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Assessment of Heavy Metal Concentration in Benthic Sediments of Ubeji River, Warri South Local Government Area, Delta State

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ABSTRACT

Composite sediment samples were collected from three sampling points along the Ubeji River in Ubeji community, Warri South Local Government, Delta State, into which industrial effluents were discharged. The sediments were prepared for heavy metals analysis using standard laboratory techniques. The concentrations of heavy metals in sediments were compared with DPR (2002) limits for benthic sediments and survival of aquatic organisms. The results showed that cadmium (1.69mg/l) at the upstream, lead (47.04mg/l), manganese (52.65mg/l), chromium (56.87mg/l) and cadmium (2.77mg/l) at the point of effluent discharge and chromium (43.39mg/l) and cadmium (1.92mg/l) at the downstream from the point of effluent discharge were not within the acceptable limits. From the findings of the study, it was recommended that proper monitoring of the type and volume of effluents discharged into the river be put under surveillance to prevent an upsurge of heavy metal concentration in the Ubeji River.

Keywords: heavy metal; bottom sediments; effluents; upstream; downstream; Ubeji River.

INTRODUCTION

Industrialization is one of the main indices of global and national development that brings about development and obvious benefits. But more often than not, industrialization has been a mixed blessing to mankind; while it enhances the quality of life, comfort, and national gross domestic product, it may also pose a serious threat to the natural ecosystems and the security of public health. Scientific evidence has shown that uncontrolled industrial practices have led to unacceptable high levels of harmful and toxic substances discharged in the air, water bodies, and on soils with significant environmental consequences (UNEP, 1992).

Many water bodies in the world are known to flow through major cities and towns to serve as a potential source of water for domestic and industrial use. Such water bodies flowing through major towns and cities include River Ubeji in Warri South Local Government Area of Delta State, Nigeria, which supports a wide diversity of both flora and fauna. Some of these water bodies have residential and industrial establishments situated along their course, and due to institutional failures, discharge their waste into the water, causing water pollution (Achudume, 2009) and river sediments pollution.

Sediments can be transported by the flowing river water and eventually deposited as layers of soil particles on the bed or bottom of water bodies. These sediments in rivers act as an intermediary between aquatic and terrestrial ecosystems (Stergiou & Browman, 2005; Jordi, Albert & Joseph, 2011). Sediments act as a carrier and sink for contaminants, reflecting the history of pollution and providing a record of catchment input into the aquatic ecosystem (Egborge, 1991). When effluents with high heavy metal concentrations are discharged into receiving rivers, they may settle down in the sediments and pose an imminent danger to the food chains and become a potential health risk to humans owing to their toxicity and carcinogenicity.

Due to the ineffectiveness of purification systems, effluents may become seriously dangerous, leading to the accumulation of heavy metals in receiving water bodies and sediments with potentially serious consequences on the ecosystem (Beg, Al-Muzaini, Saeed, Jacob, Beg, Al-Bahloul, Al-Matrouk, Al-Obaid & Kurian, 2001 and Beg, Saeed, Al-Muzaini, Beg & Al-Bahloul, 2003). This study focuses on the presence of heavy metals from petroleum hydrocarbons in sediments, which has been a major source of concern.

DESCRIPTION OF STUDY AREA

River Ubeji is located in Ubeji Community, Warri South Local Government Area of the Niger Delta region of Delta State of Nigeria. Ubeji community lies between latitudes 5°34'29" and 5°34'21 north of the Equator and longitudes 5°41'30" and 5°42'02" east of the Greenwich meridian. It covers a land area of about 16km^2 (Ministry of Land and Survey, Warri office, 2001).

The Ubeji River takes its source from a spring at Ekpan and flows for over 20km to empty into the Escravos River. The Ubeji River serves as the terminal point for storm runoff in the Ubeji community. The inhabitants of the Ubeji community and surrounding villages rely on the Ubeji River for some of their domestic water supply, fishing, sand mining, and inter-village transportation. The banks of the Ubeji River area are traversed by numerous small dendritic drainage patterns draining into the Ubeji River. This flat and low relief area often encourages flooding after rain, especially during the wet season, mainly because of the heavy rainfall, high groundwater table, and the flat-floored valley. The projected population figures by 2022, at a 2.8% geometric growth rate, were estimated as 28, 168 comprising Urhobos, Ijaws, and the Itsekiris as the largest ethnic group.

MATERIALS AND METHODS

Bottom sediments from Ubeji River were collected with a Van-veen grab sampler every week for 5 months April-August). The sediments were collected in the top layer where the deposition of the suspended material and accumulation of heavy metals occurs (Bojakowska 2001). Three samples were collected and mixed to obtain a representative sample of each sample location. The sediments were labeled S1 (200m upstream from the point of effluent discharge), S2 (point of effluent discharge), and S3 (200m Downstream from the point of effluent discharge) along the river. The samples were air dried and stored until analyzed for zinc, iron, manganese, lead, chromium, cadmium, and mercury. Table 1 shows the location of the sampling points.

TABLE 1: Coordinates of sampling points.

Location		Coordinates
Upstream	S1 – 200 metres before the outfall	5º 34´ 46.401" N, 5º 42´ 25.952"E
Midstream	S2 – Point of mixing with the effluent	5º 34´ 32.720"N, 5º 42´ 08.163"E
Downstream	S3 – 200 metres after the point of mixing with the effluent	5º 34´ 39.532"N, 5º 41´ 53.681"E

RESULTS AND DISCUSSION

Table 2 shows the summary of results of the mean concentration of the heavy metals investigated in Ubeji River sediments at 200m upstream from point of effluent discharge, at the point of effluent discharge, and at 200m downstream from the point of effluent discharge.

TABLE 2: Mean and Standard Deviation of the Concentration of Heavy Metals in Ubeji River Sediments at 200m Upstream from Point of Effluent Disposal.

	Zinc (mg/Kg)	*Iron (mg/Kg)*	*Manganese (mg/Kg)*	*Lead (mg/Kg)*	*Chromium (mg/Kg)*	*Cadmium (mg/Kg)*	*Mercury (mg/l)*
April	18.04	03.58	21.28	11.06	40.59	01.62	00.06
May	18.08	02.94	21.09	10.75	39.4	01.68	00.06
June	16.99	02.98	20.06	10.42	38.78	01.43	00.04
July	16.48	03.37	19.92	10.69	33.93	01.92	00.05
August	16.12	03.42	19.06	10.54	28.00	01.81	00.02
Mean	**17.14**	**03.26**	**20.28**	**10.69**	**36.14**	**01.69**	**00.05**
Standard Deviation	**00.89**	**00.28**	**00.91**	**00.24**	**05.21**	**00.19**	**00.02**

Source: Field Survey, 2020.

TABLE 3: Mean and Standard Deviation of the Concentration of Heavy Metals in Ubeji River Sediments at Point of Effluent Disposal.

	Zinc (mg/Kg)	*Iron (mg/Kg)*	*Manganese (mg/Kg)*	*Lead (mg/Kg)*	*Chromium (mg/Kg)*	*Cadmium (mg/Kg)*	*Mercury (mg/l)*
April	85.21	12.58	55.56	60.06	62.99	02.72	00.29
May	81.56	12.22	53.31	48.80	59.32	03.05	00.19
June	74.44	11.62	53.30	42.96	56.10	02.66	00.21
July	74.61	11.19	50.59	42.28	53.28	02.99	00.18
August	69.41	10.79	50.49	41.10	52.66	02.41	00.16
Mean	**77.05**	**11.68**	**52.65**	**47.04**	**56.87**	**02.77**	**00.21**
Standard Deviation	**06.29**	**00.73**	**02.14**	**07.86**	**24.98**	**00.26**	**00.05**

Source: Field Survey, 2020.

TABLE 4: Mean and Standard Deviation of the Concentration of Heavy Metals in Ubeji River Sediments at 200m Downstream from Point of Effluent Disposal.

	Zinc (mg/Kg)	Iron (mg/Kg)	Manganese (mg/Kg)	Lead (mg/Kg)	Chromium (mg/Kg)	Cadmium (mg/Kg)	Mercury (mg/l)
April	64.81	12.58	43.68	10.06	41.59	01.62	00.29
May	64.10	11.05	41.19	10.26	39.07	02.25	00.22
June	63.65	10.32	41.90	10.10	53.21	02.06	00.21
July	61.90	10.04	41.16	10.12	47.17	01.97	00.13
August	60.33	09.84	40.45	10.06	35.91	01.71	00.04
Mean	**62.96**	**10.77**	**41.68**	**10.12**	**43.39**	**01.92**	**00.18**
Standard Deviation	**01.82**	**01.11**	**01.23**	**00.08**	**06.87**	**00.26**	**00.10**

Source: Field Survey, 2020.

Zinc (Zn)

From Tables 2, 3, and 4, the results show that the concentration of zinc in the sediments at the upstream ranged from 16.12mg/Kg to 18.08mg/Kg with a mean value of 17.14±0.89mg/Kg. At the point of effluent discharge, the concentration of zinc ranged from 69.41mg/Kg to 85.21mg/Kg with an average concentration of 77.05±6.29mg/Kg. Similarly, at the downstream, the zinc concentration ranged from 60.33mg/Kg to 64.81mg/Kg. Within the 3 sampling points, the point of effluent discharge recorded 85.21mg/Kg and 16.12mg/Kg at the upstream as the highest and lowest concentration of zinc, respectively. From the results obtained and when compared to the DPR (2002) quality guidelines in estuarine sediments. The 3 sampling points were found to be less than the 90mg/Kg permissible limits specified and thus safe for benthic organisms.

Iron (Fe)

From Tables 2, 3, and 4, the results show the iron concentration in the sediments. At the upstream, the iron concentration ranged from 2.94mg/Kg to 3.58mg/Kg with a mean concentration of 3.26±0.28mg/Kg. At the point of effluent discharge, the iron concentration ranged from 10.79mg/Kg to 12.58mg/Kg, with a mean concentration of 11.68±0.73mg/Kg. Similarly, the iron concentration downstream from the point of effluent discharge ranged from 9.84mg/Kg to 12.58mg/Kg, with a mean value of 10.77±1.11mg/Kg. Within the 3 sampling points, the point of effluent discharge recorded 12.58mg/Kg and the upstream recorded 2.94mg/Kg as the highest and lowest concentrations of iron, respectively. From the results obtained, and when compared to DPR (2002) sediment quality guidelines in estuarine environments. The results revealed that all 3 sampling points were less than the 20mg/Kg permissible limits specified and thus safe to support benthic organisms.

Manganese (Mn)

From Tables 2, 3, and 4, the results show the manganese concentration in the sediments. From the results obtained, the concentration of manganese in the sediments at the upstream ranged from 19.06mg/Kg to 21.28mg/Kg, with a mean concentration of 20.28±0.91mg/Kg. At the point of effluent discharge, the concentration of manganese ranged from 50.49mg/Kg to 55.56mg/Kg, with a mean concentration of 52.65±2.14mg/Kg. The concentration of manganese downstream from the point of effluent discharge ranged from 40.45mg/Kg to 43.68mg/Kg with a mean concentration of 41.68±1.23mg/Kg. From the results obtained, and when compared to the DPR (2002) sediment quality guidelines in estuarine sediments. The values in sediments sampled at upstream and downstream from the point of effluent discharge were below the permissible limits, 46mg/Kg, except for the point of effluent discharge that recorded a mean value of 52.65±2.14mg/Kg, which is above the specified limits and likely to cause harm to benthic organisms.

Lead (Pb)

From Tables 2, 3, and 4, the results show the lead concentration in the sediments at the upstream ranged from 10.42mg/Kg to 11.06mg/Kg with a mean value of 10.69±0.24mg/Kg. At the point of effluent discharge, the lead concentration ranged from 41.10mg/Kg to 60.06mg/Kg, with a mean concentration of 47.04±7.86mg/Kg. Similarly, at the downstream, the lead concentration ranged from 10.06mg/Kg to 10.26mg/Kg, with a mean concentration of 10.12±0.08mg/Kg. Within the 3 sampling points, the highest and lowest values were recorded as 60.06mg/Kg and 10.06mg/Kg at the point of effluent disposal and at the downstream, respectively. From the results obtained, the concentration of lead in sediments at the upstream and downstream was below the permissible limits of 31mg/Kg by DPR (2002) for sediment quality guidelines in estuarine sediments. However, the point of effluent discharge recorded an average value of 47.04±7.86mg/Kg, which is above the specified limits to support benthic organisms.

Chromium (Cr)

From the results obtained as presented in Tables 2, 3, and 4, the concentration of chromium in the sediments at the upstream ranged from 28.0mg/Kg to 40.59mg/Kg, with a mean value of 36.14±5.21mg/Kg. At the point of effluent discharge, the concentration of chromium ranged from 52.66mg/Kg to 62.99mg/Kg, with a mean concentration of 56.87±4.32mg/Kg. The concentration of chromium at the downstream ranged from 35.91mg/Kg to 47.17mg/Kg, with a mean concentration of 43.39±6.87mg/Kg.

From the results obtained, and when compared to the DPR (2002) sediment quality guidelines in estuarine sediments. The concentration of chromium in sediments sampled at the point of effluent discharge and at the downstream were both above the permissible limits of 40mg/Kg, except at the upstream from the point of effluent discharge that recorded an average concentration level of 36.14±5.21mg/Kg which is below the specified limits and thus safe to support benthic organisms.

Cadmium (Cd)
From the results presented in Tables 2, 3, and 4, the concentration of cadmium in the sediments at the upstream ranged between 1.43mg/Kg to 1.92mg/Kg, with a mean concentration of 1.69±0.19mg/Kg. At the point of effluent discharge, the concentration of cadmium ranged between 2.41mg/Kg to 3.05mg/Kg with a mean concentration of 2.77±0.26mg/Kg. The concentration of cadmium downstream from the point of effluent discharge ranged from 1.62mg/Kg to 2.25mg/Kg with a mean concentration of 1.92±0.26mg/Kg. From the results obtained and when compared to the DPR (2002) sediment quality guidelines in estuarine sediments, the concentration of cadmium in sediments sampled at all sampling points was all above the permissible safe limits of 0.60mg/Kg and thus not safe to support benthic organisms.

Mercury (Hg)
From the results presented in Tables 2, 3, and 4, the concentration of mercury in the sediments at the upstream ranged from 0.02mg/Kg to 0.06mg/Kg with a mean concentration of 0.05±0.02mg/Kg. At the point of effluent discharge, the concentration of mercury ranged from 0.16mg/Kg to 0.29mg/Kg with a mean concentration of 0.21±0.05mg/Kg. The concentration of mercury at downstream from the point of effluent discharge ranged from 0.04mg/Kg to 0.29mg/Kg with a mean concentration of 0.18±0.10mg/Kg. From the results obtained, and when compared to the DPR (2002) sediment quality guidelines in estuarine sediments. The average concentration of mercury sampled at all sampling points was below the permissible safe limits of 0.20mg/Kg, except for the point of effluent discharge, which recorded an average concentration of 0.21±0.05mg/Kg, which is above the specified safe limits to support benthic organisms.

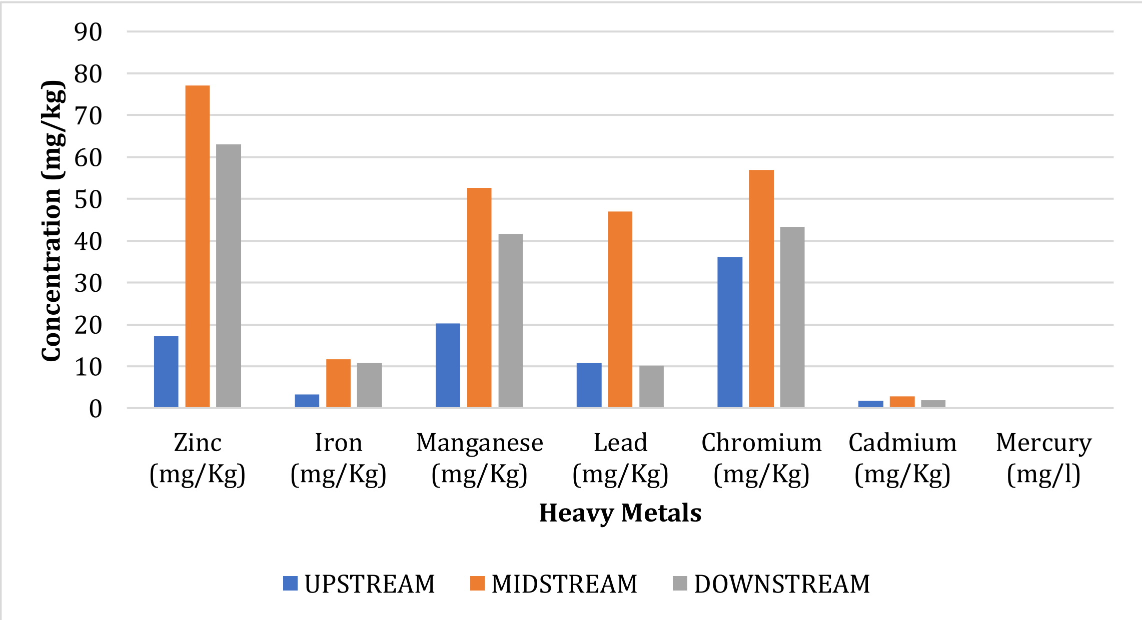

FIGURE 1: Mean Concentration of Heavy Metals at Sampling Points.

SUMMARY OF FINDINGS
A lot of researchers have used water from natural water bodies as a pollution indicator, but sediment has been known to provide a better and more accurate insight into the long-term pollution state of the aquatic environment (Ogbeibu et al, 2014; Yau and Gray, 2005). Sediments have been described as a sink of pollutants whereby they accumulate various levels of pollution (Onyari et al, 2003). This study revealed that the sediments sampled from the Ubeji River recorded the following mean concentrations at 200m upstream from the point of effluent discharge. Zinc (17.14mg/Kg), iron (3.26mg/Kg), manganese (20.28mg/Kg), lead (10.68mg/Kg), chromium (36.14mg/Kg), cadmium (1.69mg/Kg), and mercury (0.05mg/Kg).

The results obtained show that all the heavy metals investigated at the upstream fell within the DPR (2002) limits for the survival of aquatic organisms, except for cadmium. At the point of effluent discharge, the mean concentrations were zinc (77.05mg/Kg), iron (11.68mg/Kg), manganese (52.65mg/Kg), lead (47.04mg/Kg), chromium (56.87mg/Kg), cadmium (2.77mg/Kg), and mercury (0.21mg/Kg). The results show that lead, manganese, chromium, and cadmium were above the DPR (2002) limits for the survival of aquatic organisms. Analysis by ANOVA showed that there was no significant impact of refinery effluent on the quality of Ubeji River sediments at the sampling stations under investigation at 5% significance value.

RECOMMENDATIONS

In light of the research findings, the following recommendations were made:

(1) The Warri Refinery and Petrochemical Company and other companies operating in the catchment area of Ubeji River need to maximize the treatment of their effluents, as some parameters investigated were found to be above the WHO and DPR acceptable limits.

(2) Land use planning should form the basis of management planning for Ubeji River water quality control and protection since the land cover within the Ubeji community area is characterized by an increase in settlements, which include urban developments, sewage, and industrial effluents, which are threats to the Ubeji River water quality. The growth rate of urbanization should also be slowed down within the Ubeji area and extended to other areas.

(3) The Federal Environmental Protection Agency (FEPA) needs to intensify monitoring and mitigation exercises of the Ubeji River as it serves as a source of water, fish supply, and livelihood to the community along the river course.

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