Medicine and Health Sciences
2025, Vol. 1, No. 1, pp. 8–13
https://doi.org/10.11648/j.mhs.20250101.12

Research Article

Heavy Metal Bioaccumulation and Metal Induced Pathologies in the Mangrove Oyster, *Crassostrea tulipa*, Adanson (1757), from a Shipyard in Ojo Lagos Nigeria

Olarinmoye Oluwatosin[1, *], Ola Olawale Olawumi[2]

[1]Department of Fisheries, Faculty of Science Lagos State University, Lagos, Nigeria
[2]Department of Veterinary Pathology, University of Ibadan, Ibadan, Nigeria

Abstract

This study investigates the concentrations of six metals in oyster specimens collected from a novel location in Ojo, Lagos, Nigeria. The analysis focused on six priority heavy metals: Arsenic (As, Cadmium (Cd), Cobalt (Co), Chromium (Cr), Nickel (Ni), Lead (Pb) and, Mercury (Hg). Heavy metal concentrations in specimens showed low to moderate variability and, generally exceeded statutory acceptable limits on comparison. A health risk assessment was done to evaluate consumption risk for development of non-cancer conditions with sustained ingestion. This study also reports histopathological findings from the harvested oyster tissues, revealing significant alterations in the digestive gland structure. Notably, atrophy, coagulative necrosis of basal cell epithelium, and, haemocyte infiltration. The lesions suggest potential adverse effects of heavy metal accumulation on oyster health. The potential implications of heavy metal accumulation for organismal. ecosystem and, consumer health are discussed.

Keywords

C. tulipa, Consumption Risk, Bioaccumulation, Pathology

1. Introduction

Clean Water is an essential of life. Heavy metals (HM) are a well-documented class of persistent aquatic pollutants. While minute amounts of metals are relatively common in water, resulting from natural rock weathering, and other natural attritive water-rock processes and deposition of atmospheric salts in surface waters [1]. Some metals including iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), cobalt (Co), and, nickel (Ni), molybdenum (Mo) and selenium (Se), are deemed essential to the sustenance of life. Non-essential metals as the appellation suggests, including the priority heavy metals (HM) Arsenic, Cadmium Chromium lead, mercury, are neither required nor, beneficial, being toxic even at low concentrations making them frankly detrimental to ingesting and exposed life forms at any but the most minute statutorily mandated concentrations. The persistence of harmful metals in coastal waters is driven by human activities including heightened exploitative activity, urbanisation and water based recreational and, other activities including watercraft fabrication, repair and, ship breaking. These insidious anthropogenic heavy metal inputs and the activity mediated hydro-alluvial

*Corresponding author: pisxs22@gmail.com (Olarinmoye Oluwatosin)

Received: 4 March 2025; **Accepted:** 3 November 2025; **Published:** 9 December 2025

mobilisation of sediment sequestered heavy metals sustain elevated HM levels around locations where such activities as suggested are commonplace. Their suggested pernicious toxicity to humans is especially conceivable within realistic scenarios of bioaccumulation and magnification [2, 3] in more sedentary aquatic animals such as some invertebrate orders such as the Ostreoida which are a globally significant food resource [4] commonly consumed as food by humans. HM contaminated oysters thus constitute sources of potential HM toxicity and disease outcomes to consumers even in trace amounts [5] especially in particularly susceptible groups such as children and pregnant women. If consumed regularly over the course of a lifetime.

Crassostrea tulipa belongs to the family Ostreidae (true oysters) whose members consist of several species consumed as seafood worldwide. The organism is readily found seasonally along the west coast of Africa between Senegal and Angola, and commonly in Lagos, Nigeria [6]. It is a component of the characteristically, largely fish diets of artisanal fishing communities in and around the Lagos lagoon, Where It is found in sediments and, attached the roots of mangrove trees [7] rocks, debris ship hulls etc. Harvested by hand during low tidal ebbs, and, and eaten alongside other plant food staples and fish. The organism thus represents an important part of the protein complement of fishing community diets [8]. The organisms' 'sedentary habitual biology, makes it readily collectible. The city of Lagos, by its situation is surrounded by water, and there is consequently a high level of maritime activity in the form of ports, water transport, recreation and watercraft fabrication and maintenance. As The Lagos lagoon is the ultimate recipient and sinkhole of a myriad of anthropogenic domestic industrial and sundry wastes dumped largely indiscriminately in a continuous daily stream. It is conceivable that the latter water based economic and, recreational activities would be significant contributors to anthropogenic contamination of the lagoon. The implications for ecosystem and organismal health can only be conjectured, which makes preemptive, exploratory, in-situ detection, and quantification studies using local aquatic fauna as bio monitors for heavy metals temporally pertinent. Bivalves have the desired qualities for utility as bio indicators and have been used as such in many studies [9]. This investigation seeks to document the concentrations of some heavy metals of food safety concern, estimate consumption risk(s), and, in addition, estimate organismal health of a resident oyster population, in this important but largely unmonitored fishery resource in Lagos Nigeria.

2. Materials and Methods

2.1. Specimen Collection

Specimen collection, live specimens of *Crassostrea tulipa* were collected from a location close to a disused shipyard (Figure 1). In the environs of Ojo, Lagos Nigeria. (Figure below). Specimens were embedded in crushed ice in portable coolers for transport to the laboratory. Intact oysters were scrubbed and rinsed with distilled water prior to soft tissue extraction.

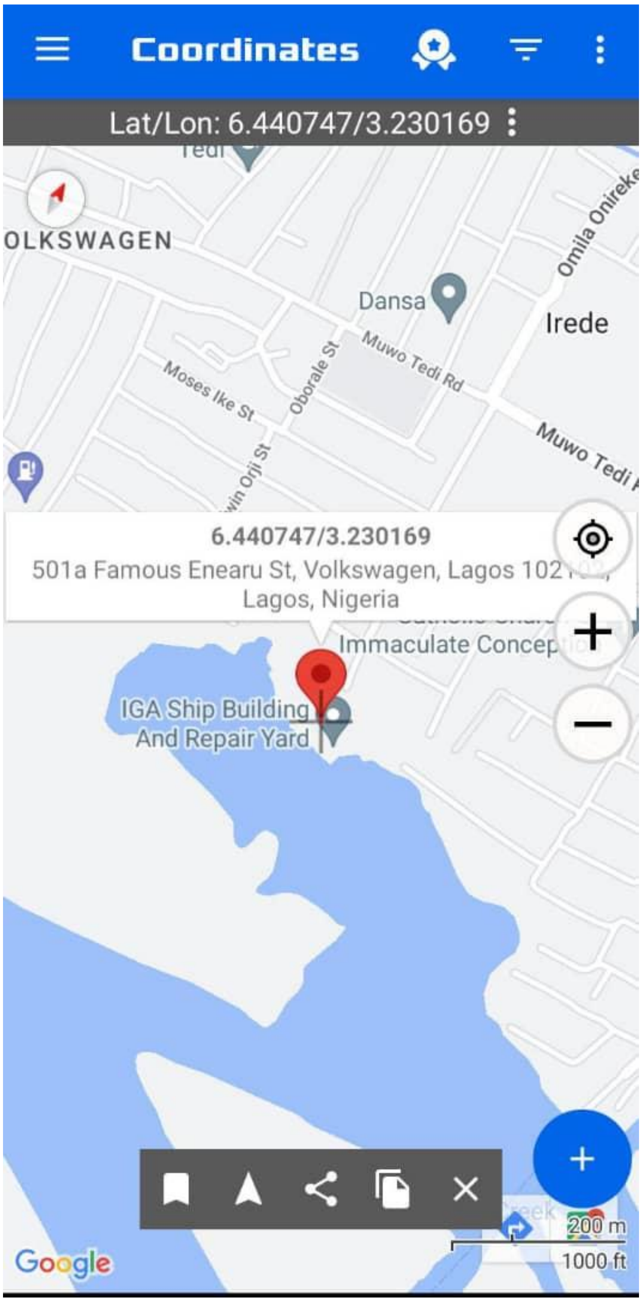

Figure 1. *Map of study location.*

2.2. Heavy Metal Quantitation Procedures

Soft oyster tissue was removed after opening the shells by severing the adductor muscles and dried in an oven at 60 ℃ for 5 h. Thereafter the samples were allowed to cool to ambient laboratory temperature, in a desiccator. 0.5 g of the dried tissue samples were weighed into labelled porcelain crucibles, and ignited in a muffle furnace at 450 ℃ for 3 h, or until ashed.

The crucible residues were allowed to cool and then separately dissolved in 1 ml of concentrated nitric acid. Each solution was then diluted to 50 ml, in a volumetric flask, with distilled water. The Resulting solutions were then filtered through Whatman® quantitative filter paper, ashless, Grade 42. And, saved for later determination of the metals by Inductively Coupled Plasma- optical emissions spectrometry using an Agilent 5800 ICP-OES, 710 Series machine with a wavelength range of 167–785 nanometers running the Agilent ICP Expert Software suite. Standard multi-element calibration solutions of the metals (0.05 - 10.0 mg/L, each) were prepared for the ICP-OES calibration curves. The solutions were prepared from the stock standard reference solution of each individual metal (1000 µg/ml), by appropriate dilution in volumetric flasks, with deionized water.

2.3. Consumer Risk Evaluations

Food safety implications of measured metal concentrations was assessed using the following indices: the Estimated Daily ingestion rate (IR), Hazard Quotient (HQ) and, Hazard index (HI) with Reference Dose (Rfd) recommendations from the USEPA, ATSDR and, literature.

Assumptions: Body Weight (BW): 70 kg (average adult). Estimated Daily Ingestion Rate (IR): 50 grams per person per day.

2.4. Histopathological Evaluations

A subsample (9 specimens), was selected for the establishment of micro pathologies occasioned by prolonged oyster exposure to the heavy metals assayed among others. Standard histological preparatory steps including immersion in formalin, graded dehydration, embedment in wax, microtomy, and staining with H&E were done. Resulting sections were viewed at a magnification of x400 using a light microscope equipped with a camera.

3. Results

Table 1 lists means with standard deviations of measured heavy metal concentrations in the soft tissue of *C. tulipa*.

Table 1. *Summary of measured population metal concentrations.*

Metal	Mean mg/kg	SD
Arsenic	0.384	0.145
Cadmium	6.987	3.738
Chromium	27.942	13.522
Cobalt	4.018	9.842
Lead	0.698	0.936
Mercury	0.308	0.116

Table 2. *Summary of risk assessment computations.*

Metal	EDI* mg/kg/day	HQ**	Rfd mg/kg/day	Hazard Index (HI)***
Arsenic	0.00002304	0.384	0.00006	14.49
Cadmium	0.537999	6.987	0.0077	
Chromium	0.083826	2.7942	0.003	
Cobalt	0.12054	4.018	0.03	
Lead	4.018	0.002792	0.004	
Mercury	0.0000154	0.308	0.00005	

Key: EDI*estimated daily intake: metal concentration x reference individual weight of 50 kg.
HQ**Hazard quotient: Estimated Daily Intake (EDI) / reference Dose.
HI***Hazard index: ∑HQ for each metal (for evaluation of noncancer risk.

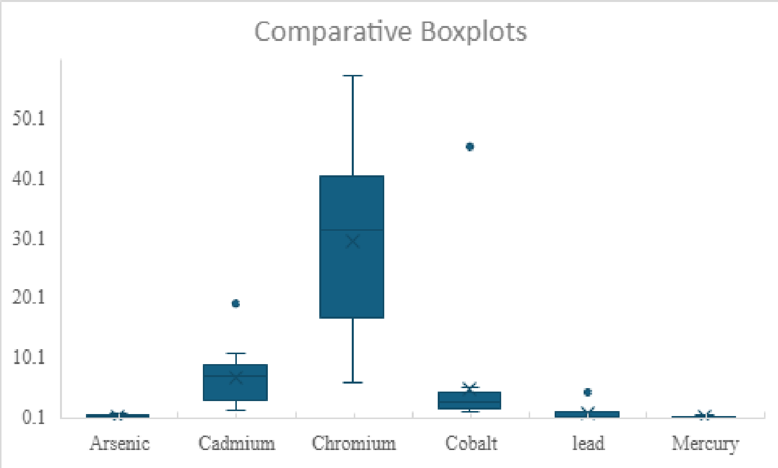

Figure 2. *Comparative boxplot depicting population metal concentrations.*

Correlation analyses revealed moderate to very weak correlatory relationships $p > 0.05$ between individual specimen weights and metal concentrations in deceasing order AS>CR>HG (Table 3). CHECK.

Table 3. *Matrix depicting correlations between metal concentrations and specimen weights.*

	Weight (gr.)	Arsenic	Cadmium	Chromium	Cobalt	Lead	Mercury
Weight (gr.)	1						
Arsenic	0.508668	1					
Cadmium	0.487233	0.313706	1				
Chromium	0.320481	0.009638	0.334647	1			
Cobalt	-0.22726	0.037551	0.144613	0.299367	1		
Lead	0.075322	0.252256	0.144642	-0.32124	-0.06379	1	
Mercury	0.173029	-0.07355	0.168535	0.390218	-0.16835	-0.20089	1

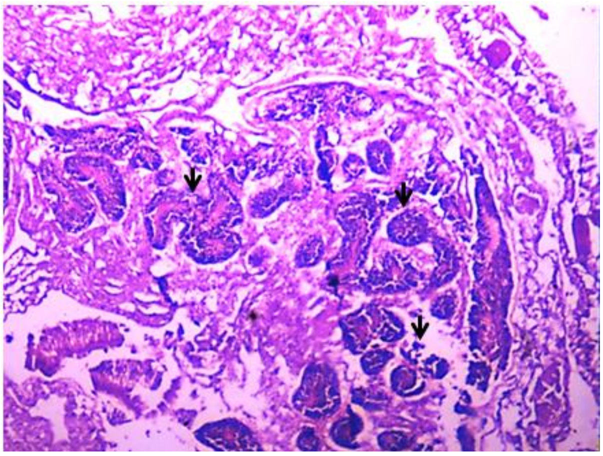

Figure 3. *Digestive gland- There is atrophy of digestive tubules and coagulation necrosis of the epithelium. HE x400.*

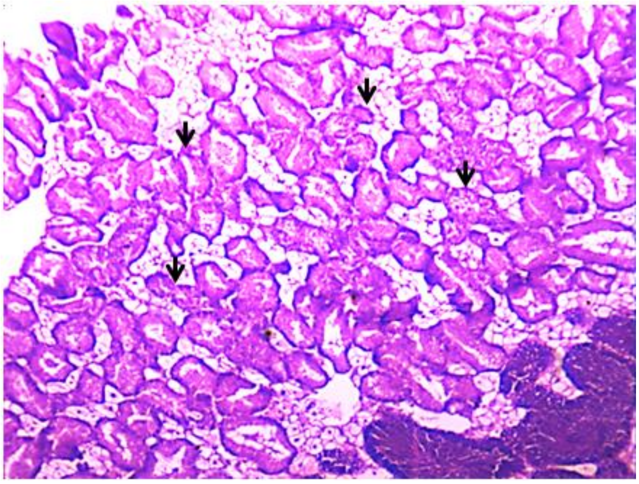

Figure 4. *Digestive gland – there is atrophy of digestive tubules (arrows), degeneration of basal cells with moderate infiltration of haemocytes. HE x400.*

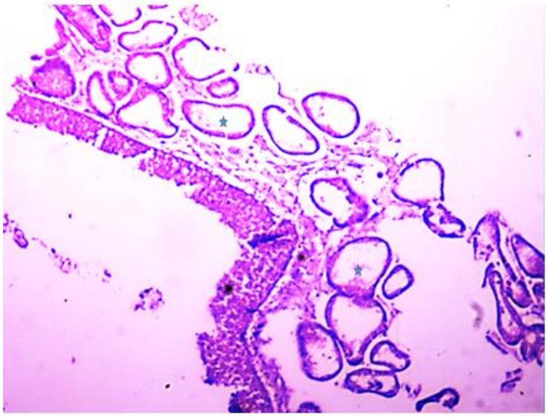

Figure 5. *Digestive gland- Ectasia of digestive tubular lumen (blue asterisks). H&E x400.*

4. Discussion

Heavy metals (HM) - a more mobile substrate where metals exhibit significant changes in behaviour and bioavailability [10] compared to the terrestrial. The latter sustained input cum mobilisation processes ensure and, sustain higher than usual metal concentrations around human habitations and sites of industrial and metallurgic activities, including shipyards bioavailability [11, 12].

It is thus conceivable that aquatic lifeforms, with their well-established bioaccumulatory potential especially, the more habitually sedentary ones in such locations will have quite elevated metal levels due to the activity sustained inputs and, maintenance of already existing base concentrations. Which could be toxic to these considering the various insidious HM entry modes described with adverse effects heightened with increasing concentrations of metals [13]. In addition the pernicious deleterious effects of heavy metal ingestion of heavy metals in humans following prolonged exposure to elevated levels are well documented [14, 15]. Thus health risk assessments of metals serve as a crucial tools for the estimation of potential consumption risks the overall exposure of populations in a specific location. In this study, Summary individual metal concentrations were high (Table 1) and consumer risk indices (Table 2) recorded exceeded permitted prescribed safe limits by several regulatory institutions, including the Usepa, FAO, WHO and, NAFDAC. Correlation analysis of individual weight and metal concentrations showed that weight has a moderate correlation only with cadmium concentration, suggesting larger specimens bio accumulate more of this specific element which incidentally had the highest computed hazard quotient value, suggesting a real intoxication risk for Cadmium with sustained consumption. The correlations between weight and the concentrations of arsenic, chromium, cobalt, lead, and mercury are all weak (Figure 2) suggesting minimal direct relationships. The calculated Hazard Index (HI) 14.49 (, which is exponentially greater than 1, indicates a frank health risk from the combined exposure to multiple heavy metals in the oysters from this location at a daily ingestion rate of 50 grams per person per day for extended periods.

The histopathological examination of harvested oyster tissues provided information on the potential impacts of heavy metal contamination in denizen oysters. The observed atrophy and coagulative necrosis of the basal cell epithelium in the digestive glands indicate significant cellular damage and tissue reaction to injury, which can impair the oyster's ability to process food and eliminate waste efficiently. Random degeneration of the tubules, coupled with ectasia of the digestive lumen, suggests that the structural integrity of the digestive system is compromised, potentially leading to reduced overall fitness and survival of these organisms from the studied environment. Furthermore, the infiltration of haemocytes observed alongside degeneration of basal cells points to an inflammatory response triggered by heavy metal exposure. This immune reaction is indicative of stress and can have cascading effects on the oyster's health, impacting growth, reproduction, and resilience against pathogens. The overall findings reiterate the importance of monitoring heavy metal concentrations and the utility of oysters as bioindicators of environmental health and potential risks to ecosystems and human consumers.

5. Conclusion

In the light of these findings, it is imperative to consider the implications for human health, especially for communities relying on oysters from this and, adjoining locations as a perennial food source. The presence of significant histopathological alterations in conjunction with elevated metal concentrations calls for a thorough risk assessment and potential reevaluation of consumption advisories for oysters harvested from the Ojo and, similar regions. These findings highlight the need for continued surveillance, monitoring and stricter management strategies to mitigate the impact of heavy metal pollution on marine life and public health.

Abbreviations

HM	Heavy Metals
PTE	Potentially Toxic Element
IR	Estimated Daily Ingestion Rate
HQ	Hazard Quotient
HI	Hazard Index
Rfd	Reference Dose
BW	Body Weight
USEPA	US Environmental Protection Agency
FAO	Food and Agricultural Organisation
WHO	World Health Organisation
NAFDAC	National Agency for Food and Drug Administration and Control

Author Contributions

Olarinmoye Oluwatosin: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Singh V., G. Ahmed, et al., 2024, Toxic heavy metal ions contamination in water and their sustainable reduction by eco-friendly methods: isotherms, thermodynamics and kinetics study. Sci Rep 14(1), 7595. https://doi.org/10.1038/s41598-024-58061-3

[2] Liu J., L. Cao, et al., 2017, Bioaccumulation of heavy metals and health risk assessment in three benthic bivalves along the coast of Laizhou Bay, China. Marine Pollution Bulletin 117(1), 98-110. https://doi.org/10.1016/j.marpolbul.2017.01.062

[3] Aslam S., M. W. H. Chan, et al., 2020. A comprehensive assessment of environmental pollution by means of heavy metal analysis for oysters' reefs at Hab River Delta, Baluchistan, Pakistan. Mar Pollut Bull 153, 110970. https://doi.org/10.1016/j.marpolbul.2020.110970

[4] Botta R., F. Asche, et al., 2020. A review of global oyster aquaculture production and consumption. Marine Policy 117, 103952. https://doi.org/10.1016/j.marpol.2020.103952

[5] McMurtrie S., 2015, Heavy Metals in Christchurch Fish and Shellfish. In: Canterbury. E. (Ed.). Christchurch NZ. EOS Ecology Shelley McMurtrie.

[6] Nicklès M., 1950, Mollusques testacés marins de la côte occidentale d'Afrique. Manuels Ouest-Africains 2012.

[7] Ansa E. J., 2007. Fishery and Culture Potentials of the Mangrove Oyster (Crassostrea tulipa) in Nigeria. Research Journal of Biological Sciences. 2(4). 392-394. https://doi.org/10.1007/978-3-319-06388-1_6

[8] Ajana A. M., 1980, Fishery of the mangrove oyster, Crassostrea tulipa, Adanson (1757), in the Lagos area, Nigeria. Aquaculture 21(2), 129-137. https://doi.org/10.1016/0044-8486(80)90021-6

[9] Zuykov M., E. Pelletier, et al., 2013, Bivalve mollusks in metal pollution studies: From bioaccumulation to biomonitoring. Chemosphere 93(2), 201-208. https://doi.org/10.1016/j.chemosphere.2013.05.001

[10] Islam M. S., M. K. Ahmed, et al., 2015, Heavy metal pollution in surface water and sediment: A preliminary assessment of an urban river in a developing country. Ecological Indicators 48, 282-291. https://doi.org/10.1016/j.ecolind.2014.08.016

[11] Srinivasa Reddy M., S. Basha, et al., 2005, Seasonal distribution and contamination levels of total PHCs, PAHs and heavy metals in coastal waters of the Alang–Sosiya ship scrapping yard, Gulf of Cambay, India. Chemosphere 61(11), 1587-1593.. https://doi.org/10.1016/j.chemosphere.2005.04.093

[12] Neşer G., D. Ünsalan, et al., 2008, the shipbreaking industry in Turkey: environmental, safety and health issues. Journal of Cleaner Production 16(3), 350-358. https://doi.org/10.1016/j.jclepro.2006.08.018

[13] Long E. R., D. D. Macdonald, et al., 1995, Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management 19(1), 81-97. https://doi.org/10.1007/BF02472006

[14] Jaishankar M., T. Tseten, et al., 2014, Toxicity, mechanism and health effects of some heavy metals. Interdiscip Toxicol 7(2), 60-72. https://doi.org/10.2478/intox-2014-0009

[15] Jomova K., S. Y. Alomar, et al., 2025, Heavy metals: toxicity and human health effects. Archives of Toxicology 99(1), 153-209. https://doi.org/ 10.1007/s00204-024-03903-2