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HEAVY METAL ANALYSIS OF SOILS AND SLUDGES OF CONTAMINATED AND UNCONTAMINATED ZONES AROUND PATNA, BIHAR (INDIA)

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Key words : Heavy Metals, Indo-Gangetic Plain, Inter fluvial basin, Groundwater, Surface water, Sewage & Waste water.

The present work is devoted to the study of distribution, behavior and effect of heavy metals, particularly Cd. Cu. Cr, Pb and Zn in the drinking water of Patna Township.

The study area comprises parts of the Patna municipal area and its outskirts covering an area of about 95 sq. Km. Geologically it forms a part of the Indo-Gangetic plain and is covered by a thick sequence of consolidated and semi-consolidated fluvial deposits of the Quaternary age. The city of Patna is located within the inter fluvial basin of Ganga-Sone-Punpun and has a linear east-west extension along the southern bank of the Ganges. The area is rich in groundwater reservoirs and enjoys a stable hydrologic environment. The drinking water is obtained from dug wells, shallow tubewells and deep tubewells.

The study reveals that Cr contents in ground water from the shallow level are slightly higher than that of the deeper levels. The concentration of Cu in water sample from open dugwell, shallow tubewell and deep tubewell is almost similar. There is no appreciable change in the Zn content of water samples from different levels. The comparative table shows that water samples taken from all the sources in and around Patna is free from heavy metal contamination as compared to the maximum permissible levels of World Health Organisation (WHO) and the Indian Standards.

INTRODUCTION

Although there is no universally acceptable definition of heavy metals; generally those with a density of 5 or more are labelled as heavy metals. The increasing load of heavy metals from industries, vehicular emissions, G-I water pipes, household utensils, paints, etc., has been a matter of grave concern for environmentalists all over the world to control the adverse effect of these non-biodegradable substances. The atmospheric concentration of toxic trace metals like Pb, Cd, Cu and Zn in and around Muradabad has been measured by Tripathy *et al.* (1990). The distribution of heavy metals between the principal components of digested sewage sludge has been investigated by Mac Nicol and Beckett (1989). Similarly the sewage and waste water farming and its management with reference to quality parameters have been studied by Sugirwala and Woodward (1977) and adverse effect of sewage pollution on the health of sewage farm workers has been studied by Vardarajan *et al.* (1991). Bubb and Lester (1990) have discussed the source and nature of heavy metals during sewage treatment processes and have examined their behaviour and fate in the aquatic environment.

The sewage system of Patna is still far from satisfactory. Although, after the start of the work of Ganga Action Plan, a number of sewage treatment plants have become operative. Major portion of the sewage and waste water of this city is discharged untreated into the river Ganga. This has a great potential for polluting not only the surface water but also the ground water of this region. The use of waste waters for crop irrigations is almost a universal practice throughout the world. However, there is paucity of data on the study of soils and sludges of contaminated zones where sewage and sludge are used for irrigation and manure. The sewage discharge carried through three major drains of Saidpur, Kankarbagh

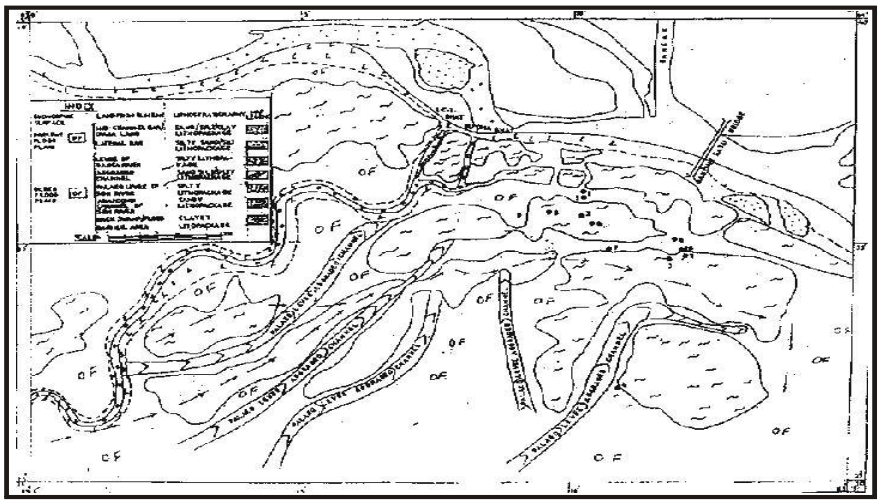

Fig.-1 : Map Showing Landform Disposition and Sample Locations in and Around Patna, Bihar.

EXPLANATION

1. Science College - W_1
2. Saidpur-S_{10} & W_2
3. Choti Pahari - B_6, B_7, S_1, S_2, S_{10}, S_{11}, S_{12}, W_3, W_{18}, W_{19} & W_{20}
4. Ramganj - B_2, B_{11}, B_{12}, S_6, S_9, W_4 & W_9
5. Bihar College of Engineering - B_5
6. Rajendra Nagar Road No. 1 - W_6
7. Kanbrbagh Water Tower No. 2 -S_{11}, W_7
8. Bahadurpur- W_9
9. Bari Pahari - B_1, B_3, S_2, S_3, S_4 & S_5
10. Rasida Chak - B_2, B_3, S_2, S_3, S_4 & S_5
11. Lahaladpur - B_9, B_{10}, S_7 & S_8

Index - W - Water, B - Biota, S - Soil / Sediment.

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and Beur drains of Patna town to Pahari pumping station, is pumped out into the existing irrigation canal which caters to the need of the local farmers for agriculture purposes in contaminated zones.

The present work was aimed to find out the extent and cause of pollution due to heavy metals so that ameliorative measures to tackle this problem could be adopted on time to arrest the increasing pollution load. Keeping this in view a comparative study of the concentration of heavy metals in the soils and sludges of the contaminated zones where sewage and sludge are used for irrigation with that of the soils and sludge of uncontaminated zones where sewage and sludge are not used for irrigation and manure has been done. This study will help in the environmental management leading to improvement in the quality of life of the people.

MATERIAL AND METHODS

Sampling Methods : Grab sewage samples were collected from Saidpur effluent channel, Kankarbagh drain and the Pahari irrigation canal which is the admixture of both the above drains. For heavy metal analysis, samples were collected in clean 5 litre PVC Jerricans and acidified with concentrated $HN0_3$ of pH less than 2. For the analysis of remaining physico-chemical parameters, samples were collected in previously washed 5-litre PVC Jerricanes. All the samples were transported to the laboratory in ice-boxes and stored at 4°C.

Random grab soil samples from 15 cum. depth of agricultural lands were collected through wooden spade. The collected samples were thoroughly mixed on a clean piece of paper and composite samples were kept and sealed in polythene bags. Sludge sample from the sewage drains were collected through grab sample and after compositing kept in polythene bags. All these samples were stored at 4°C in the laboratory. Samples' analysis was done as per standard methods (APHA, 1985).

TABLE-2 : Sampling sites for water samples from Dug wells, Tube wells, Ganga river and Sewage samples from in and around Patna.

SAMPLE				SAMPLING SITE
Sl.No.	Code	Date of Collection	Nature	Location
1	W1	13. 3. 1997	Open Dug well	Science College Campus
2	W2	13. 3. 1997	Open Dug well	Saidpur
3	W3	13. 3. 1997	Open Dug well	Chhoti Pahari
4	W4	13. 3. 1997	Open Dug well	Ramganj, Near Gourichak
5	W5	13. 3. 1997	Tubewell	Engineering College Campus
6	W6	13. 3. 1997	Tubewell	Rajendra Nagar Road No.1
7	W7	13. 3. 1997	Tubewell	Kankarbagh, Water Tower No. 2
8	W8	13. 3. 1997	Tubewell	Bahadurpur Railway Colony Pump
9	W9	13. 3. 1997	Tubewell	Ramganj, Near Gaurichak
10	W10	11. 1. 1997	Ganga river U/S (midstream)	Opp. Kurjee
11	W11	11. 1 .1997	Ganga river D/S (Right bank-14)	Near Gandhi Setu
12	W12	20. 5. 1997	Ganga river U/S (midstream)	Opp. Kurjee
13	W13	20. 5. 1997	Ganga river D/S (Right bank-1/4)	Near Gandhi Setu
14	W27	14. 8. 1997	Ganga river U/S (midstream)	Opp. Kurjee
15	W28	14. 8. 1997	Ganga river D/S (Right bank-1/4)	Near Gandhi Setu
16	W18	13. 3. 1997	Saidpur drain	Near Pahari
17	W19	13. 3. 1997	Kankarbagh drain	Checkpost Near Bypass
18	W20	13. 3. 1997	Pahari Irrigation canal (mixed sewage of W18 & W19)	Checkpost Near Bypass

TABLE-3 : Sampling sites for soil, sludge and the Ganga River sediments

SAMPLE				SAMPLING SITE
Sl.No.	**Code**	**Date of Collection**	**Nature**	**Location**
1	S1	13.3.1997	Soil	Near Bari Pahari
2	S2	13.3.1997	Soil	Rasidachak near Choti Pahari
3	S3	13.3.1997	Soil	Near Rasidachak
4	S4	13.3.1997	Soil	Rasidachak
5	S5	13.3.1997	Soil	Rasida
6	S6	13.3.1997	Soil	Ramganj, Gaurichak
7	S7	13.3.1997	Soil	Lahaladpur near Gaurichak
8	S8	13.3.1997	Soil	Lahadpur near Gaurichak
9	S9	13.3.1997	Soil	Ramganj, Gaurichak
10	S10	13.3.1997	Sludge	Saidpur drain
11	S11	13.3.1997	Sludge	Kankarbag drain
12	S12	13.3.1997	Sludge (mixed)	Pahari
13	S16	1.1.1997	Sediment	Ganga river (P2)
14	S17	1.1 .1997	Sediment	Ganga river (PD1)
15	S18	1.5.1997	Sediment	Ganga river (P2)
16	S19	1.5.1997	Sediment	Ganga river (PD1)

P2 - Midstream, PD1 - 1/4th from right bank (city side)

Physico- Chemical Characteristics :

On the sampling spot, analysis of certain parameters, etc., were carried out by the standard methods (APHA, 1985). Turbidity was measured by Nephelo-Turbidity meter (Systronics, Digital model No.-132). pH was recorded by portable pH meter (pH tester Z^W with ATC, O. AKTON, WARDS, USA).

Determination of heavy metals :

In soil and sludge :

The samples were dried in an oven at 103-105°c and crushed in agate mortar and pestle to break the aggregate or lump, taking care not to break actual soil particles taken. The soil was passed through a 2 mm. nylon sieve, 5g of sieved soil or 0.5g sludge were taken in a conical flask separately and 10ml conc. $HN0_3$ and 10ml perchloric acid was added to each, the content was evaporated gently to fumes. After cooling, 20ml. conc. $HN0_3$ was added to observe the solution colour and evaporated. This process was repeated until the solution colour turned clear. After getting the solution colour light, it was evaporated to dryness and then after cooling, 5ml. conc. HCl was added to it. The content was filtered and made up to 100ml. in a volumetric flask with distilled water. Aliquot of this solution was taken for determination of different metals.

TABLE-4 : Concentration of heavy metals in soils of contaminated zone (sewage fed farms) S_1 to S_5 at Pahari and uncontaminated zone near Gaurichak S_6 to S_9, Patna.

Code	Date of Sampling	Location	Metal Concentration (mg/L)				
			Cd	**Cr**	**Cu**	**Pb**	**Zn**
S1	13.03.97	Agricultural land of Shri Mahesh Mahto, Bari Pahari, Patna	0.001	0.0428	0.158	0.0892	0.88
S2	13.03.97	Land of Kailash Mahto of Rasidachak, near Chhoti Pahari, Patna	0.0008	0.0456	0.0314	0.0076	1.16
S3	13.03.97	Agricultural land, Pahari administrative block, Patna	0.0006	0.0456	0.0322	0.0324	0.36
S4	13.03.97	Land of Shri Narayan Mahto, near Chhoti Pahari, Patna	0.0008	0.0486	0.0324	0.006	0.2
S5	13.03.97	Land of Shri Narayan Mahto, Chhoti Pahari, Patna	0.001	0.044	0.0368	0.0064	0.2
S6	13.03.97	Land of Ramprit Yadav, Ramganj near Gaurichak, Patna	0.0008	0.04	0.0178	0.0208	0.2
S7	13.03,97	Land of Hari Shankar Prasad, Lahladpur near Gaurichak, Patna	0.001	0,0374	0.0176	0.0122	0.26
S8	13.03.97	Land of Siya Ram Prasad, Lahladpur near Gaurichak, Patna	0.0004	0.035	0.0166	0.0158	0.24
S9	13.03.97	Land of Raj Kishore Mahto, Ramganj near Gaurichak, Patna	0.0006	0.0356	0.0172	0.0128	0.18

Soils of Contaminated and uncontaminated zones :

The content of heavy metals in the soils of contaminated (near Pahari) and uncontaminated (near Gaurichak) farms are presented in Table 4. The level of Cd in the soils of contaminated farms varies from 0.0006 mg/L to 0.001mg/L. (Average 0.0084mg/L) whereas that of uncontaminated farms ranges between 0.0004 mg/L to 0.001 mg/L. (Average 0.0007 mg/L.)

The Cr. content of contaminated zones varies from 0.0428 mg/L to 0.0486mg/L and the average level is about 0.045g/L. On the other hand, the level of Cr in the soils of uncontaminated zones shows values ranging between 0.035mg/L and 0.04mg/L (average value 0.57mg/L).

The concentration of Cu in the soils of contaminated zones is much higher than that of the uncontaminated farms. The Cu content of contaminated soils varies from 0.0314mg/L to 0.0368 mg/L (average 0.058mg/L). In the uncontaminated farms the level of Cu varies from minimum of 0.0166 mg/L to maximum 0.0178mg/L (average 0.017mg/L).

The samples from contaminated zones show Pb content varying from 0.006mg/L to 0.892mg/L (average value 0.028mg/L) and in uncontaminated zones Pb content shows value ranging between 0.0122mg/L and 0.0208mg/L (average 0.0154mg/L).

The average value of 0.56gm/L of Zn level in the soils from contaminated farms is much higher than that of uncontaminated farms where average level of Zn is 0.22mg/L.

The level of Zn varies from 0.2 mg/L to 1.16mg/L in contaminated zones and from 0.18mg/L to 0.26mg/L in uncontaminated zones.

Concentration of heavy metals in soils of contaminated zones (sewage fed forms) S_1 to S_6 at Pahari and uncontaminated zones near Gaurichak S_6 to S_9, Pahari has been appended in Table-4.

RESULTS AND DISCUSSION

The present investigation revealed that average concentrations of Cd, Cr, Cu, Pb and Zn in the soils of contaminated farms are more in comparison to the uncontaminated farms.

However, the results indicated that the average core of Cu in the soils of contaminated farms increased about 3.4 times than the soils of uncontaminated farms followed by Zn whose average content increases 2.6 times and Pb whose average level increases about 1.8 times in the soils of contaminated zones in comparison to uncontaminated zones.

The average concentration of Cd, Cr, Cu, Pb and Zn in the sewage-sludge samples obtained from different sites is evidently higher than the average levels of those heavy metals in the soils of contaminated farms. It is therefore inferred that use of sewage-sludge for irrigation and manure is the cause of increased heavy metal contents in the soils of contaminated farms.

Adsorption and complexion reaction appears to be the major process controlling the transfer of soluble metal species to the particulate phase and subsequently to the sediment.

The transfer of pollutants from the water column to the bottom sediments is substantiated by the enrichment of heavy metals in the soils of contaminated farms. However, this mechanism of pollution is confined to short distances from the source of discharge of the effluent. As a result the soils of the agricultural farms receiving sewage-sludge for irrigation and manure situated at 4 to 5 kms in and around Patna, particularly Pahari shows higher concentration of heavy metals.

The different heavy metals, if ingested beyond permissible limit, have been shown to cause various toxic effects in the human beings as well as in animals.

The results of the present investigation clearly show that high content of the heavy metals found in the soils of the contaminated farms in due to sewage-sludge.

The present investigation reveals the complete spectrum of behaviour and distribution of heavy metals in the sewage, sludge and soils including that their behaviour and distribution in the biological system may be controlled by the transport process across the signating mechanism of the cell requiring energy in contrast to the adsorption and complexion processes only in the aquatic system.

The findings may give better understanding of environmental pollution by heavy metals and have direct bearing on human beings.

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