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Estimation of Some Heavy Metal Estimation at Sites of Saryug River as Lateral Tributary of the Ganga in Northern Bihar

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ABSTRACT

The Saryug river has been examined about water quality especially for heavy metal pollution by chromium (Cr), cadmium (Cd), zinc (Zn) and lead (Pb) at selected sites namely Siswan, Chapra and Dighwara during two years of study period. The estimated values were found either below or closed the permissible limit set by World Health Organization (WHO) except Cadmium. Cadmium concentration exceeded the WHO limit. This cadmium value in the river water of this area is a serious concern for human health. These heavy metals showed positive correlation with each other in both the years. The generated data may be useful to control the heavy metal pollution of the river at these sites which may even be deteriorating in near future. The present research indicates that the pollution level along the river Saryug is not very high but the increasing population load in the basin may cause long-term harm well masked by short term economic prosperity

Keywords: Saryug River water, Environmental pollution, Heavy metals pollution, Correlation matrix.

INTRODUCTION

Rivers are the major geological agents in tropical regions and considerable changes in transporting water and sediments occur due to site-specific drainage in the river path (Turner and Rabalois, 2009). It is true that river transport of particulates, nutrients and minerals maintaining river productivity but anthropogenic activities in recent years have imposed tremendous pressure on the river systems in the form of toxic drainage from point and non-point sources, which have negatively affected the natural productivity of river systems.

The previous studies have indicated about heavy metal toxicity in fish, oysters, sediments and other components of aquatic ecosystems (Aghr, 2007; Patil, 2009). These toxic heavy metals entering in aquatic environment are adsorbed onto particulate matter, although they can form free metal ions and soluble complexes that are available for uptake by biological organisms (Salomons and Forstner, 1984). The industrial drainage often contains variable amounts of heavy metals such as arsenic, lead, nickel, cadmium, copper, mercury, zinc and chromium which have the potential to contaminate crops growing under such irrigation (Singare et *al*, 2011). These heavy metals have a marked effect on the aquatic flora and fauna which through bio-magnification enter the food chain and ultimately affect the human populations. Heavy metal pollution is an ever increasing problem of aquatic systems. The heavy metal pollution in river systems is caused by mineral weathering, industrial drainage, rainfall and various non-point discharge in recent years.

The Saryug river is preceder of Ghaghra river which rises in the Himalayan glaciers near Lampia-pass at an elevation of 4800 meter at latitude 30° 38´N and longitude 80° 57´E about 60 km South-West of Mansarowar. After traversing for some length in the plains, the river branches off into several channels downstream of Chisapani.

River Ghagra continues its journey through Ayodhya where it is known by the name Saryug. The course of the Ghaghra is confined to a single channel at Dohrighat. The Rapti and the little Gandak join it from the left. After receiving the Jharahi and the Daha, two small streams on its left, the river finally joins the river Ganga few km. downstream of Chapra town in Bihar sub-basin of the River Ghaghara.

The study includes a systematic analysis of heavy metals distribution in water of the river system. The specific objectives of the study are firstly to investigate the current status of the heavy metals availability registered in the water of the river, secondly to assess the seasonal variations in the water quality of the river and to provide scientific basis to understating the environmental problem in the ecosystem context. Chapra is a city and headquarters of Saran district. The district is entirely constituted of plains but there are quite a few depressions and marshes, which create three broad natural divisions. Industries such as agro-manufacturing unit, alcohol manufacturing unit, polythene manufacturing units, leather tanning, small textile units, laundry chemicals, paints and dyes, radiators, brake wires, tire wear, anticorrosive plating are main contributors of Cd, Zn and Cr pollution in the river.

METHODS AND MATERIALS

The Saryug river water at selected sites were analyzed to Chromium (Cr), Cadmium (Cd), Zinc (Zn) and Lead (Pb) pollution during two year investigation period of study as assumed from both point and non-point agents have been identified in recent years. Zn, Pb and Cd are the most frequently researched heavy metals in bioaccumulation studies (Goodyear and McNeill, 1999). Chromium was considered due to their high amount urban drainage as corrosion-induced release from metal complexes (Wallinder et *al*, 2006; Novotny, 1995). This study has carried in previous field study and final laboratory work steps with selected three sites in this river.

The periodic samplings were carried out in monsoon, winter and summer seasons with three replicates in two consecutive years 2018-2019 and 2019-2020. The water samples were collected at depths varying from 15 to 30 cm with the help of a water sampler which consisted of a glass bottle and a cord tied to a lid. The whole assembly was lowered into water to the desired depths and the cord of the lid was pulled and released only when displaced air bubble ceased to come to the surface. The whole assembly was withdrawn and the water was then transferred into pre-cleaned polypropylene bottles. Each container was clearly marked with the name and address of the sampling site and date of sampling. All the procedures were adopted according to the standard methods recommended by APHA (1985).

The water samples (50 ml) were digested with 10 ml of conc. HNO_3 at 80^0C until the solution became transparent for heavy metal estimation (APHA, 2005). The solution was filtered through Whatman No. 42 filter paper and diluted to 50ml with double distilled water. These samples were used to determine heavy metal concentrations by Atomic Absorption Spectrophotometer. Atomic Absorption spectroscopy is an absorption methods where radiation absorbed by metal ions, excited atoms in the vapors state. In atomic absorption spectroscopy, the sample is first converted at a selected wavelength, which is characteristic of each individual element. The same experimental condition was also applied for the determination of the reference samples of known composition.

The heavy metals were directly aspirated into an air C2H2 flame of an atomic absorption spectrophotometer and absorbance measured as Chromium (Cr) at 283.3 nm, Cadmium (Cd) at 228.8 nm, Zinc (Zn) at 279.5 nm and Lead (Pb) at 358 nm.

The mean is calculated by using Σ(X) M=N; where Σ=Sum; X=Individual data points and N=Sample size. The standard deviation is calculated by using Σ(X-M)2 S2=n-1; where Σ=Sum; X=Individual score; M=Mean of all scores and N=Sample size. Correlation is Positive when the values increase together; and correlation is negative when one value decreases as the other increases Correlation can have a value; 1 is a perfect positive correlation; 0 is no correlation and -1 is a perfect negative correlation

Results and Observations

The River Saryug have several villages, towns and small cities including selected sites near Chapra district of Bihar and finally met in Ganga river. Domestic effluents are added into river from the towns and cities. Untreated industrial effluents are also added from some small scale industries in to the river. The study area covers a stretch of the river around Chapra district and findings are presented about heavy metals content in water as Table 1-4 and Figure 1-4.

Table 1: Heavy metal deposition at Site 1 in Saryug river during study period

Parameter	Year 2018-19			Year 2019-20		
	Monsoon	Winter	Summer	Monsoon	Winter	Summer
Cr (mg/l)	0.006	0.009	0.011	0.007	0.010	0.012
Cd (mg/l)	0.034	0.045	0.034	0.035	0.046	0.035
Zn (mg/l)	0.023	0.032	0.034	0.024	0.033	0.035
Pb (mg/l)	0.08	0.018	0.030	0.09	0.019	0.031

Table 2: Heavy metal deposition at Site 2 in Saryug river during study period

Parameter	Year 2018-19			Year 2019-20		
	Monsoon	Winter	Summer	Monsoon	Winter	Summer
Cr (mg/l)	0.008	0.011	0.014	0.009	0.012	0.015
Cd (mg/l)	0.036	0.047	0.036	0.037	0.048	0.037
Zn (mg/l)	0.025	0.034	0.036	0.026	0.035	0.037
Pb (mg/l)	0.010	0.020	0.032	0.011	0.021	0.033

Table 3: Heavy metal deposition at Site 3 in Saryug river during study period

Parameter	Year 2018-19			Year 2019-20		
	Monsoon	Winter	Summer	Monsoon	Winter	Summer
Cr (mg/l)	0.011	0.014	0.017	0.012	0.015	0.018
Cd (mg/l)	0.039	0.050	0.039	0.040	0.051	0.040
Zn (mg/l)	0.028	0.037	0.039	0.029	0.038	0.040
Pb (mg/l)	0.013	0.023	0.035	0.014	0.024	0.036

Table 4: Heavy metal deposition compared to WHO standards

Parameters	Minimum value at different sites/year	Maximum value at different sites/year	Permissible WHO limit (mg/l)
Cr (mg/l)	0.006- 1/2018-19	0.018-3/2019-20	0.10
Cd (mg/l)	0.034-1/2018-19	0.040-3/2019-20	0.005
Zn (mg/l)	0.023-1/2018-19	0.040-3/2019-20	5.00
Pb (mg/l)	0.008-1/2018-19	0.036-3/2019-20	0.05

Chromium (Cr^{+2}) concentration was variable from site to site and season to season for the River Saryug. The site 1 have Cr value as minimum in monsoon and maximum in summer season and also showed increment in last year of study as illustrated in Table 1-3. The data showed less deposition at site 1, moderate in site 2 and high in site 3 during the study period. The spatial distribution is given in Figure 1. The concentration is about reach point to WHO standards of pollution (Table 4).

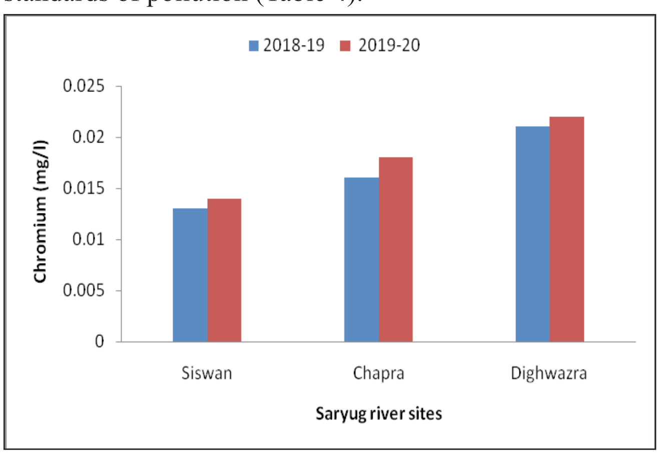

Figure 1: Chromium deposition at different sites of Saryug river

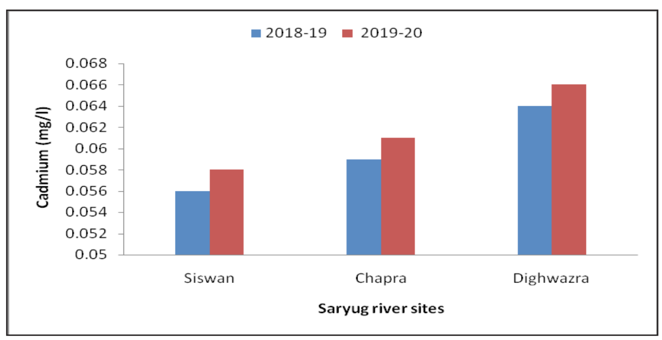

Figure 2: Cadmium deposition at different sites of Saryug river

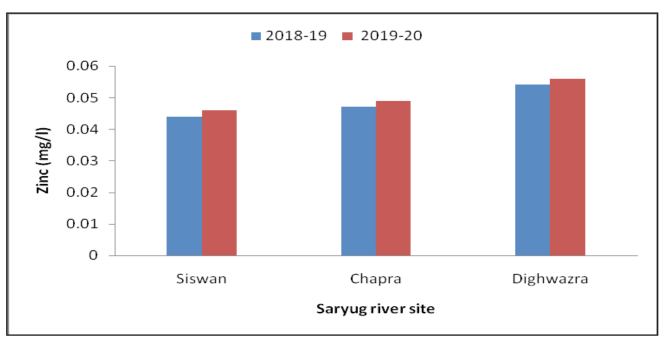

Figure 3: Zinc deposition at different sites of Saryug river

Cadmium (Cd^{+2}) The Saryug river showed different concentration at selected sites and also seasonally variable during the study period. There 1 and 3 site showed similar Cadmium concentration, however 2 site has more Cadmium value perhaps due to urban basin with several industrial discharge into the river as illustrated in Table 1-3. The spatial deposition is illustrated in Figure 2. The concentration is above WHO standards of pollution (Table 4).

Zinc (Zn^{+2}) In the Saryug, Zn concentration was less in site 1 and 2, while excessive deposition observed at site 3 during the study period. There is increasing pattern of deposition in preceding years at all sites as illustrated in Table 1-3. The spatial distribution is less in site 1, moderate in 2 and high in site 3 (Figure 3). The concentration is far less than WHO standards of pollution (Table 4).

Lead (Pb^{+2}) The Lead concentration ranged 0.008-0.013 in monsoon, 0.018-0.023 in winter and 0.030-0.035 in summer season of 2018-19, while 0.09-0.014 in monsoon, 0.019-0.024 in winter and 0.031-0.036 in summer season of 2019-20 (Table1-3). The spatial deposition is less in site 1, moderate in site 2 and high in site 3 during the study period (Figure 4). The concentration is about reach point to WHO standards of pollution (Table 4).

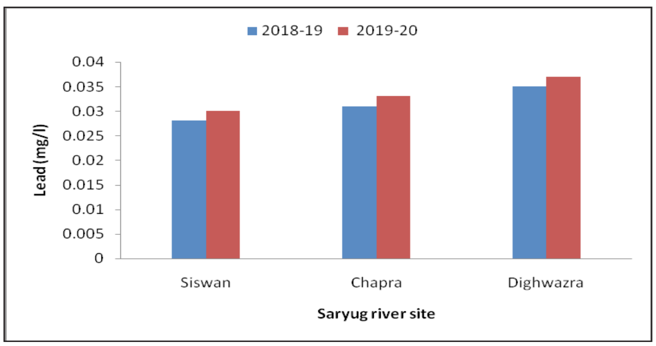

Figure 4: Lead deposition at different sites of Saryug river

Table 5: Correlation coefficients between heavy metals during the study period

	Cr	Cd	Zn	Pb
Cr	1			
Cd	0.784	1		
Zn	0.856	0.998	1	
Pb	0.974	0.994	0.971	1

The correlation coefficient between every parameter pairs was computed by taking the average values of each season for the selected sites of Saryug river during the study period. The correlation analysis showed positive correlation in heavy metal concentrations (Table 5).

DISCUSSIONS

The Cr concentration in water samples was found below the permissible limit of 0.05mg/L set by WHO (1996). The excessive use of this chemical leads to higher concentration in the effluent (Bhalli and Khan, 2006). It is the major chemical present in the effluent, which, when released into water percolates the layers of sediments. Cr compounds are used as pigments, mordents and dyes in the textiles and as the tanning agent in the leather. The sources of emission of Cr in the surface waters are from municipal wastes, laundry chemicals, paints, leather, road run off due to tire wear, corrosion of bushings, brake wires and radiators, etc. Acute toxicity of Cr to invertebrates is highly variable, depending upon species (Jain, 2002). For invertebrates and fishes, its toxicity is not much acute. There are a few recorded instances of Cd poisoning in human beings following consumption of contaminated fishes. It is less toxic to plants than Cu, similar in toxicity to Pb and Cr. It is equally toxic to invertebrates and fishes (Jain, 2002).

The Cadmium is contributed to the surface waters through paints, pigments, glass enamel, deterioration of the galvanized pipes etc. The wear of studded tires has been identified as a source of Cd deposited on road surfaces. The average Cd content in water samples was found to vary from river to river and place to place. Higher values of Cd in waste water effluent samples suggest the high level of pollution due to dyes paints and pigments manufacturing industries around. There are a few recorded instances of Cd poisoning in human beings following consumption of contaminated fishes. It is less toxic to plants than Cu, similar in toxicity to Pb and Cr. It is equally toxic to invertebrates and fishes (Jain, 2002).

Excessive concentration of Zn may result in necrosis, chlorosis and inhibited growth of plants**.** The overall concentration of Zinc as obtained from the analysis of water samples collected from different undertaken rivers varied from 0.004 mg/l to 0.096 mg/l. Since the desired level of Zinc is 5.0 mg/l, none of the samples has exceeded the limiting value. However result indicates leaching of Zinc from the waste dumping site confirming the presence of Zinc in the waste dumped.

The Lead (Pb) is one of the oldest metals known to man and is discharged in the surface water through paints, solders, pipes, building material, gasoline etc. Lead is a well known metal toxicant and it is gradually being phased out of the materials that human beings regularly use. Combustion of oil and gasoline account for >50% of all anthropogenic emissions, and thus form a major component of the global cycle of lead. Atmospheric fallout is usually the most important source of lead in the fresh waters (Jain, 2002). The average concentration of Pb in water samples collected from the river Ganga and its tributaries was found below the permissible limit for lead in drinking water is <0.05mg/L according to the USPHS drinking water standards. Acute toxicity generally appears in aquatic plants at concentration of 0.1-5.0mg/l. Acute toxicity of Pb in invertebrates is reported at concentration of 0.1-10mg/l (Jain, 2002). Higher levels pose eventual threat to fisheries resources.

CONCLUSIONS

The seasonal changes in the water quality and heavy metal deposition of the rivers were imparted mainly due to catchment characteristics and seasonal effects. These variations were noted due to the change in the volume of industrial and sewage waste being added to river at different stations of the stretch. The present experimental data indicates that the pollution level along the river Saryug is not very high but the increasing population load in the basin may cause irreparable ecological harm in the long-term well masked by short term economic prosperity. The experimental data suggests a need to implement common objectives, compatible policies and schemes for improvement in the industrial waste water treatment methods. It also suggests a need of consistent, internationally recognized data driven strategy to assess the quality of waste water effluent and generation of international standards for evaluation of contamination levels. The existing situation if mishandled.

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