimum value of chloride was found at the station-3 while the maximum concentration of chloride was found at the station-2.



Total Alkalinity

Total Alkalinity was found in the range of 128 mg/l to 288 mg/l. The value of minimum alkalinity was found in station-4 while the maximum value of alkalinity was found at station-2.

Fig- 9 Total Alkalinity at various stations of Betwa River

	Total Alkalinity
Station-1 Jhiri, Origin	176
Station-2 Mandideep near Bridge	288
Station-3 Mandideep, Downstream	228
Station-4 Bhojpur	128

Carbonate Alkalinity (CO_3^-)

In the present study the range of Carbonate Alkalinity was 0 to 12 mg/l. Carbonate was absent at station-2,3 and 4 it in station-2, station-4 while the maximum value was recorded at station-1 .

Fig- 10 Carbonate Alkalinity at various stations of Betwa River

	Carbonate alkalinity
Station-1 Jhiri, Origin	12
Station-2 Mandideep near Bridge	0
Station-3 Mandideep, Downstream	0
Station-4 Bhojpur	0

Bicarbonate Alkalinity (HCO_3-):

In the present study Bicarbonate was found in the range of 128 Mg/l to 288 mg/l. The minimum value was found in station-4 and the maximum value was found in station-2.

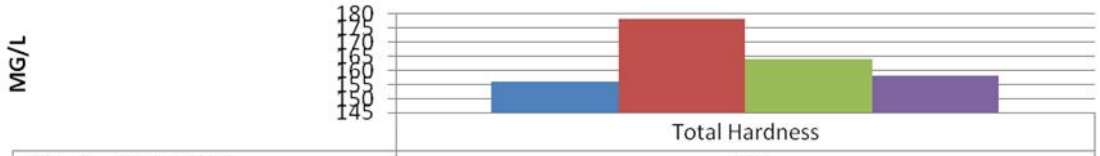
Fig- 11 Bi-carbonate Alkalinity at various stations of Betwa River

	Bi-Carbonate alkalinity
Station-1 Jhiri, Origin	164
Station-2 Mandideep near Bridge	288
Station-3 Mandideep, Downstream	228
Station-4 Bhojpur	128

Total Hardness

The total hardness was recorded in the range of 156mg/l to 178 mg/liter. The minimum value was recorded in Station-1 while the maximum value was recorded at Station-3.

Fig- 12 Total Hardness at various stations of Betwa River



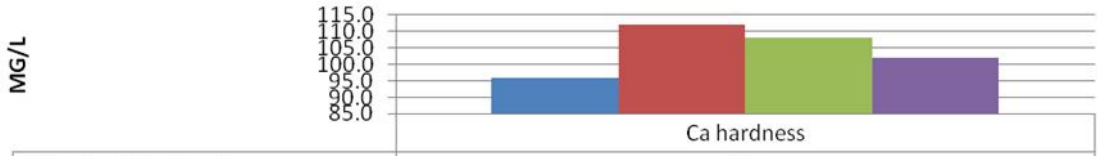
	Total Hardness
Station-1 Jhiri, Origin	156
Station-2 Mandideep near Bridge	178
Station-3 Mandideep, Downstream	164
Station-4 Bhojpur	158

Hardness is often used to assess the quality of water. Hard water contains large concentrations of alkaline earths dissolved from the drainage of calcium deposits (Wetzel, 1975). In the present study the observed values ranged from 14.6 to 58.6 mg/l. The increase in hardness can be attributed to the decrease in water volume and increase in the rate of evaporation at high temperature, high loading organic substances, detergent, chlorides and other pollutants (Rajgopal *et.al*. 2010)

Calcium Hardness

Calcium Hardness value was found in the range of 96 mg/l to 112 mg/l. The minimum value of calcium was found at station-1 while the maximum value of Ca was found at station-2.

Fig- 13 Calcium Hardness at various stations of Betwa River



	Ca hardness
Station-1 Jhiri, Origin	96.0
Station-2 Mandideep near Bridge	112.0
Station-3 Mandideep, Downstream	108.0
Station-4 Bhojpur	102.0

Magnesium Hardness

Magnesium Hardness value was found in the range of 56 mg/l to 66 mg/l. The minimum value of magnesium was found in station-3&4 while the maximum value was found at station-1.

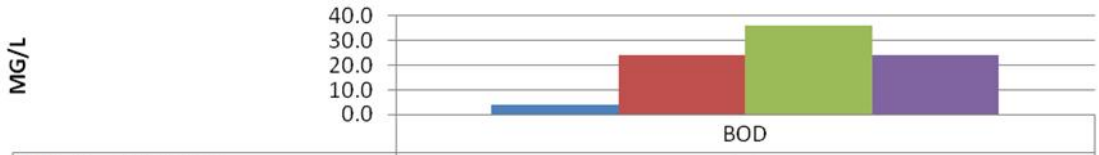
Fig- 14 Magnesium Hardness at various stations of Betwa River

	Mg hardness
Station-1 Jhiri, Origin	60.0
Station-2 Mandideep near Bridge	66.0
Station-3 Mandideep, Downstream	56.0
Station-4 Bhojpur	56.0

Biochemical Oxygen Demand (BOD)

In the Betwa River minimum BOD was recorded at station-1 and the maximum value of BOD was recorded at station-3.

Fig- 16 Biochemical Oxygen Demand at various stations of Betwa River



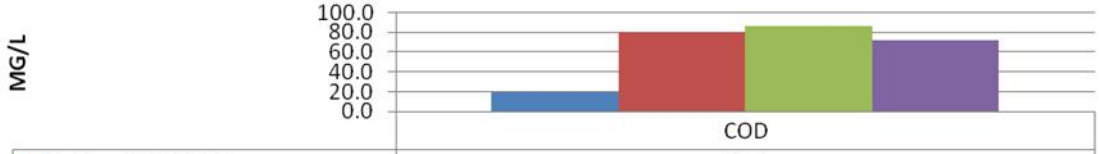
	BOD
Station-1 Jhiri, Origin	4.0
Station-2 Mandideep near Bridge	24.0
Station-3 Mandideep, Downstream	36.0
Station-4 Bhojpur	24.0

Biological oxygen demand (BOD) is an important parameter which is widely used to determine the pollution load of waste water. The aim of BOD test is determine the amount of biochemically oxidisable carbonaceous matter (Gupta et. al., 2003). BOD value of river water ranged 4 to 36mg/l. High value of BOD recorded at station 2 and 3 and 4. These were due to higher rate of decomposition of organic matter at higher temperature, turbidity and less water current (Sanap et.al. 2006).

Chemical Oxygen Demand (COD)

The minimum COD found in Betwa River was at the station-1 while the maximum COD was recorded at station-3 in first sampling.

Fig- 17 Chemical Oxygen Demand at various stations of Betwa River

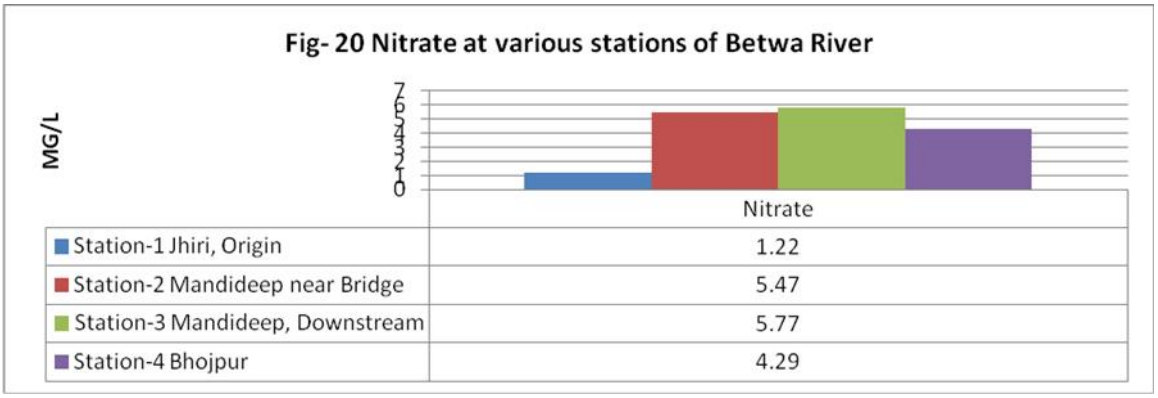


	COD
Station-1 Jhiri, Origin	20.0
Station-2 Mandideep near Bridge	80.0
Station-3 Mandideep, Downstream	86.0
Station-4 Bhojpur	72.0

Chemical oxygen demand is a test which is used to measure pollution of domestic and industrial waste. This gives valuable information about the pollution potential of industrial effluents and domestic sewage (Gupta *et. al*., 2003). In the present study the value of COD varies from 20 to 86 mg/l. highest value of COD indicates that most of pollution in study zone in Betwa River in caused by industrial effluents discharged by industrial units. Similar results were also reported by Pande and Sharma (1998)

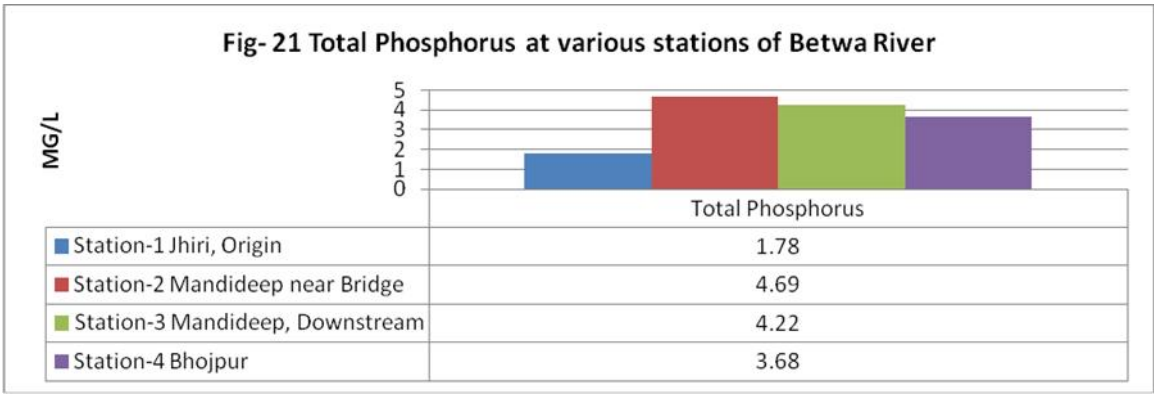
Nitrate:

The nitrate concentration in Betwa River water was found from 1.22 mg/l to 4.29 mg/l. The minimum concentration of nitrate was found at the station-1 and the maximum concentration was found at the station-3.



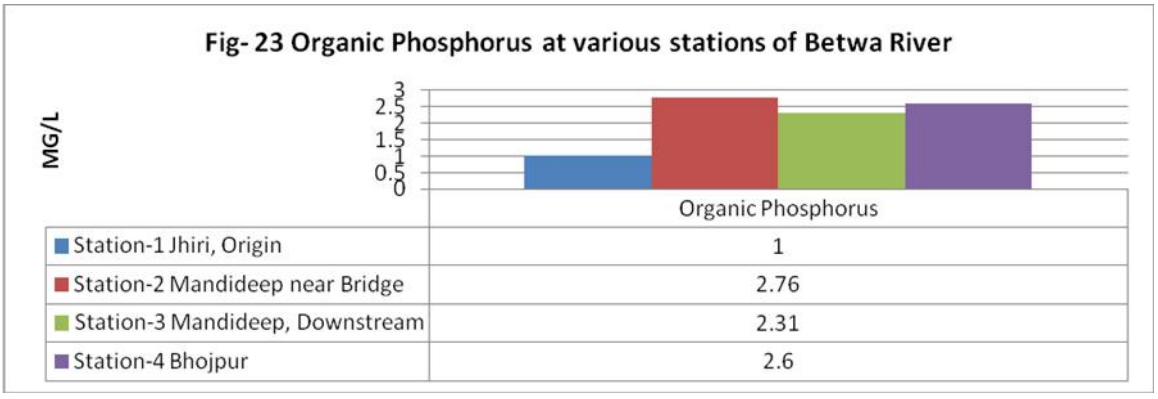
Phosphate

During the study period phosphate was found in the range of 1.78 mg/l to 4.69 mg/l. The minimum value was recorded at station-1 and it was found maximum at station-2.



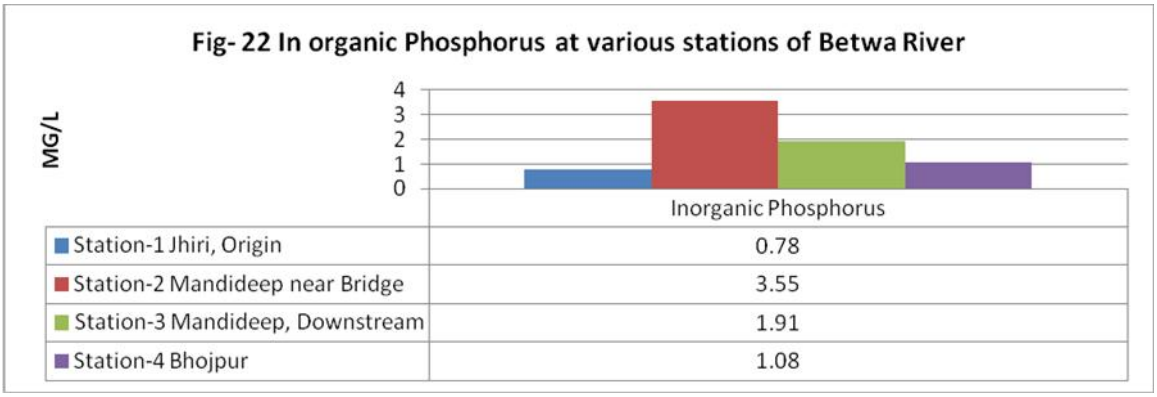
Organic Phosphate

The organic phosphate during the present investigation ranged from 1.0 mg/liter to 2.76 mg/liter. The minimum value was recorded at Station-1, while the maximum value was observed at Station-2.



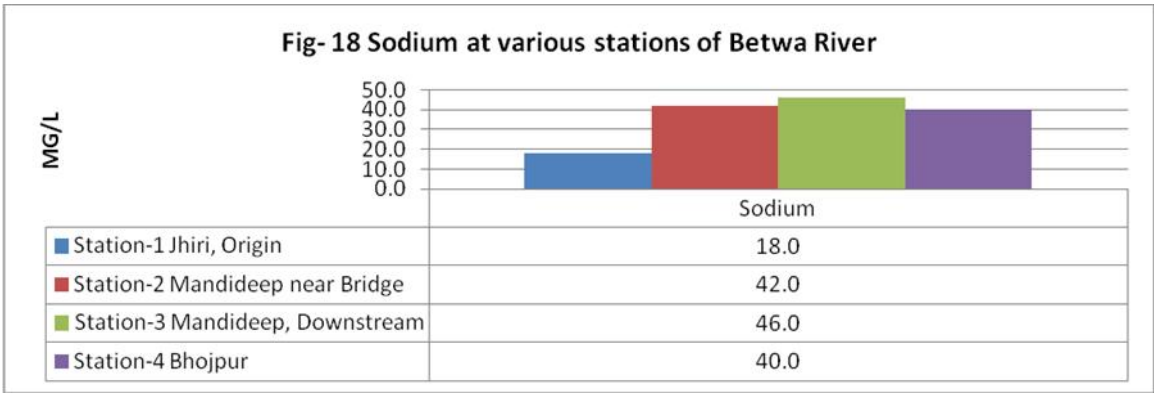
In Organic Phosphate

The in organic phosphate during the present investigation ranged from 0.78 mg/liter to 3.55 mg/liter. The minimum value was recorded at Station-1, while the maximum value was observed at Station-2.



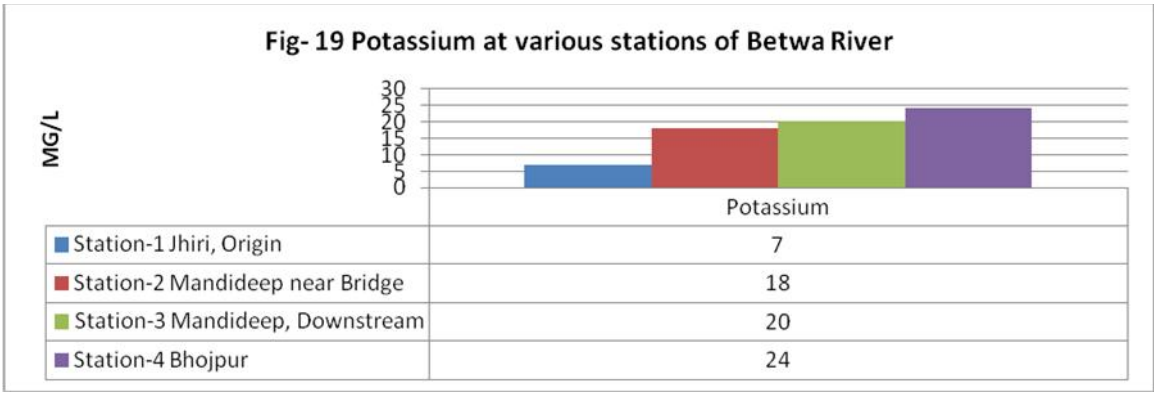
Sodium

The values of sodium during the present investigation ranged from 18.0 mg/liter to 46 mg/liter. The minimum value was recorded at Station-1, while the maximum value was observed at Station-3.



Potassium

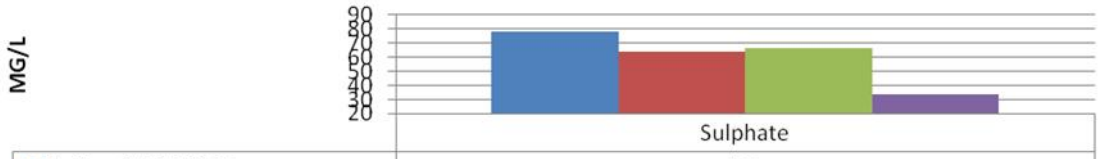
The potassium during the present investigation ranged from 7.0 mg/liter to 24 mg/liter. The minimum value was recorded at Station-1, while the maximum value was observed at Station-3.



Sulphate

The Sulphate during the present investigation ranged from 34.0 mg/liter to 78 mg/liter. The minimum value was recorded at Station-4, while the maximum value was observed at Station-1.

Fig- 24 Sulphate at various stations of Betwa River



	Sulphate
Station-1 Jhiri, Origin	78
Station-2 Mandideep near Bridge	64
Station-3 Mandideep, Downstream	66
Station-4 Bhojpur	34

pH values (6.4 to 7.8) of all sites were closed to recommended value (6.5-8.5) of water for drinking purpose. With the exception Statiuon-2 having a little low pH value (slight acidic), it was noticed that the pH value of the water appears to be dependent upon the relative quantities of calcium, carbonates and bicarbonates. The water trends to be more alkaline when it possessed carbonates (Suryanarayana, 1995). Electrical conductivity values closely correlated with content of total dissolved solids. Total dissolved solids denote presence of different minerals in water, TDS is mainly on account of carbonates, bicarbonates, chlorides, sulphates, phosphate nitrate, calcium, potassium, Iron (Trivedy and Goel 1986) TDS level tested at all sites were within the permissible limits. A high value (414 & 280 mg/liter) was observed at site-2 and site-3 respectively. Alkalinity is a measure of the capacity of water to absorb hydrogen Ion. The higher value of alkalinity indicates presence of bicarbonates, carbonates and hydroxide in water body (Jain et al 2000). Alkalinity levels tested at all sites within the permissible limits (**128 mg/l to 288 mg/l**) as recommended by BIS (1991). Hardness is caused by the presence of soluble salt of Ca. Mg. Sr. Fe. & Mn. It is characterized by reduction of lather efficiency of water with soap. In the present investigation the total Hardness values ranged from **156mg/l to 178 mg/liter. Total Hardness in** all the stations was found within the permissible limits by BIS 1991. Dissolved oxygen content is an indicator of organic pollution. Its valued lover than 4 mg/liter is not suitable for aquatic life. Dissolve oxygen at different site fluctuated from **2.4 to 8.4 mg/l. Dissolved oxygen values were** very low at site-2and site-3. This may be due to the microbial decomposition of organic component of sewage and industrial water discharged from Mandideep industrial cluster in the river water. Dissolved oxygen of water used by micro organism in the biological oxidation of organic matter is reflected in terms of BOD. The high BOD value indicates more organic waste present in the water source. BOD ranged from 4 to 36mg/l. The observed result is in close arrangement with study of Jangala and Vaishnav (2012) in Korba District, C.G. India. These value are above the standard limit for drinking water suggested BIS 1991. During the study period, Chemical Oxygen Demand (COD) value ranged between 20-86 mg/l the maximum value are observed at site-2, which may ascribe to high concentration of organic material source discharged from the adjacent industrial clusters. These ranged of value are higher than the maximum permissible limit as per BIS (1991) suggesting that water sample is more severely affected with organic pollution. Desirable limit of calcium ION in drinking water is 75 mg/l and permissible limit is 200 mg/l (BIS 1991) its concentration during the period of investigation ranged from **96 mg/l to 112 mg/l** and Station-2 recorded slight higher value of calcium. The desirable limit of magnesium for drinking water is 30 mg/l and permissible limit is 100 mg/l (BIS 1991). Its concentration during the period of investigation ranged from **56 mg/l to 66 mg/l, the** higher value was observed at site-2. Mathivany et al (2005) were of the opinion that higher value of calcium and magnesium may be due to addition of salt from detergents and other man made activities due to lack of effluent facilities and proper disposal system of waste water. Water bodies are getting polluted day by day causing adverse effect on soil flora and fauna. The sulphate concentration ranged from **34.0 mg/liter to 78 mg/liter**. The maximum value was found in water sample collected from site-1 which can be attributed to the hard soil strata of the study area. Excess amount of sulphate may have laxative effect.

The desirable limit for chlorides is of 250 mg/l as prescribed by BIS (1991). Presence of higher level of chlorides is considered as pollution indicator (Raddy and Venkate Shwarle 1987). The chloride concentration ranged from **38.98 mg/l to 67.98 mg/l**. Chloride concentrations were slightly high at Station-2. Higher value of chloride may be due to large amount of sewage discharges and increased rate of decomposition of organic matter (Khanna and Bhutani 2003). The nitrate concentrations ranged from

1.22 mg/l to 4.29 mg/l. Higher values were observed at site-2and site-3, because of mixing of various effluents from industries and other waste material. Similar observations were made by Shridhar et. al. (2006) in the Palk bay of south east coast of India.

Conclusion

The data revealed that there were considerable variations in physic-chemical parameters at different stations of Betwa River. The water quality in the stretch of the river Betwa extending from its origin near Mandideep industrial area up to Bhojpur remains poor because of the regular inflow of domestic waste of the Bhopal city through the Kaliyasot river and industrial/domestic waters from Mandideep (Kori et.al. 2006). Study of different physico-chemical parameter revealed that the intensity of pollution increased as the river was subjected to sewage and industrial waste from Mandideep industrial areas as well as from adjacent residential units.

Hence to reduce the pollution load of river Betwa that pass nearby Mandideep, it is recommended that, the municipal waste, domestic sewage, and industrial effluents should not be discharged into the river. Instead a central sewage system must be provided and the industrial effluents should be treated properly before they are drained out. Further regular monitoring of drinking water sources should be done for suggesting the remedial measures as and when required.

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