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Assessment of heavy metal load of Owah-Abbi (Ethiope) river, Delta state, Nigeria

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ABSTRACT

Total concentrations of lead, cadmium, chromium, zinc and copper in the sediments from Owah-Abbi stream, Delta State were determined using Atomic Absorption Spectrophotometer (AAS). Metal bioaccumulation studies in *Tilapia* and *catfish* were also carried out. The total heavy metal load of the stream (water) was also investigated. The trend in the concentrations of the metals investigated was Cu>Pb>Zn>Cd>Cr in *Tilapia* while that of catfish was similar with a subtle difference (Zn>Cu>Pb>Cd>Cr). The prevailing levels for the metals in the stream sediments were 2.63, 1.68, 2.34, 6.64 and 1.57mg/g for Pb, Cd, Cr, Zn and Cu respectively. The water sample gave concentrations of 0.72, 0.03, 0.36, 1.27 and 0.37mg/dm^3 for Pb, Cd, Cr, Zn, and Cu respectively. The elevated lead concentrations in samples is an indication of lead pollution of Owah-Abbi river.

Key words: Heavy metal load, rivers, Nigeria.

INTRODUCTION

An increasing world population and technologically advancing society is an attestation to the increasing net pressure of human activity on the environment[1]. Water bodies receive potentially toxic elements from both natural and a wide range of anthropogenic source, including the weathering of primary mineral; mining, fossil fuel, combustion, the metallurgical, electronics and chemical industries.

The application of domestic and industrial sludge to the soils for agricultural and disposal purposes is often the most environmentally acceptable and economical method. It is also desirable because it returns organic matter and valuable nutrients, particularly phosphorus and nitrogen to the soil. However, there is the growing concern that heavy metals and other contaminants in sludge will accumulate in the soil which will finally get into the water body through erosion.

Nigeria vast fresh water resources are among those mostly affected by environmental stress imposed by human population growth, urbanization, industrialization and the major culprit is disposal and management of waste that accrued from these human activities[2].

A large portion of heavy metal pollution comes not from production but from domestic and industrial waste especially into aquatic environment. Continuous urban development associated with population growth produces large solid waste which are major sources of pollutants that found their way into rivers, streams and ground water which are used by people residing in such vicinity.

The presence of heavy metals in the environment is of great ecological significance due to their toxicity at certain concentrations, translocations through food chains and non-biodegradabilty which is responsible for their accumulation in the biosphere. The behaviour and

biological impact of heavy metal pollutants in aquatic systems is governed by factors, such as adsorption, desopriton, sedimentation, resuspension, filtration, complexation, precipitation-solublization, biological uptake and excretion[3].

Chemical transformation and disturbances such as dredging, reclamation and erosion together with favourable conditions such as low pH, low, particulate load and high concentration of dissolved organic matter can remobilize metals from sediments into the water column[4,5].

The knowledge of heavy metal load of a water body is very essential because it gives an insight on the pollution status of the water body and also enables us to take protective measures against excessive exposure either directly or indirectly[6]. The main source of water supply to Owah-Abbi and its environs is Ethiope River hence the need to assess the level of bioaccumulation of heavy metals in the fishes and also in the water body cannot be overemphasized as a measure of the heavy metal pollution load of the river body.

EXPERIMENTAL

Sampling

Sediments and water samples were collected at three different regions representing the upstream, midstream and downstream. Two most common fish species – Tilapia (Tilapia zilli) and catfish (synodontis membraneceus) were directly procured from the fishermen at the waterside of Owah-Abbi river. The fishes were stored in a cooler under ice blocks to preserve their freshness.

Digestion of the samples

Fish sample

Each fish was cut into three parts-head, trunk and tail. 20ml of aqua regia was added to each and boiled for 30 minutes with addition of deionized water interval. The filterate was made to 200ml mark with deionized water and showed for AAS-analysis.

Sediment sample

About 2g of the sieved sediment was oven dried at 105°C and 1g accurately weighed into a Teflon beaker. A mixture of 5ml HF and 5ml acqua regia was added and then digested in a water bath at 100^0C for 1hr. subsequently, another 5ml HF and 5ml aqua regia was added and heated for a further 1.5hr. After cooling at room temperature , 20ml of saturated boric acid was added to complex with the residual HF which would otherwise attack glasswares. The digested sediments was filtered into 100ml volumetric flask using Whatman No.1 filter paper and made up to mark.

Water Sample

20ml of Aqua regia was added in 100ml of the water sample and heated until the volume reduced to half of its original volume. The digestate was cooled and filtered into a 100ml volumetric flask and made up to mark with deionized water.
The blank for all the samples was also prepared and analyzed using AAS (Chemtech Analytical alpha star model).

RESULTS AND DISCUSSION

Table 3 shows that in Tilapia Cu has the highest concentration with average percentage of 29.7%. This is closely followed by lead with the

Table 1: Average weight of fish part (gram)

Catfish	Weight(g)	Tilapia	Weight(g)
Head	11.10	Head	23.60
Trunk	8.20	Trunk	22.70
Tail	5.50	Tail	18.10

Table 2: Mean concentration of heavy metal in Tilapia (ppm)

Tilapia	Pb	Cd	Cr	Zn	Cu
Head	0.16± 0.01	0.03±0.01	0.04 ± 0.02	0.20 ± 0.01	0.17 ± 0.01
Trunk	0.08 ± 0.00	0.05 ± 0.01	0.01 ± 0.00	0.03 ± 0.00	0.03 ± 0.00
Tail	0.10 ± 0.04	0.11 ± 0.04	0.08 ± 0.00	0.08 ± 0.01	0.21 ± 0.00

Table 3: % Mean concentration of heavy metal in Tilapia

Tilapia	Total conc. (ppm)	% conc.
Pb	0.34	24.6
Cd	0.19	13.8
Cr	0.13	9.4
Zn	0.31	22.5
Cu	0.41	29.7
Mean total	1.38	

least concentration occurring in chromium. The trend in concentration is Cu>Pb>Zn>Cd>Cr.

In Tilapia, most of the metals tend to concentrate most on the tail part. The trend in the concentration is Tail>head > Trunk. Table 5 depicts % mean of conc of heavy metal in catfish with zinc having the highest concentration (0.18mg/l). the next in conc occurs in copper unlike in Tilapia. Like in Tilapia, chromium has the least concentration 0.01mg/l. The trend in concentration is Zn> Cu> Pb> Cd> Cr.

Table 4: Mean Conc. of metal in catfish(pmm)

Tilapia	Pb	Cd	Cr	Zn	Cu
Head	0.13± 0.02	0.02±0.00	0.01 ± 0.00	0.16 ± 0.01	0.15 ± 0.01
Trunk	0.20 ± 0.01	0.12 ± 0.01	0.01 ± 0.00	0.30 ± 0.00	0.25 ± 0.00
Tail	0.09 ± 0.04	0.01 ± 0.04	0.01 ± 0.00	0.08 ± 0.01	0.04 ± 0.00

Table 5: % Mean Conc. of heavy metal in catfish (ppm)

Tilapia	Total conc. (ppm)	% conc
Pb	0.14	26.4
Cd	0.05	9.4
Cr	0.05	9.4
Zn	0.18	34.0
Cu	0.15	28.3
Mean total	0.53	

Unlike in tilapia, the highest concentration of metal was found in the trunk part of the fish. The trend in the concentration of metal in the catfish part is trunk> Head> Tail.

The occurrence of heavy metal concentration in the catfish and tilapia part appears to be the reverse of the other.

It can be observed from table 6 that concentration of lead in catfish (0.14mg/L) is higher then follows the same trend as that of lead with respect to

Table 6: Heavy Metal Concentration in the fish species (ppm)

Fish species	Metal	Head	Trunk	Tail	Total	Mean	% mean conc.
Tilapia	Pb	0.16	0.08	0.10	0.34	0.11	24.4
	Cd	0.03	0.05	0.11	0.19	0.06	13.3
	Cr	0.04	0.01	0.08	0.13	0.04	8.9
	Zn	0.20	0.03	0.08	0.31	0.10	22.2
	Cu	0.17	0.03	0.21	0.41	0.14	31.1
	Total	0.43	0.20	0.58	1.38	0.45	100
Catfish	Pb	0.13	0.20	0.09	0.42	0.14	26.4
	Cd	0.02	0.12	0.01	0.15	0.05	9.4
	Cr	0.01	0.01	0.01	0.03	0.01	1.9
	Zn	0.16	0.30	0.08	0.54	0.18	34.0
	Cu	0.15	0.25	0.04	0.44	0.15	28.3
	Total	0.47	0.88	0.23	1.58	0.53	100

Table 7: Total metal concentration in the sediments (ppm)

Metal	Upstream	Midstream	Downstream	Mean conc.
Pb	2.36 ±0.28	3.66±1.04	1.86 ± 1.00	2.63
Cd	0.88 ± 0.00	1.72 ± 0.32	2.45 ± 0.05	1.68
Cr	1.14 ± 0.01	1.41 ± 0.01	4.47 ± 0.06	2.34
Zn	5.27 ± 0.01	6.38 ± 1.10	8.26 ± 0.07	6.64
Cu	1.80 ± 0.02	1.82 ± 0.04	1.10 ± 0.00	1.57
Total	11.45	14.99	18.14	14.86

Table 8: % concentration of metal in the river sediments.

Metal	%Upstream	%Midstream	%Downstream	Total
Pb	30	46	24	7.88
Cd	17	34	49	5.05
Cr	16	20	64	7.02
Zn	26	32	42	19.91
Cu	38	39	23	4.72

Table 9: Heavy metal concentration in the water sample in ppm (Upstream)

Metal	Conc (mg/L)	% conc.
Pb	0.84 ± 0.22	32.2
Cd	0.01±0.01	0.4
Cr	0.60 ± 0.01	23.0
Zn	0.94 ± 0.02	36.0
Cu	0.22 ± 0.01	8.4

Table 10: Heavy metal concentration in the water sample in ppm (midstream)

Metal	Conc (mg/L)	% conc.
Pb	0.60 ±0.00	29.6
Cd	0.03 ± 0.01	1.5
Cr	0.05 ± 0.02	2.5
Zn	0.68 ± 0.02	33.5
Cu	0.67 ± 0.01	33.0
Total	2.03	

Table 11: Heavy metal concentration in the water sample in ppm (downstream)

Metal	Conc (mg/L)	% conc.
Pb	0.72 ±0.02	20.0
Cd	0.05 ± 0.01	1.4
Cr	0.43 ± 0.02	11.9
Zn	2.18 ± 0.04	60.5
Cu	0.12 ± 0.01	6.1
Total	3.60	

Tilapia and catfish. Cadmium, chromium and zinc occur with higher concentration in Tilapia than in catfish. The mean concentration of the heavy metal investigated is higher in catfish (0.53mg/L) than in Tilapia (0.45mg/L).

Table 7 shows that highest concentration of heavy metal was found in the downstream as expected due to final deposition via water current. The trend in the level of heavy metal concentration along the length of Owah-Abbi river is Downstream > midstream > upstream.

It is observed that zinc has the highest concentration in the river sediment with an average value of 6.64mg/L as revealed in table 7. Lead and chromium closely followed each other in level of concentration while copper has the least concentration in the stream sediments. The trend in the level of heavy metal concentration in the stream sediments is Zn > Pb>Cr>Cd>Cu

In the upstream, the highest occurrence of heavy was found in zinc which was followed by Pb with average percentage of 36% and 32.2% respectively. Cadmium has a distance concentration of 0.01mg/L with average percentage of 0.4%. The observed trend in the level of heavy metal concentration is Zn> Pb> Cr> Cu> Cd.

Similar trend was observed in the downstream with the highest value of 2.18mg/dm^3 occurring in zinc and least value of 0.05mg/dm^3 associated with cadmium as can be seen from table 11.

A different trend was noticeable in the midstream as depicted in table 10. The trend is Zn>Cu>Pb>Cr>Cd. In all the three cases, cadmium has the least concentration in the water sample.

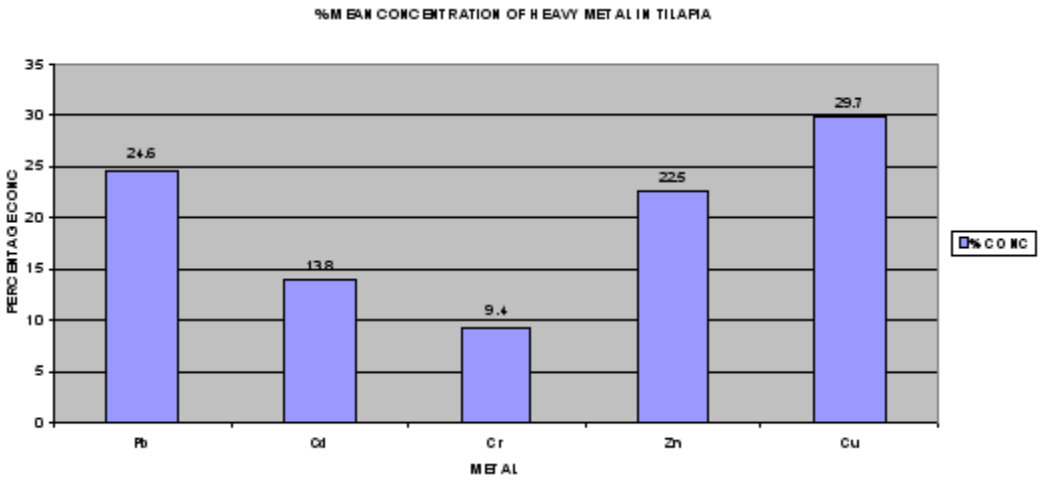

Fig. 1

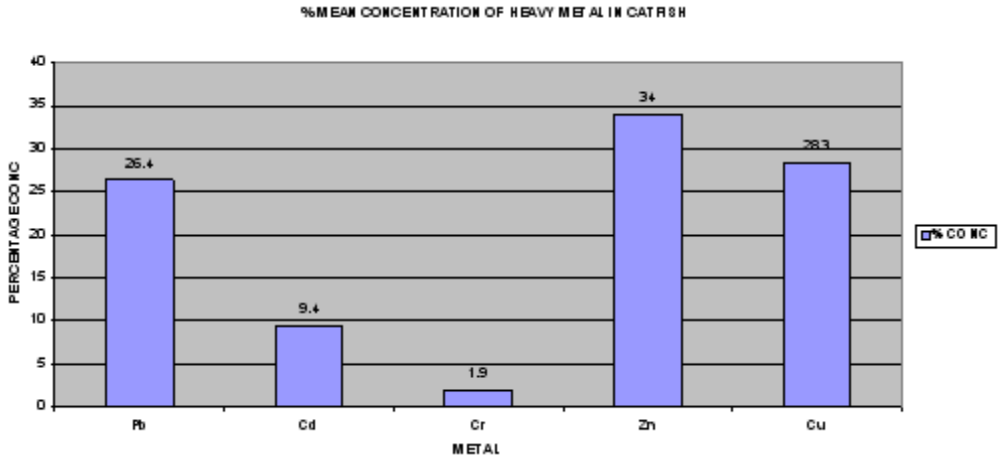

Fig. 2

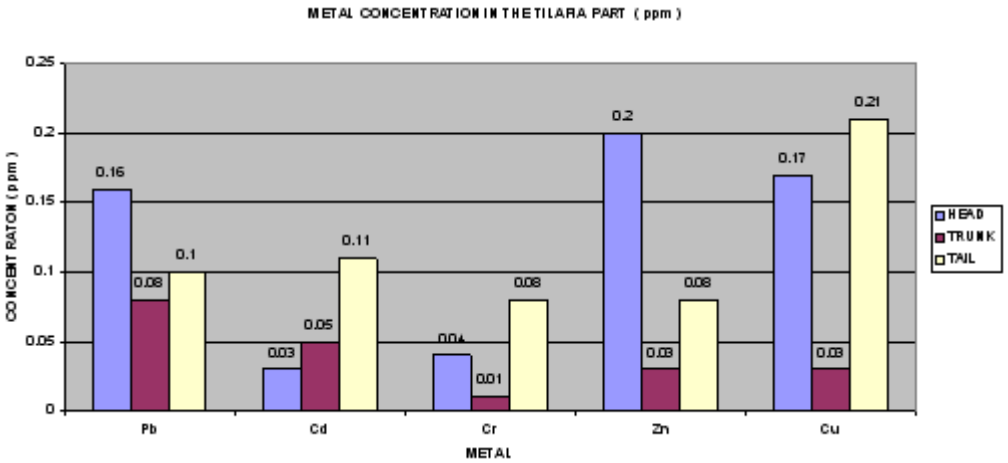

Fig. 3

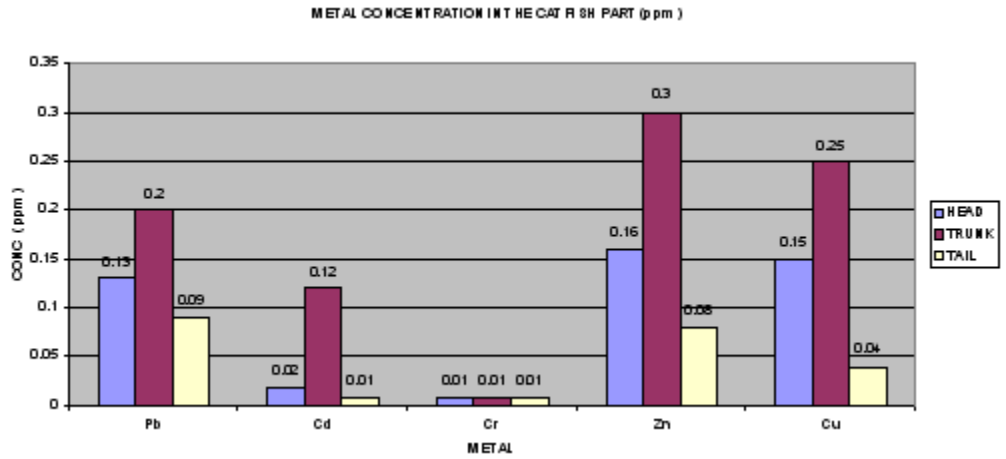

Fig. 4

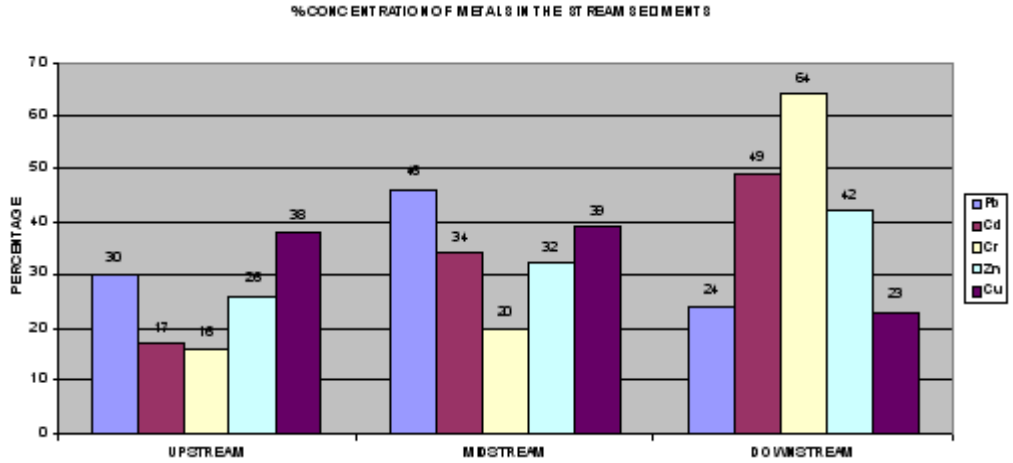

Fig. 5

The average lead concentration in the fish samples, 0.13mg/dm^3 is at the high side and potend great danger in the imminent future hence the need for proper monitoring to reduce pollution of Owah-Abbi river by lead. All other metals investigated were still within tolerance limit but there is tendency for it level to increase if appropriate measure is not put in place.

The mean concentration of lead observed in the river sediment has a value of 2.63mg/dm^3. This value is also high and may pose a treat to the consumers of the river. The concentrations of Cd, Cr, Zn and Cu were not at the high side as at time of this investigation but care should be taken to check-mate any form of further pollution of the river by these heavy metals.

The mean concentration of lead found in the water with a value of 0.72mg/dm^3 exceeds the World Health Standard of 1971 which was put at 0.05mg/dm^3. The level of cadmium and chromium with a value of 0.03mg/dm^3 and 0.36mg/dm^3 respectively in the water were also at the high side.

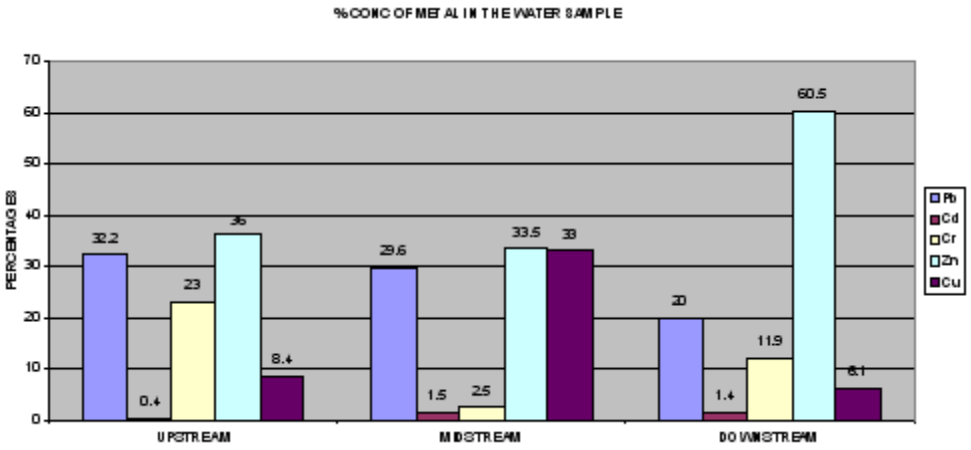

Fig. 6

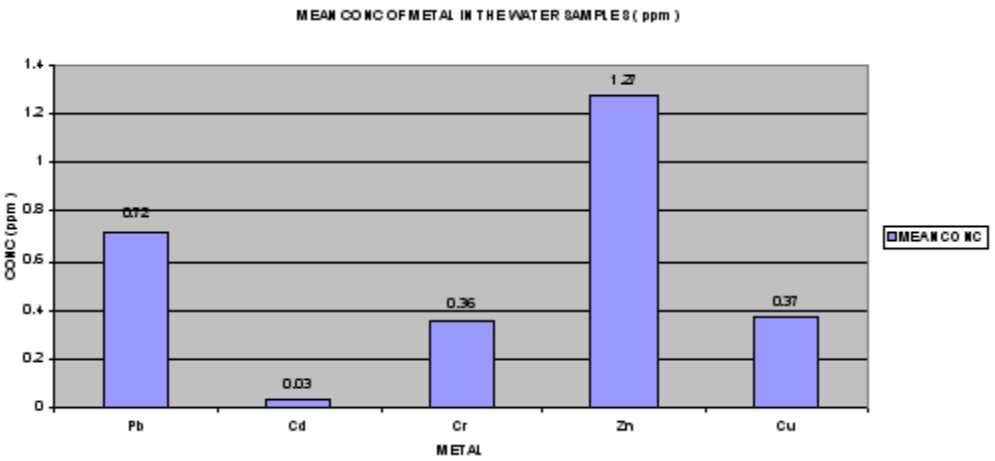

Fig. 7

CONCLUSION

The results obtained showed a high value of lead concentration in the fish species, sediments and the water sample of Owah-Abbi (Ethiope) river. The other metals (Cd,Cr,Zn and Cu) investigated were not above the tolerance limit but have the tendency to increase above the tolerance limit if adequate measures are not put in place.

Even though there has not been any reported case of lead or any other toxic metal poisoning in the area as a result of direct consumption of fish from Owah-Abbi River, the elevated level of lead concentration in this river body could pose potential health hazards, hence the need to properly monitor the pollution of the river by heavy metals most especially lead. Despite the low level of Cd, Cr, zn, and Cu as observed in the samples investigated, there is a need to put adequate control measure to ensure that Owah-Abbi river is not polluted with these metals in the imminent future.

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