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Full Length Research Paper

Assessment of the contamination of trace metal in Balu River water, Bangladesh

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The aim of this study is to assess and report trace metal contamination of water samples of Balu River, collected from four stations which was sampled every three months covering the upstream and downstream sites of major industrial area of Tajgaon of Dhaka city. The dissolve concentration Iron, Lead, Cadmium, Manganese, Cobalt, Nickel, Chromium, Zinc, Copper of water samples was determined by atomic absorption spectrometry and were found to range from 1.79 to 50.15 mg/L, <17.96 to 28.25 µg/L, <3.00 to 3.30 µg/L, 28.28 to 730.79 µg/L, <4.05 to 53.92 µg/L, <10.66 to 19.07 µg/L, <4.05 to 8.44 µg/L, 8.39 to 76.86 µg/L, and 3.81 to 19.99 µg/L. The observed concentrations of the metals varied between sampling sites and also in different season. Metal concentration was higher in the dry (March) than rainy season in most cases. The pollution level is within the limit of Bangladesh standard and below the Environmental Protection Agency and World Health Organization standard except Iron. From this study, it is clear that the water of this river is not an immediate threat to ecosystem but most of the parameters are higher than other rivers of Bangladesh and in future may cause a threat to ecosystem.

Key words: Trace metal, atomic absorption spectrophotometer, concentration.

INTRODUCTION

To date, the behaviour of organic, inorganic pollutants and trace metals in soils, sediments, ground- and surface water at catchments or regional scales is poorly understood. This lack of understanding results in part from a limited knowledge about loading, mobility and turnover of pollutants and is further complicated by the complexity and heterogeneity of the systems (Barth et al., 2007). River water has been used much as a recipient of toxic and solid waste from domestic, industrial and agricultural runoff (Aksoy et al., 2005). Heavy metal contamination is an increasing worldwide environmental concern. The main sources of heavy metals in the environment are industrial, agricultural and urban activities (Solhi et al., 2005). The economy of Bangladesh mostly depends on agriculture. But present emphasis of Bangladesh government is on industrialization. There are many chemical industries in and around the Tejgaon area of Dhaka city. Most of these industries discharge their effluents into water body like rivers without any treatment, which pollute surface water. According to British Geological Survey (BGS) (1999) and DPHE/BGS/DFID (2000), 35 million Bangladeshi people who use underground water for drinking purpose are exposed to Arsenic concentration exceeding the national standard (50 µg/L) and 57 millions of people are exposed to concentrations exceeding the World Health Organization (WHO) guideline value of 10 µg/L (Siddique et al., 2009).

Moreover, unplanned withdrawal of groundwater lowers the groundwater level and destroys water balance. Due to Arsenic contamination in ground water, the demand of drinking water can be fulfilled 1) by using rainwater, and 2) by using the surface water. In Bangladesh, rainwater is

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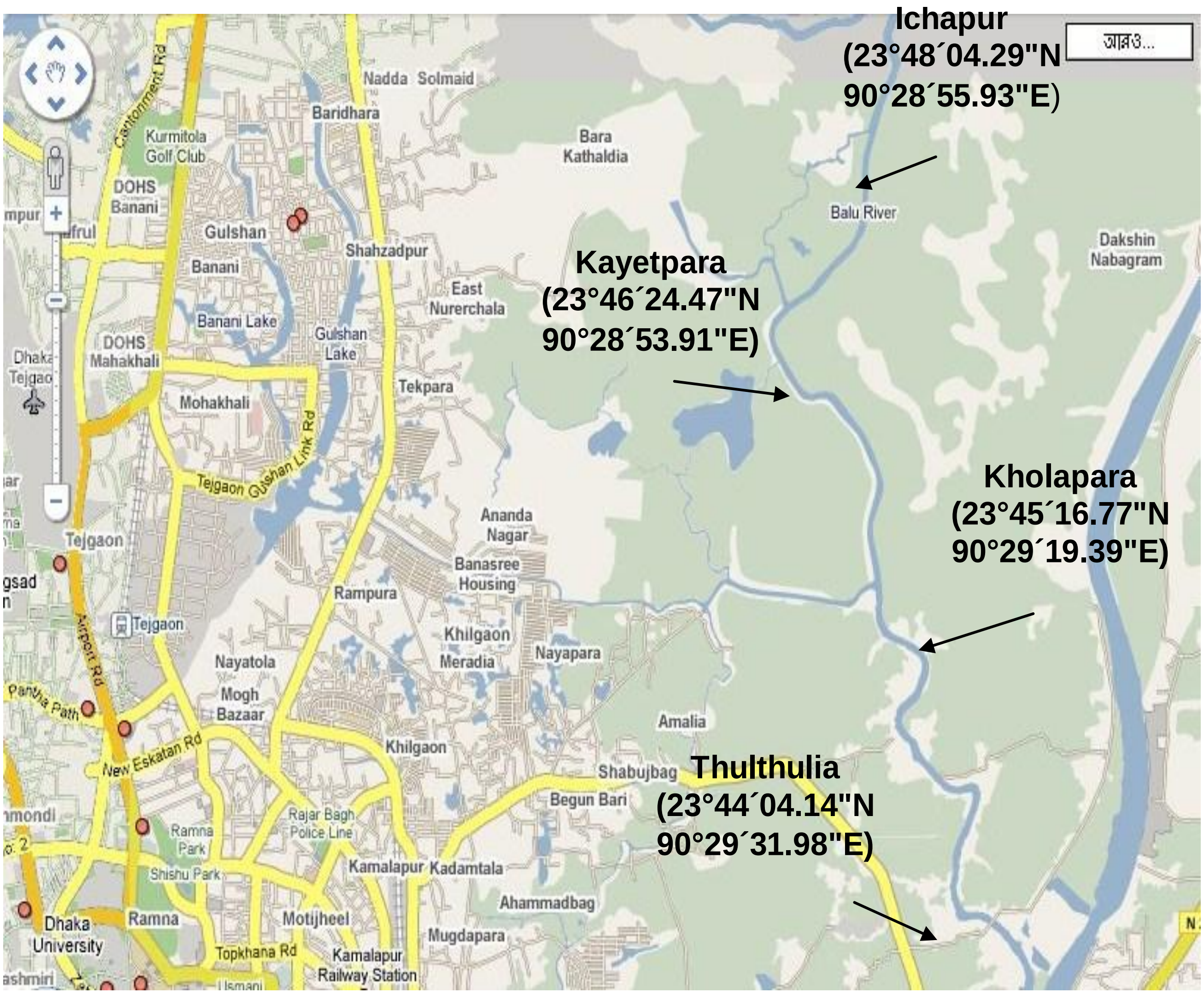

Figure 1. Sampling locations of Balu River (Source: www.google earth.com).

available for only 2 to 3 months. Due to environmental change, this duration is also reducing. So, the use of surface water like river water for drinking purpose is the immediate solution and for that knowledge on present status of water quality is very important for the design of proper treatment facilities. The data presented in this paper will help government and non-government water processing plant by giving information about the present status of water body. The objectives of the study were 1) to establish a basic understanding of the level and extent of trace metal contamination in surface water, 2) to study the spatial distribution and dispersion of trace metals in the upstream and downstream of the river, and 3) providing the base line data on surface water quality to policy makers to manage and protect water bodies from water pollution for maintaining environmental ecological balance. It is hoped that the findings will not only provide valuable information on the environmental quality of Balu River, but also present a scientific perspective of the environmental effects of trace metals so that further regulatory and scientific attention can be drawn to the issue.

EXPERIMENTAL

Study area

Water samples were collected from four different locations of Balu River from December, 2004 to September, 2005 on the basis of upstream and downstream of a lake connected with the river which carry most of the pollutants of Tajgaon industrial area. Two upstream location named Thulthulia (23°44´04.14"N 90°29´31.98"E) and Kholapara (23°45´16.77"N 90°29´19.39"E), and two downstream location were Kayetpara (23°46´24.47"N 90°28´53.91"E), and Ichapur (23°48´04.29"N 90°28´55.93"E). The sampling locations are shown in Figure 1.

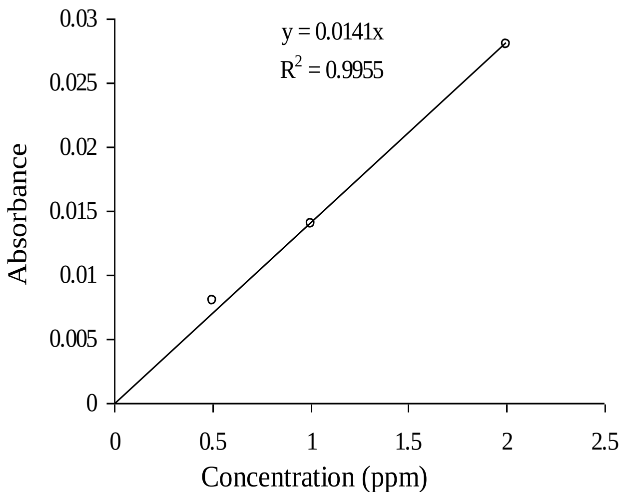

Figure 2. Calibration curve of standard Lead solution (Williams and Fleming, 1973).

Justification of location selection

The significance of a chemical analysis depends to a large extent on the sites of sample collection. An ideal sample should be one which is both valid and representative. These conditions are met by collection of samples through a process of appropriate location selection (Azim et al., 2009). Location of samples was selected based on the following:

1) The non-industrial area to see the overall condition of the river.
2) Sites of the rivers where drainage effluents like domestic, municipal and hospital wastes were discharged.

Sample collection

To study the extent of trace metal contamination of the Balu River, samples were collected from four locations by dipping two, 1 L white polyethylene plastic bottles into the river. Bottles were previously washed thoroughly with detergents and deionized water and then soaked by filling with 20% dil. HNO_3 for 24 h. The bottles were then washed with tap water and then with distilled deionized water. During collection of samples, bottles were rinsed properly with the river water samples and collect the water from the side of the river bank. The collected samples were carried to the “Atomic Energy Centre, Dhaka” laboratory as quick as possible and electrical conductivity is measured by a conductometer. Then the samples were acidified with concentrated HNO_3 to get pH <2.0. The acidified samples were kept in refrigerator at 4°C for further analysis.

Sample pre-concentration

Pre-concentration was necessary to concentrate the elements of interest to a level that is convenient for its determination (Sharma, 1994). The trace metals of water samples were pre-concentrated from 250 ml to 10/15 ml by evaporation on a hot plate after addition of 2 ml analar grade nitric acid to digest the organic matter. Where waters are relatively clean with low total dissolved solids content, water can be used directly into the instrument. After concentrated, the sample is filtered by Whatman No. 41 filter paper and transferred to 25 ml volumetric flask. The volume was made up to the mark with distilled deionized water. A blank reagent was run with every set of experiment.

Aspiration

For calibration curve, standard solutions (at least three) were prepared. Each standard metal solution was selected for each metal concentration of a sample so that they cover the optimum absorbance range. Reading was taken after the instrumental zero was adjusted. Standard solutions of known metal concentrations were prepared in metal free distilled deionized water with a matrix similar to the sample. Standards were commonly prepared from 1000 ppm stock solutions. These solutions are commercially available for use in atomic absorption spectrophotometer (AAS). Working standard and blanks were acidified to the same extent as samples.

Calibration curve

Calibration curve was prepared by plotting absorbance of standard versus their concentrations (Figure 2). At least three or more separate absorption reading was taken with each solution, and an average value was taken.

Analysis

The following eight trace metals were determined in the water samples by pre-concentrated and aspiration into an air acetylene flame: Lead, Cadmium, Chromium, Zinc, Copper, Manganese, Nickel and Cobalt. Iron was determined by direct aspiration into air acetylene flame. The PERKIN ELMER Model 3110 AAS was operated according to the manufacturer's operating manual. The nebulizer of AAS was rinsed by aspirating distilled deionized water. A blank and samples were aspirated. Absorption of metal in water were determined at 248.3 nm for Iron, 324.8 nm for Copper, 213.9 nm for Zinc, 183.5 nm for Lead, 228.8 nm for Cadmium, 279.5 nm for Manganese, 232 nm for Nickel, 357.9 nm for Chromium and 240.7 nm for Cobalt..

RESULTS AND DISCUSSION

Iron

The concentration of Iron was found remarkably higher than other metals at all of the locations of Balu River throughout the study period. The Iron concentration was higher in December and lowers in September and was ranged from 1.79 to 50.15 mg/L (Figure 3).

We know dilution is the solution of pollution. So in December, due to dryness the concentrations become very high, whereas Sitalakhya and Buriganga Rivers’ maximum concentration was only 8.31 and 8.59 mg/L, respectively. The concentration of Iron is always high in downstream of industrial discharge lake connected with Balu River. The present finding is lower than Po River (Italy), Yangtze River (China), Mississippi River (USA) and Indus River (Pakistan) which was 0.001 to .011, 5.23, 0.135, and 0.012 to 1.54 mg/L, respectively (Table 2). The discharge of various types of refuse materials

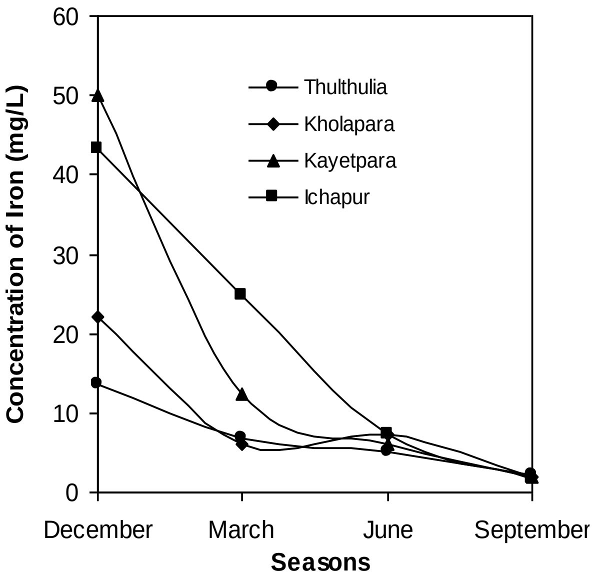

Figure 3. Seasonal variation of Iron (mg/L) in water samples at different locations of the Balu River.

from textiles, leather tanning, chemical industries etc into the river water accelerate the concentration. The concentration of Iron in the river exceeded the permissible level of Iron in river water which is set at 0.30 mg/L [WHO, Environmental Protection Agency (EPA) http://www.epa.gov/safewater/contaminents/index.html and Bangladesh standard]. So pretreatment is necessary before using this water for drinking purposes.

Lead

In most of the time, the Lead concentration was less than the detection limit. Only the detectable concentration was found to be 28.25 µg/L at Ichapur in March (Table 1) due to non-point source. Lead concentration is found higher in Indus River (Pakistan) and in Buriganga River than the present value but it is lower than the Sitalakhya River (Table 2). The level of Lead was much below the permissible levels for irrigation and livestock drinking water as recommended by FAO (FAO irrigation and drainage paper, 29, Rev. 1. 1989).

Cadmium

Only the detectable concentration of Cadmium was 3.30 µg/L in March at Kayetpara. In the Mississippi River (USA), Indus River (Pakistan) and Sitalakhya River, the Cadmium concentration is higher than the present finding. The level of concentration is till now lower than the maximum permissible level of WHO, EPA and Bangladesh standard (Table 3).

Manganese

Among the four seasons, concentration of Manganese is highest in March and lowest in September (Figure 4). In Ichapur, the concentration was highest among all of the seasons except September (dilution by rain). The lower level of concentration of Manganese was found during September at all the locations and the lowest amount of Manganese was found at Kayetpara in the same season, which was 28.28 µg/L. Here, downstream of industrial discharge lake had higher concentration than upstream except one point. Only in Yangtze River, Manganese concentration is higher than the Balu River's present study (Table 2). The maximum permissible FAO standard of Manganese for drinking water purposes is 50 µg/L and the recommended maximum concentration of Manganese for irrigation water is 200 µg/L Table 3). The concentration of Manganese in the river water under present study is higher than that of the standard permissible limit of drinking water. So pretreatment is essential for using water from these rivers for drinking purposes.

Cobalt

From Table 1, it is observed that Cobalt concentration was only detectable in March and June. The maximum concentration of Cobalt was 53.92 µg/L in March in the location of Kholapara which is higher than the Buriganga River (Table 2). Boyd and Walley (1975) worked on Cobalt in the Mississippi River water, USA and found the concentration of Cobalt to be 5.27 µg/L (Table 2) which is lower than the present finding. The concentration of Cobalt observed in the present investigation is quite lower than the standard limit of 100 µg/L for livestock drinking water and 50 µg/L for irrigation water (Table 3). So, the concentration of Cobalt is not harmful for aquatic biota as well as for human consumption.

Nickel

The maximum concentration of Nickel was 19.07 µg/L at Kholapara in December and detectable lowest concentration was 10.80 µg/L in the same station at March (Table 1) which was higher than M Pettine study in Po River (Table 2). The concentration of Nickel observed in the present study is not above the permissible limit of EPA standard of 100 µg/L for domestic purpose (Table 3).

Chromium

Detectable lowest concentration of chromium is 4.22 µg/L at Kayetpara in June and the highest concentration was 8.44 µg/L at Thulthulia in June.

Table 1. Concentration of toxic metals of Balu River water in different sampling sites at different seasons.

Sampling site	Lead (µg/L)				Cadmium (µg/L)				Cobalt (µg/L)				Chromium (µg/L)				Nickel (µg/L)			
	Dec	March	June	Sept	Dec	March	June	Sept	Dec	March	June	Sept	Dec	March	June	Sept	Dec	March	June	Sept
Thulthulia	<17.96	<17.96	<17.96	<17.96	<3.00	<3.00	<3.00	<3.00	<4.05	4.41	7.91	<4.05	<4.05	4.32	8.44	<4.05	15.89	<10.66	<10.66	<10.66
Kholapara	<17.96	<17.96	<17.96	<17.96	<3.00	<3.00	<3.00	<3.00	<4.05	53.92	12.65	<4.05	<4.05	4.94	<4.05	<4.05	19.07	10.80	15.10	<10.66
Kayetpara	<17.96	<17.96	<17.96	<17.96	<3.00	3.30	<3.00	<3.00	<4.05	24.50	14.24	<4.05	<4.05	<4.05	4.22	<4.05	12.71	<10.66	10.86	<10.66
Ichapur	<17.96	28.25	<17.96	<17.96	<3.00	<3.00	<3.00	<3.00	<4.05	32.35	11.00	<4.05	<4.05	4.69	<4.05	<4.05	15.90	18.00	18.81	<10.66

Table 2. Trace elements of some rivers.

Parameter (µg/L)	Po River, Italy (Pettine and Camusso, 1994)	Yangtze River, China (Zhang and Kezhun, 1992)	Stour River, UK (Jeniffer and Lester, 1994)	Mississippi River, USA (Boyd et al., 1975)	Niger River, Africa (Jerome, 1986)	Indus River, Pakistan (Jaleel et al., 1996)	Sitalakhya River, Bangladesh (Islam et al., 2008)	Buriganga River Bangladesh (Azim et al., 2009)	Balu River (Present study)
Iron	0.001 - 0.0116	5.23	-	0.135	-	0.012 - 1.54	1978.07 - 7553.93	120 - 8590	1785.27-50149.70
Lead	0.09 - 1.17	20.66	0.1-3.5	11.4	-	13 - 160	<17.96 - 22.60	<10.00 - 44.12	<17.96 - 28.25
Cadmium	0.10 - 0.59	0.084	0.1-0.8	5.32	0.01	10 - 22	<2.88	<4.46	<2.88 - 3.30
Manganese	0.5 - 17.6	229	-	97.4	-	11 - 38	39.48 - 120.37	31.21 - 523.49	28.28 - 911.31
Cobalt	0.004 - 0.147	0.47	-	5.27	-	-	<4.05	<4.44 - 15.27	<4.05 - 132.35
Nickel	0.44 - 4.32	2.89	3.0-19.3	-	0.45	61 - 253	<10.66	<5.3 - 27.51	<10.66 - 19.07
Chromium	-	21.0	0.5-4.5	10.9	-	12 - 41	<4.05 - 9.258	<5.07 - 137.93	<4.05 - 24.69
Zinc	0.05 - 46.5	25.0	10-325	28.3	0.31	10 - 174	14.86 - 24.68	21.05 - 143.22	8.39 - 76.86
Copper	0.95 - 3.07	7.31	3-13	31.5	0.14	10 - 91	6.36 - 11.83	3.38 - 36.48	3.81 - 19.99

Zhang and Kezhun (1992) studied the contents of Chromium in the Yangtze River and found its concentration to 21.00 µg/L which is higher than the studied value. Azim et al. (2009) finding is also higher than the present value (Table 2).

Zinc

The maximum and minimum concentrations of zinc were 76.86 µg/L (December), and 8.39 µg/L (June) found at Kayetpara and Ichapur, respectively (Figure 5). Jeniffer and Lester (1994) worked on the water samples of the Stour River, UK and found the concentration of Zinc within the range of 10 to 325 µg/L. Present level of highest concentration of Zinc is lower than the Buriganga River and higher than the Sitalakhya River (Table 2) and much below than the limit of maximum permissible level of EPA and Bangladesh standard (Table 3). The variation between Zinc and Copper concentration was due to non-point source.

Copper

The maximum permissible limit for drinking water according to WHO, EPA and Bangladesh standard is 1500, 1300 and 1000 µg/L, respectively (Table 3). The study revealed that the Copper concentration ranged from 3.81 to 19.99 µg/L (Figure 6) which is lower than the different permissible standard. The present findings show much lower values than the concentration of Copper in the Indus River, Pakistan and Mississippi River, USA (Table 2).

Electrical conductivity

The maximum and minimum values of

Table 3. Comparison of some standards of drinking water of trace elements with present findings.

Parameter (µg/L)	WHO standard	EPA standard	Bangladesh Standard (DOE, 2002)	Balu River (Present study)
Lead	50	15	50	<17.96 - 28.25
Cadmium	10	5	5	<3.00 - 3.30
Iron	0.3	0.3	0.3	1.79 - 50.15
Zinc	-	5000	5000	8.39 - 76.86
Copper	1500	1300	1000	3.81 - 19.99
Chromium	50	10	50	<4.05 - 8.44
Manganese	50	50	100	28.28 - 730.79
Cobalt	-	-	-	<4.05 - 53.92
Nickel	-	100	100	<10.66 - 19.07

World Health Organization (WHO) (1998), Environmental Protection Agency (EPA) standard, Department of Environment (DOE) Bangladesh (2002).

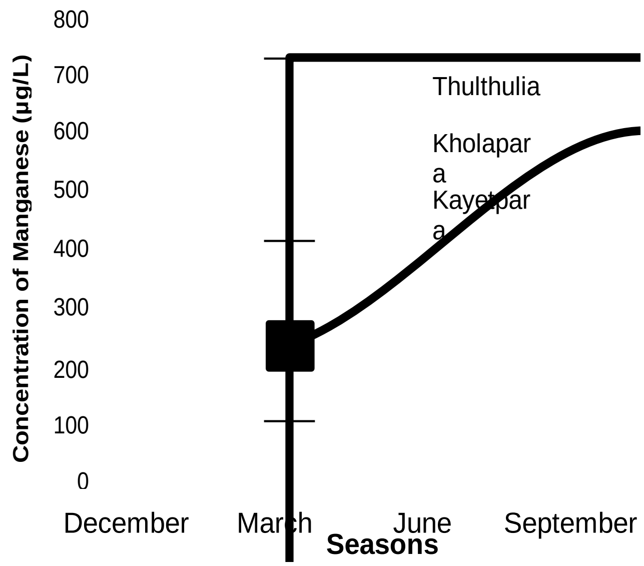

Figure 4. Seasonal variation of Manganese (µg/L) in water samples at different locations of the Balu River.

conductance was 850 µS/cm (March) and 90 µS/cm (June) observed at Thulthulia (Figure 7). The value of conductance was higher in March and lower in June at all of the locations due to the high concentration of different metals in March.

Due to high value of conductivity in December and March seasons, most of the location had high concentration of different metals.

Conclusion

The disposal of industrial waste effluents into riverine system has given rise to heavily localized pollution and threatens seriously the environment. From the study it is revealed that:

1) Iron concentration is always much higher than the other toxic elements. Maximum concentration of iron was found at Ichapur location in the Balu River and the concentration of Iron and Manganese during my study period was much higher than the standard permissible limit.

2) The heavy metal contamination is varying according to the nature of the sites and the intensity of the industrial and agricultural run off. The result may differ from site to site, depending on the actual natural and anthropogenic conditions.

3) The surface water quality of the Balu River is a great threat to ecosystem though some parameters which may not be in the dangerous level but the condition of the river side urbanization and industrialization may cause all kind of water pollution in the near future.

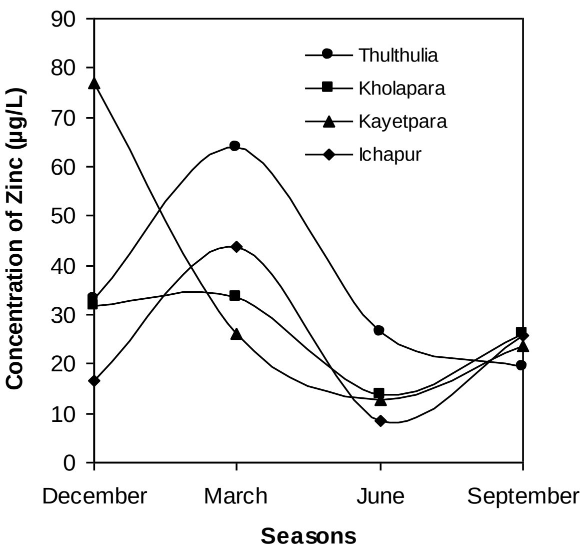

Figure 5. Seasonal variation of Zinc (µg/L) in water samples at different locations of the Balu River.

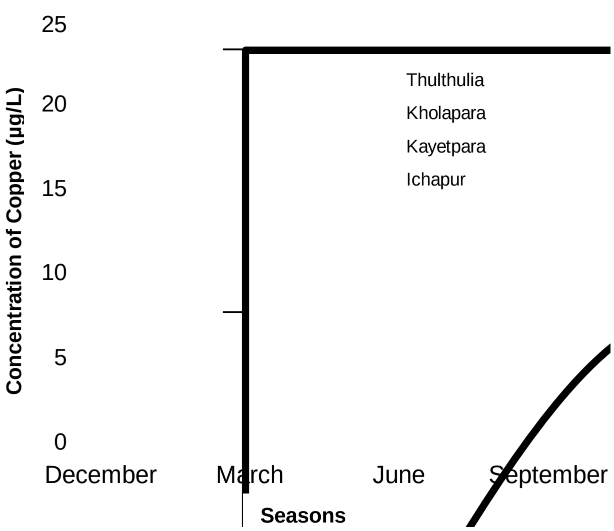

Figure 6. Seasonal variation of Copper (µg/L) in water samples at different locations of the Balu River.

On the other hand, the knowledge on the results of this interaction is an essential requirement for management of the natural resources and for environmental protection. Such kind of knowledge is of importance for regional planning and for a sustainable management of the water resources.

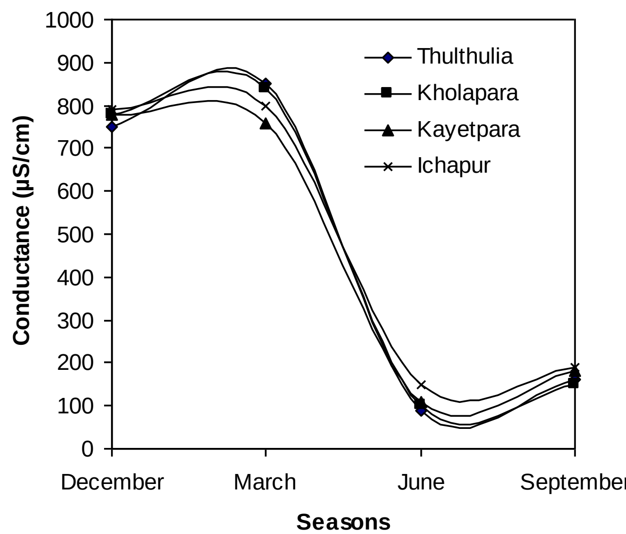

Figure 7. Seasonal variation of conductance (µS/cm) in water samples at different locations of the Balu River.

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