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TOXICOLOGICAL STUDIES OF RIVER BETWA WITH RESPECT TO SELECTIVE PHYSICO-CHEMICAL PARAMETERS

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ABSTRACT

The present study was conducted in Betwa River along a stretch of 40 kms from its origin to downstream of the river near Mandideep Industrial Area to assess the presence of selective heavy metals in the river water. The study reveals the presence of certain heavy metals in the water and also emphasises the need for strengthening the existing STPs and ETPs in the Mandideep Industrial clusters so as to prevent the degradation of water quality of the river due to intrusion of raw sewage and effluents from the adjacent domestic and industrial areas.

KEYWORDS: Betwa River, Industrial effluents, Heavy metals, toxicity.

INTRODUCTION

Water quality in general refers to assessment of physico-chemical and biological characteristics of the water. It is a measure of the condition of water with respect to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used against a set of standards against which compliance can be assessed. The most common standards used to assess water quality relates to health of ecosystems, safety of human contact and drinking water.

The significance of environmental factors in terms of water quality management for the health and well-being of human population is increasingly apparent. Environment pollution is a worldwide problem and its potential to influence the health of human populations is great. Pollution reaches its most serious proportions in the densely settled urban and industrial centres of the more developed countries. The water pollution hence became a chronic problem of whole world. This is the biggest problem that affects the health of human, animals and plants. In poor countries of the world more than 80% polluted water have been used for irrigation with only 70-80% food and living security in industrial urban and semi urban areas. In all known forms of life continuation, water is an essential substance of the natural sources. The deterioration of the water quality and water's natural balance in its environment are known as water pollution. The aquatic ecosystem consists of several components which are directly or indirectly affected by pollution. The pollution of a particular water body can always be linked to an industry, sewage or agricultural runoff. Before operating the water refinement facilities in some developed or developing countries, many rivers are being used as a place to discharge urban wastewater. Wastewater is a source of serious public health problems because it contains pathogenic bacteria and toxic substances. The impact of rapid unplanned urbanization has reflected in the water quality deterioration of River Betwa also (Vandana et al, 2006). 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. Mandideep is an industrial area with number of industries as well as human settlements which still lacks a well developed sewerage and effluent treatment facilities. As a result sewage and effluents are often discharged to this river resulting in deterioration in water quality. After flowing through several cities of Madhya Pradesh it enters the neighbouring 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.

OBJECTIVE OF THE STUDY

The objective of the present study is to assess the impact of industrial effluents on the water quality of the River. The study aimed to investigate the pollutants levels including with respect to presence of certain heavy metals (Iron, Zinc, Copper, Manganese, Cadmium and Lead) in the river water.

MATERIALS AND METHODS

Sample Collection

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 nature of catchment and various activities occurring on surrounding area of the river.

Description of sampling stations

Station-1 Jhiri, Origin
Station-2 Mandideep near Bridge
Station-3 Mandideep, Downstream
Station-4 Bhojpur

Water samples from the four sampling stations were collected in different seasons (summer, monsoon, post monsoon and winter) of the study period (April, 2016 to March, 2017) from a varying depth of 30-45 cm.

Sampling and analysis of physico-chemical parameters were carried out following the standard methods as described in **APHA 1995.**

Heavy metals in water samples were extracted with conc. HCl and preserved in a refrigerator till analysis for determination of Mn, Zn, Cd, Cr, Ni, Fe and Co (Parker, 1972).

Heavy metals were analyzed by UV Visible Spectrophotometer (HACH DREL 4000) following the procedure mentioned in Hach Manual (2010).

RESULTS AND DISCUSSION

The result of various physico chemical parameters is depicted in table- 1, 2a and 2b.

Table 1: Water Quality of River Betwa (Field Analysis).

S. No	St. Name & No.	Air Temp. ^oC	Water Temp. ^oC	pH	Free CO_2 (mg/l)	Dissolved Oxygen (mg./l)	Conductivity (mS/cm)	TDS (mg/l)	Turbidity (JTU)
1	Station-1 Jhiri, Origin	27.4	24	8.5	abs	7.6	0.56	341.6	16
2	Station-2 Mandideep near Bridge	29.7	25.8	6.7	20	5.6	0.79	481.9	66
3	Station-3 Mandideep, Downstream	28.3	25.3	6.8	12	6.4	0.44	268.40	48
4	Station-4 Bhojpur	28.6	25.1	8.5	abs	8.4	0.39	237.9	38

The water temperature in various sampling stations in the river ranged from 24 to 25.8 ^0C, minimum being at sampling station no.1 in the month of Oct. 2016 and maximum at sampling station no.2 in the month of May. 2017. The **pH** in the river water ranged from 6.7 to 6.8 at, minimum being sampling station no.2 and maximum at sampling station no.1 & 2. Free CO_2 in Betwa River ranged from Nil to 20mg/litre during the period of study while Dissolved Oxygen in different stations in the river ranged from 5.6 mg/L to 8.4 mg/L minimum being at sampling station no.2 and maximum at sampling station no.4.

Conductivity in various sampling stations in Betwa river ranged from 0.39 (mS/cm) to 0.79 (mS/cm) minimum being at sampling station no.4 and maximum at sampling station no.2. Total Dissolved Solids during this period ranged from 237.9 mg/L to 481.9 mg/L while Turbidity in the River water ranged from 16 JTU to 66 JTU, minimum being at sampling station no.1 and maximum at sampling station no.2 (Table-2a & 2b).

Table 2a: Water Quality of Betwa (Laboratory Analysis) July 2017.

St. Name & No.	Total Alkalinity	Carbonate alkalinity	Bi-Carbonate alkalinity	Total Hardness	Ca hardness	Mg hardness	Calcium content	Magnesium content	Chloride
Station-1 Jhiri, Origin	212	2	210	190	132.3	57.7	160.7	46.2	45.95
Station-2 Mandideep near Bridge	256	66	190	264	147	117	222.5	64.2	79.92
Station-3 Mandideep, Downstream	208	12	196	212	142.0	70.0	178.7	51.6	64.98
Station-4 Bhojpur	196	8	188	224	138.0	86.0	188.0	54.4	72.97

Table 2b: Water Quality of Betwa (Laboratory Analysis) July 2017.

St. Name & No.	BOD	COD	Sodium	Potassium	Nitrate	Total Phosphorus	Inorganic Phosphorus	Organic Phosphorus	Sulphate
Station-1 Jhiri, Origin	4.4	38.0	18.0	11	1.18	2.36	1.23	1.13	68
Station-2 Mandideep near Bridge	18.0	64.0	12.0	16	1.68	3.44	1.12	2.32	60
Station-3 Mandideep, Downstream	24.0	56.0	16.0	8	1.66	3.86	1.01	2.85	64
Station-4 Bhojpur	12.0	48.0	24 .0	12	1.34	2.86	0.96	1.90	56

Alkalinity is an indirect measure of the concentration of anions in water. Alkalinity in natural water is formed due to dissolution of carbon dioxide in water. Betwa River was observed within the range of 196 mg/L to 256 mg/L. Total alkalinity was comparatively high in station 2 and low in station 4. In the waters where total alkalinity is high, bicarbonate system prevails and the pH range is usually on the alkaline side (Vandana et al, 2008).

The overall increasing trend of Free CO_2 at stations 2 & 3 in contrast of other two stations i.e. origin and downstream of Betwa river could be due to the addition of some carbon rich substances like industrial effluents which are rich in aromatic hydrocarbons and various kinds of heavy metals (Goyer, 2001).

Abdel-Baky, 1998, also reported Irrespective of these, agricultural run-offs, tanneries effluents, urbanization etc are solely responsible for deposition of carbon compounds in these areas.

During present investigation total hardness values were observed within the range of 190 mg/L and 264 mg/L. The minimum value was found in the sampling station no.1 and the maximum value was found in the sampling station no.2. Hardness in water is due to carbonates and bicarbonates of magnesium and calcium.

Chapman and Donald[8] observed that hardness increases due to the presence of toxicant.

In the present study the low value of Dissolved Oxygen (DO) in stations 2 & 3 may be due to discharge of effluent from various industries, domestic pollution, cultivation of crops and other anthropogenic activities in the catchment which resulted in the depletion of DO in these stations. Emingor suggested that the effluent released by the industries often have rich organic substances that are of high oxygen demanding wastes.

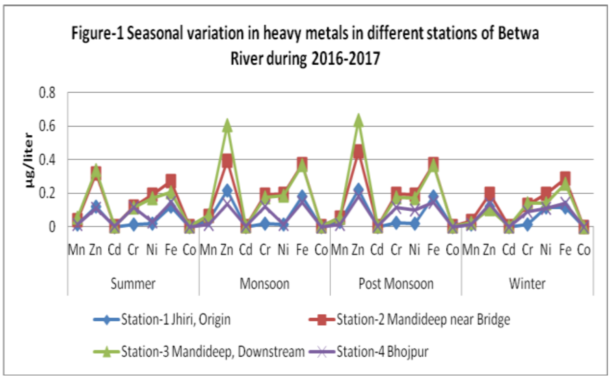
Chloride concentration during the period of investigation ranged from 45.95 to 75.97 mg/L. Higher values of chloride was recorded at station-2 which often receives discharge of untreated effluents from the industrial area.

Biochemical Oxygen Demand in the river water ranged from 4.4 mg/L to a level as high as 24.0 mg/L. High BOD values were observed at Station-2 & 3 during the present investigation.

Chemical Oxygen Demand also recorded high at both these station. Sodium value was high at station-4 while potassium concentrations remain high at station-2. Among the nutrients both Nitrate and Total Phosphorus were recorded high at Station-2&3.

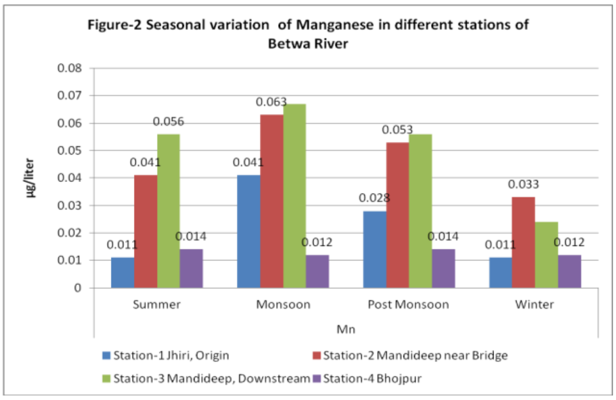
Sulphate was slightly high at Station-1 in comparison to other stations.

Seasonal variation in heavy metals in different stations of Betwa River is depicted in Figure-1.



In general higher concentration of Heavy metals were observed in monsoon and post monsoon months. Compare to other metals , concentration of zinc and iron was higher at almost all the stations during the period of study.

Seasonal variation in manganese concentration in different stations of Betwa River is depicted in Figure-2. Maximum concentration of Manganese (0.063 ppb) was recorded at Station-3 (Down stream of Mandideep industrial area), followed by Station-2 (Mandiddep Industrial area). In general higher concentration of Mn was recorded during monsoon months at almost all the stations.



Seasonal variation in Zinc concentration in different stations of Betwa River is depicted in Figure-3. Maximum concentration of Zinc (0.636 ppb) was recorded at Station-3, during Post Monsoon months followed by Station-2 . In general higher concentration of Zinc was recorded during post monsoon and monsoon months at almost all the stations.

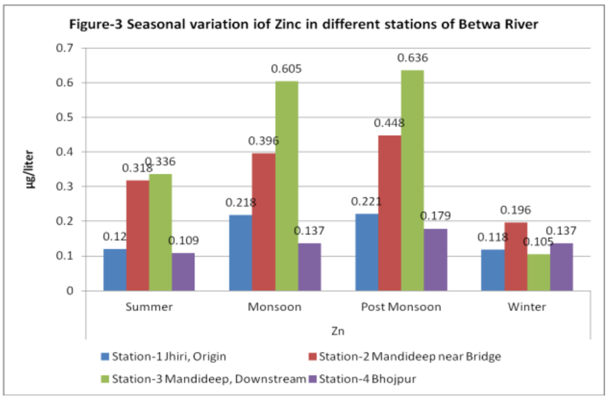


Figure-3 Seasonal variation iof Zinc in different stations of Betwa River

Seasonal variation in Cadmium concentration in different stations of Betwa River is depicted in Figure-4. Maximum concentration of Cadmium (0.005 ppb) was recorded at Station-2, during Post Monsoon months. Higher values were also observed in Post monsoon and monsoon months in other stations also (Figure-4) . In general concentration of Cadmium was comparative low when compared to othe haeavy metals (Figure-1).

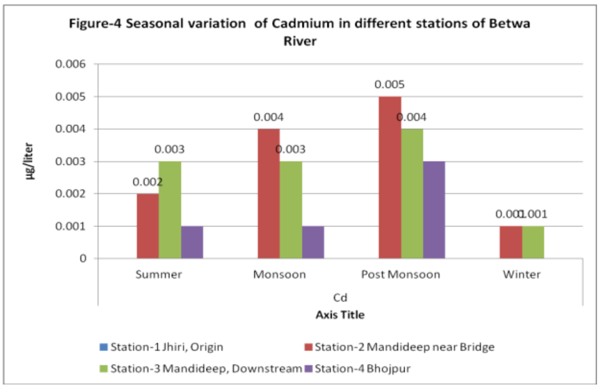


Figure-4 Seasonal variation of Cadmium in different stations of Betwa River

Seasonal variation in Chromium concentration in different stations of Betwa River is depicted in Figure-5. Maximum concentration of Chromium (0.197 ppb) was recorded at Station-2, during Post Monsoon months. Higher values were also observed at this station during the entire study period except in winter months where Chromium was slightly high at Station-3.

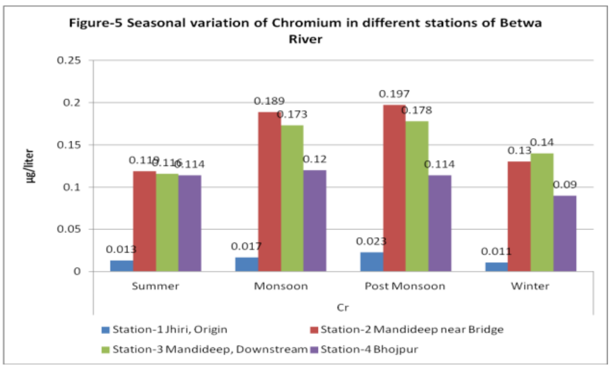


Figure-5 Seasonal variation of Chromium in different stations of Betwa River

Seasonal variation in Nickel concentration in different stations of Betwa River is depicted in Figure-6. Slightly higher concentration of Chromium (0.196 ppb) was recorded at Station-2, during Monsoon months. In general higher values of Chromium were also observed at this station during the entire period of investigation.

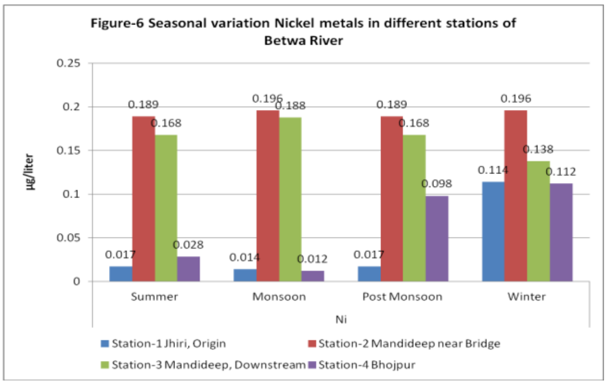


Figure-6 Seasonal variation Nickel metals in different stations of Betwa River

Seasonal variation in Iron concentration in different stations of Betwa River is depicted in Figure- 7. Higher concentration of Iron (0.481 ppb) was recorded at Station-2, during Monsoon months. In general higher values of Iron were also observed during the entire period of investigation at this station.

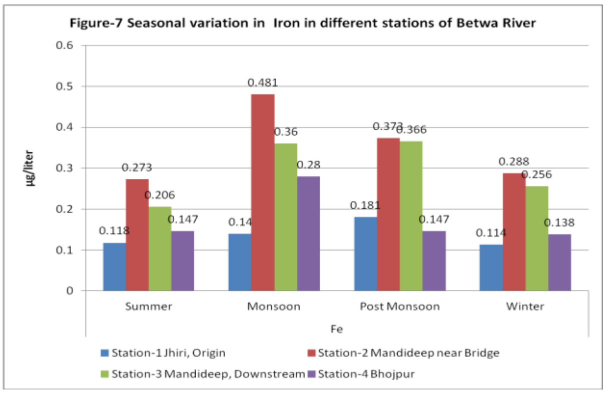


Figure-7 Seasonal variation in Iron in different stations of Betwa River

Seasonal variation in Cobalt concentration in different stations of Betwa River is depicted in Figure- 8. Presence of cobalt was recorded only at station-2 &3 during the peroiod of investigation.

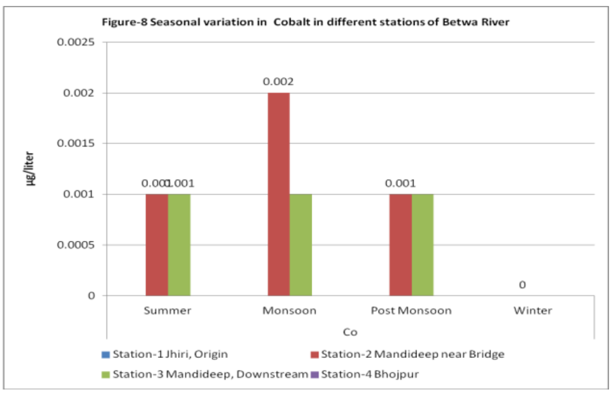


Figure-8 Seasonal variation in Cobalt in different stations of Betwa River

Pollution of the aquatic environment by inorganic and organic chemicals is a major factors posing serious threat

to the survival of aquatic organisms (Saeed and Shaker, 2008).
The agricultural drainage water containing pesticides and fertilizers and effluents of industrial activities and runoffs in addition to sewage effluents supply the water bodies and sediment with huge quantities of inorganic anions and heavy metals (ECDG, 2002). The most anthropogenic sources of metals are industrial, petroleum contamination and sewage disposal (Santos et al., 2005).

Metal ions can be incorporated into food chains and concentrated in aquatic organisms to a level that affects their physiological state. Of the effective pollutants are the heavy metals which have drastic environmental impact on all organisms. Trace metals such as Zn, Cu and Fe play a biochemical role in the life processes of all aquatic plants and animals; therefore, they are essential in the aquatic environment in trace amounts. (Mason, 2002).

During the present investigation it was observed that the metals in the river water attained their maximum values during monsoon and post monsoon season. Station 2, ranked first in accumulation of metals, while station 3 ranked second. This may be attributed to the discharges of effluents from the adjacent industrial clusters where a well developed and operational Effluent Treatment Plant is yet to be fully established.

The maximum mean values of the measured metals (Fe, Mn and Cd) were recorded at Station-2 & 3. This may be attributed to the huge amounts of raw sewage, agricultural and industrial wastewater discharged into the river from the adjacent catchment area. Higher values of heavy metals due to discharge of raw sewage and industrial effluents were also reported by Khallaf et al.1998 and Abdel-Moati & El-Sammak, 1997. The high levels of Zn and Fe in the river water can be attributed to industrial and agricultural discharge (Mason, 2002).

Although heavy metals are naturally occurring elements that are found throughout the earth's crust, most environmental contamination and human exposure result from anthropogenic activities such as mining and smelting operations, industrial production and use, and domestic and agricultural use of metals and metal-containing compounds (He ZL, Yang XE, Stoffella PJ, 2005, Goyer RA, 2001, Herawati N, et al., 2000 and Shallari et al, 1998).

The increase in the environmental concentrations of chromium can be linked to air and wastewater release of chromium, mainly from metallurgical, refractory, and chemical industries. Chromium released into the environment from anthropogenic activity occurs mainly in the hexavalent form. Hexavalent chromium is a toxic industrial pollutant that is classified as human carcinogen by several regulatory and non-regulatory agencies (IARC, 1990), USEPA, 1992.

The health hazard associated with exposure to chromium depends on its oxidation state, ranging from the low toxicity of the metal form to the high toxicity of the hexavalent form.

Cadmium is frequently used in various industrial activities. The major industrial applications of cadmium include the production of alloys, pigments, and batteries (Wilson, 1988).

Although the use of cadmium in batteries has shown considerable growth in recent years, its commercial use has declined in developed countries in response to environmental concerns.

One of the major problems of river Betwa is the pollution from the industries. Innumerable industries are located on the bank of the river and some of the industries do not have well-established sewage treatment facilities therefore effluents from these industries are directly discharged in the river water. This resulted in frequent depletion of oxygen concentration in the river. As a consequence the Biological Oxygen demand and Chemical Oxygen Demand is usually very high.

The Betwa originates from groundwater recharge near Jhiri village (50 km from Bhopal) in the Vindhyas. After flowing 216 km in Madhya Pradesh it enters Uttar Pradesh and meets the Yamuna River at Ghatampur (near Hamirpur). It is 573 km long with a total catchment area of 4.9 m ha. Rampant violations of environmental norms by industries and gross negligence on the part of MPPCB are the main cause of river pollution.

While comparing the values of above physic-chemical and heavy metal parameters it can be concluded that the river is mainly polluted by the industrial and urban wastes from Mandideep, industrial areas and the affect of all these parameters could also be noticed in the downstream of the river.

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