RESEARCH PAPER:

Heay metal content in Gomti river water, sediment and hydrobiota in Jaunpur

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SUMMARY

Heavy metal concentrations *viz.*, Zn, Cu, Fe, Cd and Ni in the river Gomti, flowing along the city Jaunpur, have been reported selecting four stations. Analysis of water, algal populations and sediments samples from Gomti river was carriedout for a period of 12 months, for quantitative estimation of metals. The values were found to be maximum at mixing zone (S3) followed by S2, S4 and S1. All metal values were higher in algal cells and sediments than water concentration. The sediment samples were also analysed for particle size, distribution of organic carbon, nitrogen and extractable metals. There has been more clay and organic matter in sediment of S3 alongwith higher concentration of each metal in sediment and water.

Key words :
Heavy metals, Algal cells, sediments, River water quality

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In natural water bodies, there are several sources of input of heavy metals and non-heavy metals and other chemicals which are required in very small quantities for good growth of plant and animals but when they reach in higher concentrations cause pollution in aquatic life and through food chain can cause serious health problem in terrestrial animal and man (Bowen, 1966).

Metals are an unique class of toxicants since they can not be broken to non-toxic forms. Environmental contamination by toxic heavy metals due to many human activities is a serious problem due to their biomagnification and accumulation in food chain and continued persistance in terrestial and aquatic ecosystem (Abhik and Susmita, 1990). There are few reports available on studies of heavy metals in water, plankton, sediment and in animal tissues (Kureishy *et al.*, 1979; Ayyadurai *et al.*, 1994; Madhystha *et al.*, 1996; Biswal *et al.*, 1998; Rao and Rao, 2001; Fotedar and Raina, 2009; Ali *et al.*, 2009). Several heavy metals present in wastewaters of the industries and municipal sewage find their way into the river but their toxic concentration can cause serious health problem.

Bioavailability of metals in sediments and planktons is governed by various factors including precipitation, adsorption on to the organic and inorganic sediments fractions. Several reports are available on the distribution and accumulation of heavy metals in sediments and planktons of river, lakes and other water bodies (Rao and Rao, 2001; Roy and David, 2002; Biswal *et al.*, 1998; Abidin *et al.*, 2009; Ali *et al.*, 2009). Measurement of the total metal concentration in soil, sediment or in cells are, therefore, unlikely to reflect the amount of metal actually available to the biota. The present study was, therefore, undertaken with a view to determine the concentration of heavy metals at various stations all along the route of the river Gomti in Jaunpur (U.P.).

MATERIALS AND METHODS

Gomti river:

The riner Gomti, ranks third Position in eastern W.P. of India among the hobiest riner Ganga near kaithi of district variance. over 940 km. journey with water restoring anea of nearly 30,437 km^2, on its way it is joined by many small seasonal and perennial rivers River in polluted at several stretcher by different industries.

Site selection :

Four sampling sites were selected all along the 4 km route of the river in Jaunpur city from Kalichabad to Ramghat. Five major drainage channels and several open drains are adding effluents and domestic wastes into the river which enhance the pollution load in river water and aquatic flora and fauna. Selected sampling sites were : Baradavi ghat (S1); Bajarang ghat (S2); Achala Devi ghat (S3) and Ram ghat (S4).

Water sampling and heavy metal analysis:

For heavy metal analysis in water,

sediments and algal cells, samples in triplicate were taken from each station in a high grade polythene bottles of 2l lit capacity. The samples were stored in ice box till brought to the laboratory. Out of different heavy metals only Zn, Cu, Fe, cb and Ni were selected in the present endeavour and determined by method prescribed in APHA (1989).

Analysis of metals in algal cells :

Algal population was dried and crushed to powder and a known weight was digested with conc. HNO_3 in a Kjeldahl flask and treated with perchloric acid. Digestion was continued till the end of white fumes. The samples were filtered and estimated as method prescribed in APHA (1989).

Sediments analysis :

Sediments, from each sampling site, were randomly collected at water depth using PVC tube fitted with a detachable 25cm sample section. Collected samples were brought to laboratory and stored at 4^0C till processed. Prior to storage, excess water from each core was drained off and core extruded from the sampling pipe. The top 165cm layer of each sediment core was placed in a suitable container and mixed to form five composite samples. Physico-chemical characteristics of these composite samples were then determined by using standard methods for soil and water analysis. Heavy metals in sediments were analysed following procedure outlived by Rao (1988). pH of the sediment was estimated by using pH meter. Sediment particle size was measured by using Robinson pipette method (Piper, 1966). Organic carbon and nitrogen in sediment was estimated by using Walkley Black (1947) and Heese (1971) method respectively.

Results and Discussion

The physico-chemical characteristics of sediments showed variation from station to station (Table 1). The colour of the sediment varied from dark grey (S3) to light grey (S4), grey (S2) and light olive grey (S1) with objectionable odour at S2, S3 and S4. pH varied from 6.5 to 7.5 and temperature from 26.8±0.2^{O}C to 28.5±0.5^{O}C from station to station. The organic matter in the sediments ranged from 30% to 70% with highest level at S3 (70%) followed by 55% (S2); 45% (S4) and 30% (S1). Total nitrogen content in sediment wen highest 1.8% at S3 and lowest 0.8% at S1. The high content of organic matter in sediments at S3 and S2 was primarily attributed to the relatively high supply of organic matter from domestic wastes and industrial effluents. S1 and S4 contained less organic matter and nitrogen. It might be due more dissolved oxygen in comparision to S3 and S2. The present finding agreed with the earlier report for sediment of Kollen lake (Rao and Rao, 2001).

River water :

The heavy metal concentration in river water (Table 2) was found to be considerably varied with maximum occurrence at S3 (effluent mixing zone). Zn was recorded in range of 0.1±0.05 to 0.225±0.010 mgl^{-1} at S1. The effluent mixing zone (S3) contained Zn in the range of 0.34±0.05 mgl^{-1} to 0.690.10 mgl^{-1} and at S2 the concentration ranged from 0.30±0.001 to 0.58±0.030 mgl^{-1} and at S4 the concentration was 0.18±0.01 mgl^{-1} to 0.60±0.003 mgl^{-1}. Dissolved Cu levels varied between 0.011±0.002 mgl^{-1} to 0.03±0.001 mgl^{-1} at S1, at S2, S3 and S4 it was recorded 0.025 0.00 mgl^{-1} to 0.071±0.002 mgl^{-1}, 0.03±0.010 to 0.080±0.005 mgl^{-1} and 0.020±0.005

Table 1: Physico-chemical characteristics of composit sediments at different sampling sites

Parameters	Sites			
	S_1	S_2	S_3	S_4
Colour	Light olive grey	Grey	Dark grey	Light grey
Odour	Odourless	Objectionable	Objectionable	Objectionable
Particle size (H)				
Particle distribution (%)				
53-20	10.0	4.0	0.0	0.00
20-10	55.0	28.5	18.5	30.00
10-02	30.0	57.5	61.5	65.00
<2.0	5.0	10.0	20.0	5.00
pH	6.8-7.2	6.5-7.2	6.5 –7.5	68.-7.2
Temperature	26.8±0.5	28.1±0.2	28-5±0.5	27.3±0.2
Organic carbon	30%	55%	70.0%	45.0%
Total nitrogen	0.80%	1.4%	1.8%	1.2%

Table 2 : Minimum and maximum concentration of metals (mg.l^{-1}) with their respective ±S.D. at different sampling sites of river Gomti at Jaunpur (month is given in parenthesis)

Metals	Sites							
	S_1		S_2		S_3		S_4	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Zn	0.1±0.05 (Jul. Aug.)	0.225±0.01 (May)	0.30±0.001 (July)	0.58±0.03 (June)	0.34±0.05 (Aug.)	0.69±0.10 (June)	0.18±0.01 (Aug.)	0.60±0.003 (June)
Cu	0.011±0.002 (Aug)	0.031±0.001 (June)	0.025±0.00 (July)	0.071±0.002 (May)	0.031±0.010 (July)	0.080±0.005 (June)	0.020±0.005 (Aug)	0.073±0.010 (May)
Fe	0.116±0.021 (July)	2.18±0.003 (June)	0.135±0.12 (July)	2.48±0.005 (June)	0.038±0.05 (July)	2.52±0.03 (May)	0.120±0.11 (July)	2.30±0.001 (June)
Cd	0.040±0.005 (July)	0.070±0.002 (Jay, June)	0.040±0.03 (Aug.)	0.084±0.05 (May)	0.040±0.10 (Aug.)	0.096±0.001 (June)	0.035±0.01 (Aug)	0.080±0.021 (June)
Ni	0.086±0.002 (March)	0.815±0.006 (June)	0.120±0.012 (June)	1.118±0.008 (June)	0.128±0.005 (July)	1.35 ±0.112 (June)	0.122±0.020 (July)	1.252±0.125 (May)

to 0.073±0.010 mgl^{-1}, respectively. Maximum and minimum concentration of Fe in river water varied from 0.116±0.02 mgl^{-1} to 2.18 ±0.003mgl^{-1}, 0.135±0.12 mgl^{-1} to 2.48 ±0.005 mgl^{-1}; 0.038±0.05 mgl^{-1} to 2.52±0.03 mgl^{-1}, 0.120±0.11 to 2.30±0.001 mgl^{-1} at S1, S2, S3 and S4, respectively (Table 2). Cd (Cadmium) concentration ranged between 0.04±0.005 mgl^{-1} to 0.096±0.001 mgl^{-1} at different sampling sites with maximum and minimum concentration at S3 and S1, respectively. Ni (Nickel) concentration ranged at S1, 0.086±0.002 mgl^{-1} to 0.815±0.006 mgl^{-1} at S2, from 0.120 ±0.012 to 1.118±0.008 mgl^{-1} at S3, from 0.128±0.005 to 1.135±0.112 mgl^{-1} and at S4 from 0.122±0.020 to 1.252±0.125 mgl^{-1} (Table 2).

Algal cells :

The concentration of heavy metals in algal cells has been presented in Table 3. Although the concentration of all six metals under examination were found to be high at S3, the level of accumulation of Zn was found to be higher than other metals in algal cells. Zn concentration in algae was found to be 18.5±1.5 mg.100g^{-1} dry.wt at S1 whereas at S2 it was 92.2±2.12 mg.100g^{-1} drywt, 112.8±5.6 mg.100g^{-1} dry.wt at S2 with subsequent reduction at S4 *i.e.* 90.5±4.2 mg.100g^{-1} drywt. Cu concentration in algal cells was 17.6±3.5 mg.100g^{-1} dry.wt (S1); 45.7±8.5mg.100g^{-1} drywt (S2), 58.5±6.5 mg.100g^{-1} dry wt (S3) and 50.1±2.5 mg.100g^{-1} dry.wt (S4). Highest accumulation of Fe in algal cells was found 50.6±7.2 mg. 100g^{-1} drywt at S3 and lowest 16.3±0.8 mg.100g^{-1} drywt at S1. Cd and Ni accumulation in algal cells also followed the similar trend of earlier metals with highest concentration of 20.2±2.1 mg.100g^{-1}drywt and 12.8±1.2mg.100g^{-1} drywt, respectively at S3 (Table 3).

Table 3 : Analysis of heavy metals in algal cells at different sampling sites of Gomti river at Jaunpur (mg.100g^{-1} dry wt.)

Heavy metals	Sites			
	S_1	S_2	S_3	S_4
Zn	18.5±1.5	92.2±2.12	112.8±5.6	90.5±4.2
Cu	17.6±3.5	45.7±8.5	58.5±6.5	50.1±2.5
Fe	16.3±0.8	45.2±4.2	50.6±7.2	45.3±3.5
Cd	4.0±1.25	12.5±0.5	20.2±2.1	9.5±0.5
Ni	3.5±1.2	10.2±0.5	12.8±1.2	9.3±0.2

Heavy metals in sediment :

The concentration of heavy metals in sediments to its corresponding water samples has been presented in Table 4. The concentration of Zn in sediment ranged from 30.5±4.2 mg.kg^{-1} (S1) to 43.5±1.0 mg.kg^{-1} (S3). The concentration of Cu varied from 35±3.5 mg.kg^{-1} (S1) to 65.8mg.kg^{-1}. The level of Fe was found in the range of 200.1±10.5 mg.kg^{-1} to 435.0±8.6mg.kg^{-1}. The level of Cd and Ni was lower than those of other metals (Table 4).

Table 4 : Analysis of heavy metals in sediments of Gomti river (mg.kg^{-1})

Heavy metals	Sites			
	S_1	S_2	S_3	S_4
Zn	30.5±4.2	40.1±3.5	43.5±1.0	38.8±0.5
Cu	35.1±3.5	49.1±2.8	65.8±1.5	43.5±1.2
Fe	200.1±10.5	338.6±12.2	435.0±8.6	295.2±3.5
Cd	2.0±0.5	2.8±1.2	3.8±0.8	2.9±0.5
Ni	0.4±0.02	1.6±0.5	2.20±0.81	1.8±0.35

In order to understand the overall relationship among the various elements, correlation coefficient have been calculated and data are presented in the form of a matrix (Table 5). The data reveal that there was a positive

Table 5 : Correlation coefficient among metals

	Organic matter	Zn	Cu	Fe	Cd	Ni
Organic matter	1.0					
Zn	0.31	1.0				
Cu	0.20	0.22	1.0			
Fe	0.25	0.685	0.756	1.0		
Cd	0.15	0.05	-0.55	-0.35	1.0	
Ni	-0.20	-0.63	0.35	0.755	-0.68	1.0

correlation between organic matter and concentration of Zn, Cu, Fe and Cd except Ni nidicating a common source. Cu and Fe exhibited a positive correlation. A negative correlation of Cd was found with Cu, Fe while Ni established a positive correlation Cu and Fe (Table 5).

Metal load in river water have been studied by many workers (Say and Whitton, 1982; Verma; 1990, Kaushik *et al.*, 2001; Singh and Mishra, 2007; Fotedar and Rania, 2009; Ali *et al.*, 2009). Trace metals in river are added from different autochthonous and allochthonous sources due to extensive interchange of land and water, still the major source is industrial discharge as effluent waste water without any pretreatment. There was an increasing trend of metal concentration in river water upto S3 and reduced at S4. It might be due to gradual decrease of metallic concentration from point source of pollution to downstream in accordance with earlier findings of Duinker and Nolting (1977) for river Rhine. The highest concentration of metals in summer months might be due to slow and reduced water level while minimum concentration in rainy season might be due to dilution as a result of rain. A significant number of contaminants of environment contain heavy metals as their constituents (Atchison *et al*.,1989).

Organic matter and pH play an important role for the precipitation of metals as they precipitated at or below pH 7.0 (Polpreasort, 1982; Whitton, 1985). The level of heavy metals in algal community was observed highest at S3 and followed the similar trend as in river water. The accumulation of heavy metals by algal cells might be due to adsorption by physical and ion-exchange phenomena. A high level of metals at S3 (an effluent mixing zone) in algal cells can also be correlated with low pH, DO and high temperature.

There has been more clay with high percentage of organic matter at S3 which showed more metal accumulation in sediment. There has been more clay and organic matter in sediments of site S3 alongwith higher concentration of metals in river water at this site which may play an important role for metal accumulation in sediments of S3. The present finding agreed with earlier report of Biswal *et al.*, (1998), Tikoo (2004) and Fotedar and Raina (2009). Thus, the present study has shown that river sediments serve as a sink in river for heavy metals which may release in river water by adsorption, precipitation and chelation mechanism and thus reflect the water quality. pH, calcium carbonate and organic matter are also playing an important role for metal precipitation and concentration.

It is well established that metals *viz*., Cd, Cu, Mn, Pb, Zn etc. show the tendency of biomagnification (Abhik and Susmita, 1990) in food chain, under elevated metallic levels which may lead diseases in consumers of metal rich food continuously. Heavy metals are mostly water soluble, non-degradable vigorous oxidising agent and strongly bounded to bio-molecules especially polypeptide and proteins (Guard and Wilcox, 1956). Thus, severity of metal pollution may treat the hydrobiota. Therefore, effluent treatment by suitable measures is necessarily required before its discharge in river to the life.

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