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Original Research Article

Assessment of Heavy Metals Concentrations in River Sone, Bihar, India

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Abstract

This paper assesses heavy metals like Pb, Cr, Zn and Cd from the selected stations in the river Sone at Bihar, India during 2009 – 2010. The presences of heavy metals were observed in all the stations throughout the study period. The results show that the mean concentrations of heavy metals in the river water followed the sequence of Zn>Pb>Cr>Cd. The higher concentration of Pb 0.1160 ppm was registered in Tilauthu (S_2) during winter season. The maximum level of Cr 0.0588 ppm was observed in Indrapuri (S_3) during rainy season. Similarly, at Indrapuri (S_3) the higher level of heavy metal Zn 0.2275 ppm was noticed during retreat season. The maximum level of Cd 0.0150 ppm was observed during summer season at Jehanabad (S_9). The analysis of variance (ANOVA) did not show significant differences (p>0.05) in the season wise. However, station wise merely Zn showed significant differences (p<0.05) during the investigation. The presence of heavy metal in the study area shows the great concern because of their toxicity when their concentration are more than the level of anticipation.

Keywords

Health hazard
Heavy metals
River Sone

Introduction

Water is one of the important compounds that sustain all forms of life (Vanloon and Duffy, 2005). Water contamination has been a major source of health risk exclusively in the developing countries (Ul-Haq et al., 2011). Heavy metals are one of the most persistent pollutants in water. Unlike other pollutants, they are difficult to decompose and can accumulate producing potential human health problems and ecological disturbances (Sahni, 2011). Heavy metals occurrence and accumulation in the environment is because of direct or indirect human activities such as rapid industrialization, urbanization and anthropogenic sources (Hussein et al., 2005; Gardea-Torresdey et al., 2005; Martin-Gonzalez et al., 2006).

Heavy metals can affect our body system enormously in negative ways (Adepoju et al., 2005). They can disturb our metabolic activity in the body. They have a great affection for the central nervous system and neurons. They bind to blood cells impairing them; they are accumulated in bones, kidney, liver and most organs of the body, causing organ damage; they compete with nutritional metals for binding hormones that control our endocrine system and disrupt the reproductive functions. As a result of these actions includes fatigue, memory loss, attention loss, weight loss, irreversible neurological damage, tremor, insomnia, depression, anaemia, low blood pressure and a host of other symptoms. Some elements like Fe, Zn, Cu, Cr, Mn and Ni are needed in small quantities for human metabolism but may be toxic at higher levels. Others like Hg, Cd, AS etc have no beneficial role in human system (Sahni, 2011).

Scientists should contemplate a rapid degradation of water quality unless concrete steps are taken immediately to abate pollution (Singh et al., 1995). An intensive agricultural practice, sewage effluents and small-scale industrial waste dumping on the river Sone bed has been noticed. There has been an unofficial complaint of heavy metal related poisoning. Therefore, the heavy metals contamination in waters from the river Sone has been analyzed and evaluated in this study.

Materials and methods

Study area and monitoring sites

The study was carried out in river Sone. It is one of the largest (784 km) rivers in India. It originates near Amarkantak in Madhya Pradesh, just east of the headwater of the Narmada River, it flows through four states i.e. Madhya Pradesh, Uttar Pradesh, Jharkhand and Bihar. In Bihar it joins the Ganges just near Patna. In the present investigation Bihar is chosen for study by selecting 10 different sampling stations.

Fig. 1: Map Showing Location of the Sampling Sites.

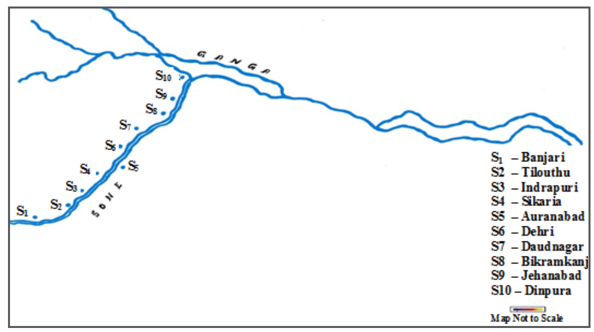


Table 1. Description of 10 different sampling stations.

Station	Description
Banjari (S_1)	One of the largest cement manufacturing facilities of the state, Kalyanpur Cements Ltd. is Situated in this station.
Tilauthu (S_2)	Discharge of domestic waters, poultry waste and slaughter house wastes discharged into the river.
Indrapuri(S_3)	Disturbed by an appreciable amount of discharge of domestic waters and tourism, festival, fisheries activities.
Sikaria(S_4)	Domestic wastes, septic tank wastes, and agricultural run-off from the fields.
Aurangabad (S_5)	Mainly attributed to the agricultural run-off from the fields.
Dehri (S_6)	Affected by sewage effluents, day time either by cattle or by people washing cloth, cleaning utensils, bathing.
Daudnagar (S_7)	Considerable pollution load from the town and severe anthropogenic activities.
Bikramganj (S_8)	Discharge of wastes into the river by Baloo Ghat Company.
Jehanabad (S_9)	Industrial area and siltation and aquatic plants in the river.
Dinapur (S_{10})	Much anthropogenic activities due to capital city near Patna.

Method of study

The water quality survey was conducted during different seasons of the year from 2009-2010. The samples were collected in 5L plastic container between 8 to 10 AM. The containers were thoroughly washed and rinsed with concentrate HNO_3 followed by distilled water. To investigate the heavy metal fifty milliliters of water sample was digested with 10 ml of concentrated HNO_3 at 80°C until the solution became translucent (APHA, 1987). The solution was filtered through Whatman no. 42 filter paper and the filtrate was diluted to 50 ml with distilled water. Then the filtrate samples were estimated by an atomic absorption spectrophotometer (Perkin Elmer model 2130, USA), fitted with a specific lamp of particular metal using appropriate drift blank. Blank samples were analyzed after every three samples. Merck analytical grade chemical reagents were used for analysis. Quality control measures were taken to assess contamination and reliability of data. To calibrate the instrument Blank and drifts standards (Sisco Research

Laboratory Pvt. Ltd., India) were run after five readings. Data obtained were statistically analyzed at 5% level of significance by using one-way ANOVA using LSD, Tukey with the help of IBM SPSS statistics version 20 software package.

Results and discussion

The result of the Atomic Absorption Spectrophotometer (AAS) analysis of all the samples are shown in tables and figures below.

Table 2. Heavy metal concentrations (ppm) in river Sone at Banjari(S_1).

Heavy metals	YEAR 2009 – 2010				
	Rainy	Retreat	Winter	Summer	Safe limit*
Pb (ppm)	0.03 ±0.02	0.025 ±0.005	0.027 ±0.027	0.026 ±0.016	0.01
Cr (ppm)	0.0085 ±0.0025	0.009 ±0	0.008 ±0.004	0.004 ±0.003	0.05
Zn (ppm)	0.1405 ±0.0115	0.085 ±0.066	0.148 ±0.002	0.1576 ±0.0086	3.00
Cd (ppm)	0.00175 ±0.0017	0.0015 ±0.0005	0.0034 ±0.0024	0.003 ±0.001	0.01
Source:**International standards for drinking water*, Geneva (WHO, 2007).					

Table 3. Heavy metal concentrations (ppm) in river Sone at Tilauthu(S_2).

Heavy metals	YEAR 2009 – 2010				
	Rainy	Retreat	Winter	Summer	Safe limit*
Pb (ppm)	0.085 ±0.025	0.105 ±0.015	0.103 ±0.03	0.063 ±0.043	0.01
Cr (ppm)	0.0052 ±0.0022	0.0065 ±0.005	0.0121 ±0.0031	0.008 ±0.004	0.05
Zn (ppm)	0.1942 ±0.0202	0.142 ±0.007	0.1646 ±0.0206	0.1476 ±0.0286	3.00
Cd (ppm)	0.0043 ±0.003	0.0055 ±0.0025	0.003 ±0.003	0.005 ±0.001	0.01
Source:**International standards for drinking water*, Geneva (WHO, 2007).					

Table 4. Heavy metal concentrations (ppm) in river Sone at Indrapuri (S_3).

Heavy metals	YEAR 2009 – 2010				
	Rainy	Retreat	Winter	Summer	Safe limit*
Pb (ppm)	0.0425 ±0.0225	0.085 ±0.055	0.05 ±0.05	0.103 ±0.003	0.01
Cr (ppm)	0.05875 ±0.05175	0.0035 ±0.0005	0.0046 ±0.0046	0.005 ±0.005	0.05
Zn (ppm)	0.209 ±0.021	0.1555 ±0.0065	0.203 ±0.028	0.1853 ±0.0223	3.00
Cd (ppm)	0.006 ±0.006	0.0005 ±0.0005	0.0043 ±0.0043	0.00136 ±0.00036	0.01
Source:**International standards for drinking water*, Geneva (WHO, 2007).					

Table 5. Heavy metal concentrations (ppm) in river Sone at Sikaria (S_4).

Heavy metals	YEAR 2009 – 2010				
	Rainy	Retreat	Winter	Summer	Safe limit*
Pb (ppm)	0.0625 ±0.0325	0.025 ±0.005	0.043 ±0.043	0.03 ±0.02	0.01
Cr (ppm)	0.01275 ±0.00175	0.008 ±0.002	0.0046 ±0.0046	0.0053 ±0.0053	0.05
Zn (ppm)	0.1355 ±0.0325	0.165 ±0.53	0.13943 ±0.03613	0.148 ±0.036	3.00
Cd (ppm)	0.00475 ±0.00475	0.003±0	0.0036±0.0036	0.00143 ±0.00143	0.01
Source:**International standards for drinking water*, Geneva (WHO, 2007).					

Table 6. Heavy metal concentrations (ppm) in river Sone at Aurangabad (S_5).

Heavy metals	YEAR 2009 – 2010				
	Rainy	Retreat	Winter	Summer	Safe limit*
Pb (ppm)	0.04 ±0.03	0.065 ±0.045	0.063 ±0.053	0.06 ±0.026	0.01
Cr (ppm)	0.01 ±0.004	0.0075 ±0.0025	0.008 ±0.008	0.00503 ±0.00596	0.05
Zn (ppm)	0.031425±0.00475	0.122 ±0.102	0.084 ±0.066	0.1193 ±0.0993	3.00
Cd (ppm)	0.00355 ±0.00355	0.003 ±0.003	0.00153 ±0.00153	0.00346 ±0.00106	0.01
Source:**International standards for drinking water*, Geneva (WHO, 2007).					

Table 7. Heavy metal concentrations (ppm) in river Sone at Dehri (S_6).

Heavy metals	YEAR 2009 – 2010				
	Rainy	Retreat	Winter	Summer	Safe limit*
Pb (ppm)	0.0975 ±0.0175	0.0615 ±0.0615	0.046 ±0.046	0.01 ±0.01	0.01
Cr (ppm)	0.0045 ±0.0025	0.002 ±0.001	0.00703 ±0.00003	0.00123 ±0.00112	0.05
Zn (ppm)	0.07275 ±0.05475	0.182 ±0.033	0.104 ±0.085	0.156 ±0.034	3.00
Cd (ppm)	0.0025 ±0.0025	0.0032 ±0.0018	0.0036 ±0.0036	0.00556 ±0.00286	0.01

Source:**International standards for drinking water*, Geneva (WHO, 2007).

Fig. 2: Seasonal variations of heavy metals at Dehri (S_7).

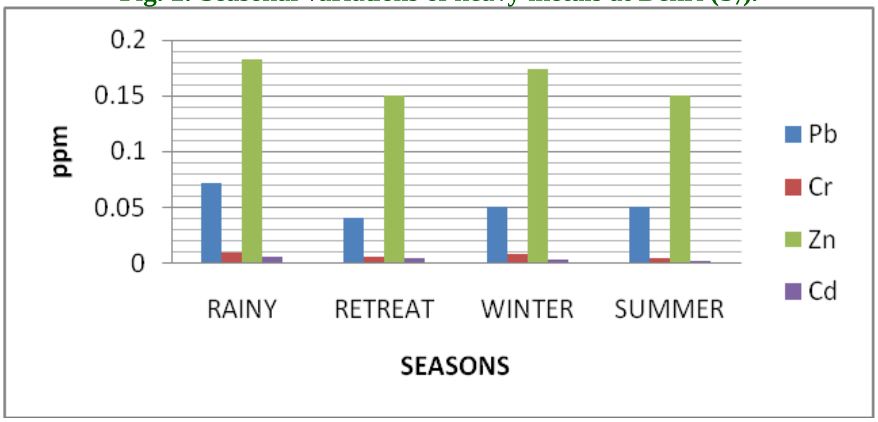


Fig. 3: Seasonal variations of heavy metals at Bikramganj (S_8).

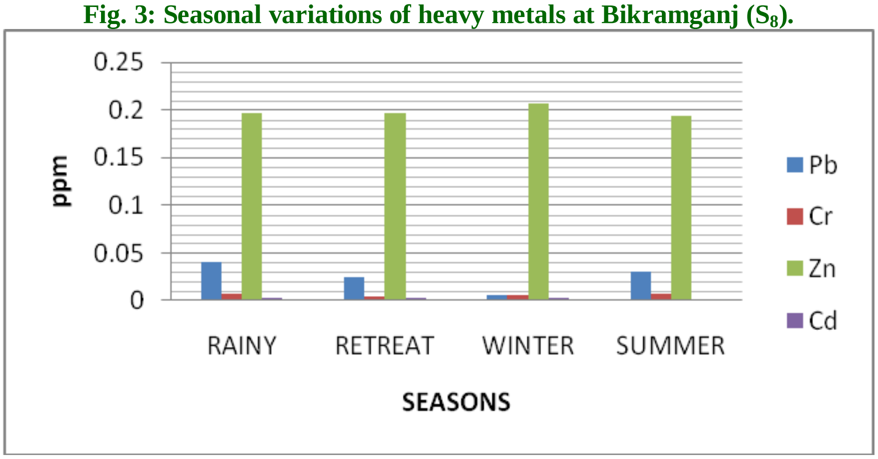


Fig. 4: Seasonal variations of heavy metals at Jehanabad (S_9).

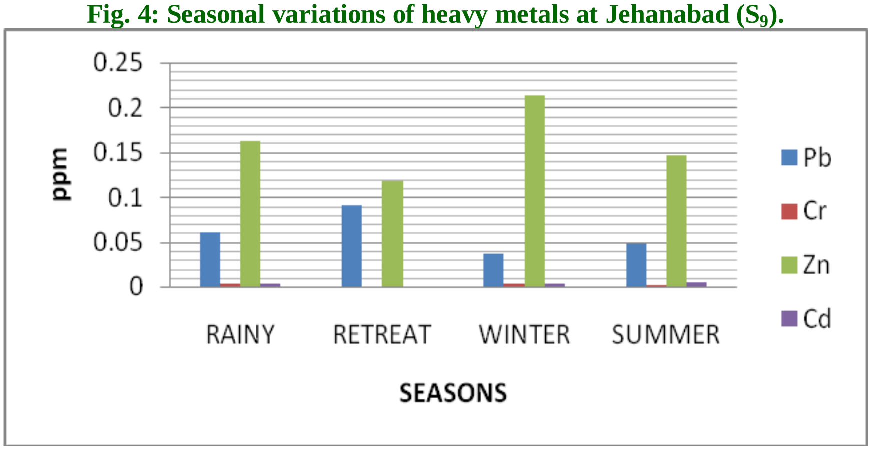
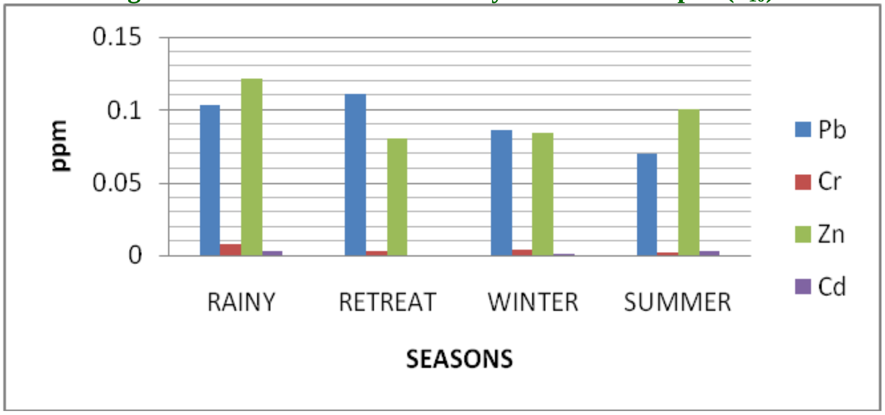


Fig. 5: Seasonal variations of heavy metals at Dinapur (S_{10}).



Leads naturally exist in the environment. It is an unwanted trace metal, which is less plentifully found in the earth's crust. It is also found in soil vegetation, animals and food. It is a serious cumulative body poison. Lead inhibits several key metabolic intermediate accumulations. In the present investigation, the minimum value 0.006 ppm observed during winter season at Bikramganj (S_8) the maximum of 0.1105 ppm observed during retreat at Dinapur (S_{10}). Lead content in water samples among 10 stations did not show significant variation (F = 3.042; p>0.05). All the values of lead are showed greater than the approved set by WHO (0.01ppm) except during summer season at Dehri (S_6).This could be as a result of the use of leaded petrol in cars, generators and even some mechanic workshops around these areas especially battery chargers (Oniye et al., 2005).

Lead contamination of the water may be the result of entry from industrial effluents, old plumbing, household sewages, agricultural run-off containing phosphatic fertilizers and human and animal excreta (Sirajudeen and Abdul Jameel, 2006). The small quantities of lead leads to high blood pressures, kidney damage etc. In addition to the symptoms found in acute lead exposure, symptoms of chronic lead exposure could be allergies, arthritis, hyperactivity, mood swings, nausea, numbness, lack of concentration, seizures and weight loss.

Chromium is considered as a relative biological and pollution significance element (Aggarwal et al., 2000). It is an indispensable micronutrient for animals and plants. In the present investigation, the concentration of chromium range from 0.001-0.0587ppm. The minimum value observed during retreat season at Jehanabad (S_9) and maximum value observed during rainy season at Indrapuri (S_3). Chromium level in various stations during the study period does not show significant variation (F=0.905; p>0.05). In our study, the chromium concentration is recorded well within the permissible limit set by WHO (0.05 ppm). The level of chromium in these ten samples could be due to the presence of chromium in varying concentrations in nearly all uncontaminated aquatic and terrestrial ecosystem. Also, the presence of chromium in soaps and detergents used for washing and bathing could be responsible for the high chromium level in these samples (Mohammed and Gupta, 2009).

Zinc is one of the essential trace elements that play a vibrant role in the physiological and metabolic process of many organisms. Nevertheless, at higher concentration of zinc can be toxic to the organisms (Hess and Schmid, 2002). It is also plays a significant role in protein synthesis. In the present study, the maximum of zinc 0.2136 ppm observed during winter season at Jehanabad (S_9) and the minimum of zinc 0.0314 ppm observed during rainy season at Aurangabad (S_5). Zinc content in water show variation among 10 stations during the investigation show significant variation (F= 5.742; p<0.05). However, all the values of zinc are showed within the limit of WHO (3ppm) standards. The presence of zinc in the water samples mainly due to the Zinc ores. Furthermore municipal refuse, automobiles and agricultural use of pesticides and fungicides containing ZnSo4 are the additional sources of zinc in the water sample. Zinc influences growth rate and bone development. The deficiency of zinc manifests itself by retardation of growth, anorexia, lesions of the skin and appendages, impaired development and function of reproductive organs (Dara, 2004). Cadmium is a crystalline non-essential metal and its static state in the natural environment (Prabhahar et al., 2011). Cd is one of the most dangerous pollutants due to its high-potential toxic effects. Cadmium is extremely toxic and the primary use of water high in Cd could cause renal disease and cancer to consumers (Satheeshkumar and Senthilkumar, 2011).

In the present observation, the higher concentration of Cd 0.006 ppm during rainy season at Indrapuri (S_3) and lower concentration of Cd 0.0005ppm during retreat season at Jehanabad (S_9). Statistically the Cd content in water reveals among 10 stations during the study does not show significant variation ($F = 0.761$; $p>0.05$).The entry of cadmium in the riverine system may be through paints, pigments, glass enamel, deterioration of the galvanized pipes etc. The wear of scattered tires has been identified as a source of Cd deposited on the surface of the river. However, in our study the cadmium concentration is recorded well within the permissible limit set by WHO (0.01 ppm).

Conclusion

Seasonal variations of heavy metals are investigated among the 10 chosen stations in the river Sone – Bihar during the year 2010-2011. From the statistical analysis of season wise, the heavy metals do not show any significant variation but only Zinc shows significant variation in station wise. The values of Cr, Zn, and Cd values are registered quite well within the permissible limit set by WHO which may not be hazardous to human beings. However, Pb concentrations are as high in all the stations except at Dehri (S_6) during summer season.

It is quite evident that these heavy metals may enter the food chain through bioaccumulation and bio-magnifications; they may impact the future which can lead to imbalance of aquatic and terrestrial ecosystem. Simultaneously humans will get affected and will be prone to various diseases and health complications. Hence, regular monitoring of the water quality is required utmost to access the heavy metal contents in water so that remedial measures can be adopted to save the river from heavy metal pollution. Not only monitoring the water quality is needed but also co – operative measures from industries too. As industrial and sewage contamination is too much, working as one-man army will not help to eradicate this issue. Therefore united hands are needed which include industries and society as well so that awareness can be invoked in the minds of people.

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