



# **ECO-TOXICOLOGICAL MONITORING OF RIVER GANGES IN WESTERN UTTAR PRADESH (INDIA)**

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## **ABSTRACT**

The physico-chemical characteristics and distribution of trace metals in the ecological elements of the river Ganges in the Western Uttar Pradesh (India) were monitored during the year 2007 to 2008. The core parameters as per the *National Water Quality Monitoring Program* such as pH, temperature, conductivity, DO, BOD, nitrate-N, nitrite-N, faecal coliforms and total coliforms and other general parameters were studied, which showed that the river water is mildly polluted at various sampling stations from Hardwar to Kanpur. The degree of pollution varies significantly with respect to individual parameters. The pH, temperature, conductivity and dissolved oxygen were found to designate the river water in A-class of water as per the criteria made for the use based classification of surface waters in India. While the other core parameters like Faecal and total coliforms suggest it to be placed in the C-class of water. Deposition of trace metals in the river sediments was found to vary from 1.55 to 4.80 times except Cr and follows the increasing trend as : Cr >>> Co ≥ Pb > Cd > Zn > Ni > Mn > Cu. The Cr accumulation at Kanpur-d/s sediments was found 37.8 times higher than at Kanpur-u/s sediments, which is an indication of the worst case of sediment contamination.

The aquatic sub-merged plants were found to accumulate toxic metals in the order : Ni > Cr > Pb > Cd up to Kannauj and thereafter, abundant Cr accumulation was observed in the plants in and around Kanpur region. While in the case of fish samples, the toxic metals were found to remain lesser than 5 µg/g up to Kannauj sampling station and thereafter, a very sharp increase was observed in the Kanpur region especially in the case of Pb and Cr. The accumulation trend of toxic metals in fish samples were followed as Cr > Pb > Ni > Co > Cd at Kanpur-u/s and Pb > Cr > Ni > Co > Cd at Kanpur-d/s.

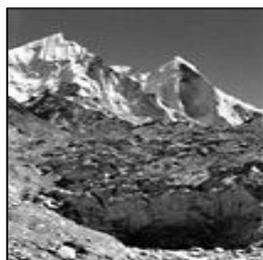
**Key words:** Ecological elements, Aquatic plant, Toxic metal, Fish, Physicochemical characteristics, River Ganges pollution, Western Uttar Pradesh, Trace metals, Sediments.

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## INTRODUCTION

The river Ganges is a perennial river formed by the confluence of the river Bhagirathi (originating from a cave at Guamukh in the Gangotri glacier) and the Alaknanda river (originating from Sapta Tal glacier in Himalayan Region) at Devaprayag. It covers about 220 km in the Himalayan region before entering the plains at Hardwar. Thereafter, it covers about 2510 km through the Indian states of Uttarakhand, Uttar Pradesh, Bihar and West Bengal before its merger in the Bay of Bengal. So long as the population was small and industrial and other human activities were limited, the autopurification or natural purification processes were able to take care of the pollutants. But during the last few decades, eco-toxicological pollution of the river Ganges has become a matter of great concern especially in the light of a wide range of hazardous substances<sup>1-2</sup>.



(a)



(b)



(c)



(d)

**Fig. 1 : The river Ganges at (a) Gaumukh (b) Hardwar (c) Religious ghats (d) High way crossings**

According to *Central Pollution Control Board* report<sup>3</sup>, over 29 big cities, 70 smaller cities and thousands of villages extend along the river Ganges, which discharges over 1.3 billion liters of sewage per day directly into the river along with thousands of

animal carcasses. Besides this, about 260 million liters of industrial wastes are added to this by hundreds of industrial establishments along the river bank. The sacred practices of depositing various kinds of offerings, human remains and partially cremated cadavers are also transforming the river in eco-toxicologically fragile conditions (Fig. 1).

Although, a number of governmental and non-governmental agencies and program like *CPCB*, *CWC*, *GAP* etc. have taken various commendable steps for the cleaning of the river water, but it has been reported<sup>4-5</sup> that the river ecosystem has continuously been contaminated in recent years at various points. These studies have shown that heavy metals especially Pb, Cd, Cr, Ni, Zn, Mn and Fe etc. are found in the ecological elements of the river Ganges. In this regard, various workers<sup>6-8</sup> have studied the distribution of heavy metals in the river Ganges and its tributaries at different locations in Uttar Pradesh and Bihar etc. These studies indicate that the heavy metals may remain in aqueous phase in their adsorbed form on the particulate matter or precipitated on to the river sediments. Hence, it is obvious to observe a variable degree of river pollution at different locations.

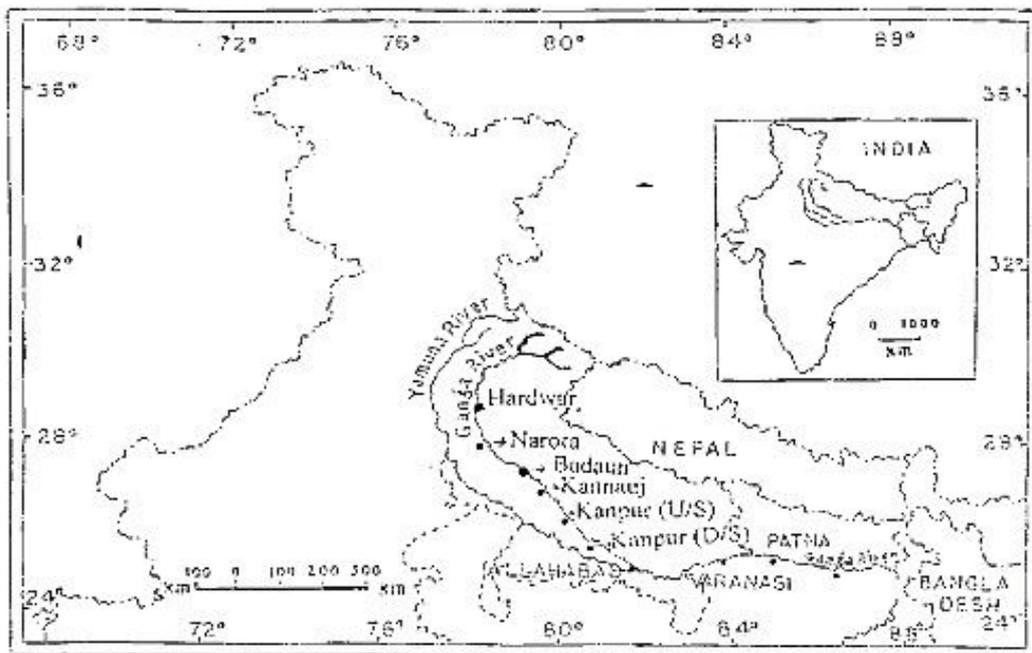
In the light of the above, the river ecosystem has been suggested<sup>9</sup> to be monitored continuously at different locations and stretches. The present study was carried out for eco-toxicological monitoring of the river Ganges in the Uttarakhand and Western Uttar Pradesh region from Hardwar to Kanpur.

## EXPERIMENTAL

### Material and methods

#### Sampling stations

The river Ganges covers about 540 km stretch in the plains of Uttarakhand and Uttar Pradesh from Hardwar to Kanpur. A number of religious stations and industrial establishments are present or being upcoming in this stretch. The places of importance are in the districts of Hardwar, Meerut, Bulandshahar, Badaun, Kannauj and Kanpur. Therefore, the following sampling stations were selected as Hardwar, Narora (Rajghat), Badaun (Kachlaghat), Kannauj, Kanpur (Ranighat) and Kanpur (Jajmau). The locations of these sampling stations are given in Fig. 2. At the sampling stations, two sampling points were made as up-stream (u/s) sampling point (just before entering the city station) and the down-stream (d/s) sampling point (just after leaving the city station)



**Fig. 2 : Map showing locations of sampling stations of river Ganga in western Uttar Pradesh**

## **Physicochemical parameters and trace metals in the ecological elements of the river Ganges**

### **The river water**

Five water samples were collected from each sampling point along the width of the river. The samples (500 mL each) were acidified with 10 mL of  $\text{HNO}_3$  (Analytical Grade) and carried to the laboratory in acid washed plastic bags. The water samples were concentrated to 25 mL and analyzed for heavy metals by the atomic absorption spectrophotometer (Model : AAS-4141, Make : ECIL). The water samples were also analyzed for other physicochemical characteristics by standard methods of water examination<sup>10</sup>. A blank sample was also made for each measurement in order to account for the instrumental or analytical errors.

### **The river sediment**

Sediment samples were collected from each sampling point using grab sampler and carried to the laboratory in an acid-water washed glass containers. The sample was then air-dried, ground and passed through 100 mesh sieves BSS. A 5g sediment sample was

refluxed with conc.  $\text{HNO}_3$  for two hours. It was then cooled, brought to 25 mL volume with 2%  $\text{HNO}_3$  and the supernatant liquid is used for the determination of heavy metals<sup>11</sup>.

### **The aquatic plants**

The commonly found aquatic plants irrespective of their species were collected from the sampling points and washed immediately with acid water and transported to the laboratory in clean plastic bags. The plant samples were then repeatedly washed with distilled water and dried at 105 °C to a constant weight. The plant material is then analyzed by atomic absorption spectrophotometer<sup>12</sup>.

### **The fish**

A common fish (*Heteropneustes fossilis*) generally found in the river Ganges was captured and transported to the laboratory. It was then washed and dried at 120 °C to obtain the constant weight. The dried samples were grounded and stored for heavy metal determination by atomic absorption spectrophotometer. The detailed analytical procedures for metal determination are given in literature<sup>13</sup>.

## **RESULTS AND DISCUSSION**

### **The river water**

The physicochemical characteristics and other eco-toxicological parameters of the water samples were selected as per the *National Water Quality Monitoring Programme*. The values are reported in Table 1. It shows that the temperature of the river water remain in the range of 14.5 to about 29.4 °C with an average of around 23 °C at all the sampling points studied. The average temperature increased when the river goes towards the Eastern Uttar Pradesh. Table 1 also shows that the river water has been mildly polluted at various sampling stations. The degree of pollution varies with respect to the parameter of study. For example, the pH and dissolved oxygen level (D. O. level) of the river water remains in the range of the 'A' class water (6.5 to 8.5 and 6 mg/L or more, respectively) as per the CPCB classification<sup>14</sup> for best use of water at all the sampling stations from Hardwar to Kanpur-R. However, at Kanpur-J, the D. O. level of river water falls to about 5.5 to 3.4 with a seasonal average of 3.9. While in the case of BOD<sub>5days</sub> at 20 °C and total coliforms organism (MPN/100 mL), the river water shows a mild (Hardwar and Narora) to very high level of pollution at Kanpur.

**Table 1. Physicochemical characteristics of river water**

Parameters	Hardwar	Narora	Badaun	Kannauj	Kanpur-R	Kanpur-J	Samples analyzed
Temperature ( °C)	14.5 - 24.6 (20.40)	19.8 - 26.2 (22.70)	16.4 - 27.3 (23.90)	18.2 - 29.4 (23.10)	18.8 - 28.9 (24.10)	18.7 - 28.9 (24.10)	15
pH	7.5 - 7.8 (07.60)	7.34 - 8.60 (08.15)	7.35 - 8.15 (08.00)	7.98 - 8.59 (08.38)	7.95 - 8.85 (08.25)	7.90 - 8.75 (08.15)	15
TDS (mg/L)	171.2 - 196.4 (186.10)	198.2 - 252.4 (234.80)	188.2 - 242.4 (198.80)	275.4 - 313.6 (298.50)	268.4 - 308.6 (287.20)	325.0 - 402.5 (378.50)	10
Turbidity (FTU)	6.9 - 9.8 (07.80)	7.1 - 8.8 (07.40)	6.9 - 9.7 (08.60)	8.3 - 9.7 (09.30)	8.5 - 10.4 (09.50)	12.5 - 14.8 (13.20)	10
Hardness (mg/L)	108.4 - 119.5 (114.50)	138.4 - 152.6 (141.50)	192.3 - 197.4 (194.50)	117.6 - 129.7 (126.40)	136.4 - 149.2 (142.50)	193.9 - 198.0 (197.30)	10
Total Alkalinity (mg/L)	88.2 - 91.8 (90.10)	168.6 - 181.3 (179.10)	178.3 - 179.2 (178.80)	173.8 - 189.4 (181.50)	182.1 - 204.0 (193.80)	180.3 - 199.0 (184.20)	10
Chloride (mg/L)	7.8 - 8.1 (07.90)	15.4 - 38.6 (21.30)	18.9 - 39.4 (24.70)	18.8 - 37.2 (23.70)	19.0 - 38.6 (24.50)	21.2 - 39.6 (28.80)	10
Sulphate (mg/L)	7.8 - 9.3 (08.10)	9.1 - 9.8 (09.40)	14.5 - 15.3 (11.40)	10.5 - 12.4 (11.00)	18.9 - 20.1 (19.50)	16.3 - 18.5 (17.10)	10
Fluoride (mg/L)	0.08 - 0.08 (0.08)	0.42 - 0.44 (00.43)	0.45 - 0.47 (00.47)	0.47 - 0.71 (00.58)	0.58 - 0.88 (00.71)	0.60 - 0.78 (00.69)	10
DO (mg/L)	7.8 - 10.4 (08.80)	7.4 - 8.4 (08.20)	8.3 - 12.9 (10.10)	7.9 - 9.1 (08.60)	6.5 - 8.8 (07.90)	3.4 - 5.5 (03.90)	10
BOD (mg/L)	2.9 - 5.3 (04.80)	3.4 - 6.3 (05.10)	3.8 - 7.4 (05.80)	4.9 - 6.1 (05.90)	5.6 - 7.4 (06.40)	6.7 - 8.9 (07.60)	10
COD (mg/L)	4.3 - 6.0 (04.90)	8.3 - 12.2 (09.80)	8.0 - 12.7 (09.30)	6.4 - 7.3 (06.80)	11.8 - 13.8 (12.50)	11.8 - 15.3 (13.10)	10
Conductivity (µmhos/cm)	540 - 645 (562.00)	203 - 347 (264.00)	188 - 278 (215.00)	191 - 426 (321.00)	241 - 592 (426.00)	249 - 617 (485.00)	15
Faecal Coliform (MPN/100 mL)	21 - 28 (25.00)	110 - 340 (280.00)	120 - 310 (270.00)	2350 - 8950 (6500.00)	1050 - 12650 (3800.00)	1250 - 9800 (3845.00)	15
Total Coliform (MPN/100 mL)	1450 - 1680 (1610.00)	256 - 1350 (685.00)	950 - 1280 (1050.00)	7450 - 36590 (15600.00)	4450 - 23540 (9850.00)	4650 - 22150 (8260.00)	15

The amount of nutrient elements found in the water of the river Ganges at different locations of Western Uttar Pradesh is given in Table 2. It shows that the average nitrogen (ammonium, nitrate and nitrite) was found to be lowest at Hardwar and highest at Kanpur-J. It was also observed that the increasing trend was followed from Hardwar (1.56 mg/L) to Badaun (2.46 mg/L) and then decreases up to Kanpur-R (1.96 mg/L). It may be attributed to the fact that there are less number of religious and social activities in this area in comparison to the other segment of the study stretch. The average amount of phosphorus

content in water varied from 0.42 mg/L at Hardwar to 0.61 at Kanpur-R while the average potassium was found in a very less amount in the Hardwar and Narora. It was below the detection limit at other places of study.

**Table 2 : Amount of some nutrients elements found in the water of river Ganges at various locations in western Uttar Pradesh (mg/L)**

Locations	NH <sub>4</sub> - N	NO <sub>3</sub> -N	NO <sub>2</sub> -N	Phosphorus as P	Potassium as K
Hardwar	0.90- 0.98- 0.92	0.61-0.78- 0.64	ND	0.32-0.64- 0.42	1.3-1.9- 1.5
Narora	1.06 -1.12- 1.05	0.53- 0.98- 0.85	ND	0.45-0.78- 0.56	2.0-2.0- 2.0
Badaun	0.82-0.97- 0.91	0.79-1.87- 1.16	0.20-0.62- 0.39	0.45-0.77- 0.57	ND
Kannauj	0.24 -0.34- 0.27	1.05-2.24- 1.54	0.27-0.79- 0.45	0.37-0.71- 0.58	ND
Kanpur-R	0.26 -0.38- 0.31	0.22-2.15- 1.38	0.13-0.58- 0.27	0.48-0.78- 0.61	ND
Kanpur-J	0.46 -0.56- 0.52	0.24-3.87- 2.34	0.16-0.93- 0.44	0.40-0.68- 0.59	ND

Values are in the sequence of Minimum-Maximum-Average of total readings

The average amount of calcium and magnesium (Table 3) were found to vary from 48 mg/L to 142 mg/L and 22 mg/L to 55 mg/ at Badaun and Kannauj, respectively. The possible reason for the higher Ca and Mg content in the region could be due to the more agricultural practices and construction activities of Kachla Bridge Development Project. The average amount of micronutrient elements (Table 3) such as Zn, Mn, Cu and Fe in the water of river Ganges at various locations in Western Uttar Pradesh was observed in the range of 9.34 to 46.31µg/L; 31.55 to 82.50µg/L; 2.82 to 10.33µg/L and 36.1 to 54.0µg/L, respectively. A large seasonal variation in the metal concentration was found at all sampling locations especially in the case of Zn, Mn and Cu at Badaun and Zn at Kannauj. It may be attributed to the seasonal industrial activities (like sugar factories etc) in the western Uttar Pradesh, which remains operative in few months of summer season.

**Table 3: Amount of some general and trace metals found in the water of river Ganges at various locations in Western Uttar Pradesh**

Locations	Ca <sup>2+</sup>	Mg <sup>2+</sup>	Zn <sup>2+</sup>	Mn <sup>2+</sup>	Cu <sup>2+</sup>	Fe <sup>3+</sup>
	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L
Hardwar	58-74- 64	46-51- 49	28.2- 32.4-30	38.3-42.5- 39.7	5.4-10.2- 8.4	35.5-39.2- 36.1
Narora	82-136- 108	24-39- 27	43.5- 52.6-46	41.6-48.4- 42.5	6.5-8.3- 7.3	52.5-59.6- 54.0
Badaun	33-62- 48	28-34- 22	22.8- 41.5-38	27.1-40.5- 31.6	3.5-6.2- 4.5	45.5-49.7- 46.9
Kannauj	138- 147-142	52-56- 55	7.4-14.3- 9.3	43.5-49.4- 44.5	2.5-3.5- 2.8	41.2-44.5- 42.3
Kanpur-R	125- 141-135	40-49- 44	11.2- 15.2-12	41.2-46.3- 45.2	5.5-9.2- 7.5	34.5-42.5- 38.3
Kanpur-J	122- 138-126	41-49- 45	13.3- 15.3-14	78.7-92.4- 82.5	8.9-14.7- 10.3	43.0-46.8- 45.5
	15	15	15	15	15	15

Values are in the sequence of Minimum-Maximum-Average of total readings

**Table 4 :Amount of some toxic trace metals found in the water of river Ganges at various locations in western Uttar Pradesh (µg/L)**

Locations	Cadmium as Cd <sup>2+</sup>	Chromium as Cr <sup>3+</sup>	Cobalt as Co <sup>2+</sup>	Nickel as Ni <sup>2+</sup>	Lead as Pb <sup>2+</sup>
Hardwar	ND	34.5-38.6- 35.5	ND	1.5-1.8- 1.6	0.05-0.06- 0.06
Narora	0.11-0.12- 0.12	43.5-53.3- 45.6	8.8-11.6- 9.2	5.8-6.2- 6.0	0.81-0.90- 0.85
Badaun	0.08-0.10- 0.09	49.5-54.6- 51.1	7.8-9.9- 8.5	4.2-5.9- 5.0	0.54-0.68- 0.58
Kannauj	0.10-0.10- 0.10	48.9-55.5- 52.0	7.6-9.7- 8.4	4.5-4.8- 4.5	0.35-0.55- 0.46

Cont...

Locations	Cadmium as Cd <sup>2+</sup>	Chromium as Cr <sup>3+</sup>	Cobalt as Co <sup>2+</sup>	Nickel as Ni <sup>2+</sup>	Lead as Pb <sup>2+</sup>
Kanpur-R	0.24-0.25- 0.25	52.8-63.1- 55.4	5.6-7.4- 6.0	5.5-6.5- 5.8	0.95-0.98- 0.97
Kanpur-J	0.56-0.60- 0.57	51.9-65.8- 58.2	8.4-10.1- 9.5	5.8-6.9- 6.2	1.14-1.32- 1.20
	15	15	15	15	15

Values are in the sequence of Minimum-Maximum-Average of total readings

The average concentration of toxic metals such as Cd, Cr, Co, Ni and Pb in the river water (Table 4) was observed in the range of ND to 0.57µg/L; 35.5 to 58.2µg/L; ND to 9.5µg/L; 1.6 to 6.2µg/L; and 0.06 to 1.20µg/L, respectively. The highest concentration of these toxic metals was found at Kanpur-J and lowest at Hardwar sampling stations. A large number of industrial establishments such as fertilizer and tanneries etc. in and around the Kanpur city have been assigned reason for the high trace metal concentration in the river water<sup>15</sup>. However, this trend could not always be observed in the river water due to various other physicochemical as well as dynamic mobility reasons.

The presence of various metals in the aquatic eco-system is dependent on a wide range of physicochemical, biological and environmental factors. Among these, pH has been considered as a dominant factor<sup>16</sup> to influence the availability and speciation of trace metals in the water bodies. It shows that free ions are found mainly at lower pH whereas they get precipitated at higher pH values. As the pH of the river water was found to be in the alkaline range (7.50 to 8.85) through out the study stretch from Hardwar to Kanpur, the lower concentration of all the trace metals have been observed except that of chromium. However, in the present study, the general trend in the trace metal concentration has not followed the pH or any other individual criteria strictly because of the entries of various kinds of the pollutants from diverse non-point sources into the river water.

### The river sediments

The sediment samples collected from Hardwar to Kanpur-J segment of river Ganges in Western Uttar Pradesh were analyzed for eight selected trace metals namely : Cd, Co, Cr, Cu Ni, Mn, Pb and Zn. The maximum, minimum and average concentrations of these metals are given in Table 5. It shows that the maximum concentration range of all the trace metals was found at Kanpur-J locations and minimum at Hardwar except at Narora and Badaun where Cu concentration was found about fifteen percent lesser than

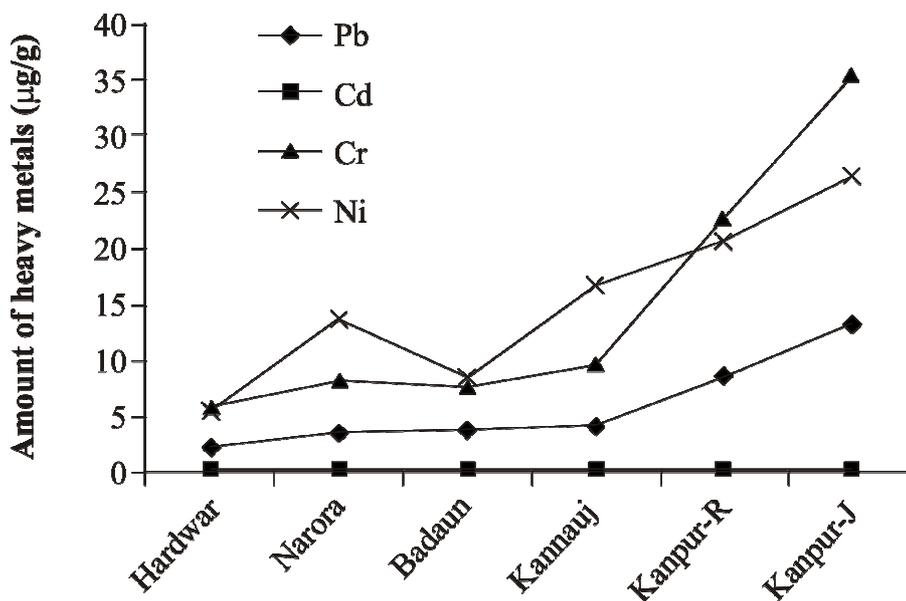
those at Hardwar. The variation of average concentration of trace metals when compared from Hardwar and Kanpur-J was found to fluctuate in the range of 1.55 to 4.8 times except Cr and follows the increasing trend as :  $Cr \gg \gg Co \geq Pb > Cd > Zn > Ni > Mn > Cu$ . An abnormally high accumulation of Cr in the sediments of Kanpur-J locations has been observed in the present study, which is an indication of the worst case of sediment contamination. However, all the trace metals were found below the world average<sup>17</sup> of these trace metals except Cr at Kanpur region. Other studies<sup>18,19</sup> have also reported abnormally high increase in Cr metal contamination at Kanpur region (10 fold and 30 fold respectively), which shows that contamination at Kanpur region is not fully managed since last ten years and it persists still at 37.8 fold increase as per our studies. The average levels of various trace metals in the river sediment samples when compared with their lowest effect level<sup>20</sup> and probable effect level<sup>21</sup>, only chromium at Kanpur-J was found to contribute sediment toxicity to the river water eco-system. All other trace metals in sediment samples at different sampling stations were found well below the LEL and PEL values.

**Table 5: Amount of trace metals ( $\mu\text{g/L}$ ) in the sediments of Ganga river at different locations of western U. P.**

Heavy metals	Hardwar	Narora	Badaun	Kannauj	Kanpur-R	Kanpur-J
Cadmium	ND	0.15 - 0.21- 0.18	0.20-0.23 0.21	0.29- 0.34-0.31	2.5-5.4- 3.47	2.1-3.2- 2.6
Chromium	1.22-1.80- 1.64	2.81- 3.10-2.88	2.20-4.80 3.35	1.31- 1.53-1.35	5.15- 5.25- 5.20	152.0- 315.2-196.5
Cobalt	2.45-3.50- 2.85	7.95 – 8.17-8.10	5.20- 5.80-5.45	3.45- 4.61-3.85	12.5- 16.4- 13.8	12.8-16.4- 13.8
Lead	0.5-2.9-1.8	6.5 – 7.6-7.1	3.40- 3.80-3.50	1.65- 2.71-2.05	4.8-7.5- 5.1	4.5 -12.4- 8.6
Nickel	3.75-4.65- 3.95	8.45 – 10.25-9.20	4.20- 5.50-4.75	3.80- 4.10-3.95	5.8-8.3- 6.4	7.5-12.6- 9.8
Zinc	24.5-30.2- 28.8	37.8 – 59.4-48.6	25.5-28.0 -26.0	24.3- 28.4-25.6	35.0- 54.6- 43.5	68.5-105.0 - 88.5

Heavy metals	Hardwar	Narora	Badaun	Kannauj	Kanpur-R	Kanpur-J
Manganese	78.9- 115.4-88.5	124.5- 198.6 - 168.2	98.8- 152.8- 126.4	92.1- 145.5- 110	95-156- 124	182-267- 198
Copper	7.1-12.4- 11.5	6.5 – 11.6-9.8	7.4-12.2- 9.8	8.1-12.0 -10.0	8.5-12.6- 10.5	14.6-19.0- 17.8

Values are in the sequence of Minimum-Maximum-Average of total readings

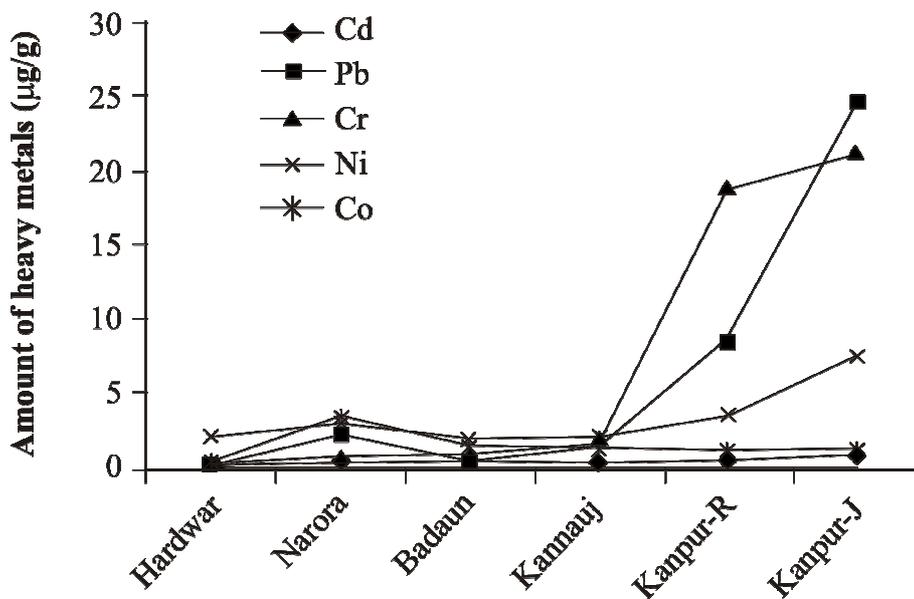


**Fig. 3:** Amount of toxic metals in the sub-merged plants collected from the river Ganges

The average amounts of some toxic metals found in the sub-merged common plants of the river eco-system are presented in Fig. 3. It shows that the aquatic plants accumulate toxic metals in the following increasing order : Ni > Cr > Pb > Cd up to Kannauj and thereafter, abundant Cr accumulation was observed in the plants. It is obvious because of a large amount of Cr accumulation in the sediment samples of the Kanpur region. Fig. 3. Also indicates that Pb and Cr was smoothly increased from Hardwar to Kannauj and thereafter, rapidly increased in the Kanpur region. While in the case of Ni, a highly fluctuating trend was observed through out the study stretch from Hardwar to

Kanpur and the range was from 5.5 to 26.5  $\mu\text{g/g}$ . The average amount of cadmium was found to be in the range of 0.08 to 0.30  $\mu\text{g/g}$ . It shows that the fertilizer industries in the Kanpur region, which was held responsible for Cd contamination<sup>22</sup>, has now controlled their effluent discharge quality effectively.

Fig. 4 shows the average amount of toxic metals such as Pb, Cd, Cr and Ni accumulated in the common fish (*Heteropneustes fossilis*) generally found in the river Ganges. It was observed that all the toxic metals were found to remain lesser than 5  $\mu\text{g/g}$  up to Kannauj sampling station and thereafter, there was a very sharp increase in the Kanpur region especially in the case of Pb and Cr. The accumulation trend of toxic metals in fish samples were followed as  $\text{Cr} > \text{Pb} > \text{Ni} > \text{Co} > \text{Cd}$  at Kanpur-R and  $\text{Pb} > \text{Cr} > \text{Ni} > \text{Co} > \text{Cd}$  at Kanpur-J.



**Fig. 4 : Amount of toxic metals in the fish samples captured from the river Ganges**

The concentration of toxic metals in fish samples have been reported to be affected by various factors such as food habits and seasonal change<sup>23</sup>, source of metal contamination and its distance for the organism<sup>24</sup>, physicochemical properties of water<sup>25</sup> and others. Moreover, nickel and chromium produced a combined effect in altering the metabolic functions of the fresh water fish. The result indicates that the heavy metal contamination definitely affects the aquatic life of the fresh water fish. Hence, a scientific method of detoxification is essential to improve the health of the economic fish in any

stressed environmental conditions.

## CONCLUSION

The eco-toxicological monitoring of the river Ganges in Western Uttar Pradesh shows that the water quality of the river was observed to be improved moderately at some locations with respect to some specific parameters. The river water and other ecological parameters such as sediments, sub-merged plants and commonly found fish were found to be less contaminated in the initial stretch of study area as compared to the Kanpur region. However, self-purification character of the river is again distinctly appreciable. The average concentration of Pb, Cr and to some extent Ni in the fish samples captured from Kanpur region was found to be high and its accumulation in the body of its consumer may cause some toxic effects, if consumed regularly.

## ACKNOWLEDGEMENT

The author wishes to express a note of appreciation to the Principal, Kumaon Engineering College, Dwarahat for providing necessary facilities and permission for carrying out the above work at various locations of Uttarakhand and Uttar Pradesh.

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