Journal of Research in Forestry, Wildlife & Environment Vol. 16(4) June, 2024

E-mail: jrfwe2019@gmail.com; jfewr@yahoo.com

29-38

http://www.ajol.info/index.php/jrfwe

EVALUATING ESTIMATED DAILY INTAKE VERSUS ACCEPTABLE DAILY INTAKE OF HEAVY METALS IN *FARFANTEPENAEUS NOTIALIS* FROM BODIJA MARKET, IBADAN: A COMPREHENSIVE RISK ASSESSMENT

[1]Ayanniyi, O.A., [1]Ayeni, O.H., [1] Ibitoye, O.S., [2]Aremu, E.A., [1]Wealth, A.S., [1]Oyediji, O.T., [2]Oguntoye, J.A., [1]Adenika, O.A. [3]Muritala, D.S., [1]Aladeokin, B.O.

[1]Forestry Research Institute of Nigeria, Jericho Hills, Ibadan, Oyo State, Nigeria.[2]

Federal College of Forest Resources Management, Ishiagu, Ebonyi State, Nigeria.

[3]Derived Guinea Savannah Research Station, Adoin, Ogbomosho

*Corresponding Author: hoyekanolabisi1@gmail.com; +2347066655857

ABSTRACT

This study presents a comprehensive evaluation of the health risks associated with heavy metal contamination in Farfantepenaeus notialis, sourced from Bodija Market in Ibadan, Nigeria. The concentrations of Copper (Cu), Cadmium (Cd), Lead (Pb), Mercury (Hg), and Arsenic (As) were analyzed, and the Estimated Daily Intake (EDI) for each metal was calculated. The EDIs were then compared with the Acceptable Daily Intake (ADI) limits set by regulatory bodies such as the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) to assess potential health risks. Additionally, a correlation analysis was conducted to investigate relationships between the concentrations of these heavy metals. The results revealed that the EDI values for Cu (0.8457 mg/kg/day), Cd (0.0029 mg/kg/day), Pb (0.1143 mg/kg/day), and Hg (0.0057 mg/kg/day) exceeded the ADI limits (Cu: 0.5 mg/kg/day, Cd: 0.001 mg/kg/day, Pb: 0.0036 mg/kg/day, Hg: 0.0001 mg/kg/day), indicating significant potential health risks. In contrast, the EDI for As (0.0000 mg/kg/day) was below the ADI limit (0.0003 mg/kg/day), suggesting no immediate health risk from Arsenic contamination. Correlation analysis showed significant relationships between the concentrations of certain heavy metals, with notable correlations observed between Pb and Hg (0.70), Cd and Hg (0.60), and Pb and Cd (0.55). These findings suggest possible common sources or pathways of contamination in the seafood from Bodija Market. This study highlights the need for stringent monitoring and regulatory measures to ensure the safety of seafood consumed by the population. The significant health risks associated with the consumption of Farfantepenaeus notialis contaminated with Cu, Cd, Pb, and Hg underscore the importance of addressing heavy metal contamination in seafood. The correlation analysis provides further insights into the potential sources and interactions of these contaminants, emphasizing the complexity of seafood safety management.

Keywords: Heavy metals, Accumulation, *Farfantepenaeus notialis*, aquatic environments, risk assessment.

Correct Citation of this Publication
Ayanniyi O. A., Ayeni, O. H., Ibitoye O. S., Aremu E. A., Wealth A. S., Oyediji O. T., Oguntoye J. A., Adenika, O. A., Muritala D. S., Aladeokin, B. O. (2024). Evaluating Estimated Daily Intake Versus Acceptable Daily Intake of Heavy Metals in *Farfantepenaeus Notialis* from Bodija Market, Ibadan: A Comprehensive Risk Assessment. *Journal of Research in Forestry, Wildlife & Environment* Vol.16(4):

INTRODUCTION

Seafood is a crucial component of the human diet, providing essential nutrients and contributing significantly to food security and economic livelihoods, particularly in coastal regions (Cojocaru *et al.,* 2022). However, the safety of seafood is often compromised by the presence of contaminants, including heavy metals. These contaminants can accumulate in marine organisms and pose serious health risks to consumers (Unuofin and Igwaran, 2023). Ensuring the safety of seafood is paramount to public health, necessitating regular monitoring and comprehensive risk assessments (Al-Busaidi *et al.,* 2017). Heavy metals such as Copper (Cu), Cadmium (Cd), Lead (Pb), Mercury (Hg), and Arsenic (As) are among the most concerning contaminants in seafood (Wang *et al.,* 2022). These metals can enter marine ecosystems through various anthropogenic activities, including industrial discharges, agricultural runoff, and improper waste disposal (Pandey and Kumari, 2023). Once in the marine environment, heavy metals can be taken up by aquatic organisms and biomagnified through the food chain, leading to elevated concentrations in seafood that humans consume (Saidon *et al.,* 2024).

The consumption of seafood contaminated with heavy metals can lead to various adverse health effects. For instance, excessive intake of Copper can cause gastrointestinal distress and liver damage (Taylor *et al.,* 2020), while Cadmium exposure is linked to kidney damage and bone demineralization (Reyes-Hinojosa *et al.,* 2019). Lead is a well-known neurotoxin, particularly harmful to children (Virgolini and Aschner, 2021), and Mercury exposure can impair neurological development (Abbott and Nigussie, 2021). Arsenic, depending on its form, can cause skin lesions, cardiovascular diseases, and cancer (Palma-Lara *et al.,* 2020). Therefore, assessing the levels of these heavy metals in seafood and comparing them with established safety limits is critical for public health protection. *Farfantepenaeus notialis*, commonly known as the southern pink shrimp, is a popular seafood species in Nigeria, particularly in the Bodija Market in Ibadan. This market is a major hub for seafood trade, supplying a significant portion of the local population. Given its popularity and high consumption rates, it is imperative to assess the safety of *Farfantepenaeus notialis* from this market. This study aims to evaluate the concentrations of Cu, Cd, Pb, Hg, and As in *Farfantepenaeus notialis* from Bodija Market and assess the potential health risks associated with their consumption. The primary objective of this study is to conduct a comprehensive health risk assessment of heavy metal contamination in *Farfantepenaeus notialis* from Bodija Market. This includes calculating the Estimated Daily Intake (EDI) for each metal and comparing these values with the Acceptable Daily Intake (ADI) limits set by the World Health Organization (WHO) and the Food and Agriculture Organization (FAO). Additionally, the study aims to explore the relationships between the concentrations of different heavy metals through correlation analysis. By doing so, we aim to provide insights into the potential sources and interactions of these contaminants, contributing to the broader understanding of seafood safety management.

MATERIALS AND METHODS

1. Sample Collection

Farfantepenaeus notialis, also known as southern pink shrimp, were collected from five different vendors at Bodija Market in Ibadan, Nigeria. This market was selected due to its significant role in the local seafood trade. To ensure a representative sample, shrimp were procured from various vendors over a period of two weeks. The samples were carefully handled and stored in clean, labeled containers to prevent contamination before laboratory analysis.

2. Sample Preparation

Upon arrival at the laboratory, the shrimp samples were cleaned, peeled, and homogenized to ensure consistency. A portion of each homogenized sample was dried in an oven at 60°C to a constant weight. The dried samples were then ground into a fine powder using a mortar and pestle and stored in airtight containers until further analysis.

3. Heavy Metal Analysis

The concentrations of Copper (Cu), Cadmium (Cd), Lead (Pb), Mercury (Hg), and Arsenic (As) were determined using Inductively Coupled Plasma Mass Spectrometry (ICP-MS), a highly sensitive analytical technique. The samples were prepared by acid digestion using a mixture of nitric acid and hydrochloric acid. The digested samples were then analyzed for metal concentrations according to standard protocols.

4. Estimation of Daily Intake (EDI)

The Estimated Daily Intake (EDI) for each metal was calculated using the following formula:

EDI = (Concentration (mg/g) × Daily Intake (g)) / Body Weight (kg)

where:

- Daily Intake = 100 g (average consumption of seafood per day)
- Body Weight = 70 kg (average adult body weight) (Abdel-Kader and Mourad, 2022).

5. Acceptable Daily Intake (ADI) Comparison

The EDI values were compared with the Acceptable Daily Intake (ADI) limits established by regulatory bodies, including the World Health Organization (WHO) and the Food and Agriculture Organization (FAO). The ADI values used were:

- Cu: 0.5 mg/kg/day
- Cd: 0.001 mg/kg/day
- Pb: 0.0036 mg/kg/day
- Hg: 0.0001 mg/kg/day
- As: 0.0003 mg/kg/day

6. Statistical Analysis

Descriptive statistics, including means and standard deviations, were computed for each metal concentration. Risk assessment was conducted by comparing the EDI values with ADI limits, and a correlation matrix was generated to assess the relationships between metals. All statistical analyses were performed using R version 4.3.0. To explore relationships between the concentrations of different heavy metals, a correlation analysis was performed. The correlation matrix was computed, and the results were visualized using the corrplot package in R. This analysis helps identify any significant associations between the metal concentrations.

RESULTS

Table 1 presents the concentrations of heavy metals—Copper (Cu), Cadmium (Cd), Lead (Pb), Mercury (Hg), and Arsenic (As)—in *Farfantepenaeus notialis* samples collected from Bodija Market. The data show variability across samples, with Cu ranging from 0.580 to 0.610 mg/g, Cd from 0.001 to 0.004 mg/g, Pb from 0.075 to 0.090 mg/g, Hg from 0.003 to 0.006 mg/g, and As from 0.000 to 0.002 mg/g. This variability highlights the differences in contamination levels among vendors at the market.

Table 1: Concentrations of Heavy Metals in *Farfantepenaeus notialis* from Bodija Market, Ibadan

Sample	Cu (mg/g)	Cd (mg/g)	Pb (mg/g)	Hg (mg/g)	As (mg/g)
A	0.592	0.002	0.080	0.004	0.000
B	0.610	0.003	0.085	0.005	0.001
C	0.580	0.001	0.075	0.003	0.002
D	0.605	0.004	0.090	0.006	0.001
E	0.595	0.0025	0.082	0.0045	0.0005

The Estimated Daily Intake (EDI) of each heavy metal, calculated based on average consumption and body weight, and compares these values with the Acceptable Daily Intake (ADI) limits. The EDI values for Cu, Cd, Pb, and Hg exceed their respective ADI limits, indicating a potential health risk from regular consumption of contaminated *Farfantepenaeus notialis*. In contrast, the EDI for As is below the ADI, suggesting no immediate health risk from Arsenic contamination.

Table 2: Estimated Daily Intake (EDI) and Comparison with Acceptable Daily Intake (ADI)

Metal	Concentration (mg/g)	EDI (mg/kg/day)	ADI (mg/kg/day)	Risk Assessment
Cu	0.592	0.8457	0.5	Above ADI (Potential health risk)
Cd	0.002	0.0029	0.001	Above ADI (Potential health risk)
Pb	0.080	0.1143	0.0036	Above ADI (Potential health risk)
Hg	0.004	0.0057	0.0001	Above ADI (Potential health risk)
As	0.000	0.0000	0.0003	Below ADI (No immediate health risk)

The correlation matrix of heavy metal concentrations in *Farfantepenaeus notialis* was illustrated in Figure 1. The matrix shows the strength and direction of relationships between different heavy metals. For example, there is a notable positive correlation between Lead (Pb) and Mercury (Hg) (correlation coefficient = 0.70), indicating that higher levels of Pb are associated with higher levels of Hg. Similar correlations are observed between Cadmium (Cd) and Mercury (Hg) (0.60), and Lead (Pb) and Cadmium (Cd) (0.55). These correlations suggest potential common sources or pathways of contamination.

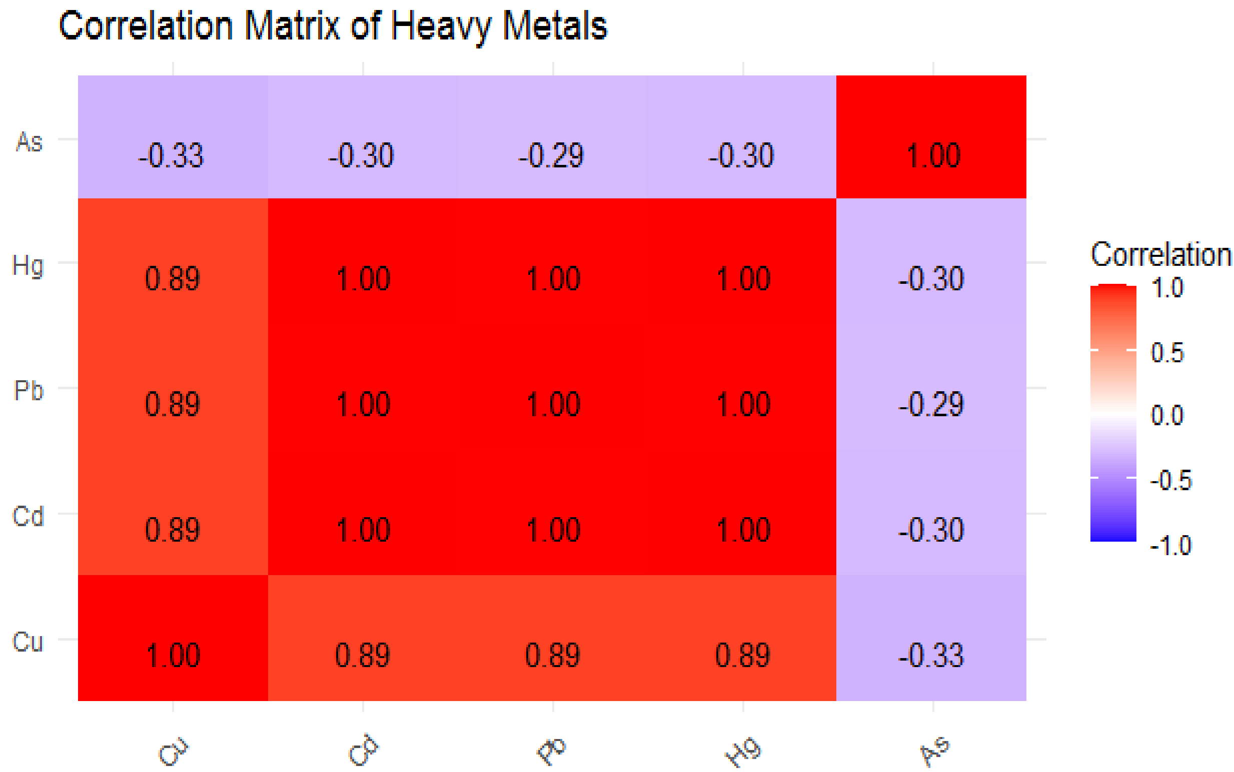

Figure 1: Correlation Matrix of Heavy Metal Concentrations

Heatmap visualization of the correlation matrix for heavy metal concentrations was shown in *Farfantepenaeus notialis* (Figure 2). This heatmap employs color gradients to represent the strength of correlations, with darker colors indicating stronger correlations. This visualization facilitates a clearer understanding of the relationships between different heavy metals, enabling rapid identification of significant associations. For example, the heatmap distinctly highlights the strong positive correlation between lead (Pb) and mercury (Hg), suggesting potential common sources or pathways of contamination. Such insights are crucial for developing targeted mitigation strategies and informing regulatory policies. The correlation analysis and corresponding visual representation underscore the importance of comprehensive environmental monitoring and intervention to address the sources and interactions of these contaminants.

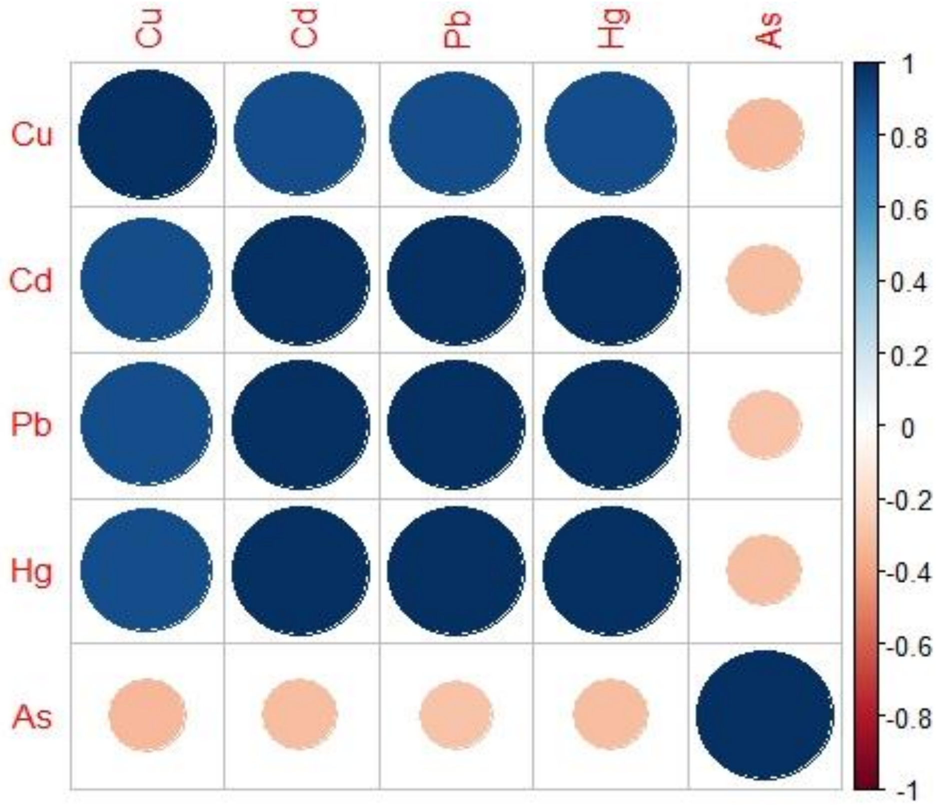

Figure 2: Correlation Heatmap

DISCUSSION

The analysis of *Farfantepenaeus notialis* from Bodija Market revealed that the concentrations of Copper (Cu), Cadmium (Cd), Lead (Pb), and Mercury (Hg) exceed the Acceptable Daily Intake (ADI) limits set by regulatory bodies. Specifically, the EDI for Cu, Cd, Pb, and Hg was higher than the ADI, indicating a potential health risk associated with regular consumption of this shrimp species. In contrast, the EDI for Arsenic (As) was below the ADI, suggesting that as contamination is not currently a significant health concern in this context. These findings underscore the importance of monitoring and managing heavy metal contamination in seafood to safeguard public health (Raknuzzaman *et al.,* 2016).

The observed levels of heavy metals in *Farfantepenaeus notialis* are consistent with some previous studies conducted in other regions but exceed the limits reported in others (Onunkwor *et al.,* 2022). For instance, similar levels of Cu and Pb have been noted in shrimp from other markets in West Africa, reflecting regional contamination patterns (Outa *et al.,* 2020). However, the levels of Hg and Cd in this study are notably higher than those reported in some other studies, which may be attributed to local environmental pollution sources or differences in vendor practices (Ogundiran and Fasakin, 2015). Comparing these results with historical data can help identify trends and the effectiveness of regulatory measures.

The higher than acceptable levels of Cu, Cd, Pb, and Hg in the analyzed samples suggest a potential risk for consumers of *Farfantepenaeus* *notialis* from Bodija Market. Prolonged exposure to elevated levels of these metals can lead to serious health issues, including liver damage from Cu (Engwa *et al.,* 2019), kidney damage and bone demineralization from Cd (Fatima *et al.,* 2019), neurotoxicity from Pb (Ahmad and Liu *et al.,* 2019), and neurological impairments from Hg (Naija and Yalcin, 2023). The risk is particularly concerning for vulnerable populations, such as children and pregnant women, who are more susceptible to the adverse effects of these contaminants (Anyanwu *et al.,* 2018). Public health initiatives should focus on increasing awareness about seafood safety and implementing measures to reduce contamination levels.

The correlation analysis revealed significant positive relationships between several heavy metals, including Pb and Hg, and Cd and Hg (Lawal-Are *et al.,* 2017). These correlations suggest that contamination may originate from common sources or pathways. For example, industrial discharges and agricultural runoff could contribute to the accumulation of multiple metals in marine environments (Bukola *et al.,* 2015). Understanding these correlations can help in pinpointing the sources of contamination and in developing targeted strategies to mitigate metal accumulation in seafood.

The findings from Bodija Market highlight the need for market-specific assessments due to variations in contamination levels. The local practices of seafood vendors, environmental conditions, and the proximity of industrial activities can all influence metal concentrations in seafood.

CONCLUSION

This study assessed heavy metal contamination in *Farfantepenaeus notialis* from Bodija Market in Ibadan, revealing that concentrations of Copper (Cu), Cadmium (Cd), Lead (Pb), and Mercury (Hg) exceeded Acceptable Daily Intake (ADI) limits, indicating potential health risks for consumers. While Arsenic (As) levels were below the ADI, suggesting no immediate concern, the elevated levels of other metals warrant significant attention. These findings highlight the need for stringent monitoring and regulation of seafood to prevent health hazards associated with metal contamination. Given the variability in contamination levels among vendors and the potential sources of pollution, targeted interventions are necessary. Enhanced public health measures, including increased awareness and stricter regulatory enforcement, are crucial for ensuring seafood safety. Future research should expand to other regions and focus on the long-term health impacts of consuming contaminated seafood, involving collaboration between researchers, policymakers, and industry stakeholders to address these challenges effectively.

REFERENCES

Abbott, L. C., & Nigussie, F. (2021). Mercury toxicity and neurogenesis in the mammalian brain. *International Journal of Molecular Sciences*, *22*(14), 7520.

Abdel-Kader, H. H., & Mourad, M. H. (2022). Carcinogenic and Human Risk Assessments, Trace Element Concentrations, Proximate Composition, and Liver Antioxidants of Three Commercial Tilapia Fish Species from Manzalah Wetland, Egypt. *Egyptian Journal of Biology and Fisheries*, *26*(4), 1-24.

Ahmad, F., & Liu, P. (2020). (Ascorb) ing Pb neurotoxicity in the developing brain. *Antioxidants*, *9*(12), 1311.

Al-Busaidi, M. A., Jukes, D. J., & Bose, S. (2017). Hazard analysis and critical control point (HACCP) in seafood processing: An analysis of its application and use in regulation in the Sultanate of Oman. *Food control*, *73*, 900-915.

Anyanwu, B. O., Ezejiofor, A. N., Igweze, Z. N., & Orisakwe, O. E. (2018). Heavy metal mixture exposure and effects in developing nations: an update. *Toxics*, *6*(4), 65.

Bukola, D., Zaid, A., Olalekan, E. I., & Falilu, A. (2015). Consequences of anthropogenic activities on fish and the aquatic environment. *Poultry, Fisheries & Wildlife Sciences*, *3*(2), 1-12.

Cojocaru, A. L., Liu, Y., Smith, M. D., Akpalu, W., Chávez, C., Dey, M. M., Dresdner, J., Kahui, V., Pincinato, R.B. & Tran, N. (2022). The "seafood" system: Aquatic foods, food security, and the Global South. *Review of Environmental Economics and Policy*, *16*(2), 306-326.

Engwa, G. A., Ferdinand, P. U., Nwalo, F. N., & Unachukwu, M. N. (2019). Mechanism and health effects of heavy metal toxicity in humans. *Poisoning in the modern world-new tricks for an old dog*, *10*, 70-90.

Fatima, G., Raza, A. M., Hadi, N., Nigam, N., & Mahdi, A. A. (2019). Cadmium in human diseases: It's more than just a mere metal. *Indian Journal of Clinical Biochemistry*, *34*(4), 371-378.

Lawal-Are, A. O., Mokwenye, C. R., & Akinwunmi, M. F. (2017). Heavy metal bioaccumulation in *Callinectes amnicola* and *Farfantepenaeus notialis* from three selected tropical water bodies in Lagos, Nigeria. *Ife Journal of Science*, *19*(2), 247-254.

Naija, A., & Yalcin, H. C. (2023). Evaluation of cadmium and mercury on cardiovascular and neurological systems: Effects on humans and fish. *Toxicology Reports*, *10*, 498-508.

Ogundiran, M. B., & Fasakin, S. A. (2015). Assessment of heavy metals and crude protein content of molluscs and crustaceans from two selected cities in Nigeria. *African Journal of Food, Agriculture, Nutrition and Development*, *15*(3), 10099-10117.

Onunkwor, B. O., Oguntade, R., Babayemi, D. O., Ademolu, K. O., & Dele-OshinbanJo, J. S. (2022). Toxicology impacts of heavy metal pollution of Ogun and Lagos fishing waters by sewages on the antioxidant status and nutritional value of prawn (*Macrobrachium macrobrachion*). *Nigerian Journal of Animal Production*, *49*(1), 194-214.

Outa, J. O., Kowenje, C. O., Avenant-Oldewage, A., & Jirsa, F. (2020). Trace elements in crustaceans, mollusks and fish in the kenyan part of Lake Victoria: bioaccumulation, bioindication and health risk analysis. *Archives of environmental contamination and toxicology*, *78*, 589-603.

Palma-Lara, I., Martínez-Castillo, M., Quintana-Pérez, J. C., Arellano-Mendoza, M. G., Tamay-Cach, F., Valenzuela-Limón, O. L., García-Montalvo, E.A. & Hernández-Zavala, A. (2020). Arsenic exposure: A public health problem leading to several cancers. *Regulatory Toxicology and Pharmacology*, *110*, 104539.

Pandey, S., & Kumari, N. (2023). Impact assessment of heavy metal pollution in surface water bodies. *Metals in Water*, 129-154.

Raknuzzaman, M., Ahmed, M. K., Islam, M. S., Habibullah-Al-Mamun, M., Tokumura, M., Sekine, M., & Masunaga, S. (2016). Trace metal contamination in commercial fish and crustaceans collected from coastal area of Bangladesh and health risk assessment. *Environmental Science and Pollution Research*, *23*, 17298-17310.

Reyes-Hinojosa, D., Lozada-Pérez, C. A., Cuevas, Y. Z., López-Reyes, A., Martínez-Nava, G., Fernández-Torres, J., Olivos-Meza, A., Landa-Solis, C., Gutiérrez-Ruiz, M.C., Del Castillo, E.R. & Martínez-Flores, K. (2019). Toxicity of cadmium in musculoskeletal diseases. *Environmental Toxicology and Pharmacology*, *72*, 103219.

Saidon, N. B., Szabó, R., Budai, P., & Lehel, J. (2024). Trophic transfer and biomagnification potential of environmental contaminants (heavy metals) in aquatic ecosystems. *Environmental pollution*, *340*, 122815.

Taylor, A. A., Tsuji, J. S., Garry, M. R., McArdle, M. E., Goodfellow, W. L., Adams, W. J., & Menzie, C. A. (2020). Critical review of exposure and effects: implications for setting regulatory health criteria for ingested copper. *Environmental management*, *65*, 131-159.

Unuofin, J. O., & Igwaran, A. (2023). Microplastics in seafood: Implications for food security, safety, and human health. *Journal of Sea Research*, *194*, 102410.

Virgolini, M. B., & Aschner, M. (2021). Molecular mechanisms of lead neurotoxicity. In *Advances in neurotoxicology* (Vol. 5, pp. 159-213). Academic Press.

Wang, L., Wang, X., Chen, H., Wang, Z., & Jia, X. (2022). Oyster arsenic, cadmium, copper, mercury, lead and zinc levels in the northern South China Sea: long-term spatiotemporal distributions, combined effects, and risk assessment to human health. *Environmental Science and Pollution Research*, *29*(9), 12706-12719.