



Pre and Post-monsoon Seasonal Variation of some Heavy Metal Pollution in Sediments of river Gomti in the Vicinity of Lucknow City, India

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ABSTRACT: The concentration of heavy metals (Fe, As and Cu) was examine in riverbed sediments of Gomti river, Lucknow at selected sites in pre and post monsoon season for three consecutive years (2009-11). The concentration was ranged between (As: 0.07-0.7, Fe: 7462.00-7977.00, Cu: 10.98-36.73 $\mu\text{g g}^{-1}$) in pre-monsoon and in post-monsoon metal concentration was ranged between (As: 0.05-0.07, Fe: 543.00-7797.00, Cu: 32.00-9. 23 $\mu\text{g g}^{-1}$). Whereas Geo accumulation index (I geo), contamination factor (CF), US EPA guideline also apply to determine the readily toxicity. Fe and As pollution was found from negligible to low level while Cu leads from low to moderate pollution. Significant correlation found between the metals in pre and post-monsoon of studied years, in case of As it was found insignificant. Conservation and management plan is also suggest for contaminated sites.
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Pollution of heavy metals in the aquatic environment has noticed by researcher and scientists worldwide due to its abundance, persistence and environmental toxicity (Ali *et al.*, 2016). Overload of contaminations both organic and inorganic produce huge load, which distorted water quality and adversely affected the rich biodiversity of the rivers (Gaikwade and Kamble, 2014). Sediments of the rivers are the major factor for the assessment of the pollution introduced by anthropogenic activity, in the case of heavy metals pollution river sediments played important role in both the ways as sources and sink of heavy metals. Pollutants/contaminants settled down in the sediments along with water flow and pollute/contaminate sediments for many kilo meters, therefore metal pollution of river sediments become burning issue in concern of aquatic environment of the rivers (Marathe *et al.*, 2011). River flows through urban areas are also have pollution load due to the discharged of untreated municipal sewage and small

scale industries waste which raise in concentration of heavy metals in water and sediments of river. Heavy metals have unique importance in eco-toxicology and also potentially lethal for aquatic environment (Singare *et al.*, 2012). Heavy metals go through many changes involving process like precipitation, dissolution, sorption for their speciation which affects the bio-availability hence the metals are responsive indicators for the change in the environment (Sundaray *et al.*, 2012). The metals which are known toxic to the aquatic life and aquatic system are Lead Cadmium, Mercury, Copper, Zinc, Iron, and Arsenic. Industrial waste like vegetable Oil, milk dairy, and other industrial and sewage waste are also dumped in the river (Araya *et al.*, 2011). The aim of this study is to investigate and report the temporal and seasonal variation of As, Fe, and Cu pollution in sediments of river Gomti in vicinity of Lucknow city India with special conservation and management plan

Table 1 Heavy metal pollution in sediment of river Gomti in Lucknow city

Sources	Source category		Pollutant Type			Matrix involved	Pollution	Mechanism
	Point/	Non point	As	Fe	Cu			
A. Natural:-								
a) Lithogenic						River water suspended load, bed sediment soil, ground water	Dissolution Suspension Deposition Re-preparation	
b) Amphibious			Y	Y	Y			
c) Granites								
d) Gneisses, Ultra-								
e) basic rock and								
f) Carbonate								
B. Anthropogenic :-								
1. Industrial :-								
a). Textile	Y	Y				Soil suspended load, Biomass Bed sediment Soil and Ground water	Land Spreading Soaking, CEC Seepage, Plumes Mixing, Dispersion Sorption, Seepage Soaking	
b). Paper	-							
c). Distillery	Y		Y	Y	Y			
d). Miscellaneous	Y		Y	Y	Y			
2. Municipal:-								
a). Sewage effluent			Y	Y	Y	-	Suspension, Seepage soaking	
b). Sewage sludge	Y	-	Y	Y	Y			
c). Garbage dump	Y		Y	Y	Y			
3. Agriculture:-								
a). Return flow	Y	Y	Y	Y	Y	-	Deposition Land Spreading soaking	

Y=sources are available

MATERIALS AND METHODS

Sample collection: The bed sediments samples were collected from shallow water about 20 m from the bank of river at three points (1/4, 1/2, 3/4) across the river width at all the 10 sites during the study period using grab sampler and kept in polythene bags.

Sample preparation: The samples were air dried for removal of water contents associated with the sediments. The dried samples were then grinded with pestle mortar, homogenized, sieved to below 100 mesh size, sealed in clean polythene bags and stored in refrigerator till the final analysis. The total metal content was determined by digesting 1.0 g of homogenized and powdered sediment sample from each site with a mixture of concentrated HNO₃ and HClO₄ (10 ml + 2 ml). The digested samples were filtered through Whatman filter No. 42 and finally volume were made 10 ml with 0.1 N

Sample analysis: Metal content was estimated using Varian Model Spectra AA-250 plus Atomic Absorption Spectrophotometer.

Data analysis: The data was analyzed using one way ANOVA (Analysis of Variance). The difference between treatments was considered significant at $p \leq 0.05$.

Estimation according to contamination factor: The contamination factor and degree of contamination are used to conclude the contamination position of the sediment in the given study. Contamination factor is calculated according to (Tomlinson *et al.*, 1980).

Geo-accumulation index: The evaluation of sediments contamination with heavy metals using index of accumulation, Igeo which permits assessment the extent of sediments contamination with respect to global standard.

Igeo calculated by method of Muller (1979) using the following mathematical relation.

$$I_{geo} = \log_2 C_n / (1.5 B_n)$$

Where C_n is the concentration of the examined metals in the sediment, B_n is the geochemical

background value of a given metal and 1.5 is the background matrix correction factor.

- <0 practically unpolluted
 0—1 Unpolluted to moderately pollute
 1—2 Moderately polluted
 2—3 Moderately to strongly polluted
 3—4 Strongly polluted
 4—5 Strong to very strongly pollute
 >5 Very strongly polluted
 C Background value = background value

RESULT AND DISCUSSION:

Table 2 Content of heavy metals ($\mu\text{g g}^{-1}$) in sediment of Gomti river sediments in the vicinity of Lucknow city during pre-monsoon season 2009

Sampling Sites	Arsenic	Iron	Copper
Sitapur over bridge (Inlet)	0.593±0.02	6300.00±126.0	10.98±0.21
Kudiaghat	0.643±0.03	6425.00±54.25	20.23±1.02
Hanuman setu	0.675±0.05	6503.00±96.09	25.85±1.29 ^a
Laxmanmela park	0.722±0.01 ^a	5563.00±78.56	23.63±0.47
Saheed park	0.611±0.02	5401.00±89.54	23.12±0.69
Dilkhusha railway over bridge	0.523±0.01	7462.00±44.95 ^a	21.53±0.43

Values shown are the mean±S.D. of 6 samples. a= significant value

Table 3 Content of heavy metals ($\mu\text{g g}^{-1}$) in sediment of Gomti river sediments in the vicinity of Lucknow city during post-monsoon season 2009

Sampling Sites	Arsenic	Iron	Copper
Sitapur over bridge (Inlet)	0.632±0.032	5300.00±116.0	10.54±0.31
Kudiaghat	0.651±0.014	5332.00±229.8	15.21±0.95
Hanuman setu	0.532±0.024	5431.00±104.6	29.03±0.87 ^a
Laxmanmela park	0.522±0.020	5264.00±107.4	21.31±0.53
Saheed park	0.531±0.010	5093.00±101.8	19.05±0.49
Dilkhusha railway over bridge	0.653±0.026 ^a	5384.00±203.2 ^a	20.43±0.61

Values shown are the mean±S.D. of 6 samples, a= significant value

Table 4 Content of heavy metals ($\mu\text{g g}^{-1}$) in sediment of Gomti river sediments in the vicinity of Lucknow city during pre-monsoon season 2010

Sampling Sites	Arsenic	Iron	Copper
Sitapur over bridge (Inlet)	0.523 ±0.008	6485.00±97.06	12.73±0.04
Kudiaghat	0.72 2±0.067 ^a	7795.00±54.89	14.54±0.06
Hanuman setu	0.713±0.081	6925.00±74.56	36.73±2.74 ^a
Laxmanmela park	0.725 0±0.071	5758.00±43.97	25.84±1.43
Saheed park	0.744±0.053	5975.00±98.32	25.872±1.94
Dilkhusha railway over bridge	0.793±0.029	7957.00±80.21 ^a	29.93±2.59

Values shown are the mean±S.D. of 6 samples, a= significant value

Table 5 Content of heavy metals ($\mu\text{g g}^{-1}$) in sediment of Gomti river sediments in the vicinity of Lucknow city during post-monsoon season 2010

Sampling Sites	Arsenic	Iron	Copper
Sitapur over bridge (Inlet)	0.431±0.004	4980.00±134.75	9.73±0.03
Kudiaghat	0.5173±0.001	5125.00±21.43	19.23±0.53 ^a
Hanuman setu	0.5621±0.001	5362.00±37.84	23.23±0.69
Laxmanmela park	0.5438±0.01	4954.00±75.96	23.74±0.43
Saheed park	0.564±0.002	4834.00±86.21	22.153±0.26
Dilkusha railway over bridge	0.487±0.002 ^a	6753.00±53.97 ^a	19.29±0.75

Values shown are the mean±S.D. of 6 samples, a= significant value

Table 6 Content of heavy metals ($\mu\text{g g}^{-1}$) in sediment of Gomti river sediments in the vicinity of Lucknow city during pre-monsoon season 2011

Sampling Sites	Arsenic	Iron	Copper
Sitapur over bridge (Inlet)	0.423 ±0.008	6485.00±97.06	12.73±0.04
Kudiaghat	0.62 2±0.067 ^a	6795.00±54.89	16.54±0.06
Hanuman setu	0.711 ±0.081	6905.00±44.16	26.73±2.74
Laxmanmela park	0.73 0±0.076	5761.00±43.17	25.84±1.43
Saheed park	0.763±0.053	5975.00±98.32	25.87±1.94
Dilkusha railway over bridge	0.798±0.021	7977.00±89.21 ^a	29.93±2.59 ^a

Values shown are the mean±S.D. of 6 samples, a= significant value

Table 7 Content of heavy metals ($\mu\text{g g}^{-1}$) in sediment of Gomti river sediment in the vicinity of Lucknow city during post-monsoon season 2011

Sampling Sites	Arsenic	Iron	Copper
Sitapur over bridge (Inlet)	0.501±0.003	5321.23±0.014	13.94±0.03
Kudiaghat	0.540±0.001 ^a	5433.12±0.018	14.13±0.02
Hanuman setu	0.509±0.01	4783.21±0.011 ^a	28.13±3.0 ¹
Laxmanmela park	0.503±0.01	4331.22±0.016	28.56±3.04
Saheed park	0.548±0.01	4101.21±0.003	29.93±3.05
Dilkusha railway over bridge	0.408±0.02	4321.32±0.005	32.11±3.04

Values shown are the mean±S.D. of 6 samples, a= significant value

Content of Heavy Metals ($\mu\text{g-g}^{-1}$) In Sediment:

Arsenic (As): As level in pre-monsoon season of year 2009 was ranged from 0.523 – 0.722 $\mu\text{g g}^{-1}$ maximum level was observed at the site Laxamanmela Park. In post-monsoon 2009 As ranged from 0.522 – 651 $\mu\text{g g}^{-1}$ here the maximum level was observed at the Kudiya ghat (Table 3.). In pre-monsoon 2010 As range was observed from 0.798 – 0.523 $\mu\text{g g}^{-1}$ site Dilkusha rail over bridge its level was higher (Table 3), whereas in post monsoon its range was observed from 0.5621 – 0.431 $\mu\text{g g}^{-1}$ and highest level was observed at the site Hanuman setu (Table 4). In pre-monsoon season 2011 the level of As was observed from 0.793 – 0.423 $\mu\text{g g}^{-1}$ (Table 5) and in post-monsoon season of year 2011 it ranged from 0.548 – 0.408 $\mu\text{g g}^{-1}$. By evaluating the tables (1-6) the level of As was found higher most at site Laxamanmela park and Hanuman setu it is due to the disposal and discharge of sewage and effluent.

Iron (Fe): In the year 2009 pre-monsoon season the level of Fe was ranged from 549 – 746 $\mu\text{g g}^{-1}$ and its range was found between 5263 – 5431 $\mu\text{g g}^{-1}$ in post monsoon 2009. However the higher values are found at the site Dilkusha rail over bridge in pre-monsoon and Hanuman setu at post monsoon. In pre-monsoon and in post monsoon 2010 Fe level was found 6753 – 4980 $\mu\text{g g}^{-1}$ and 4834 – 6753 $\mu\text{g g}^{-1}$ however in pre and post-monsoon it the maximum level was recorded at Dilkusha rail over bridge season. In year 2011, pre-monsoon season maximum level of Fe was found at site Dilkusha rail over bridge in 7977 $\mu\text{g g}^{-1}$ and range was observed from 7977 – 5758 $\mu\text{g g}^{-1}$ (Table 5). In post-monsoon season 2011 highest level was observed at site Kudiya ghat 5433 $\mu\text{g g}^{-1}$. It was noted that the site Sitapur over bridge is least polluted in all the season in all the three years (Table 1-6). Singh *et al.*, (2005) and also observed range of Fe from 5051.485 – 8291.485 $\mu\text{g g}^{-1}$ in Gomti river sediments

Copper (Cu): In case of the Cu in pre-monsoon period 2009, it ranged from 25.85-10.98 $\mu\text{g g}^{-1}$ maximum level was observed at station Hanuman setu i.e. 25.85 $\mu\text{g g}^{-1}$ (Table 1). The level of Cu in post-monsoon ranged from 29.03– 10.54 $\mu\text{g g}^{-1}$, highest value was observed at the site Hanuman setu which is situated at the midpoint of city (Table 2). In the pre-monsoon period 2010 maximum level of Cu was observed at the site Hanuman setu 36.73 $\mu\text{g g}^{-1}$. Whereas in post-monsoon 2010 season highest level was observed at the site Laxamanmela park 23.74 $\mu\text{g g}^{-1}$.

g⁻¹. While in pre-monsoon season 2011 and its level was ranged from 29.93-12.73 $\mu\text{g g}^{-1}$ (Table 5), maximum value of Cu was observed at site Dilkusha rail over bridge, whereas in post-monsoon season it was found high at site Dilkusha 32.11 $\mu\text{g g}^{-1}$ and range was observed between 32.11 13.94 $\mu\text{g g}^{-1}$ (Table 6). By comparing the guideline for contaminated fresh water sediments (US EPA, 1977) its concluded that site Hanuman setu, Laxaman mela park, Saheed park and Dilkusha were found moderate polluted at most of the sampling time while in term of As and Fe it was found low polluted to unpolluted.

Index of Geo Accumulation:

Table 8 Geo accumulation index of Gomti river in vicinity of Lucknow city pre and post monsoon of 2009, 2010 and 2011

Sampling Sites	Arsenic	Iron	Copper
Sitapur over bridge	0	0	0
Kudiyaaaghat	0	0	0
Hanuman setu	0	0	0
Laxamanmela park	0	0	0
Saheed Park	0	0	0
Dilkusharailover bridge	0	0	0

Index of geo accumulation (Igeo) calculated for all the heavy metals (As, Fe, Cu,) given in table. The geo accumulation index consists of seven grade ranged from unpolluted to highly polluted. Class 6 indicates that 64 fold enrichment above the background value. The Igeo class for Gomti river sediments varies metal to metal and place to place As, Fe, and Cu. Based on the geo accumulation indices, the Gomti river sediments from Sitapur over bridge to Dilkusha rail over bridge considered to be unpolluted with respect to As, Fe, and Cu during the studied period 2009, 2010 and 2011 pre and post monsoon at the given sites (Table 7).

By categorizing Gomti river sediments from Sitapur over bridge to Dilkusha rail over bridge according to geo accumulation index the studied sediments are considered to be unpolluted with respect to As, Fe, and Cu all over the studied time 2009, 2010 and 2011 pre and post monsoon at the given sites. Singh *et al.*, (2005) and Gaur *et. al.*, (2005) also resulted in their study that the Gomti river sediments are in unpolluted from the Fe, Cu, Cd, Mn were in case of other metal Pb its recorded partially to moderate polluted.

Contamination Factor (CF):

Table 9 Description of the contamination factor

Contamination factor	Description
CF < 1	Low level of contamination
1 ≤ 3	Moderate level of contamination
3 ≤ 6	Considerable level of contamination
6 ≤ CF	Very high level of contamination

The CF value of As was ranged from 0.04 – 0.06 (Table 8) and the highest CF value was recorded at the site Dilkusha rail over bridge (outlet of river from city) in pre- monsoon season. In the case of Fe the CF as noted from 0.10 – 0.17 in studied year 2009 to 2011 the lowest value was recorded in the year 2009 in post monsoon season at Saheed Park were as the highest value was recorded at Dilkusha rail over bridge in pre-monsoon season. The CF value of Cu was ranged from 0.24 – 0.81 the lowest value was recorded at the site Sitapur over bridge in pre monsoon season were as the highest value was noted at the site Hanuman setu. The CF value of Cu at site Hanuman setu in 2010 post-monsoon season was recorded 0.81 nearby 1. Sediments of river Gomti in Lucknow is found to low level of contamination but rising towards moderate level of contamination and according to the Pollution load Index the load of studied pollutant was founded low at the inlet of the city while it was found to rising staidly as the river flow out of the city. It is also concluded from the study that the average concentration of the metals

in sediments of river Gomti at studied site are found rising continuously year by year season by season.

Correlation Coefficient:

Table 10 Correlation in heavy metal concentration pre and post monsoon 2009, 2010 and 2011

	As	Fe	Cu
Arsenic (As)	-0.246		
Iron (Fe)		0.126	
Copper (Cu)			0.750

Correlation among the studied heavy metals of Gomti river sediments as given in Table 9 revealed significant relation between the concentration of metals in pre and post- monsoon of 2009, 2010 and 2011 in case of Cu (0.75) and Fe (0.12), were as in case of As it was found insignificant (-0.24) it prove that except As the nature and source of pollutants in both the season and in all the analysis years (2009, 2010 and 2011) found same, This nature of relation among the pollutants justified that the metal concentration in sediments of river Gomti in vicinity of Lucknow city is mostly influenced by the disposal and discharge of the un treated waste water because except As the other studied metals (Fe, and Cu) are found usually in the house hold and industrial waste.

Conclusion: In pre monsoon season concentration of metals are observed more than post monsoon, Cu leads to low polluted to moderate pollute according to the guide line of US EPA (1977), whereas Fe and As leads to no polluted to high polluted, Geo accumulation Index state that the quality of bed sediments of Gomti river is low polluted but in turns to moderate polluted readily the same consequence also discovered by estimating the Contamination factor and Pollution load.

Managemant plan for restoration of Gomti river sediments at Lucknow city India

The recognition of major risks and satisfactory management of sediment pollution with removal/deleting of pollutants is essential for the development of river ecosystem and human health (Todorova *et al*,2015).The primarily sources of heavy metals in a river system is naturals sources like weathering of soil and rocks and the other major source is anthropogenic/human activity anthropogenic/human activity is mainly responsible for the over load of pollution in river Gomti within vicinity of Lucknow city (Srivastav *et al*,2011). Khera and Khera (2012) reported that the waste water sample collected from the adjacent of industrial area

and reticently locality was found unfit for direct disposal in river. Suggestions for the protection of river from pollution (1) Using alternative method for sewage disposal like dry sanitation, sanitation involve less or no water for disposal (2) Properly maintenance of sewage and drainage system, and STP (3) Uses of latest technologies for recycling of waste instated of disposal (4) There should be arrangement of proper sewerage system on the river side (both the banks) for the appropriate collection and treatment of sewage, modified drainage system and land use changes can reduce pollution load on Gomti river in Lucknow city (5) Prohibited in-appropriate garbage dumping on the river side (6) Arrangements of public laboratory for the prevention of open defecation (7) At the banks of river vegetation should grow to improve the quality of water and sediments.

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