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Heavy Metal Levels in the Sediment of Mgbuoshimini River, Port Harcourt, Rivers State

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Abstract

Background and Objective: Sediment contamination by heavy metals is of particular concern because these pollutants are non-biodegradable, persistent, and capable of bioaccumulation within aquatic organisms. As a result, sediments preserve evidence of both present and past pollution, making them valuable indicators of long-term environmental quality. The Objective of the study was to evaluate the levels of Heavy Metals in the Sediment of Mgbuoshimini River, Port Harcourt. **Materials and Methods:** Sediment samples were collected with replicates from three sampling stations - upstream, midstream (point of discharge) and downstream) using Eckman's grab and placed in a pre-cleaned labeled polythene bag for preservation. Standard analytical procedures were used to determine the Heavy Metals in sediment samples (APHA) while ANOVA was used to determine significant differences. **Results:** The results revealed variations across the stations ($P<0.05$). Heavy metals in sediment such as Pb (8.63±0.32-15.49±0.98mg/kg), Cr (6.64±0.16 & 29.52±1.30mg/kg), Zn (5.82±0.23-10.55±0.30mg/kg), and Fe (50.74±1.21-177.20±6.42mg/kg) were all below permissible limit (USEPA) except Cr (29.52 ± 1.30 mg/kg) in the midstream. Further analysis using ecological indices such as Contamination Factor, Pollution Load Index and Geo-Accumulation Index (Igeo) classified the stations as unpolluted with the studied metals. **Conclusion:** This study indicates that continuous discharge of untreated effluent, refuse disposals and other anthropogenic activities may contribute to the presence of heavy metals in the sediment and in turn pose potential ecological risks to the aquatic environment. Therefore, there is a need for constant monitoring of the environment by regulatory agencies to avoid contamination.

Keywords: Abattoir Effluent, Ecological Risk Assessment, Heavy Metals, Sediment Contamination

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INTRODUCTION

Sediments are important components of aquatic ecosystems because they serve as sinks and reservoirs for contaminants discharged into water bodies (Farhan et al., 2023). Pollutants introduced into rivers through anthropogenic activities are often deposited and accumulated within bottom sediments where they may persist for long periods. Consequently, sediment quality is widely used as an indicator of environmental pollution in aquatic ecosystems.

Abattoir activities generate large quantities of solid and liquid wastes containing organic matter, nutrients, pathogens, and heavy metals. In many developing countries, untreated abattoir wastes are discharged directly into nearby rivers and streams, resulting in contamination of both water and sediment. Sediment contamination by heavy metals is of particular concern because these pollutants are non-biodegradable, persistent, and capable of bioaccumulation within aquatic organisms (Adesemoye et al., 2006). Heavy metals such as lead, cadmium, chromium, zinc, and iron may accumulate in sediments through direct discharge of abattoir effluent, surface runoff, and deposition processes (Singh et al., 2011). Elevated concentrations of these metals can alter sediment composition, reduce benthic biodiversity, and pose risks to aquatic organisms and human health through biomagnification along the food chain.

The Mgbuoshimini River in Port Harcourt receives untreated effluent from slaughterhouse activities and refuse dumps along the shoreline. Despite the environmental importance of the river, limited information exists regarding the extent of sediment contamination in the area. This study therefore assessed the levels of heavy metals in the sediment of Mgbuoshimini River, Port Harcourt.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted on the Mgbuoshimini River around the Mgbuoshimini abattoir area of Port Harcourt Local Government Area, Rivers State, Nigeria. Mgbuoshimini abattoir lies between latitudes N 4048’7.17336” longitudes E 6058’16.43484” (Figure 1)

Anthropogenic activities include slaughtering, skinning, evisceration, roasting and washing of animals in the abattoir; others include dumping of waste by surrounding residents and fishing. These activities may affect the water quality and the aquatic ecosystem as a whole.

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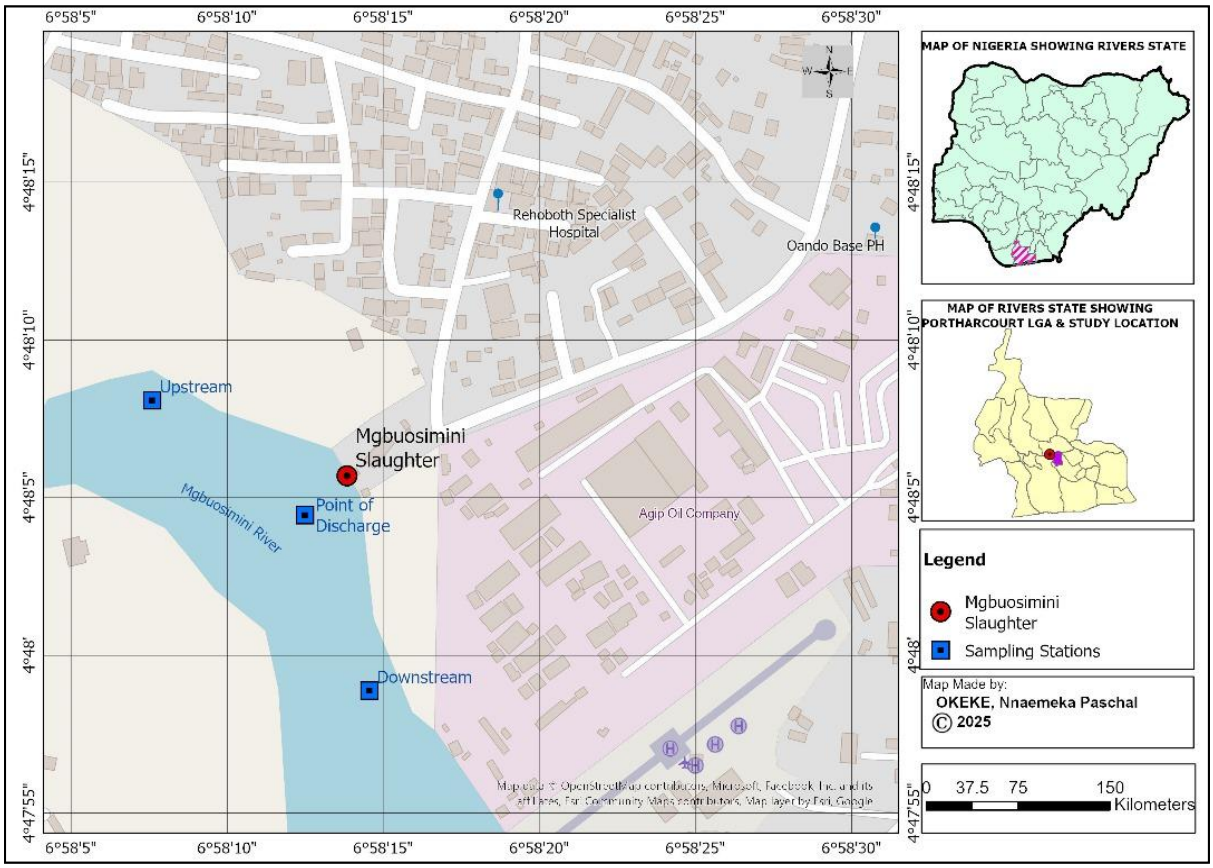


Figure 1: Map of Study area

Sampling Stations

Sediment samples were collected from Mgbuoshimini River at three main stations; -Upstream which was located 100 meters upstream of the abattoir effluent point of discharge, Midstream which was the point of discharge of abattoir effluent; and Downstream which was located 100 meters downstream of the abattoir effluent point of discharge

Field Sampling Operations

Sediments were collected from the designated sampling stations. The positions were accurately geo-located with the Global Positioning System (GPS). An open fiber boat was used as a means of transportation with which sampling was carried out at each of the designated sampling stations. Sampling was carried out once with a replicate for each station collected.

Sample Collection

The sediment samples were collected using Eckman's grab from each station and placed in a pre-cleaned labeled polythene bag for preservation[4]. All samples were transported cool (4^0C) to the laboratory for analyses within 2 hours of collection in an ice chest, where the samples were transferred to a refrigerator prior to chemical analysis.

Analysis of Samples

Sediment samples were collected from the intertidal at low tide with the use of a stainless Eckman's grab. The samples were placed in pre-cleaned well-labelled polythene bags and

transferred in an ice chest to the laboratory. In the laboratory, samples were air-dried for two to three weeks at room temperature until weight was constant. After drying the sediment sample, visible remains of organisms and debris were removed; the sample was crushed in a mortar and sieved using a 200 µm sieve to normalise particle size. Samples were further homogenised in a porcelain mortar, sieved (using a 2-mm mesh size) and stored in a plastic container. Two grams of crushed sample was dissolved in 5 ml of ultra pure Nitric acid 10% in HCL solution. The solution was filtered into a cleaned and dried 20 ml standard volumetric flask. The solution was then aspirated onto the Atomic Absorption spectrophotometer (AAS) model GBC Avanta Version 2.02 and the metal concentrations were recorded in ppm.

Statistical Analysis

The heavy metal data were subjected to analysis of variance (ANOVA). Tukey's multiple-comparison test was used to compare mean values among sampling stations. Values of $p < 0.05$ were considered statistically significant. All statistical analyses were carried out using SPSS version 20.

Contamination Factor (CF), Pollution Load Index (PLI) and Geo-accumulation Index (Igeo)

The contamination level of sediment is expressed as a contamination factor (CF) calculated from:

$CF = C_m$ sample/C_m background

Where: C_m sample = the concentration of a given metal in sediment; C_m background = the value of the metal equal to the Average Shale Value (ASV) (Turekian and Wedepohl, 1961) - Cr (90), Zn (95), Pb (20) and Cd (0.3).

Pollution Load Index (PLI)

Pollution load index (PLI) (Anaero-Nweke et al., 2018), as a means of assessing the quality of the study area with respect to heavy metal contamination was evaluated as:

$$PLI = (CF_1 \times CF_2 \times CF_3 \times \ldots\ldots CF_n)^{1/n}$$

Where: n is the number of metals, CF is the contamination factor of an individual metal.

When the value of PLI is 1, it indicates heavy metal load close to background levels, while values above 1 indicate pollution.

Index of Geo-accumulation (Igeo)

The geo-accumulation index (Igeo) (Anaero-Nweke et al., 2018), compares current concentration of heavy metals with the preindustrial level. The geo-accumulation index (Igeo) values were calculated for the different metals using the equation:

$$Igeo = \text{Log } 2 (C_n/1.5\ B_n)$$

Where: C_n= Measured concentration of element in the sediment sample, B_n= geochemical background for the element n.

The factor 1.5 is used to compensate for possible variations with respect to background and lithological variations. Average shale values (ASV) by Anaero-Nweke et al. (2018) in mg/kg of Cr (90), Zn (95), Cd (0.3), and Pb (20) were used as the background values to estimate Igeo.

RESULTS AND DISCUSSION

Heavy Metal Concentration in Sediment

The concentration of heavy metals in sediment varied significantly. However, according to Sediment Quality Guideline (USEPA, 1999), the heavy metal concentration in sediment (Table 1) was below permissible limit indicating absence of pollution levels in the sampled sediment except Cr 29.52 ± 1.30 in the midstream. Ecological indices revealed that the metal contamination factor in the creek sediments across all sampling stations was of low contamination levels. The Pollution Load Index (PLI) in all the sampled stations was <1, which revealed that the study area was not polluted with the studied metals (Table 2; Table 3). This is in agreement with Anaero-Nweke et al., (2018) and in contradiction with a study of heavy metal concentration in the Choba section of the New Calabar River, Eastern Niger Delta (Nwankwoala & Angaya, 2017) that expressed the area as polluted; however their result on CF is in agreement with results obtained in this study. Analysis using Geo-accumulation Index (Igeo) revealed values <1, which also indicated that Mgbuosimini River sediment was not polluted with the studied metals at the time of sampling.

Table 1: Heavy Metal concentration in Sediment from Mgbuoshimini River

Parameter	Upstream	Midstream	Downstream	SQG USEPA (1999)
Lead (mg/kg)	8.63 ± 0.32^{a}	15.49 ± 0.98^{c}	10.3 ± 0.27^{b}	40mg/kg
Chromium (mg/kg)	0.05 ± 0.00^{a}	29.52 ± 1.30^{c}	6.64 ± 0.16^{b}	25mg/kg
Cadmium (mg/kg)	$<0.009 \pm 0.00^{a}$	$<0.009 \pm 0.00^{a}$	$<0.009 \pm 0.00^{a}$	0.6mg/kg
Zinc (mg/kg)	5.82 ± 0.23^{a}	10.55 ± 0.30^{c}	8.18 ± 0.11^{b}	110mg/kg
Iron (mg/kg)	50.74 ± 1.21^{a}	177.2 ± 6.42^{c}	64.62 ± 2.26^{b}	-

< = Less than detection limit
NA =Not Available

Table 2: Contamination Factor (CF) and Pollution Load Index (PLI) of Heavy Metals in Sediment during the Study

	Contamination factor (CF)			PLI
Metals	Upstream	Midstream	Downstream	
Lead (Pb)	0.43	0.77	0.52	0.5563
Chromium (Cr)	0.0006	0.33	0.074	0.0245
Cadmium (Cd)	0.03	0.03	0.03	0.0300
Zinc (Zn)	0.06	0.11	0.09	0.0841

CF < 1: Low degree of contamination 1≥CF<3: Moderate degree of contamination
3≤CF<6: Considerable degree of contamination CF≥6: Very high degree of contamination

Table 3: Geo-Accumulation index (Igeo) of Heavy Metals in Sediment during the Study

Metal	Lead (Pb)	Chromium (Cr)	Cadmium (Cd)	Zinc (Zn)
Upstream (mg/kg)	8.63	0.05	<0.009	5.82
Upstream Igeo	–1.79	–11.4	–5.64	–4.61
Midstream (mg/kg)	15.49	29.52	<0.009	10.55
Midstream Igeo	–1.38	–2.20	–5.64	–3.76
Downstream (mg/kg)	10.3	6.64	<0.009	8.18
Downstream Igeo	–1.55	–4.35	–5.64	–4.12

Igeo<O(Practically unpolluted) Igeo ≤1 (Uncontaminated to Moderately Polluted I<Igeo<2 (Moderately Polluted) 3≤Igeo≤ 4 (Heavily Polluted) 2<Igeo≤ 3 (Moderately to heavily Polluted 5 ≤Igeo>6 (Extremely Contaminated) 4 <Igeo≥5 (Heavily to extremely contaminated.

CONCLUSION

This study indicates that continuous discharge of untreated effluent, refuse disposals and other anthropogenic activities may contribute to the presence of heavy metals in the sediment and in turn, pose potential ecological risks to the aquatic environment. Therefore, there is need for constant monitoring of the environment by regulatory agencies to avoid contamination.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Conflict of Interest

There was no conflict of interest between Authors.

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AI- Assisted Technologies

This manuscript was prepared through the intellectual contributions of the author(s) to the study design, data analysis, interpretation of results, and scholarly content. ChatGPT, Claude and Perplexity were used solely to assist with grammatical refinement and reference formatting during manuscript revision. The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

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