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Research Article

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# Assessment of Heavy Metal Concentrations in Tympanotonus Fuscatus of Escravos Estuary, Niger Delta, Nigeria

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**ABSTRACT**
Surface water pollution is associated with an increased volume of effluent from both geogenic and anthropogenic origins. Information on the impacts of heavy metals (HM) on the fauna species of the Escravos Estuary (EE) is limited. Therefore, this study was conducted to investigate the levels of HM in the stomach and muscles of Tympanotonus fuscatus (T. fascatus). Spatially, the EE was stratified into three stations (D1, D2, D3) based on fish landing sites, while monthly stratification covered February to May 2024. The T. fascatus samples were collected from the intertidal zone. The stomach and muscle contents of T. fuscatus were harvested and preserved in Bouin's fluid. Samples were digested, and concentrations of HM (Pb, Fe, Cr, and Al) in T. fuscatus (mg/Kg) were determined using Atomic Absorption Spectrophotometry. Data obtained were analyzed using descriptive and inferential statistics at $\alpha=0.05$. Spatially, the significantly highest Pb level in the stomach of T. fuscatus ranged from 0.31±0.11 mg/Kg in D1 to 0.53±0.10 mg/Kg in D3. Monthly, February recorded the lowest Pb concentration as 0.18±0.01 mg/Kg, while April recorded the highest as 0.51±0.13 mg/Kg. For Chromium (Cr) in the muscles of T. fuscatus, the highest concentration was recorded in March as 0.49±0.12 mg/Kg, while the lowest was in April as 0.42±0.23 mg/Kg. The relatively higher concentrations of Pb and Cr compared to established limits pose warning signals and could threaten the survival of T. fuscatus in the Escravos Estuary. These results can serve as a baseline reference for further studies.

**Keywords:** Intertidal Zone, Effluents, Fauna Species, Aquatic Pollution

## Introduction

Heavy metals, metallic elements with high atomic weights and densities, can enter the aquatic system through points and non–point sources and accumulate in the aquatic biota [1]. Pollution of the aquatic ecosystem by heavy metals is a major ecotoxicological concern because they are toxic in high concentrations and persist in the aquatic environment even after removing the source of the pollutants [2,3].

Heavy metals can constitute negative impacts through oxidative stress, tissue damage, growth impairment, reproductive dysfunction, DNA damage, and mortality [4]. Some heavy metals (copper, zinc, and iron) are essential for the normal functioning of living organisms at their recommended standard but can become toxic at high concentrations, while others such as mercury, lead and cadmium, have no biological functions and are harmful even at minute concentrations [5,6].

Tympanotonus fuscatus (West African mud creeper) is a species of gastropod mollusk living in brackish water environments [7]. It is the only extant species within the genus Tympanotonus and is characterized by its ability to thrive in fluctuating salinity levels, which is a distinctive adaptation to its habitat [8]. The habitat of T. fuscatus spans across the west coast of Africa, from Nigeria, Angola, Senegal, and Cape Verde [9]. These gastropods are typically found in mangrove swamps along the Escravos Estuary, Lagos Lagoon, where they exhibit amphibious behavior. The salinity in their habitat can vary significantly, from 0.1‰ during the rainy season to 25‰ in the dry season when the habitat dries up.

However, T. fuscatus is exposed to various environmental stressors, such as pollution, habitat degradation, and climate

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change that may affect its health and survival. Heavy metals are major pollutants in the aquatic environment because they are persistently toxic and are of geogenic and anthropogenic origin. It is an important source of food and income for many coastal communities in Nigeria where it is harvested and consumed by millions of people [9]. It is a key component of the aquatic ecosystem, as it plays an essential role in nutrient cycling, sediment stabilization, and food web dynamics [10].

Ecologically, T. fuscatus plays a crucial role as a deposit feeder. It feeds on mud, digesting detritus and other organic matter, which contributes to the nutrient cycling within the ecosystem [7]. This feeding behavior also positions it as an integral part of the food web, serving as a food source for higher trophic levels [7]. Recent research has focused on the bioaccumulation patterns of heavy metals in fish tissues and the associated health hazards in human populations [11].

The Escravos Estuary is a semi-enclosed natural body of water with a free connection to the open sea allowing the dilution of seawater with freshwater derived from land drainage [1]. The morphology of the Escravos Estuary is influenced by both fluvial and marine sources with sediment affected by tides and wave processes [12]. Estuary environmental conditions are dynamic, with the estuary functioning as a transient open system in a 'steady state' through exchanges of energy, water, and sediment with the surrounding systems which contribute to its high nutrient levels, and primary and secondary productivity [13,14].

Estuaries, being transitional zones between freshwater and marine communities, are essentially prone to contamination due to natural processes and anthropogenic activities [15,16]. Recent studies have highlighted the seasonal variation and contamination risk of heavy metals in estuarine fauna species, emphasizing the need for continuous monitoring and assessment of these environments [17,18].

Escravos Estuary is a coastal water body found in the Niger Delta region of Nigeria [19]. It is subjected to severe environmental perturbation which majorly includes oil spills, gas exploration and exploitation, agriculture, and urbanization that have led to the contamination of surface water and sediment with heavy metals [12]. These pollutants alter the water quality, sediment constituents, and biodiversity of the estuary [1]. Information on heavy metal concentrations (Pb, Fe, Cr, and Al) in its fauna species are limited. Therefore, this study was carried out to assess the level of heavy metal in the stomach and muscles of Tympanotonus fuscatus obtained from Escravos Estuary.

## Materials and Methods

### Study Area

Escravos Estuary is located on latitudes 5°37′62″ N and 5°37′16″ N of the equator and longitudes 5°23′69″ E and 5°23′12″ E of the Greenwich meridian (Figure 3.1), while the exact locations of all sampling stations were determined using Garmin GPSMAP eTrex10 type sensors. It is located in a mangrove swamp forest with major identified mangrove species as Rhizophora racemose (red), Avicennia africana (white) mangroves, while its dwellers are mainly fisherfolks [12]. The study area has humid climate, with wet season occurring from March – October and a dry season (November – February). The estuary is influenced by the freshwater input from the Escravos River and the saltwater intrusion from the Atlantic Ocean and supports a rich biodiversity of flora and fauna species.

### Sampling Techniques

The Escravos Estuary was spatially stratified into three stations (D1, D2, D3) based on proximity to key anthropogenic activities. Monthly stratification covered February – May, 2024. The T. fuscatus samples were collected on monthly basis for four months and identified to species level by using standard keys (Fishbase, 2020).

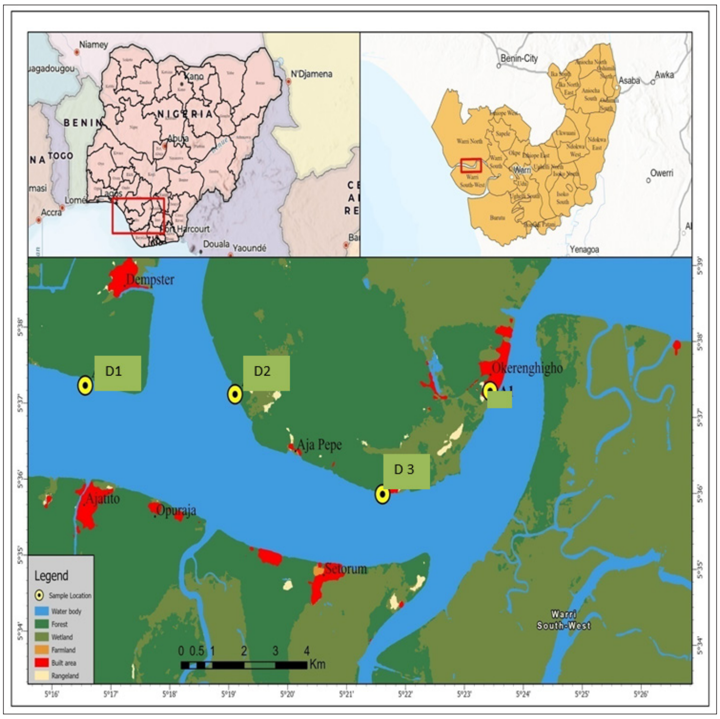


**Figure 1:** Map of study area
Source: Field survey, 2024

**Collection of T. Fuscatus and Preservation of Harvested Tissues (Muscle and Stomach)**
Samples of T. fuscatus were collected from the inter – tidal zone of the Escravos Estuary, while the harvested tissues (muscle and stomach) were preserved in bouin's fluid and taken to the laboratory for further analyses as described by APHA [20].

**Digestion of T. Fuscatus Tissues and Determination of Heavy Metals**
The digestion of T. fuscatus tissues and heavy metal determination was done according to the methods described by Gupta and AOAC as follows: Five grammes (5g) of T. fuscatus stomach and muscle samples were oven-dried at 105 in a Gallenkamp oven to a constant weight [21,22]. The samples were each ground into powdery form with the aid of a pestle and mortar. The powdered samples were further dried to constant weights while 0.5g of each sample was collected for digestion with the aid of an electric sensitive weighing balance. About 0.5g of each sample was placed in a 50 mL conical flask and 20mL of HNO3, 2 mL of H2SO4 and 4 ml of perchloric acid (a catalyst) were added. The samples were each transferred to hot plates in a fume cupboard and heated for one hour at 200 after which the temperature was reduced to 70 and digestion allowed to continue.

The samples which showed black fumes were further acidified with 10 mL of HNO3 and the digestion was allowed to continue until the white fumes of per chloric acid disappeared leaving a clear yellowish solution. The resultant yellowish solutions were allowed to cool and then filtered. The filtrate in the standard volumetric flask was made up to 50 mL mark with distilled water as described by Gupta [21]. Thereafter, heavy metals in T. fuscatus stomach and muscle samples were determined using Atomic Absorption Spectrophotometer (AAS) based on American Public Health Association APHA and American Society for Testing of Materials [20].

**Statistical Analyses**
Data from this study were analysed using descriptive (means and standard deviation) and inferential statistics (one-way ANOVA) by using SPSS (version, 22).

**Results**
Spatially and monthly heavy metal concentrations in the stomach of T. fuscatus are presented in Tables 1 and 2, respectively. Spatially, Chromium recorded the highest concentrations in Stations D3, while Al recorded the least value in Station D2, respectively. Chromium recorded the highest concentrations of heavy metals in April, while the least was Al in March. Concentrations of Pb recorded in February, March and May were lower than recommended values. Concentrations recorded for Al throughout the study were below the recommended limits (0.2mg/Kg) by FEPA and USEPA [11,23].

**Table 1: Spatial Heavy Metal Concentrations in the Stomach of Tympanotonus Fuscatus**

| Heavy Metals | Stations | | | FEPA, (2011) | USEPA, (2009) |
|---|---|---|---|---|---|
| | D1 | D2 | D3 | | |
| Pb (mg/Kg) | 0.46±0.21a | 0.31±0.11b | 0.53±0.10b | 0.5 | 0.3 |
| Fe (mg/Kg) | 0.35±0.27a | 0.39±0.16b | 0.37±0.18a | - | - |
| Cr (mg/Kg) | 0.65±0.44 | 0.71±0.41 | 0.84±0.23 | 0.5 | 0.3 |
| Al (mg/Kg) | 0.17±0.19b | 0.15±0.11a | 0.16±0.23b | 0.2 | 0.2 |

**Table 2: Monthly Heavy Metal Concentrations in the Stomach of Tympanotonus Fuscatus Escravos Estuary**

| Heavy Metals | Months | | | | FEPA, (2011) | USEPA, (2009) |
|---|---|---|---|---|---|---|
| | February | March | April | May | | |
| Pb (mg/Kg) | 0.18±0.01b | 0.25±0.17a | 0.51±0.13a | 0.23±0.54a | 0.5 | 0.3 |
| Fe (mg/Kg) | 0.18±0.20c | 0.14±0.81c | 0.17±0.16a | 0.16±0.12b | - | - |
| Cr (mg/Kg) | 0.98±0.49a | 0.82±0.93a | 0.99±0.74a | 0.52±0.14b | 0.5 | 0.3 |
| Al (mg/Kg) | 0.15±0.13b | 0.11±0.01a | 0.18±0.43a | 0.16±0.11a | 0.2 | 0.2 |

Spatially, the results of heavy metal concentrations in the muscle of Tympanotonus fuscatus Escravos Estuary are presented in Table 3, while monthly concentrations are presented in Table 4, respectively. Spatially, Pb recorded the highest, while the least concentration was Fe in Station D2. Chromium and Pb recorded the highest and least monthly concentrations in April, respectively. Values of Pb, Cr and Al were higher than recommended standards of 0.5mg/K and 0.3mg/Kg by FEPA and USEPA respectively [11,23].

**Table 3: Spatial Heavy Metal Concentrations in the Muscle of Tympanotonus Fuscatus Escravos Estuary**

| Heavy Metals | Stations | | | FEPA, (2011) | USEPA, (2009) |
|---|---|---|---|---|---|
| | D1 | D2 | D3 | | |
| Pb (mg/Kg) | 0.33±0.01 | 0.51±0.14 | 0.32±0.10 | 0.5 | 0.3 |
| Fe (mg/Kg) | 0.30±0.08b | 0.25±0.14b | 0.41±0.21a | - | - |
| Cr (mg/Kg) | 0.45±0.10a | 0.31±0.11b | 0.54±0.22b | 0.5 | 0.3 |
| Al (mg/Kg) | 0.33±0.23b | 0.32±0.01a | 0.31±0.19b | 0.2 | 0.2 |

**Table 4: Monthly Heavy Metal Concentrations in the Muscle of Tympanotonus Fuscatus Escravos Estuary**

| Heavy Metals | Months | | | | FEPA, (2011) | USEPA, (2009) |
|---|---|---|---|---|---|---|
| | February | March | April | May | | |
| Pb (mg/Kg) | 0.35±0.11b | 0.45±0.29a | 0.46±0.23a | 0.43±0.14a | 0.5 | 0.3 |
| Fe (mg/Kg) | 0.39±0.19b | 0.31±0.01b | 0.45±0.16a | 0.31±0.22b | - | - |
| Cr (mg/Kg) | 0.48±0.21a | 0.42±0.23a | 0.49±0.12a | 0.29±0.10b | 0.5 | 0.3 |
| Al (mg/Kg) | 0.26±0.16b | 0.36±0.10a | 0.35±0.12a | 0.32±0.03a | 0.2 | 0.2 |

## Discussion

### Heavy Metal in the Stomach and Muscle of Tympanotonus Fuscatus

The Pb (lead) concentrations in the stomach of Tympanotonus fuscatus were significantly higher than both FEPA's and USEPA's values (0.2 mg/Kg) by a factor of 4.7. The standard deviation (±0.11 mg/Kg) indicates a relatively narrow range of variation, suggesting significant Pb contamination in the estuary's food web. This poses ecological and health risks, as Pb can accumulate in organisms, leading to biomagnification. Consequently, the contamination of the food chain could potentially affect humans [24].

Elevated concentrations of chromium (Cr) in the muscle tissue of T. fuscatus from the Escravos Estuary present considerable concerns for the health of the organism, the ecosystem, and human consumers [25]. This accumulation signifies Cr's bioavailability and its potential for biomagnification within the food chain [26]. Chromium toxicity can result in oxidative stress and DNA damage in aquatic organisms, potentially weakening the immune system of T. fuscatus and increasing its susceptibility to diseases [4,27].

Chromium is a known carcinogen, and prolonged consumption of T. fuscatus with high Cr levels may increase the risk of cancer [14]. This poses a significant health risk to human consumers who rely on these organisms as a food source [28,29]. Heavy metal pollution in aquatic systems is a major ecotoxicological concern due to the high toxicity of these metals at elevated concentrations and their persistence in surface water, even after the removal of the pollution source [30-32]. The presence of high Cr levels in T. fuscatus highlights the ongoing contamination issues in the Escravos Estuary.

## Conclusion

The elevated concentrations of Pb (lead) and Cr (chromium) in T. fuscatus from the Escravos Estuary pose significant risks to the organism, the broader ecosystem, and human consumers. The high levels of these heavy metals indicate severe contamination, which can lead to bioaccumulation and biomagnification, causing oxidative stress, DNA damage, weakened immune systems, and increased cancer risks. Addressing this contamination is crucial to protect aquatic life and ensure the safety of food sources for humans.

## Recommendations

Based on the results from this finding, regular monitoring, ecological assessments, evaluation of Escravos Estuary's health and regular policy review should be done to inform management decisions.

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