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DISTRIBUTION OF HEAVY METALS IN PERIWINKLES (TYMPANOTONUS FUSCATUS) AND THE ACCUMULATION FROM CONTAMINATED WATER AND SEDIMENT FROM ELECHI CREEK IN RIVERS STATE

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ABSTRACT

This paper examined the distribution and accumulation of heavy metals in periwinkles (Tympanotonus fuscatus) from Elechi Creek, Rivers State, Nigeria. In both wet and dry seasons, periwinkles, sediment, and water samples were collected monthly at three stations. Chromium, lead, copper, cadmium, and iron were analyzed using Atomic Absorption Spectrophotometry. The highest concentrations of Cd (0.008) in periwinkles were observed at Station 3, followed by Pb (0.002 mg/kg), Fe (28.14 to 48.4 mg/kg), As (0.005 mg/kg), Zn (132.2 to 167.3 mg/kg), and Cu (4.53 to 6.65 mg/kg). In surface water, Fe concentrations varied from 33.2 to 35.8 mg/L, Zn from 10.6 to 11.9 mg/L, Pb at 0.07 mg/L, Cd from 0.04 to 0.06 mg/L, Cu from 111.4 to 114.1 mg/L, and As at 0.004 mg/L. There were elevated Fe concentrations at Station 3, Zn from 210.9 to 211.9 mg/kg, Pb from 9.6 to 10.2 mg/kg, Cd from 3.02 to 3.43 mg/kg, Cu from 382.9 to 425.1 mg/kg, and As. from 0.014 to 0.017 mg/kg in sediments. Across all stations, Fe (1.352 mg/kg) and Zn (14.07 mg/kg) showed the highest bioconcentration factor (BCF) values, while As was consistent at 1.25 mg/kg. The highest Fe bioaccumulation was found at Station 3 (0.300 mg/kg), and the highest Zn bioaccumulation was found at Station 3 (0.793 mg/kg). These findings underscore spatial disparities in heavy metal concentrations, indicating potential ecological and health risks, and highlight the need for ongoing monitoring and pollution control in Elechi Creek.

KEYWORDS

Metal Accumulation, Bioaccumulation, Periwinkles, Creek

Introduction

Oil exploration and industrial wastes in the leading oil-producing region of Nigeria- Niger Delta-act on the entire ecological system and degrade it severely (Sam et al., 2017; Onyena and Sam, 2020). The region is richly endowed with high biodiversity and heavily dependent on the aquatic environment, yet it suffers from the rising levels of pollution with crude oil and allied industries. This has heightened the concern level for the safety of water resources and aquatic life that local communities gain a living from. According to Oluniyi (2017), in all these cases, there are heightened concerns about safety.

Heavy metals such as lead, cadmium, and mercury have become some of the major contaminants in aquatic ecosystems the world over, especially in regions with immense industrial activities, such as the Niger Delta (Bashir et al., 2020; Odekina et al., 2021). These metals, being non-degradable, toxic, and capable of bioaccumulation, accordingly, pose long-term dangers to aquatic life and the health of human populations (Ungureanu and Mustatea, 2022). Because of these properties, heavy metals may persist in water and sediment with the potential to act on marine organisms and, by extension, human consumers.

Among the various aquatic species in the Niger Delta, periwinkles (Tympanotonus fuscatus) are an appropriate bioindicator for heavy metal pollution due to their sedentary behaviour and bioaccumulation of metals over time. The BAF (define at 1st instance) of metals in periwinkles can indicate how these contaminants may enter the food chain and reflect the degree of contamination in the immediate environment (Kennish, 2019; Gu et al., 2022). These mollusks are an important source of protein in the communities along their natural habitats, and therefore their pollution directly poses a danger to human health.; Briffa et al. (2020) and Genchi et al. (2020) report that periwinkles constitute an important source of protein for the local communities. Contamination of periwinkles may thus pose a direct threat to public health.

BAF is a very useful concept in ecotoxicology, defining the degree of metal accumulation in organisms when compared to the environment (Mohammadi et al., 2019). Taking into consideration by making comparisons with T. fuscatus, the study contextualizes the extent of pollution in the Niger Delta with respect to any possible implications for food safety and ecosystem health (Chapman and Wang, 2001). This approach also helps identify pathways through which metals move from sediments to organisms, possibly affecting humans.

Bioaccumulation of heavy metals is more serious due to potential toxicity even at low concentration, affecting several organs and physiological functions in both aquatic organisms and humans (Ali et al., 2019). For instance, exposure to lead impairs cognitive development, while mercury and cadmium have been associated with kidney and liver damage (Ungureanu and Mustatea, 2022). Hence, knowledge of the BAF of those metals in periwinkles would provide insight into broader ecological and human health risk associated with metal pollution in the Niger Delta.

Aquatic resource contamination in the Niger Delta results from oil spills, industrial effluents, and agricultural runoff, among others (Sankhla et al., 2016). Each one of these activities contributes to the accumulation of toxic metals in water bodies, thus affecting the environment and organisms within it. Bioaccumulation of heavy metals in periwinkles can thus depict an integrated effect of a variety of sources of pollution - a toxicity indicator of environmental health in this important ecosystem (Ayyamperumal et al., 2022).

Although there have been calls through various studies for the need to monitor heavy metal pollution, data on its bioaccumulation in organisms like T. fuscatus in the Niger Delta is still scanty. In fact, Masindi and Muedi (2018) and Anyanwu et al. (2018) express the need to monitor heavy metals pollution. In view of their twin roles as environmental indicators and basic food items, a concentrated analysis of BAF in the organisms becomes paramount for the formulation of effective risk management and public health strategies (Mishra et al., 2019). Thus, this study has been designed to partly fill this important knowledge gap with respect to the bioaccumulation in aquatic organisms of Elechi Creek and provide useful insights into the impacts of industrial pollution on both local ecosystems and human populations.

2. MATERIAL AND METHODS

2.1 Study Area

This study was conducted in Elechi Creek in Port Harcourt, as shown in Figure 1. It is a tributary of the estuary of Bonny. This brackish stream, which stretches to the Illoabuchi street water bank in Port Harcourt, is impacted by tidal fluxes at Eagle Island. The River State University of Science and Technology forms the northern boundary of Eagle Island, which is situated southwest of Port Harcourt. There is mangrove vegetation along the stream, and the creek basin varies in width. Upstream, Station 1 is located at N04°47.149' and E006°58.958'; midstream, Station 2 (the Sawmill area) is located at N04°47.28' and E006°59.255'; and downstream, Station 3 is the Appa area, located at N04°47.047' and E006°59.362'.

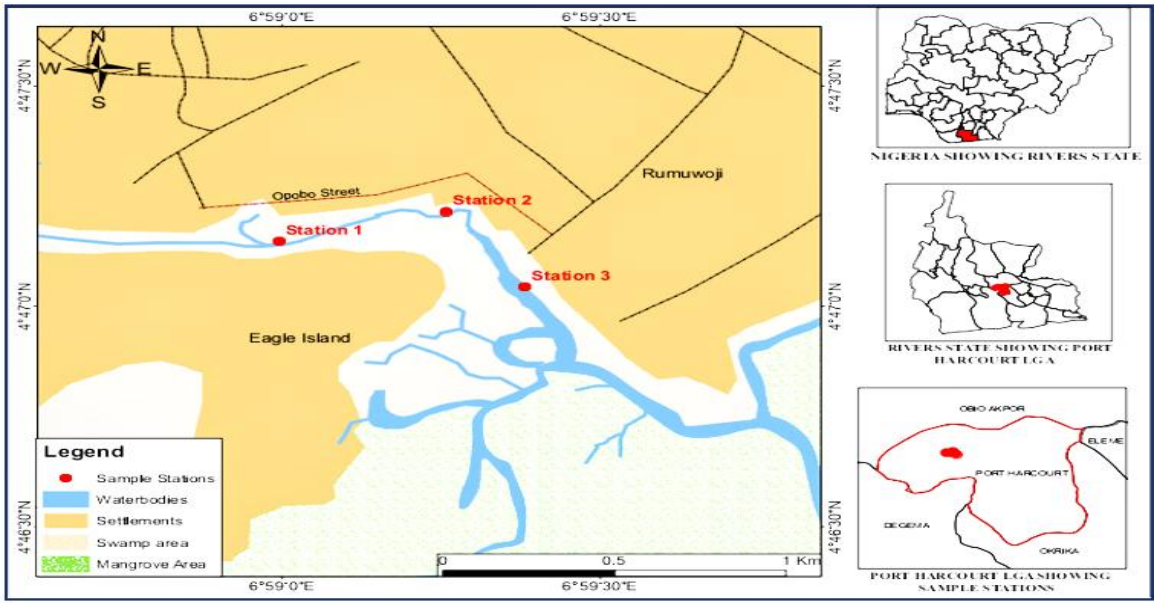

Figure 1: Map of Elechi Creek showing the sampled stations

2.2 Sample and Sampling Techniques

The sampling locations from the research region were identified with GPS coordinates. Triplicate samples of fish, sediment and water were taken once every month from three (3) designated locations. The period for sample collection in this research was six calendar months (wet season and dry season).

2.3 Sampling Procedure

A total of three stations was selected and was at least 1000 meters apart along the river. Based on the characteristics and features found in the research region of this creek, three sampling sites was chosen within the river to represent varied activities in the areas: Station 1, Station 2 and Station 3. Samples obtained for analysis comprised sediment, water and shellfish. All sites were geo-referenced using a portable global positioning system (GPS) receiver unit (Magellan GPS 315) to produce geographic coordinates (longitudes and latitudes) of the sample region. Sampling was done once a month from January to June 2024. This was carried out during the first week of each sample month.

2.3.1 Collection of Periwinkles (Tympanotonus fuscatus) Samples

The shellfish samples were obtained from the local fishermen at each study site and kept in a cooler filled with ice block to retain freshness and then transferred to the laboratory.

2.3.2 Water Sample Collection

High-density Schott glass bottles that had been previously cleaned were used to collect surface water samples. After being washed with detergent and rinsed with tap water, the sample bottles were immersed in 50% hydrochloric acid (HCl) for a full day prior to sampling. Before sampling, the bottles were rinsed with triple-distilled water and cleaned with tap water. Before sampling, the bottles were cleaned to make sure they were free of metal residue and to stop metals from sticking to glass surfaces since acidifying glass promotes metal disintegration. Following collection, the samples were appropriately packaged and sent to the lab for examination in an ice pack.

2.3.3 Sediment Collection

Nine sediment samples were collected from three monitoring points at monthly intervals throughout the course of six months, from January to June 2024. Using a "Ekman grab" sampler, the sediments were taken once a month for three months in the form of composite from three distinct locations in both streams. They were then stored in a plastic container that had been treated with 10% nitric acid for a whole day and washed with de-ionized water. Due to the poor porosity of sandy material, muddy sediment was gathered instead.

Giolee Global Resources Limited, located at 18 Uyo Street, Rumuomasi, Port Harcourt, received all the samples. Samples were kept at 20°C in the lab until they were processed further and examined using an Atomic Absorption Spectrophotometric Machine (API-RP 45). In order to guarantee that the water and sediment samples accurately reflected the real and noticeable pollution pockets in the research region, the sampling distance was set away from the bank. Sediment samples were allowed to air dry; shellfish samples were ground in a blender, and 20 millilitres of concentrated H_2SO_4 were used to digest the water.

2.4 Heavy metal analysis

APHA 3111 was used for the heavy metal analysis (Eze and Chigbu, 2015). Chromium (Cr), lead (Pb), copper (Cu), cadmium (Cd), and iron (Fe) were the heavy metals that were examined using the Atomic Absorption Spectrophotometric (AAS) technique. The operating conditions and instrument configuration were completed in compliance with the manufacturer's guidelines.

2.4.1 Total Digestion for Heavy Metals

Nitric acid, perchloric acid, and sulfuric acid were used for extraction (APHA 3030I modified, full digestion method). Twenty millilitres of digestion solution were added to 250 millilitres of sediment and granulated fish samples. To guarantee full digestion, the samples were heated in a fume hood equipped with an electrical mantle to 250 °C until the granules turned from dark to grey in colour. After being heated, the digested solution was taken out of the fume hood, set on the workbench, and left to cool. After adding 20 millilitres of distilled water, the mixture was let to cool even further. A 100 ml glass volumetric flask was filled with the digested solution after it had been sieved with Whatman 42 filter ashless filter paper. The volumetric flash's digested filtrate was added till the flask's 100 ml mark was reached. Later, this was moved to a labelled, sterile 100ml plastic bottle. The sample extracts for Pb, Cr, Cu, Cd, and Fe were prepared for AAS analysis.

2.4.2 Evaluation of Tissue Concentration of Heavy Metals

The tissue concentration of heavy metals through water and sediments was calculated by simple form bioaccumulation factor (BAF), and bioconcentration factor (BCF). Thus, BCF was computed as the quotient of the concentration of heavy metals in the shellfish tissue with respect to that present in the water. On the other hand, BAF was obtained by dividing the concentration of heavy metals in the shellfish tissue to that in the sediment. In the determination, dry weight concentrations were adopted (Davies et al., 2023).

2.5 Quality Assurance/Quality Control

Quantitative analysis was carried out under ideal experimental conditions using an internal standard by following the method developed by Shi et al. (2018). All the necessary steps to ensure that quality assurance was availed were adhered to in all the stages of this investigation, and modifications were also affected in both the field and laboratory techniques with a view of streamlining the entire quality of the data. In this respect, for instance, cleaning of all the sample vials was made in the laboratory using mild hydrochloric acid and subsequently rinsed with de-ionized water. The glass was carefully cleaned, and all the used chemicals were of analytical grade. All heavy metals and mineral elements analyses in the shellfish, water, and sediments were done using standard analytical techniques. This was analysed using a Perkin-Elmer atomic absorption spectrophotometer and Flame Photometer (FP Model 140). Deionized water was used throughout the experiment. Samples of the said heavy metals were collected in Port Harcourt and taken for independent analysis. The shellfish was then stored in an ice chest container for dependability until it was sent to the lab for further analysis. Sediment, water, and shellfish were all labelled appropriately.

3. RESULTS

3.1 Concentrations of Hazardous Metals in Periwinkles (Tympanotonus fuscatus)

Table 1 shows the mean variations in metal levels in periwinkles (T. fuscatus) at three different stations, with concentrations measured in milligrams per kilogram (mg/kg). Cd, Pb, Fe, As, Zn, and Cu levels were assessed. Cd concentrations remained consistently low across all stations, ranging from 0.007 to 0.008 mg/kg. Similarly, Pb concentrations were uniformly low, registering at 0.002 mg/kg across all stations. Fe concentrations exhibited variability, with values ranging from 28.14 to 48.4 mg/kg. As

concentrations remained consistently low at 0.005 mg/kg across all stations. Furthermore, Zn concentrations showed variability, peaking at 167.3 mg/kg at Station 3. Similarly, Cu concentrations varied, with the highest level recorded at 6.65 mg/kg at Station 3. These findings underscore the spatial discrepancies in heavy metal concentrations in periwinkles, highlighting the importance of comprehensive monitoring and management strategies in aquatic environments.

Table 1: Concentrations of The Metals Levels in Periwinkles (T. fuscatus)

Heavy metals	Station 1	Station 2	Station 3
Cd	0.008±0.001	0.007±0.001	0.008±0.001
Pb	0.002±0.00	0.002±0.00	0.002±0.00
Fe	34.7±3.43	28.14±2.55	48.4±2.35
As	0.005±0.001	0.005±0.001	0.005±0.001
Zn	149.2±21.23	132.2±22.1	167.3±14.9
Cu	5.23±2.04	4.53±3.01	6.65±3.42

3.2 Concentrations of Hazardous Metals in Surface Water

Figure 2 reveals that hazardous metals' concentrations vary from station to station. Station 1 consistently exhibits the lowest levels for Fe (33.2 mg/L), Zn (10.6 mg/L), Pb (0.07 mg/L), Cd (0.04 mg/L), Cu (111.4 mg/L), and As (0.004 mg/L). Conversely, Station 3 demonstrates slightly higher concentrations for Fe (35.8 mg/L), Zn (11.9 mg/L), Cd (0.06 mg/L), and Cu (114.1 mg/L), while maintaining comparable levels of Pb (0.07 mg/L) and As (0.004 mg/L) to Station 1. Station 2 generally falls between Station 1 and 3 in terms of metal concentrations. These findings underscore the spatial disparities in hazardous metal contamination, indicating potential health and environmental risks associated with surface water pollution.

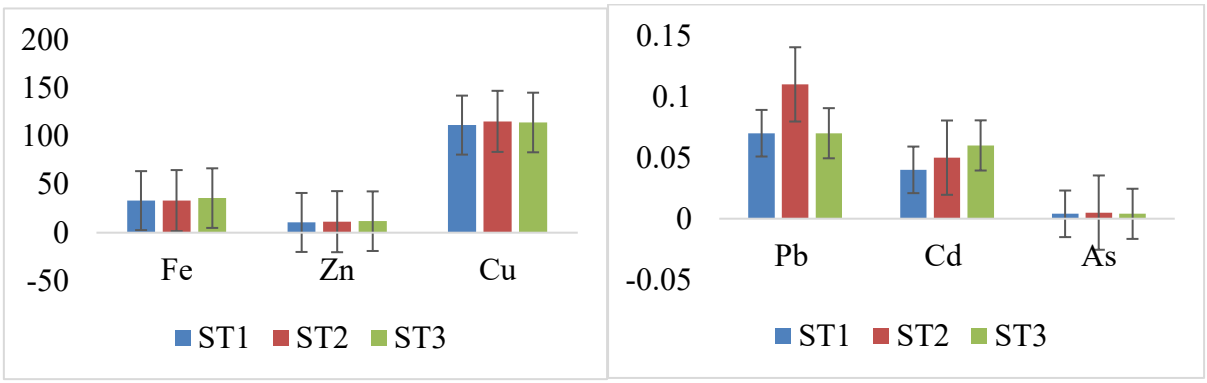

Figure 2: Concentrations of Heavy Metals in Surface Water

3.3 Mean Variations of The Heavy Metals Concentrations in Sediment

Figure 3 presents the mean variations of hazardous metal concentrations in sediment samples at three different stations (ST1, ST2, and ST3). For Station 1 (ST1), the mean Fe concentration is 154.1 mg/kg with a standard deviation of ±20.3, while the mean Zn concentration is 211.9 mg/kg with a standard deviation of ±22.3. The mean value of Pb is 9.60 mg/kg with an SD of ±5.23; the mean value of Cd is 3.02 mg/kg with an SD of ±1.14. The mean Cu concentration is 382.9 mg/kg with a standard deviation of ±22.5, and the mean As concentration is 0.014 mg/kg with a standard deviation of ±0.003.

For Station 2 (ST2), the mean Fe and Zn concentrations are identical to those of ST1, both at 154.1 mg/kg for Fe and 211.9 mg/kg for Zn, with the same standard deviations. Similarly, the mean Pb, Cd, Cu, and As concentrations are also identical to those of ST1.For Station 3 (ST3), the mean Fe concentration is slightly higher at 161.1 mg/kg with a standard deviation of ±27.3. The mean Zn concentration remains similar to ST1 and ST2 at 210.9 mg/kg with a standard deviation of ±20.7. The mean Pb concentration is slightly elevated at 10.20 mg/kg with a standard deviation of ±2.17. The mean Cd concentration is 3.43 mg/kg with a standard deviation of ±1.68. The mean Cu concentration is higher at 425.1 mg/kg with a standard deviation of ±22.4. The mean As concentration is also slightly higher at 0.017 mg/kg with a standard deviation of ±0.003.

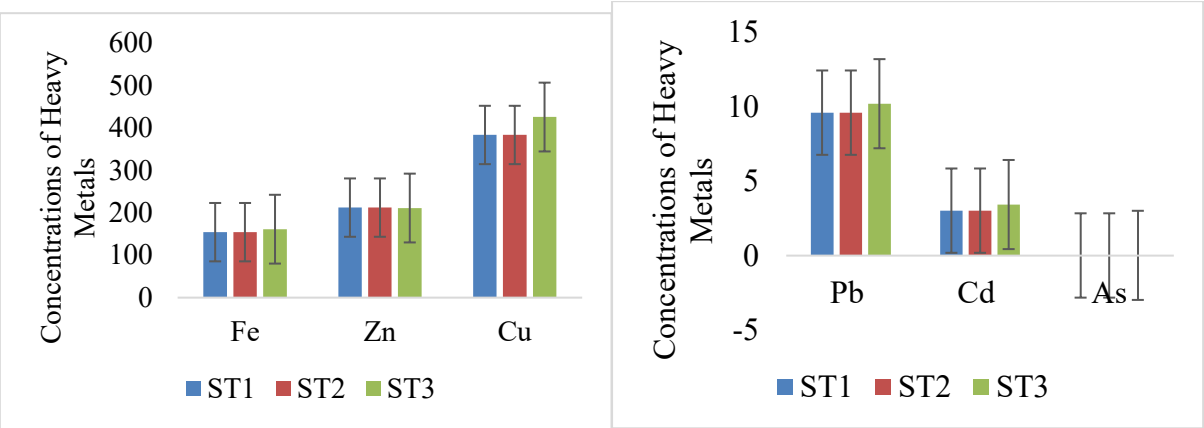

Figure 3: Concentrations of Heavy Metals in in Sediment

3.4 Bioconcentration Factor (BCF) of Metals in Periwinkles (Tympanotonus fuscatus)

Bioconcentration factors (BCFs) for metals in periwinkles (T. fuscatus) were evaluated at three different sampling sites. Table 4 shows the Bioconcentration Factor (BAF) of metals in Periwinkles (T. fuscatus) at various sampling stations. For iron (Fe), the highest BAF is at Station 3 (ST3) with 1.351955 mg/kg, while the lowest is at Station 2 (ST2) with 0.84759 mg/kg. In terms of zinc (Zn), the highest BCF is at ST1 with 14.07547 mg/kg, and the lowest is at ST2 with 11.59649 mg/kg. Lead (Pb) shows consistent BCF values at all stations, with the highest and lowest values at ST1, ST2, and ST3 being 0.028571 mg/kg. However, Cadmium (Cd) has slight fluctuations, with the highest BCF at ST1 (0.2 mg/kg) and the lowest at ST3 (0.133333 mg/kg). The BCF values for copper (Cu) have minimal variation, with the highest at ST3 (0.058282 mg/kg) and the lowest at ST2 (0.039299 mg/kg). Lastly, for arsenic (As), consistent BCF values are seen at all stations, with the highest and lowest values at ST1, ST2, and ST3 being 1.25 mg/kg.

Table 4: Bioconcentration Factor (BCF) of Metals in Periwinkles (T. fuscatus)

Stations	Fe	Zn	Pb	Cd	Cu	As
ST1	1.045181	14.07547	0.028571	0.2	0.046948	1.25
ST2	0.84759	11.59649	0.018182	0.14	0.039299	1
ST3	1.351955	14.05882	0.028571	0.133333	0.058282	1.25

3.5 Bioaccumulation Factor (BAF) of Metals in Periwinkles (Tympanotonus fuscatus)

In Table 5, the bioaccumulation factor (BAF) values of various metals in periwinkles (T. fuscatus) at three different stations (ST1, ST2, ST3) were examined. The analysis of metal values at each station reveals the following: Iron (Fe) in Station 3 exhibits the highest bioaccumulation of iron in periwinkles compared to stations 1 and 2. Zinc (Zn) in Station 3 demonstrates the highest bioaccumulation of zinc in periwinkles compared to stations 1 and 2. However, Lead (Pb) concentration differences were observed in lead bioaccumulation between stations. Negligible variances exist in cadmium bioaccumulation between stations. Copper (Cu) in Station 3 shows slightly elevated copper bioaccumulation compared to stations 1 and 2. However, Arsenic (As) values in station 1 display the highest bioaccumulation of arsenic in periwinkles compared to stations 2 and 3. In conclusion, there are disparities in the bioaccumulation of different metals across the three stations, with certain metals exhibiting higher concentrations in specific stations relative to others.

Table 5: Bioaccumulation Factor (BAF) of Metals in Periwinkles (Tympanotonus fuscatus)

Stations	Fe	Zn	Pb	Cd	Cu	As
ST1	0.225178	0.704106	0.000208	0.002649	0.013659	0.357143
ST2	0.182609	0.623879	0.000208	0.002318	0.011831	0.333333
ST3	0.300435	0.793267	0.000196	0.002332	0.015643	0.294118

4 DISCUSSIONS

4.1 Concentrations of Hazardous Metals Level in Periwinkles (Tympanotonus fuscatus)

Low levels of metals Cd and Pb have been recorded in all stations, reflecting the low contamination of these metals (Rahman and Singh, 2019; Hong et al., 2020). However, an appreciable variation in Fe, Zn, and Cu was shown between different stations, underpinning the possible source of contamination and spatial inequality in the accumulation of metals. According to Leal et al. (2023), Cd and Pb may induce neurotoxicity, renal impairment, and developmental disorders, among other health effects. In contrast, chronic exposure to such metals, even at very low levels, through seafood contamination may result in significant health risks to those more sensitive to these toxicants, such as pregnant women and children. These observed low concentrations agree with the suggestions of Fuentes-Gandara et al. (2018) where low concentration would lead to a very limited chance of potential immediate hazards to health, and proper monitoring and management plans should be continued to avoid accumulation and bioaccumulation in the Cd and Pb food chains.

Iron (Fe) concentration exhibits significant variation among stations, which indicated heterogeneous distribution and possible contamination sources in line with Ahmed et al. (2016) and Wang et al. (2020). Accordingly, high Fe levels can be associated either with natural weathering of sediments, their resuspension, or with industrial activities in the neighbourhood, while low Fe levels at Stations 1 and 2 can be explained by dilution, slower sedimentation, or a difference in sediment composition (Maurya and Kumari, 2021). Chronic exposure to high levels of Fe through contaminated seafood could result in iron overload and health issues, particularly in individuals with disorders of iron such as hemochromatosis (Haffert et al., 2020; Sahoo and Sharma, 2023). The consistently low values of arsenic in periwinkle samples throughout the stations are indicative of minimum contamination from the metalloid in the study area. Arsenic is attributed to industrial processes, mining, and agricultural

procedures that may be dangerous to aquatic organisms and human populations. On the contrary, even low exposure levels of As during long periods may cause chronic health disorders due to skin lesions, cardiovascular diseases, and different types of cancer (Palma-Lara et al., 2020; Sinha et al., 2020). The uniform concentrations of As in all stations would also suggest natural background levels or very low anthropogenic inputs, hence requiring further research for possible sources and pathways of As contamination. With the persistence of As in the environment, continued monitoring on levels of As in seafood is an important concern to human consumption of such foods (Huang et al., 2021).

While differences in the Zn and Cu concentrations among the stations, especially the higher values in Station 3, testify to some spatial discrepancies in metal accumulation and sources of contamination, the chances of health risks due to these metals are a concern. However, high concentration of metals like Fe, Zn, and Cu in periwinkle specimens from Elechi Creek in Niger Delta may have serious health implications on aquatic organisms and even human consumers. The contamination of heavy metals in aquatic ecosystems disrupts its functioning, impairs nutrient cycling, reduces biodiversity, and eventually affects health and well-being of both ecosystems and human populations (Silva et al., 2019; Gunturu and Dharmarajan, 2020).

4.2 Concentrations of Hazardous Metals Level in Sediment

The hazardous metal concentration in sediment samples for spatial distribution and variation in Elechi Creek at three different stations of ST1, ST2, and ST3 bear significant value for analysis. Basically, these variations are of prime importance to assess the potential environmental risk and their implications on the health of ecosystems and humans. The data presented shows roughly constant hazardous metal concentrations across both ST1 and ST2, with a slight increase at ST3, especially in Fe, Pb, Cu, and As. Mean concentrations of Fe and Zn were identical among stations; thus, it can be suggested that sediment characteristics are identical or similar sources of pollution are affecting deposition. However, ST3 showed relatively higher mean concentrations of Pb, Cu, and As compared to ST1 and ST2, indicating the possibility of a localized contamination or certain anthropogenic inputs around ST3.

The order in the spatial variations of hazardous metals in concentrations within sediment samples may relate to differences among the stations receiving pollutants from industrial facilities, urban areas, or agricultural activities through direct discharges, runoff, or atmospheric deposition. In the case of the ST3 station, it could be stated that industrial facilities and urban settlements or agricultural lands around the station can also be causes of higher metals in the sediment input, showing a higher concentration of metals than at other stations (Wang et al., 2020; Xiao et al., 2021).

Sediment enriched with such metals may harm benthic organisms, such as sediment-dwelling invertebrates, microorganisms, and aquatic plants (Bellasi et al., 2020). It is also true that toxicity of metals may result in reduced biodiversity, altered community structure, and impaired ecosystem functioning, further affecting nutrient cycling, sediment stability, and habitat quality. Sediment-bound metals can pose risks to human health through direct contact, ingestion, or inhalation during recreational activities, sediment dredging, or sediment resuspension events. Where chronic exposure to such metals like Pb, Cu, and As in sediment can cause various health conditions related to neurological disorders, respiratory problems, and various carcinogenic effects (Anyanwu et al., 2018).

With increasing the concentration of metals in the sediments, its quality and physical properties change more and thus will disturb its habitat suitability for benthic organisms more. Changes in sediment structure and stability could further influence the sediment-water interactions and nutrient dynamics, with implications for oxygen availability, ecosystem processes, and the distribution of sediment-dwelling biota. Such being the case, Xiao et al. (2021) have discussed several concepts of ecosystem engineering. These storms, on the other side, flooding, or even anthropogenic activities inducing sediment resuspension events may transport metals downstream, redistribution in contaminants within the water column, hence impacting water quality and ecological integrity of downstream habitats (Mahamoud et al., 2018). Sediment resuspension can result in the episodic exposure of benthic organisms to higher metal concentrations and act as an ecological stress that could further reduce ecosystem resilience. Chakraborty and Chakraborty (2021) further added that exposing sediment to hazardous metals can have long-lasting effects on the structure, function, and resilience of an ecosystem. However, Anyanwu et al. (2018) suggest that long-term heavy metal contamination in sediments may arise with legacy ecological effects on a community, its dynamics, trophic interactions, and productivity, which change with time.

4.3 Concentrations of Hazardous Metals Level in Surface Water

Metal surface water contamination within the Niger Delta varies significantly as stated in three selected stations of high importance for health and environmental risk assessment due to surface water pollution, especially at Elechi Creek. Station ST1 showed the lowest values of toxic metals such as Fe, Zn, Pb, Cd, Cu, and As compared with Station ST2 and Station ST3. On the other side, Station ST3 has a higher concentration for most metals such as Fe, Zn, Cd, Cu; however, the concentration of Pb and As in this station is close to Station ST1. The dependence of these spatial variations on several factors is very much in the proximity to sources of pollution, rates of water flow and sedimentation, and processes of mixing. Where water flows more slowly or does not flow much at all, there may be higher concentrations of metals compared with bodies of flowing water (Sun et al., 2019; Allajbeu et al., 2020; Aminiyan et al., 2022). According to Taka et al. (2022), the sediment composition differences, like organic matter content, mineralogy, and particle size distribution, may determine the adsorption and desorption and consequent transport of metals in an aquatic environment. Sampling stations with sediment types more prone to metal adsorption may have lower dissolved metal concentrations in the water column.

The spatial disparity in hazardous metal concentrations has great importance from both human health and ecosystem integrity standpoints. It has also been stated severally that toxic metals in surface water with their high concentration can be hazardous to human health through direct contact exposure in recreational areas, ingestion of contaminated drinking water, and contaminated seafood consumption with metals (Safiur et al., 2021). This agreed with Budi et al. (2024), who further reiterated that chronic exposure to metals such as Pb, Cd, and As may cause neurological disorders, damage to the kidneys, and carcinogenic effects. Consequently, some hazardous metals bioaccumulate in sediments, biota, and food webs, leading to ecological disturbances and losses in biodiversity. However, according to Huang et al. (2021), such hazardous metals could bioaccumulate in aquatic organisms and pose risks to their health and survival while biomagnifying along the food chain, influencing higher trophic levels and ecosystem functioning.

The high concentration of toxic metals in surface water, according to Huang et al. (2021), has the potential to disrupt aquatic food chains by actually altering trophic cascades and ecosystem processes. Contaminants like metals change key interactions among species, predation, competition, and resource utilization, which consequently alter community diversity and composition (Safiur et al., 2021). Also, Saidon et al. (2024) stated that cascading effects on ecosystem function and structure, induced by the disappearance of key species or functional groups due to intoxication by metals, may determine the status regarding services provided by aquatic ecosystems. As it has been pointed out by Sánchez-Bayo (2021), this may ensue. According to Ouma et al. (2020), surface water metal contamination leads to habitat degradation and loss of ecological integrity in aquatic ecosystems. During sedimentation, metals deposited within the bed of rivers and estuarine environments reduce benthic habitats, impair substrate quality, and decrease habitat availability for aquatic organisms (Kjelland et al., 2015). Metal contamination may thus impact key water quality parameters like pH, conductivity, and dissolved oxygen, which in turn would impact nutrient cycling and biogeochemical processes in the aquatic ecosystems (Philippot et al., 2021; Palit et al., 2022). Metal-induced eutrophication and hypoxia may further enhance ecological stressors toward a large-scale degradation of ecosystems and loss of biodiversity.

4.4 Bioconcentration Factor (BAF) of Metals in Periwinkles (Tympanotonus fuscatus)

The measured values of the BAF for metals in T. fuscatus from different stations in Elechi Creek have important health implications for aquatic ecosystems and human populations. Higher values of metallic elements like zinc, iron, and copper can be noxious for the ecosystem health in Elechi Creek and may alter the general biodiversity by upsetting the ecosystem dynamics (Amadi et al., 2020; Okwor et al., 2022). Besides, zinc and copper disturb enzymatic activities in aquatic organisms, culminating in metabolic disturbances and reduced reproductive success (Oduro et al., 2021). Iron accumulation leads to oxidative stress and tissue damage, impacting the health of periwinkles and other aquatic species (Babatunde et al., 2023). Ecological perturbations may be cascaded along the food web and affect higher trophic levels and ecosystem resilience.

The high level of metals consumed with the periwinkles constitutes a health hazard to the human consumers, especially the communities who have used seafood from Elechi Creek as a food item (Adetunde et al., 2022). When bioaccumulated in the tissues, it can be a means of exposure to humans consuming them and may lead to adverse effects. Chronic consumption of metals such as lead, cadmium, and arsenic through the ingestion of contaminated periwinkles may thus result in heavy metal toxicity in humans, which is symptomatic of gastrointestinal disorders, neurological impairment, renal dysfunction, and even carcinogenic effects (Saeed et al., 2022).

Periwinkles are an essential source of protein and other nutritional needs in many shore communities' diets. Nutritional risks of consumable metal-contaminated periwinkles may be viewed through the aspects of safety and compromised quality of periwinkles. Nutrient deficiencies or imbalances, such as these, may in turn exacerbate vulnerable populations' health problems (Márquez et al., 2023). The communities that cannot do without seafood as part of their diet, particularly indigenous communities and low-income households relying on subsistence fishing, bear higher health burdens compared to other communities because of metals present. According to Saeed et al. (2022), toxic exposure may

have overall additive effects in its toxicity, and such poor health disparities could add to contributing to socioeconomic issues and generally a poorer quality of life.

4.5 Bioaccumulation Factor (BAF) of Metals in Periwinkles (Tympanotonus fuscatus)

These BAF values of metals in T. fuscatus from Elechi Creek have major implications for health in both ecological integrity and human health. Such differences show the clear varying degree of contamination within the environment, while higher ranges of BAF values provide evidence of ecological risk possibly characterized by habitat degradation, modified community dynamics, and impaired reproductive success in aquatic organisms (Okwor et al., 2022; Márquez et al., 2023). Bioaccumulation of these metals indicates that periwinkles contaminated with high metal levels could pose a serious health risk to the human population dependent upon seafood from Eagle Island Creek. Bioaccumulation in one organism and biomagnification via the food chain exposes humans to toxic metals like lead, cadmium, and arsenic at higher concentrations (Kaur et al., 2021). Chronic exposure to these metals causes neurological disorders, renal dysfunction, cardiovascular diseases, and carcinogenic effects. Metal contamination in periwinkles could deteriorate seafood nutritional quality and, thus, human health (Babatunde et al., 2023). Nutrient needs from periwinkles are largely outweighed by the dangers in metal exposure, as revealed by Nwankwo et al. (2021), leading to nutritional imbalance and deficiency among populations where this occurs, including more vulnerable segments such as children and pregnant women. Communities that depend heavily on seafood for sustenance may bear disproportionate health risks due to metal pollution, particularly low-income and indigenous groups. Prolonged exposure to seafood tainted with metals may worsen existing health inequities, leading to financial hardships and a reduced standard of living (Okwor et al., 2022).

5. CONCLUSION

This study on heavy metal contamination in periwinkles in Elechi Creek, Niger Delta, found significant spatial variation. Higher concentrations of zinc, iron, copper, cadmium, and arsenic were found at Station 3. While cadmium and lead were consistently low, elevated levels of these metals raise potential health and ecological concerns due to bioaccumulation and biomagnification. Periwinkles (T. fuscatus) serve as valuable bioindicators, reflecting aquatic ecosystem contamination levels. The study suggests monitoring metal concentrations in surface water, sediment, and periwinkle tissues, especially in areas affected by industrial and urban runoff. Stricter regulations on industrial and agricultural runoff and remediation methods like sediment dredging and phytoremediation could help mitigate metal contamination. Collaboration between policymakers, scientists, local communities, and stakeholders is crucial for promoting ecosystem health and public safety. Proactive management practices and strong regulatory frameworks are also needed to ensure periwinkles are free of metal pollution. Programs for ongoing observation and remediation may also be necessary.

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