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ASSESSMENT OF TRACE AND TOXIC METALS IN BRAHMANI RIVER BASIN

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ABSTRACT

The present investigation is aimed at assessing the concentration of heavy metal ions along the stretches of Brahmani river basin.Nine samples were collected along the stretches of Brahmani basin during the period September-2013 to August-2014. The purpose of this study was to estimate nine heavy metals (Cu, Zn, Cd, Pb, Hg, Fe, As, Ni and Cr) in the surface water of the Brahmani river, one of the most important rivers in Odisha, India. In the selected research area, the Brahmani River is receiving the domestic, industrial, and municipal waste waters/effluents all along its course. All in all, the ascendancy of the analyzed heavy metals in the surface water of Brahmani followed the sequence: Cu>Ni>Pb>Cr>As>Fe>Zn>Hg>Cd. My findings highlighted the deterioration of water quality in the rivers due to industrialization, mining and human activities.

INTRODUCTION

The study is carried out in Brahmani river which is the second largest river of Odisha is also one of the most important peninsular river systems in India. The confluence of the Rivers Koel and Sankh at Vedvyasa near Rourkela in the district of Sundergarh gives rise to the river Brahmani. It travels southward through the districts of Sundergarh, Deogarh, Angul, Dhenkanal, Jajpur and Kendrapara and finally flows in to Bay of Bengal. It makes the lifeline of the inhabitants of these districts. Major industries like Rourkela Steel Plant (RSP) at Rourkela, National Aluminium Company (NALCO) at Anugul and the upcoming industries like Bhusan Steel Plant and the Kalinga Nagar Industrial Complex in the district of Jajpur are all in the bank of Brahmani river, which is considered as one of the India's important industrialized areas known for ore mining, steel production, power generation, cement production and other related activities. So Brahmani river is joined by several drains carrying industrial effluents, city wastes and mining residues. As water is one the most basic necessities of the habitants, its safeness must be studied before use. The present study aims at detecting the presence of trace and toxic heavy metals.

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Heavy metals are metallic elements which have a high atomic weight and have much high density at least 5 times that of water. They are stable elements i.e. they cannot be metabolized by the body and bio-accumulative i.e. passed up the food chain to humans. They are highly toxic and can cause damaging effects even at very low concentrations. Increasing urbanization and industrialization have increased the levels of trace metals, especially heavy metals, in water ways. There are over 50 elements that can be classified as heavy metals, but only 17 that are considered to be both very toxic and relatively accessible. Mercury, lead, arsenic, cadmium, selenium, copper, zinc, nickel, and chromium should be given particular attention in terms of water pollution. Heavy metal toxicity has severe effect on our mental health, nervous system, kidneys, lungs and other organ functions. Surface water bodies get polluted due to urban sewage discharge (Dayal, 1994; Jain and Salman, 1995; Pophali *et al*., 1990) Present study is focused on quantitative analysis of heavy metals of Brahmani river.

STUDY AREA

Nine different stations as mentioned below are selected across the stretch of the Brahmani river. The selection of the sites were done depending upon the industrial and mining activities along the river bank.

Table 1.

Sample Code	Name of the station	River/ Tributary	State	District	Description of the location
S_1	Tiga	Sankh	Jharkhand	Simdega	Upstream of Panposh
S_2	Jaraikela	Koel	Odisha		Upstream of Panposh
S_3	Panposh	Brahmani	Odisha	Sundergarh	Confluence of Koel and Snkh to form Brahmani
S_4	Tarkera (R S P)	Brahmani	Odisha	Sundergarh	Mixing point of Rourkela Steel Plant Effluent with Brahmani
S_5	Gomlai	Brahmani	Odisha	Sundergarh	About 50 km down stream of Rorkela
S_6	Talcher	Brahmani	Odisha	Sundergarh	About 5 km upstream of the Nalco effluent confluence with Brahmani
S_8	Nandira	Brahmani	Odisha	Sundergarh	confluence of Nalco effluent with Brahmani
S_9	Kamalanga	Brahmani	Odisha	Sundergarh	1.5 km down stream of the confluence of Nalco effluent with Brahmani
S_1	Jenapur	Brahmani	Odisha	Jajpur	Before the bifurcation of Brahmani to form Kharasrota

Two stations, one each on Sankh and Koel the two tributaries are selected. Remaining stations are mainly based on the Rourkela industrial area, Angul and Talcher area and at the fag end the Kalinganagar industrial area. The details of the nine sampling stations are given in Table 1.

MATERIALS AND METHODS

Water samples were collected during Sept.-2013, Nov-2013, Jan-2014, Mar-2014, June-2014 and Aug.-2014 from nine different stations as mentioned below, in clean and dry polythene bottles. The water samples were collected and preserved for testing of various parameters at 10°C throughout the period of chemical analysis. The heavy metals were preserved by adding 5 mL of 1N HNO_3 in one litre of sample to maintain the pH below 4.0.The samples were then filtered through Whatman filter paper No. 40 and the filtrate was directly used for analysis in the Atomic Absorption Spectrophotometer (Agemian and Chau, 1975). At the time of sampling the samples are acidified as per standard, international method reference given by APHA (APHA, 1998).

RESULTS AND DISCUSSION

The analysis of water quality of Brahmani river was carried out for heavy metals viz: Cu, Cr, Fe, As, Zn, As, Cd, Hg and Pb. The maximum, minimum and average values of all the parameters are given in Table 1, 2 and 4. The units used are being μ gm/l (ppb). The variation of these parameters are discussed below. The variation of the concentrations of each of the parameter along the river basin at each sampling stations is graphically shown parameter wise in Figures 1 to 9.

Iron (Fe): Iron may be present in varying amounts i.e from 0.5 ppb to 100ppb in surface water. Iron was found in the range of 0.019 ppb to 5.248 ppb which is well within the permissible limits as prescribed by ICMR (1975), WHO (1993) and BIS (1991) standards. Iron ingestion is not generally unhealthy and is absolutely necessary in small amounts. Deficiency of iron in human body causes anemia.

Arsenic (As): The usual arsenic level in drinking water is about 0.002 ppm (Hutton, 1987; Nriagu *et al*., 1988). However, in the present study arsenic was found well within the the acceptable limit of BIS. The range is 0.06 ppb at Jaraikela to 9.24ppb at Jenapur. All types of arsenic exposure can cause kidney and liver damage, and in the most severe exposure there is erythrocyte hemolysis. During chronic intoxication "garlic breath", skin sensitivity, dermatitis, and keratitis occurs very frequently. The acute effect of arsenic poisoning by oral intake are intense abdominal pairs, nausea, vomiting, diarrhoea resulting from gastro- intestinal tract damage and all terminating in coma and death (Jadhav *et al*., 2014).

Cadmium (Cd): Cadmium is highly toxic because of the absence of homeostatic control of this metal in the human body. When excessive amount of cadmium is ingested, it replaces zinc at key sites and induces metabolic disorder. Cadmium was found within acceptable limits in water of Brahmani river. The range is 0.00 ppb at Panposh and Jenapur to 1.32 ppb at Nandira. Metabolic disorder. Cadmium was found within acceptable limits in water of Brahmani river. The range is 0.00 ppb at Panposh and Jenapur to 1.32 ppb at Nandira.

Lead (Pb): Lead contamination in Brahmani water is considerable. In the month of June it was at its peak at almost all stations highest being at Tarkera.(RSP). During the monsoon period the concentration of lead was at its lowest. The range was 0.08 ppb to 18.32 ppb. In most individuals there is a "lead balance", that is one excretes as much as they take in. However an increase in the rate of intake will result in accumulation or a "positive lead balance". Since lead is chemically very similar to calcium, it is handled by the body as if it were calcium. Thus the first place to which it is transported is to the plasma and the membrane sites in soft tissues. It is then distributed to the other sites where calcium plays an important role, most notably in the teeth of developing children and in bone at all ages. Acute toxicity of Pb in invertebrates are reported at concentration of 0.1-10 mg L-1 (Berma, 1980; Moore and Ramamoorthy, 198412,13).

Copper (Cu): Copper is one of the earliest known metals. ISI (8) has prescribed the limit of copper is 0.05 ppm. In the present study the copper was found within acceptable limits at most of the places. High values were observed at Tilga , Talcher and in the down stream Jenapur. This may be due to the industrial activities in the adjoining areas.The range of copper contamination of Brahmani river during the study period was found to be 4.32 ppb at Nandira to 39.70 ppb at Jenapur. Copper is an essential components of key metalloenzymes that maintains the vascular and nervous system.

Mercury (Hg): High level of mercury can cause harmful effects like nerve, brain and kidney damage, lungs irritation, eye irritation, skin rashes, vomiting and diarrhea. The usual mercury level in drinking water is about 0.001 ppm (Hutton *et al*., 1987 and Nriagu, 1988). However, in the present study mercury was found well within the the acceptable limit of BIS. The range is 0.000 ppb at most of the places to 0.680ppb at Tarkera (RSP).

Chromium (Cr): Chromium can be present in the atmosphere from -2 to +6 oxidation states. But in the environment it is mainly present in trivalent or hexavalent state.

Table 2.

Parameters	S_1 (Tilga)			S_2 (Jaraikela)			S_3(Panposh)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Iron (Fe)	0.071	2.503	0.100	0.019	1.269	0.567	0.042	3.299	1.105
Arsenic(As)	0.33	2.89	1.107	0.06	1.96	0.853	0.52	3.95	2.087
Cadmium (Cd)	0.02	0.51	0.203	0.02	0.32	0.164	0.00	0.42	0.107
Chromium (Cr)	0.02	16.28	2.022	0.01	8.56	0.660	0.18	13.20	1.090
Copper (Cu)	6.63	39.29	10.73	6.65	20.81	11.845	6.68	19.67	10.750
Nickel(Ni)	0.00	22.49	10.260	0.00	24.50	10.179	0.00	24.70	14.940
Lead (Pb)	0.62	8.20	4.567	0.23	8.13	4.023	3.08	14.41	7.695
Zinc (Zn)	0.005	1.850	0.371	0.006	1.355	0.291	0.004	1.835	0.390
Mercury(Hg)	0.000	0.63	0.310	0.00	0.610	0.480	0.00	0.55	0.233

Table 3.

Parameters	S_4(RSP)			S_5(Gomlai)			S_6(Talcher)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Iron (Fe)	0.283	5.248	1.786	0.049	1.164	0.509	0.03	2.30	0.748
Arsenic(As)	0.68	4.62	2.412	0.18	3.18	1.084	0.12	2.54	1.350
Cadmium (Cd)	0.08	0.620	0.280	0.01	0.43	0.257	0.02	1.19	0.276
Chromium (Cr)	0.26	16.20	3.264	0.06	10.00	0.740	1.95	9.08	4.945
Copper (Cu)	7.92	22.63	12.34	6.66	24.92	11.840	3.26	38.81	7.380
Nickel(Ni)	0.02	16.210	15.260	0.00	12.75	9.349	0.00	12.10	10.325
Lead (Pb)	4.62	18.32	8.92	0.19	13.69	6.064	0.04	17.49	7.567
Zinc (Zn)	0.008	2.320	0.484	0.005	0.860	0.234	0.02	1.853	0.366
Mercury(Hg)	0.000	0.68	0.316	0.00	0.610	0.480	0.00	0.57	0.315

Table 4

Parameters	S_7(Nandira)			S_8(Kamalanga)			S_9(Jenapur)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Iron (Fe)	0.080	3.20	0.848	0.064	2.94	0.764	0.031	2.366	0.849
Arsenic(As)	0.18	3.28	1.620	0.12	2.92	1.240	0.61	9.24	2.437
Cadmium (Cd)	0.08	1.32	0.321	0.06	1.06	0.282	0.00	0.86	0.186
Chromium (Cr)	2.24	11.24	4.21	1.68	10.24	3.64	0.60	22.79	1.180
Copper (Cu)	4.32	36.42	8.62	3.84	28.41	7.64	5.45	39.70	8.525
Nickel(Ni)	0.08	12.14	8.46	0.04	10.26	6.49	0.00	14.39	9.703
Lead (Pb)	0.08	18.62	8.238	0.06	15.62	7.143	0.89	17.24	7.813
Zinc (Zn)	0.042	1.928	0.462	0.036	1.828	0.392	0.000	1.635	0.311
Mercury(Hg)	0.000	0.610	0.332	0.00	0.425	0.218	0.000	0.59	0.253

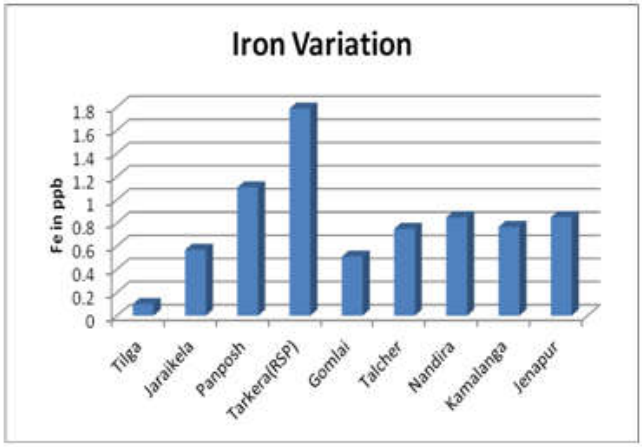


Figure 1.

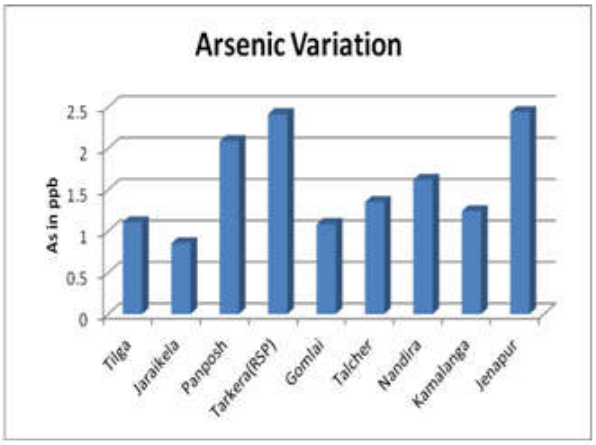


Figure 2.

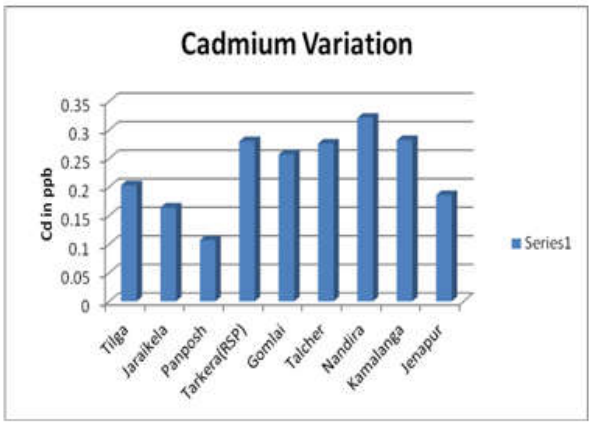
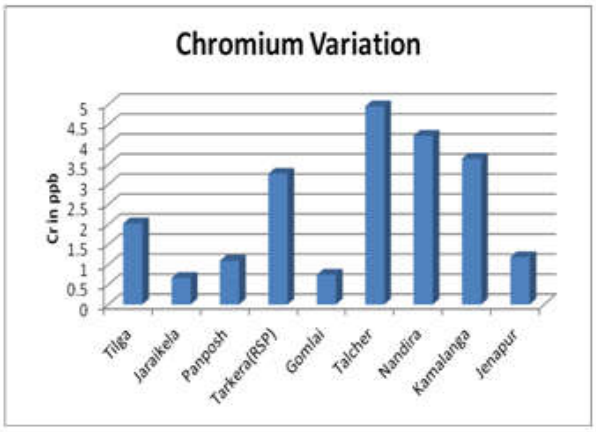


Figure 3.



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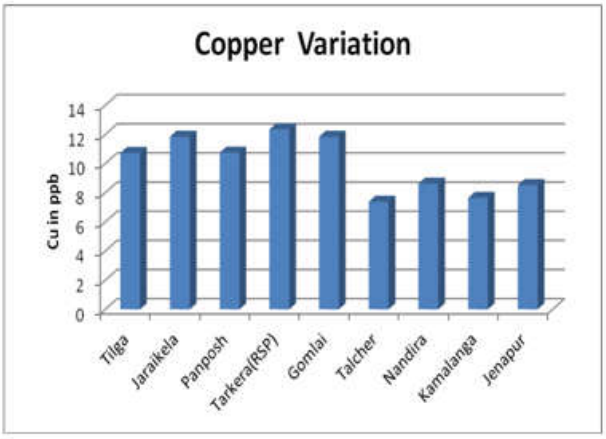

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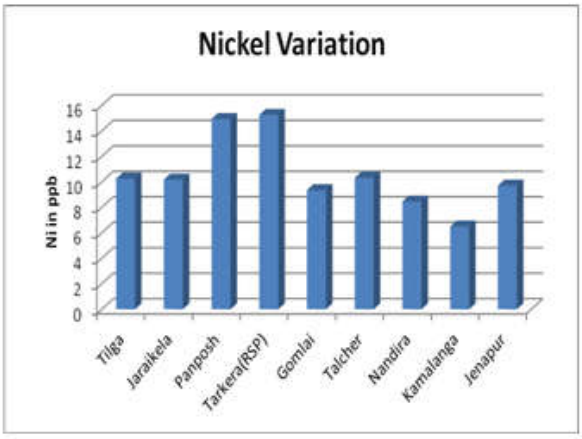

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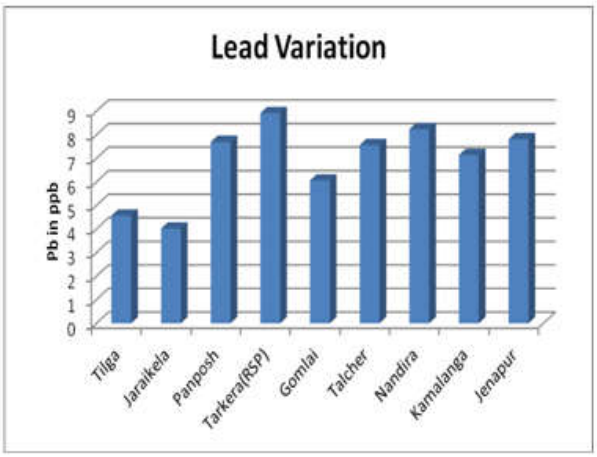

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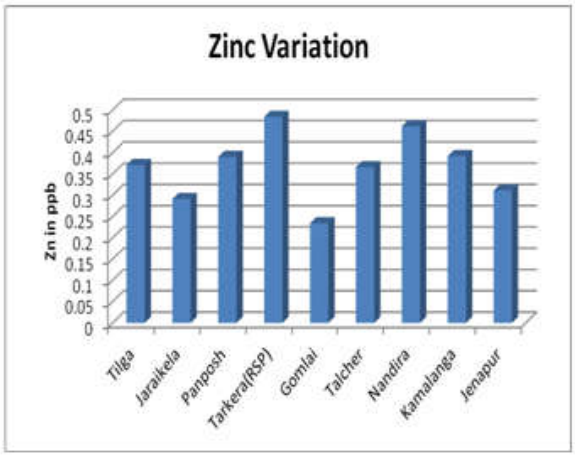

Figure 8.

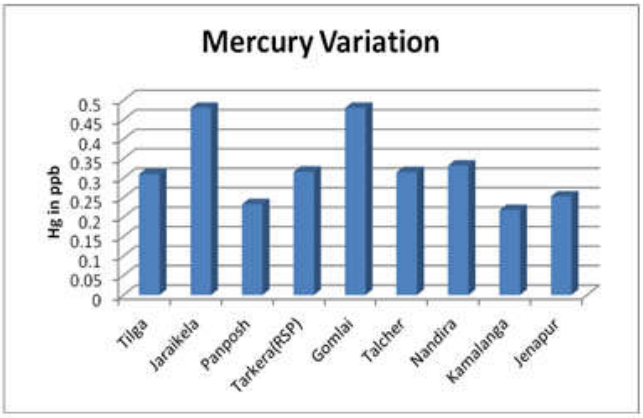

Figure 9.

Hexavalent chromium is toxic to human health. People working in steel and textile industries are exposed to hexavalent chromium. Tobacco smokers have a higher exposure to chromium toxicity. Chromium(VI) causes various health effects like allergic reactions, skin rash, irritations ,nose bleeding, stomach ulcers, respiratory problems, lungs cancer and kidney and liver damage. Chromium was found within the range of 0.01ppb at Jaraikela and and 22.79 ppb at Jenapur.

Zinc (Zn): zinc is the twenty-fifth most abundant element**.** Zinc is essential in both plants and animals for the functioning of various enzymes. Higher dose of zinc causes toxic effect like vomiting, nausea, stomach cramps and diarrohea. Permissible limit for zinc is 15 mg/l. During the monsoon period the concentration of Zinc was at its lowest. The range was 0.00 ppb to 2.320 ppb which is well within the permissible limit.

Nickel (Ni): nickel is the twenty- fourth most abundant element (twice as copper). Nickel is released in to the atmosphere during industrial activities. Small quantity of nickel is essential but when the uptake is too high it can be toxic. The primary symptoms of Nickel contamination are headaches, nausea, dizziness, vomiting and epigastric pain. The secondary symptoms include chest constriction, chills and sweating, shortness of breath, coughing, musclepains, fatigue, gastrointestinal discomfort and in severe cases convulsions and delirium. High values of nickel were observed at Tilga and Jaraikela.The range is 0.000 ppb to 24.50 ppb.

Applications

These results are useful to know the quality of the river water in the study region and how far it is polluted.

Conclusion

In the present study Fe was found in the range of 0.019 ppb to 5.248 ppb which is well within the permissible limits as prescribed by WHO and BIS standards. Concentration of Cu was within acceptable limits though relatively higher values at Tilga, Talcher and Jenapur. Concentration of Hg was below detection limit during most of the times. Concentrations of other metals like As, Cd, Ni, Zn, Pb and Cr were within permissible limits of WHO and BIS.

Since the effect of copper contamination is more good than bad for health the water of Brahmani river is suitable for drinking and irrigation purposes in heavy metal concentration point of view.

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