Quest Journals
Journal of Research in Environmental and Earth Sciences
Volume 8 ~ Issue 6 (2022) pp: 08-12
ISSN(Online) :2348-2532
www.questjournals.org

Research Paper

Assessment of toxic heavy metals in drains sludge and sediments in the lower most stretches of river Ganga

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ABSTRACT
Anthropogenic activities is are primarily responsible for causing pollution in the environment including aquatic ecosystems. River Ganga is also affected by this problem. Our object of study is to assess the heavy metals (Cd, Cr, Ni, Pb, Fe and Zn) status of drains sludge, which is introduced into the river from Kolkata/Howrah and also to find accumulation of the metals in the river surface bottom sediment. The mean value of total heavy metals concentration in drains sludge is in the order: Fe(5256.0 µg/g) > Zn(1131.05 µg/g) > Cr(76.46 µg/g) > Pb(55.07 µg/g) > Cd(10.01 µg/g) > Ni(7.78 µg/g), while in river bed sediments is the values are in the order: Fe(2863.0 µg/g) > Zn(62.28 µg/g) > Cr(51.23 µg/g) > Pb(6.27 µg/g) > Cd(4.39 µg/g) > Ni(3.59 µg/g). As per the guideline of the US EPA, Cd, Cr and Zn in drains sludge shows its heavily polluted whereas, in river sediments metal concentrations belong to non polluted to moderately polluted status. According to the Muller classification of I_{geo} Cr/Ni/Fe of drain sludges belongs to Class "0", Pb belongs to Class "1", Zn belongs to Class "3", Cd belongs to Class "4". In case of river sediments I_{geo} of Cr/Ni/Pb/Fe/Zn belongs to Class "0", only Cd belongs to Class "3".

KEY WORDS: *Drains sludge, river sediment, heavy metal, contamination, geoaccumulation index.*

***R**eceived 05 June, 2022; **R**evised 18 June, 2022; **A**ccepted 20 June, 2022 © The author(s) 2022.*
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I. INTRODUCTION

Ganga is one of the largest riverine system of India with well developed ecosystem and has great importance to nations cultural, economical and environmental values. It provides water to approximately 450 million people with an average over 550 individuals per square kilometre[1]. During the last part of 20th century and running part of 21st century we are the enjoying the benefits of rapid industrialisation, urbanisation and digitalization. Simultaneously we had also to accept environmental pollutions and its harmful effect on the ecosystem. Our holy river Ganga is also threatened by different types of pollutants, which are mostly contributed by sewage discharge. A solution to this universal problem requires a routine monitoring programme to quantify the level of the metals and their ecotoxicity potential for river like Ganga so that the remedial measures are better and rapidly implemented in local to regional scales[2]. The present studies objects to assess the concentration of heavy metals pollutants (*Cd, Cr, Ni, Pd, Fe* and *Zn*), Geo accumulation Index (I_{geo}) of drains sludges and river sediments, which are directly introduced by the major sewages of Kolkata / Howrah and finally settled down in river bed.

II. STUDY AREA

A total of 14 sewage drains discharged directly into the Ganga were selected out of which 7 were from Kolkata side and 7 from Howrah side. For river samples 5 collection sites were selected, one is from above the all drains, one is from below the all drains and three were in between the 14 drains. The GPS map and coordinates of the sites are as mentioned below.

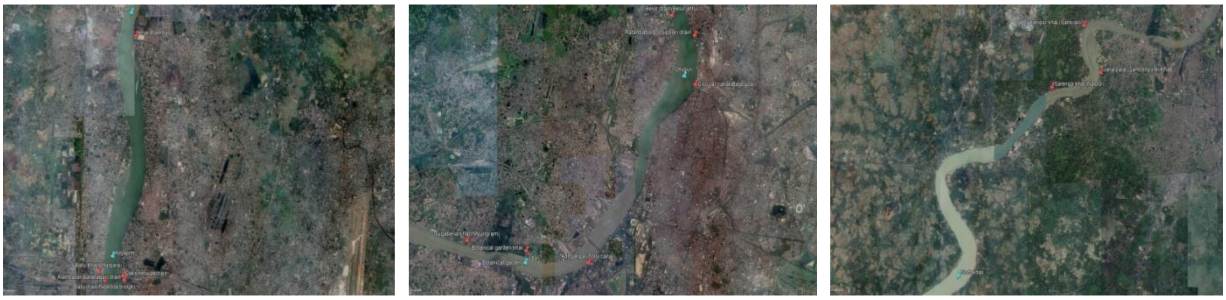

Fig 1. GPS maps of the study area in three clusters

Table 1. GPS locations of samples collection sites

Code	Drains sites	Latititude	Longitude
1K.	Khardha Khal (Kolkata side)	22°43'34.88"(N)	88°21'44.53"(E)
2K.	Dakshineswar drain (Kolkata side)	22°39'13.08"(N)	88°21'26.68"(E)
3K.	Alambazar/Baranagar drain (Kolkata side)	22°39'8.96" (N)	88°21'28.21"(E)
4K.	Ratanbabu(Cossipore) drain (Kolkata side)	22°37'26.17"(N)	88°22'1.87" (E)
5K.	Circular canal(Bagbazar) (Kolkata side)	22°36'28.76"(N)	88°22'2.92" (E)
6K.	Adi ganga (Tolly canal) (Kolkata side)	22°33'0.15" (N)	88°19'29.99"(E)
7K.	Jana para (Santoshpore) Khal (Kolkata side)	22°31'43.37"(N)	88°14'48.49"(E)
8H.	Bally Khal (Howrah side)	22°39'17.92"(N)	88°20'53.14"(E)
9H.	Bally drain under Nibedita bridge (Howrah side)	22°39'8.74" (N)	88°21'1.48" (E)
10H.	Belur drain near Belur jetty (Howrah side)	22°37'49.58"(N)	88°21'29.42"(E)
11H.	Botanical garden khal (Howrah side)	22°33'14.36"(N)	88°18'0.64" (E)
12H.	Gugaberia khal (Mourigram) (Howrah side)	22°33'26.33"(N)	88°16'36.36"(E)
13H.	Banipur khal (Sankrail) (Howrah side)	22°33'31.00"(N)	88°13'59.93"(E)
14H.	Sarenga khal (Nalpur) (Howrah side)	22°31'10.34"(N)	88°12'26.75"(E)
Code	**River sites**	**Latititude**	**Longitude**
1R.	Titagarh	22°44'0.32"(N)	88°21'38.17"(E)
2R.	Adyapith	22°39'35.13"(N)	88°21'11.99"(E)
3R.	Ghusuri	22°36'38.62"(N)	88°21'46.65"(E)
4R.	Botanical garden	22°33'0.39"(N)	88°17'59.46"(E)
5R.	Godakhali	22°23'59.10"(N)	88° 7'54.82"(E)

III. MATERIAL AND METHODOLOGY

Sampling was done seasonally, in pre monsoon, monsoon and post monsoon seasons of 2019. Sludge samples were collected manually with protective gloves from 14 selected drains and river sediment were collected from 5 river sites with the help of grab sampler. Collected samples were kept in pre sterilized plastic bags and brought to the laboratory. All samples were spread into the pre cleaned plastic containers and kept under shade for drying in air. Dried samples were crushed in porcelain mortar and sieved through a stainless steel sieve 85 mesh size. One g of dried and sieved sample was taken in glass beaker for digestion with tri acid mixture ((HNO_3:$HClO_4$:H_2SO_4::10:4:1). For each sample 15 ml triacid were applied, the sample plus acid mixtures were kept for overnight before being transferred on the hot plate at 105^{o}C temperature. This temperature was maintained until all samples were thoroughly digested. After digestion was over, samples were kept at room temperature for cool down and filtered through Whatman 42 no filter paper with the addition of Milique water and made up the volume to 100 ml. Filtered samples were kept in sterilized plastic containers. The metals in the samples measured through Perkin Elmer made Atomic Absorption Spectrophotometer in flame mode and .

IV. RESULTS AND DISCUSSION

A) Assessment of total heavy metals concentration

The metal concentrations in drain sludge are given in Table 2. All the targeted elements which include toxic heavy metals like Cd, Pb, Ni and Cr along with Zn, Fe were recorded at varying concentrations in sludges of different drains which confluence in the lower most stretch of Ganga. In drain sludges, the *Cd* concentration ranges from 0.1 to 29.5 µg/g, *Cr* 45.7 to 171.9 µg/g, *Ni* 0.01 to 40 µg/g, *Pb* 10.96 to 98.4 µg/g, *Fe* 4323 to 8198 µg/g and *Zn* 149.6 to 2242 µg/g. The mean concentration of the metals found in sludges was in the order Fe>Zn>Cr>Pb>Cd>Ni (higher to lower).

Table 2. Total metal concentration (µg/g) in drains sludge

Drains	Cd	Cr	Ni	Pb	Fe	Zn
1K.	7.8	101	7.2	10.96	8198	383
2K.	29.5	51.8	6.3	68.41	4438	580
3K.	24.8	45.7	4.4	12.8	4600	638.4
4K.	12.6	171.9	5.4	52.23	4543	1518
5K.	6.8	79.8	0.01	61	8026	149.6
6K.	9.8	61.7	5	65.93	4637	1762
7K.	7.4	59.2	5.6	75	4542	1861
8H.	6.2	89.7	0.1	54.39	4389	603.1
9H.	8.4	59.5	6	44.56	4345	1516
10H.	0.1	63.1	4	57	4323	2242
11H.	8	93.6	15.2	98.4	7944	451.6
12H.	0.1	82.1	4.7	51.53	4586	1959
13H.	12.3	61.4	5	63.72	4446	1149
14H.	6.4	49.9	40	55.11	4567	1022
Mean	**10.01**	**76.46**	**7.78**	**55.07**	**5256.00**	**1131.05**
Max	**29.5**	**171.9**	**40**	**98.4**	**8198**	**2242**
Min	**0.1**	**45.7**	**0.01**	**10.96**	**4323**	**149.6**
SD	**8.15**	**32.45**	**9.92**	**22.44**	**1521.29**	**677.68**

Like in drain sludges, all the targeted elements were also detected in river sediments and the concentrations are given in Table 3. The *Cd* concentration in river sediments varied from 0.1 to 9.45 µg/g, *Cr* 36.3 to 64.2 µg/g , *Ni* 0.01 to 6.3 µg/g, *Pb* 4.76 to 7.89 µg/g, *Fe* 2299.5 to 4469 µg/g and *Zn* 3.45 to 295.1 µg/g. The decreasing order of mean concentrations of metals found in river sediments was similar to that observed in case of sludges i.e. Fe>Zn>Cr>Pb>Cd>Ni.

Table 3. Total concentration (µg/g) of metals in river sediments

River	Cd	Cr	Ni	Pb	Fe	Zn
1R.	7.85	43.8	4.55	5.04	2299.5	4.45
2R.	1.05	56.85	6.3	7.89	2701	3.75
3R.	0.1	64.2	5.9	6.6	2487	3.45
4R.	9.45	55	1.2	7.03	2358.5	4.65
5R.	3.5	36.3	0.01	4.76	4469	295.1
Mean	**4.39**	**51.23**	**3.59**	**6.27**	**2863.00**	**62.28**
Max	**9.45**	**64.2**	**6.3**	**7.89**	**4469**	**295.1**
Min	**0.1**	**36.3**	**0.01**	**4.76**	**2299.5**	**3.45**
SD	**4.12**	**11.09**	**2.83**	**1.33**	**910.89**	**130.15**

The chemical contaminations in the sediments were evaluated by comparison with United States Environmental Protection Agency (USEPA) sediment quality guidelines; these criteria are shown in the Table 4. The present study reveals that though the some of the drains sludge was heavily polluted with *Cd*, its accumulation in river sediment was at lower level and did not qualify it to be heavily polluted. Similarly, in case of *Cr* drains sludge was heavily polluted but the river sediments were moderately polluted with *Cr*. *Ni* content in both drains sludge and river sediments fell in non polluted category. While the drains sludge was moderately polluted with *Pb* contamination but the river sediments were unpolluted with *Pb*. *Zn* content in drains sludge was in the heavily polluted category and manifold higher than that in river sediments where it became non polluted.

Table 4. US EPA(2002) guideline for the sediments in ppm

Metal	Non Polluted	Moderately Polluted	Heavily Polluted	Mean of drains sludge	Mean of river sediment
Cd	-	-	>6	10.01	4.39
Cr	<25	25 - 75	>75	76.46	51.23
Ni	<20	20-50	>50	7.78	3.59
Pb	<40	40 - 60	>60	55.07	6.27
Zn	<90	90 - 200	>200	1131.05	62.28

B) Assessment of Geoaccumulation Index (Igeo)

The geo-accumulation index is a common criterion to evaluate the heavy metal pollution in sediments. Geoaccumulation index proposed by Muller[3] to determine metals contamination in sediments, by comparing current concentrations with pre-industrial levels and can be calculated using the following formula:

$$I\ geo = \log_2 [Cn / 1.5Bn]$$

Where, Cn is the concentration of element "n" and Bn is the geochemical background value [In this study, consider Bn = world surface rock average given by Turekian and Wedepohl[4] (shown in Table 5)]. The factor 1.5 is incorporated in the relationship to account for possible variation in background data due to lithogenic effect. The geoaccumulation index (Igeo) scale consists of seven grades (0 - 6) ranging from unpolluted to highly pollute (shown in Table 6).

Table 5. Pre-industrial background values determined by Turekian and Wedepohl

Metals	Background Values in ppm
Cd	0.3
Cr	90
Ni	68
Pb	20
Fe	47200
Zn	95

Table 6. Muller's classification for the Geo-accumulation Index

Igeo Value	Class	Sediment Quality
<0	0	Unpolluted
0 - 1	1	From unpolluted to moderately polluted
1 -2	2	Moderately polluted
2 - 3	3	From moderately to strongly polluted
3 - 4	4	Strongly polluted
4 - 5	5	From strongly to extremely polluted
>6	6	Extremely polluted

According to Muller classification the I_{geo} values for sludges of drains are shown in Table 7. In case of *Cd*, highest value found in 2K site and lowest value found in 10H and 12H sites. The mean value represented that drains sludges are strongly polluted with *Cd*. In case of *Cr*, highest value found in 4K site and lowest value found in 3K site. The mean value represented that drains sludges were unpolluted with *Cr*. In case of *Ni*, highest value was found in 14H site and lowest found in 5K. The mean value represented that drains sludges are unpolluted with *Ni*. In case of *Pb*, highest value found in 11H sites and lowest value found in 1K site. The mean value represented that drains sludges were unpolluted to moderately polluted with *Pb*. In case of *Fe*, the highest value was observed in 1K site and the lowest in 9H and 10H sites. The drains sludges were unpolluted with *Fe*. In case of *Zn*, the highest value found in 10H and lowest in 5K sites. The mean value represented that drains sludges were moderately to strongly polluted with *Zn*.

Table 7. Geoaccumulation Index(I_{geo}) value for the sludges of drains

Drains	Cd	Cr	Ni	Pb	Fe	Zn
1K.	4.12	-0.42	-3.83	-1.45	-3.11	1.43
2K.	6.03	-1.38	-4.02	1.19	-4.00	2.03
3K.	5.78	-1.56	-4.54	-1.23	-3.94	2.16
4K.	4.81	0.35	-4.24	0.80	-3.96	3.41
5K.	3.92	-0.76	-13.32	1.02	-3.14	0.07
6K.	4.44	-1.13	-4.35	1.14	-3.93	3.63
7K.	4.04	-1.19	-4.19	1.32	-3.96	3.71
8H.	3.78	-0.59	-9.99	0.86	-4.01	2.08
9H.	4.22	-1.18	-4.09	0.57	-4.03	3.41
10H.	-2.17	-1.10	-4.67	0.93	-4.03	3.98
11H.	4.15	-0.53	-2.75	1.71	-3.16	1.66
12H.	-2.17	-0.72	-4.44	0.78	-3.95	3.78
13H.	4.77	-1.14	-4.35	1.09	-3.99	3.01

14H.	3.83	-1.44	-1.35	0.88	-3.95	2.84
Mean	**3.54**	**-0.91**	**-5.01**	**0.69**	**-3.80**	**2.66**
Max	**6.03**	**0.35**	**-1.35**	**1.71**	**-3.11**	**3.98**
Min	**-2.17**	**-1.56**	**-13.32**	**-1.45**	**-4.03**	**0.07**

According to Muller classification the I_{geo} values for sediments of river are shown in Table 8. In case of *Cd*, highest value found in 4R site and lowest value found in 3R site. The mean value represented that river sediments were moderately to strongly polluted with *Cd*. In case of *Cr*, the highest value was found in 3R site and the lowest in 5R site. The mean value represented that river sediments were unpolluted with *Cr*. *Ni* was highest in 2R site and lowest in 5R. The mean value indicated that river sediments were unpolluted with *Ni*. The highest value of Pb was recorded in 2R sites and the lowest in 5R site and the river sediments were unpolluted with *Pb*. In case of *Fe* and Zn also river sediments were unpolluted.

Table 8. Geoaccumulation Index(I_{geo}) value for the sediments of rivers

River	Cd	Cr	Ni	Pb	Fe	Zn
1R.	4.12	-1.62	-4.49	-2.57	-4.94	-5.00
2R.	1.22	-1.25	-4.02	-1.93	-4.71	-5.25
3R.	-2.17	-1.07	-4.11	-2.18	-4.83	-5.37
4R.	4.39	-1.30	-6.41	-2.09	-4.91	-4.94
5R.	2.96	-1.90	-13.32	-2.66	-3.99	1.05
Mean	**2.11**	**-1.43**	**-6.47**	**-2.29**	**-4.68**	**-3.90**
Max	**4.39**	**-1.07**	**-4.02**	**-1.93**	**-3.99**	**1.05**
Min	**-2.17**	**-1.90**	**-13.32**	**-2.66**	**-4.94**	**-5.37**

V. CONCLUSION

It is evident from the present studies the sludges of drains which are directly discharged into the lower most stretch of Ganga river are highly contaminated with heavy metals and according to the US EPA most of them are marked as heavily polluted. It is clear from the present studies that the lower most part of the river Ganga sediments were also contaminated with the heavy metals like Cd, Cr, Ni, Pb, Fe and Zn found in drain sludges. According to Igeo value, Cr/Ni/Fe in drains sludges shown the negative value and others shown the positive value, in case of river sediments all shown the negative values except Cd. So, sediments of the river were much less polluted than the sludges which are discharged into the river through different drains. However, continuous discharge of the toxic metals could lead to threat to all biotic communities in the aquatic ecosystem and affect the aquatic food chain.. To save this larger river ecosystem and maintaining the sustainability, it is necessary to check the point sources of pollutants and follow the proper treatment procedure of these direct discharges entering into the holy river.

REFERANCE

[1]. Behera S., Areendran G., Gautam P. and Sagar V. (2011). For a living Ganga–working with people and aquatic species. *New Delhi, WWF-India*, 1-84.
[2]. Jain, C.K. (2002). A hydro-chemical study of a mountainous watershed: the Ganga, India.*Water Research*, 36, 1262– 1274.
[3]. G. Muller (1981). The Heavy Metal Pollution of the Sediments of Neckars and Its Tributary: A stocktaking," *Chem. Zeit*., Vol. 105, 1981, pp. 157-164.
[4]. Turekian, K.K., Wedepohl, K.H., (1961). Distribution of the elements in some major units of the Earth's crust. Geol. Soc. Am. Bull. 72 (2), 175–192.
[5]. Pandey, R., Raghuvanshi, D., Sharma, P. K., Singh, H., Tripathi, B., Bajpai, S. and Dikshit, A. (1916). Evaluation of the status of heavy metal contamination in Sediment of the river ganga at Allahabad, india. I.J.S.N., VOL.7 (4) 2016:852-859.