Nwanna, L. C.; Ajani, E. K.; Omitoyin, B. O.; Magawata, I. Ayoola, S. O.; Orisasona, O.; Kareem, O. K and Abubakar, M. Y. (Eds.) (2004) ***Proceedings of the Fifth Conference of Association of Nigerian Fisheries Scientists.*** **"SUSTAINABLE FISHERIES AND AQUACULTURE PRODUCTION FOR ENHANCING LIVELIHOOD IN NIGERIAN ECONOMIC DEVELOPMENT"** 9TH – 11TH JULY, 2024 In the University of Lagos, Lagos, Nigeria

Heavy Metals Profile and Physicochemical Indices of Fishes at Ajah Axis of Lagos lagoon

***Obute, C. U.[1], Ayoola, S. O.[2], Olarewaju, V. O.[1] and. Agada, O. E.[2]**

[1]Department of Fisheries Technology, Federal College of Fisheries and Marine Technology,

Victoria Island. Lagos, Nigeria.

[2]Department of Marine Sciences, Faculty of Science, University of Lagos, Nigeria

*Corresponding Author: obute@fcfmt.edu.ng, 07039594171

ABSTRACT

This study was assessed for heavy metal contamination profile and physico-chemical indices of fishes at the Ajah axis of Lagos Lagoon, Lagos State, Nigeria. Samples were collected randomly from two locations: Badore Jetty and Ebute and analyzed for Lead (Pb), Chromium (Cr), Cadmium (Cd), Iron(Fe), Zinc (Zn), Nickel (Ni), and Copper (Cu). Physico-chemical parameters were analyzed using standardized methods. Three commercially important fishes: Catfish (Siluriformes), Tilapia (*Oreochromis niloticus* and shiny nose (Threadfin Salmon), from the Ajah axis of the Lagos Lagoon, using Atomic Absorption spectrophotometer, were investigated. The physicochemical characteristics revealed range values of Dissolve Oxygen (3.60 and 8.70 mg/L), water temperature (26.10˚C and 29.19˚C), pH (6.63 and 7.93), Conductivity (0.52 and 29.95 µs/cm), Biochemical Oxygen Demand (3.60 and 8.70 mg/L), Salinity (0.25 and 18.50 ppt), Turbidity (NTU) (3.55 and 202.50mg/L), Nitrite (0.05 and 0.07 mg/L), and Phosphate (0.13 and 0.27mg/L). The concentration of DO, BOD, and Turbidity were higher than the WHO standard. pH, conductivity, Nitrite, and Phosphate were within the recommended limit. The concentrations of the metals in the tissues of Catfish (Siluriformes), Tilapia (*Oreochromis niloticus* and shiny nose (Threadfin Salmon) were all above the regulatorylimits, Cu was low which implies the values of toxic heavy metals in the tissues of the fish sample in the lagoon are higher than recommended values. The different fish species have different abilities to eliminate or accumulate these metals in their bodies. Establishing and maintaining robust monitoring programs for heavy metals and physicochemical indices in aquatic ecosystems is crucial.

Keywords:
Heavy metals, Physico-chemical parameters, Lagoon, Fish

Introduction

Lagoons are complex coastal zones that connect the land and the sea. Estuaries, coastal wetlands, seagrass, meadows, coral reefs, mangrove and kelp forests, and upwelling areas are all examples of coastal zones or waters (Femi et al., 2021). Lagoons are large bodies of water that provide essential services that help boost the economy and ecology of the areas around them (Davies- Vollum et al., 2019). Lagoons provide vital ecosystem services that benefit both the economy and ecology of the area (Davies-Vollum et al., 2019). The lagoon is also used by the inhabitants to transport people and commodities to nearby towns and villages for socioeconomic activities (Ndimele, 2019).

Unfortunately, lagoon ecosystem services are being threatened by environmental pollution. Untreated municipal, agricultural, and industrial wastes are discharged into lagoons, polluting the water. Even when the wastes are treated, the byproducts, which are still potentially harmful to aquatic organisms and humans, are discharged into the lagoons (Kumolu-Johnson and Ndimele, 2012). Pollution affects lagoons' water quality, biodiversity, and ecosystem services provided by lagoons (Gianello et al., 2019; El Mahrad et al., 2020). Human populations who live near lagoons and rely on them for sustenance are affected by the loss of ecological services such as coastal protection and fisheries (El Mahrad et al., 2020). One of the common pollutants in water are heavy metals (Kinuthia et al., 2020).

Heavy metals naturally occur in the environment and are vital for survival, but they may become hazardous when they accumulate in organisms. A few of the most frequent heavy metals that contaminate the environment include mercury, cadmium, arsenic, chromium, nickel, copper, and lead (Hazrat et al., 2019). They pose a significant threat to the health of organisms, including fish, and can have far-reaching ecological and human health implications. (Naseem et al., 2022). Heavy metals commonly found in aquatic ecosystems include mercury (Hg), lead (Pb), cadmium (Cd), arsenic (As), chromium (Cr), copper (Cu), and zinc (Zn). These metals can enter water bodies through natural processes such as weathering and erosion, as well as anthropogenic activities such as industrial discharges, agricultural runoff, and mining. Once released into aquatic environments, they can persist for long periods and accumulate in various organisms, including fish, through processes such as bioaccumulation and biomagnification. (Krishnan and Wang, 2019).

Fish is also an important part of the human diet because of its high nutritional quality (Ayanda et al., 2018). However, the presence of heavy metals in aquatic ecosystems poses a significant threat to both fish populations and human health. To understand the potential risks associated with fish consumption and monitor the environmental health of aquatic ecosystems, it is essential to study the heavy metals profile and physicochemical indices of fishes.

This study was aimed to investigate the heavy metals profile and physicochemical indices of fishes in Lagos lagoon, along the Ajah axis. By analyzing the concentrations of heavy metals in fish tissues and measuring key physicochemical parameters of the water. More so, seeks to provide valuable information on the ecological health and potential risks associated with heavy metal contamination in the study area.

Materials and Method

Study Area

The Ajah axis of Lagos Lagoon lies along the Lagos Lagoon, located in South-Western Nigeria, Lagos State lies between latitude 06°30′35.57″N and longitudes 4°7′57.58″E. The lagoon lies within the rainforest belt of southern Nigeria, experiencing two major seasons. Riparian vegetation at the bank of the lagoon consists mainly of grasses and secondary rainforests. Agriculture, Anthropogenic, sand mining, fishing, restaurants and bars, and transportation of people and goods using motorized boats are some of the human activities that take place along the study stretch.

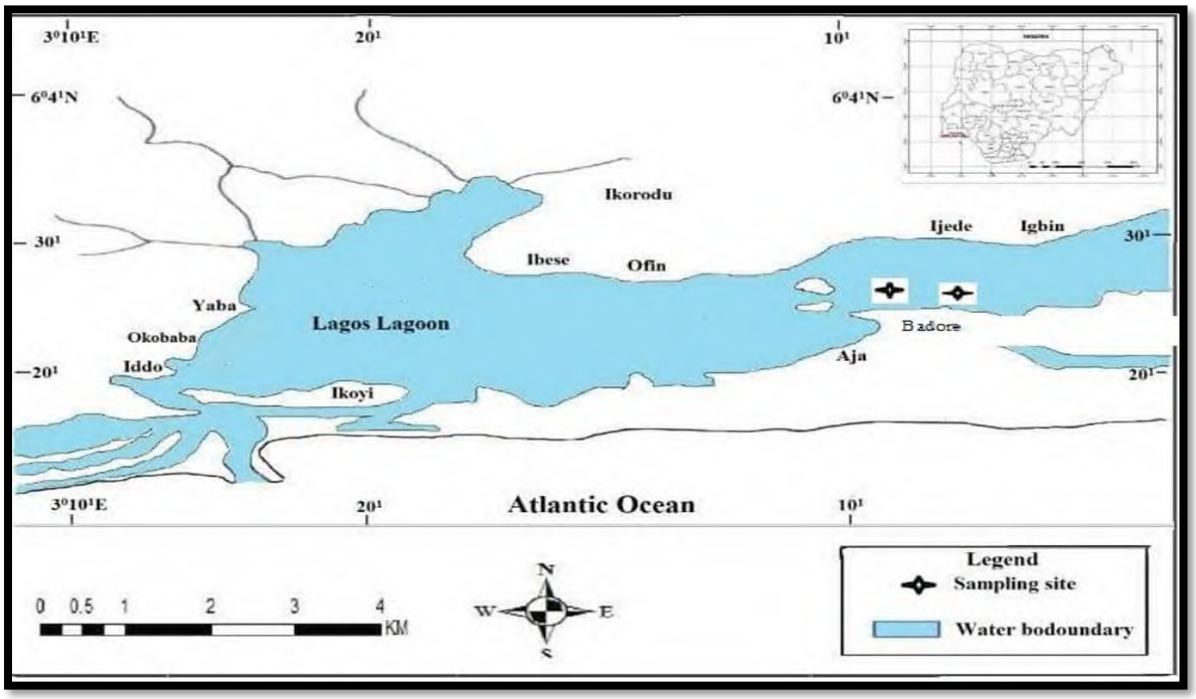

Figure 1. Map of Lagos Lagoon showing the Study area.

Sample Collection

Edible fishes of the Lagos Lagoon, along the Ajah axis were procured from the fisherfolks from April to September 2022 at the two selected stations (Badore Jetty and Ebute). The sampling gears used for fishing include basket traps, baited long lines and set gill net. Three (3) fish species were collected (Catfish (Siluriformes), Tilapia (Oreochromis niloticus and shiny nose (Threadfin Salmon) for the analysis. A total of eighteen (18) fish samples were collected. The samples were wrapped in aluminum foil sealed and transported in an ice Polythene Bag to the Nigerian Institute for Oceanography and Marine Research (NIOMR) Central Laboratory, at Victoria Island, Lagos for proper identification and examination.

Physico-Chemical Parameters of Water

Water samples were scooped, using clean 5L bottles at different sampling locations in the Lagoon. Samples were taken at least once a month, but also on every fish sampling day. The collected samples were kept in 250ml reagent bottles and clean 750ml Bottle water and transported to the Nigerian Institute for Oceanography and Marine Research (NIOMR), Central Laboratory, at Victoria Island, Lagos, and stored at 4 °C, before laboratory analysis. Some water parameters including temperature, salinity, pH, dissolved oxygen, Turbidity NTU, Nitrite, Nitrate, Phosphate, Biochemical oxygen demand, and conductivity were measured, and readings were taken with a parameter probe (Horiba U50 Series).

Heavy Metal Digestion of Fish Samples

Method for Heavy metals; EPA 7000 A&B was employed. 5g each of the fish sample (tissue) was treated with 15 ml HCl and 5ml HNO_3 (ratio 3:1). The sample was then heated on a hot plate with the temperature gradually increased until decomposition was complete and volume reduced by evaporation

to about 5ml. The samples were filtered, washed with de-ionized and double-distilled H_2O, and transferred quantitatively to a 50ml volumetric flask. The digested samples were analyzed for heavy metals with an Atomic Absorption Spectrophotometer (PG A500).

Heavy Metal Digestion of Water Samples

25 ml each of the water samples was treated with 15 ml HCl and 5 ml HNO_3 (ratio 3:1). The sample was then heated on a hot plate with the temperature gradually increased until digestion was complete and volume reduced by evaporation to about 5ml. The samples were filtered, washed with de-ionized and double-distilled H_2O, and transferred quantitatively to 50ml volumetric flask. The digested samples were analyzed for heavy metals with an Atomic Absorption Spectrophotometer (PG A500).

Statistical Analysis

Mean values of results from the study were subjected to One-way Analysis of Variance (ANOVA) ɒ show significant differences in the mean concentrations of the heavy metals in fish.

Result

Physiochemical parameters of the water

The mean variations in the physico-chemical parameters analyzed in the water were water temperature, salinity, pH, dissolved oxygen, Turbidity NTU, Nitrite, Nitrate, Phosphate, Biochemical oxygen demand, and electrical conductivity are presented in Table 1.

Table 1. The mean values of Physio-chemical parameters in water samples from Ajah axis, along Lagos Lagoon

Variables	April	May	June	Range	FMEnv.
Temperature 'C	29.19 ± 0.02	26.10 ± 0.16	29.36 ± 0.06	26.10 – 29.19	**35°C**
pH	6.63 ± 0.05	7.93 ± 0.38	6.86 ± 0.42	6.63 – 7.93	**6-9**
Turbidity (NTU)	3.55±0.15	24.0±17.30	202.50 ± 70.50	3.55 – 202.50	**5.0**
Conductivity (µS/cm)	29.95±0.25	2.22±0.87	0.52 ±0.10	0.52 – 29.95	**125.00**
Salinity (ppt)	18.50±0.20	1.15±0.45	0.25±0.05	0.25 – 18.50	**0.00-0.10**
Nitrite (mg/L)	0.05±0.002	0.07±0.03	0.05±0.002	0.05 – 0.07	**-**
Nitrate (mg/L)	0.12±0.04	0.33±0.24	0.12±0.04	0.12 – 0.33	**20.0**
Phosphate (mg/L)	0.13±0.04	0.27±0.11	0.13±0.04	0.13 – 0.27	**20.0**
Dissolved Oxygen (mg/L)	10.30±0.90	5.60±0.80	10.30±0.90	5.60 – 10.30	**5.0**
Biochemical Oxygen Demand (mg/l)	8.70±0.10	3.60±0.40	8.70±0.10	3.60 – 8.70	**30.0**

Heavy metals in water

The concentrations of the different metals analyzed in water samples are as presented in Table 2. In the water samples, Zinc recorded the highest in April and exceeded the permissible level of WHO and FMEnv. respectively.

Table 2: The mean values of Heavy Metals in water samples from Ajah axis, along Lagos Lagoon

S/N	Heavy Metals	April	May	June	WHO	FMEnv.
1	**Pb**	0.05	0.17	0.00	0.05	0.05
2	**Fe**	0.68	2.23	-	20	20.0
3	**Zn**	202.50	0.33	0.15	1	1.0
4	**Cr**	0.52	-	-	1	1.0
5	**Cd**	-	0.02	0.01	0.05	0.05
6	**Ni**	0.15	-	-	1	1.0
7	**Co**	0.07	0.03	0.03	5	5.0

Heavy Metals in Fish Samples

The mean concentrations of heavy metals in Catfish (Siluriformes), Tilapia (Oreochromis niloticus and shinynose (Threadfin Salmon) species are presented in Table 3. The analysis of variance (ANOVA) of the concentrations of the heavy metals revealed that there were no significant differences ($p>0.05$) of the metals in the three fish species from two locations.

Table 3: Mean variations of Heavy Metals in Fish from Ajah axis, along Lagos Lagoon

Fish	Pb	Fe	Zn	Cr	Cd	Ni	Co
Catfish A	0.62	7.86	6.43	0.17	0.05	0.40	0.31
Catfish B	1.42	6.85	5.38	0.17	0.01	0.28	0.42
Shiny nose A	0.58	6.14	5.42	0.17	0.01	0.33	0.39
Shiny nose B	0.89	5.43	6.58	0.20	0.07	0.71	0.38
Tilapia A	1.06	5.26	5.87	0.17	0.09	0.57	0.43
Tilapia B	0.43	7.65	2.94	0.17	0.03	0.35	0.21

N/B: A: Ebute Sample Location, B: Badore Jetty Sample Location; $p>0.05$ indicated no significant differences

Correlation coefficient

The Correlation coefficient of the heavy metals in water and fish species is presented in Table 4. The Correlation coefficient showed that heavy metal concentrations did not have any significant differences ($p>0.05$) in the fish species across the sampling period. However, there were generally significant differences ($p<0.05$) amongst the metals of the fish species.

Table 4: Correlation coefficient of heavy metals in water and fish species

	Catfish A	Catfish B	Shiny nose A	Shiny nose B	Tilapia A	Tilapia B	Water
Catfish A	1.00						
Catfish B	0.993*						
Shiny nose A	0.999*	0.991*					
Shiny nose B	0.969*	0.958*	0.979*				
Tilapia A	0.979*	0.974*	0.987*	0.998*			
Tilapia B	0.929*	0.932*	0.910*	0.810*	0.837*		
Water	0.562	0.531	0.598	0.742	0.705	0.215	1.00

Discussion

The assessment of physicochemical parameters and heavy metal concentrations in water samples from the Ajah axis of the Lagos lagoon is crucial for understanding the environmental health and safety of this ecosystem. This study highlights the significance of monitoring these parameters to evaluate water quality, which directly impacts the survival and productivity of aquatic organisms, particularly fish. (M. P. Kuton. 2021). The pH levels observed in the water samples (ranging from 6.63 to 7.93) fell within the recommended range (6.0-9.0) for aquatic life. Maintaining appropriate pH levels is essential as it influences the biotic communities within the lagoon, with most plant and animal species thriving within a narrow pH range. Additionally, optimal pH conditions help minimize the dissolution of metals into the lagoon water, thereby reducing potential toxicity to aquatic organisms. (Rameshkumar *et al*,. 2019) Temperature and electrical conductivity measurements were relatively consistent and within acceptable limits throughout the study period. The observed temperature range (26.10ºC - 29.19ºC) is conducive for supporting dissolved oxygen levels crucial for aquatic life. Electrical conductivity values ranged from 0.52 to 29.95 mS/cm, indicating good ionic solubility in the water. However, the measured values were significantly lower than the recommended limit (125.00 mS/cm), suggesting minimal ionic pollution.

Dissolved oxygen (DO) levels ranged from 5.60 to 10.30 mg/L, surpassing the recommended minimum of 5.0 mg/L for healthy aquatic ecosystems. The higher DO levels observed could be attributed to water turbulence and increased solubility at lower temperatures, contributing to a favorable environment for aquatic life. (Ice *et al*., 2021, Orodo *et al.*, 2024). On the other hand, elevated turbidity levels (ranging from 3.55 to 202.50 NTU) suggest the presence of suspended particles and potentially high nutrient content entering the lagoon from surrounding areas. Similarly, salinity levels (ranging from 0.25 to 18.50 ppt) exceeded recommended limits (0.00-0.10 mg/L), indicating sources of contamination affecting water quality (Belzile and Chen 2017).

Analysis of heavy metal concentrations in water and fish samples revealed alarming levels of lead and cadmium, exceeding safe limits for human consumption. Lead concentrations ranged from 0.33 to 2.08 ppm, significantly higher than WHO's recommended limit for drinking water. Anthropogenic activities such as lead-acid batteries and soldering contribute to elevated lead levels in the lagoon. Cadmium concentrations (ranging from 0.07 to 0.10 ppm) were also above permissible limits, likely attributed to

oil and grease from engine boats. Other metals like iron, zinc, chromium, nickel, and copper were within acceptable limits, although caution is warranted due to the potential bioaccumulation of chromium in fish tissues. (Ihayere, C. A. and Igben, J. L. 2021, Chee Kong Yap. 2021).

Conclusion

The heavy metals profile and physicochemical indices of fish are essential indicators of environmental quality and potential risks to human health. Understanding the bioaccumulation of heavy metals in fish tissues and monitoring the physicochemical parameters of water provide valuable insights into the ecological health of aquatic ecosystems. Continued research and monitoring efforts are necessary to evaluate the effectiveness of mitigation strategies and ensure the long-term sustainability of fish populations and human well-being. Establishing and maintaining robust monitoring programs for heavy metals and physicochemical indices in aquatic ecosystems is crucial. Furthermore, Comprehensive risk assessments should be conducted to evaluate the potential risks associated with heavy metal contamination in fishspecies and their impact on human health. The findings of these assessments can guide the development of appropriate risk management strategies, including consumption advisories, fishing restrictions, and pollution control measures.

References

Ayanda, I. O., Dedeke, G. A., Ekhator, U. I., and Etiebet, M. K. (2018). Proximate composition and heavy metal analysis of three aquatic foods in Makoko River,Lagos. Nigeria. *Journal of Food Quality*.

Belzile, N., & Chen, Y. W. (2017). Thallium in the environment: a critical review focused on natural waters, soils, sediments and airborne particles. *Applied Geochemistry*, *84*, 218-243.

Davies-Vollum, K. S., Zhang, Z., & Agyekumhene, A. (2019). Impacts of lagoon opening and implications for coastal management: case study from Muni-Pomadze lagoon, Ghana. *Journal of Coastal Conservation*, *23*, 293-301.

El Mahrad, B., Abalansa, S., Newton, A., Icely, J.D., Snoussi, M. and Kacimi, I. (2020). SocialEnvironmental Analysis for the Management of Coastal Lagoons in North Africa. Frontier in Environmental Science, 8:37. Doi: 10.3389/fenvs.2020.00037

Femi, O.G., Owonire, L.M. and Efe, U.R. (2021). Evaluation of Water Quality and Heavy Metal Concentration across Two Connecting Tropical Lagoons in Lagos, Nigeria. *Journal of Biological Research & Biotechnology*, 19 (1): 1202-1209. https://dx.doi.org/10.4314/br.v19i1.1

Gianello, D., Ávila-Hernández, E. and Aguer, I. (2019): Water quality assessment of a temperate urban lagoon using physico-chemical and biological indicators. SNApplied Sciences 1: 470. https://doi.org/10.1007/s42452-019-0469-5.

Ice, G. G., Hale, V. C., Light, J. T., Muldoon, A., Simmons, A., & Bousquet, T. (2021). Understanding dissolved oxygen concentrations in a discontinuously perennial stream within a managed forest. *Forest Ecology and Management*, *479*, 118531.

Jang, Y. C., Kim, M. S., Choi, J. Y., Kim, J. S., & Kim, K. W. (2019). Heavy metal contents in electronic waste and their potential environmental impact in Korea. *Sustainability*, *11*(9), 2504. https://doi.org/10.3390/su11092504

Krishnan, S., and Wang, Y. (2019). Mechanistic Insights into the Bioaccumulation of Heavy Metals in Fish: A Comprehensive Review. Chemosphere, 214, 743-764.

Kuton, M. P., Ayanda, I. O., Uzoalu, I. A., Akhiromen, D. I., George, A., & Akinsanya, B. (2021). Studies on heavy metals and fish health indicators in Malapterurus electricus from Lekki Lagoon, Lagos, Nigeria. *Veterinary and Animal Science*, *12*, 100169.

Naseem, S., Ghaffar, A., Hussain, R., & Khan, A. (2022). Inquisition of Toxic Effects of Pyriproxyfen on Physical, Hemato-Biochemical and Histopathological Parameters in Labeo rohita Fish. *Pakistan veterinary journal*, *42*(3).

Ndimele, P.E. (2019). Integrating Indigenous Knowledge in the Communication of Ecosystem Services of Lagos Lagoon Complex to its Local Dependents.Limnology and Oceanography, 28 (1): 19-20. https://doi.org/10.1002/lob.10302.

Orodo, V. A., Abuom, P. O., Shikanga, E. A., Osewe, E. T., Anyona, D. N., Mngube, F. M., & Odongo, S. A. (2024). Effects of Papyrus Plants (Cyperus papyrus) on the Physicochemical Parameters and Nutrient Levels of Water and Sediments in Yala Swamp Wetland in Western Kenya. *Journal of Biophysical Chemistry*, *15*(1), 1-23.

Rameshkumar, S., Radhakrishnan, K., Aanand, S., & Rajaram, R. (2019). Influence of physicochemical water quality on aquatic macrophyte diversity in seasonal wetlands. *Applied Water Science*, *9*, 1-8.

ANIFS 2024
© 2024
***Proceedings of the Fifth Conference of Association of Nigerian Fisheries Scientists.* "SUSTAINABLE FISHERIES AND AQUACULTURE PRODUCTION FOR ENHANCING LIVELIHOOD IN NIGERIAN ECONOMIC DEVELOPMENT"**
9TH – 11TH JULY, 2024 in the University of Lagos, Lagos, Nigeria