Innovations

Bioaccumulation of heavy metals in the tissues of some fish species in selected wetlands in Lagos Nigeria

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Abstract

The study investigated the heavy metals content in fish species in selected wetlands in Lagos, Lagos state Nigeria for its suitability for human consumption and for export. It was an ex-post facto research that answered 4 research questions and tested a hypothesis. To achieve these, 5 wetlands were randomly selected from the 13 wetlands in Lagos. The fish species used for the study are Tilapia zilli and Clariasspp and the sampling period was between September 2022 to February 2023. The wetlands were mapped into 5 sampling zones and 3 fishes samples were collected from each zone with the assistance of artisanal fishermen. The fishes from zones were bulked and 3 samples randomly collected from each wetland. The analytical standard adopted was USEPA 601020 and the instrument used for the determination of individual metals was Agilent AAS model 240 FSAA. The grand mean results obtained were Pb; 0.14±0.03mg/kg, Cr; 0.13±0.03mg/kg, Cd, 0.13±0.02mg/kg, V; 0.15±0.02mg/kg and Hg; 0.11±0.01mg/kg. The grand mean results were subjected to test of significance with ANOVA deploying SPSS model 29 at 0.05 level of significance. The p-value was 0.34 thus rejecting H_0. The study concludes that the wetlands investigated are polluted with heavy metals above maximum permissible concentrations and recommends that fishes in the wetlands should not be consumed and should not be exported. The impacted wetlands should be remediated and the monitoring agency NESREA should step up it game in surveillance

Keywords: *industries, heavy metals, wetland, fishes, bioaccumulation*

Introduction

Fish is an essential component of human diet that is highly cherished globally due to its taste, availability, affordability and nutritive usefulness. Nearly every species of fish both marine and fresh water is edible (Ahmed *et al*., 2015, Varol*et al*., 2017, Dey*et al*., 2015). Fish is an important source of protein, fat, vitamin and mineral (Ogwu*et al*., 2022b, Islam, et al., 2014, Rahman *et al*., 2012, Amm*et al*., 2011). It contains between13 to 20 percent protein and has a food value of 300-1600 calories per pound (Xie*et al*., 2010, Cifta*et al*., 2015, Hossein*et al*., 2014). Fish contains 5 essential amino acids and large amount of phosphorus (abdel-Khalek*et al*., 2016, Ogwu, 2021 . Keshavarzi*et al*., 2018, Liu *et al*., 2018) andin 2013 fish accounted for 17 percent global population animal protein intake and 6.7 percent of all proteion consumed (Food and Agricultural Organisation 2018, Monsefrad*et al*., 2012, Ogwu*et al*., 2021a, Yi and Zhang, 2012). Fish provides easy sources of two minerals ioden and selenium that are essential for thyroid gland functioning and are not easily available in other food sources(Ogwu*et al*., 2020 , Tekin-

Ozan&Aktan, 2012, Mercial*et al*., 2012). Its by-products include fish glue, fish oil, isinglass, fish quano (manure) (Ogwu*et al*., 2021, Zhong*et al*., 2018, Saha*et al*., 2016a, Rahma*et al*., 2012). Medically, fish is a source of insulin (Rahman *et al*., 2019, Castro-Gonzalez & Mendez-Armanta, 2008, Azamen, 2015, Parente& Hauser-Davis, 2015). Fish and fisheries provide employment for over 820 million people globally in pre-harvest, harvest and post-harvest operations (Ogwu*et al*., 2021b, Zamrie*et al*., 2016, Luczynska*et al*., 2018, Siddique, 2015). There is a global growth in fish consumption due largely to the awareness of its nutritive and health benefit (FAO, 2018, Ogwu*et al*., 2022b, Zeltoun*et al*, 2014, Aliskhan, 2018, Aythman*et al*., 2015).

World fish production volume was 184.6 million tonnes in 2022 with china, Indonesia, India and Vietnam being the greatest world fish producers in that order (Ogwu*et al*., 2023a, FAO, 2018). Africa contributes 6 percent to the world fish production with production volume of 995518 tonnes (FAO, 2022, Ghana Stat, 2022, World Food programme, 2022). Nigeria fish production was 1.169 million metric tonnes in 2020 and Lagos state with production volume of 174000 metric ton is Nigeria highest fish producing state (National Bureau of Statistics, 2022, Ruwani, 2022, Oteriba, 2022, Federal Ministry of Agriculture, 2022).

Lagos is Nigeria industrial commercial hub with 13 industrial estates and high proliferation ofmanufacturing and processing companies (Lagos Factsheet, 2018, Ogwu*et al*., 2023b, Sanusi, 2018, Ogunsola, 2018). It is a state of "aquatic splendor" with 13 out of 24 local government areas sandwiched by wetlands (Ogwu et al., 2023b, Afolabi, 2017, Dawodu, 2018, Ogunjobi, 2020). The wetlands are the recipients of wastes generated by the clusters of industries through direct disposals, runoffs, flashfloods and erosion (Adebuwale, 2020, Ifaloye, 2021, Odofin, 2022). Industrial wastes and by-products include detergents, micro plastics, furams dioxins, pesticides, polyaromatic hydrocarbons, heavy metals, amongst others.

Heavy metals are metals with high atomic weight (WHO, 2014, United State Environmental Protection Agency (USEPA), 2012, Atshana&Atshana, 2012). Human exposure to heavy metals lead to varying health complications such as cardiovascular diseases, cancer, respiratory problems, memory problems and even death (WHO, 2014, USEPA, 2012, Ogwu*et al*., 2023c).

The focus of this studyis the assessment of the heavy metals content of fish species in some wetlands in Lagos, Lagos state, Nigeria The heavy metals investigated are Pb, Cr, Cd, V and Hg.

The study was guided by research questions as below:

- whatare the concentrations of Pb, Cr, Cd, V and Hg in fish species in wetland in Lagos?
- are the concentrations of Pb, Cr, Cd, V and Hg in the fish species within the maximum permissible concentrations of the metals as stipulated by World Health Organisation, 2014?
- are the fish produce healthy for human consumption?
- Can the produce pass Codex Alimentarius standards for agricultural produce exports?

The study was guided a hypothesis as below:

H_0 :there is no significant difference between the concentrations of the heavy metals investigated in the fish species and WHO maximum permissible concentrations for heavy metals in fish.

Map of Lagos
Source: Google map, (2023)

Study Area
Lagos state is one of the 36 states that make up Federal Republic of Nigeria. It lies within the geographical coordinates of 6°5244'N and 3°3792'E with a population of 28 million (google estimate, 2022) and a land area of 1,171km^2. Lagos is the industrial and commercial nerve of Nigeria with a gross domestic product of 136 billion dollars in 2017 (National Bureau of Statics, 2022). The city has its southern flank occupied by Lagoon and Atlantic ocean with numerous wetlands in 13 local government areas in the city of Lagos. The wetlands and the lagoon are the recipients of the municipal and industrial effluents generated by industries and teeming inhabitants of Lagos.

Materials and Methods

Ethical consideration
The samples for this study were collected from the wild. The samples were not endangered, threatened or under any protection law. Permit was not sought because the wetlands are free and were not under any protection or laws prohibiting cropping or harvesting of any aquatic species. Therefore there was no ethical consideration for this study.

Sampling
Lagos state is made up of 24 local government area with 13 local governments conurbating into Lagos city with industrial estates located in 13 local government in the city. 5 wetlands representing 38 percent in the 13 local government hosting industrial estates were randomly selected to make the study. These are Ajah wetland in Ibeju Lekki, Kirikiri in Apapa local government, Ebuta Meta wetland in Mainland local government, Iba wetland in Ojo local government, andAgo-Okota wetland in Oshodi/Isolo local government area.
Each wetlands was mapped out into 5sampling zones, (Abdulwaheed, 2018, Afolabi, 2019, Asuquo, 2022). The fish species used for this study are *Tilapia zili and Clariass*spp and sampling period was between September 2022 to February 2023. Three (3) samples of each species were collected from each sampling zone in each wetland and 3 fish species randomly collected from each wetland. The samples collection

were done with the help of artisanal fishermen using gill, seine and cast nets. The samples were stored in ice cooled flasks kept at -20° for analysis.

Analysis and Determination of Metals

The fish samples were defrozenedat room temperature and the scales of *Tilapia zili* removed with stainless steel scapels. They were then dissected with stainless steel dissecting knives and various organs gills, liver and flesh separated (Surdaray*et al*., 2011, wang*et al*., 2017) and digestion carried by method described by (Chung *et al*., 2017, Qin, 2015). Adopting this procedure, 1 gram of each of the fish smaples was digested using perchloric acid and nutric acid in ratio of 1:1 (HNO_3:$HClO_4$ and this is followed by the addition of H_2SO_4(sulphuric acid). The mixture was then heated at a temperature of 200°C for half an hour (30 mins) using Agilent (G1530-60815 gas chromatograph door oven). The digest were then allowed to cool at room temperature and then made up to mark to 50ml using distilled water. The metals; Pb, Cr, Cd, V and Hg were determined using Agilent atomic absorption photometer model 240 FSAA Analytical blank was equally prepared adopting similar procedure.

Quality Assurance

The reagents utilized for this study were of high grades and standards. The glass wares used were rinsed thoroughly with distilled water after being soaked in nitric acid (HNO_3) for 24 hours. They were also washed with potassium permanganate, ($KMNO_4$)and again rinsed with distilled water. Precautions and occurrence were checked and verified using International Atomic Energy Agency Customer Relationship Management (IAEACRM 407) reference material. The result of 240 FSAA in the quality control indicated a very satisfactory and accurate reading of the heavy metals investigated with a certified value of 99 to 100 percent.

Results

The results of the analyses are as in Figures 2-7.

Figure 2: Results of the heavy metals in fish species in Ajah wetland and WHO MPC in mg/kg

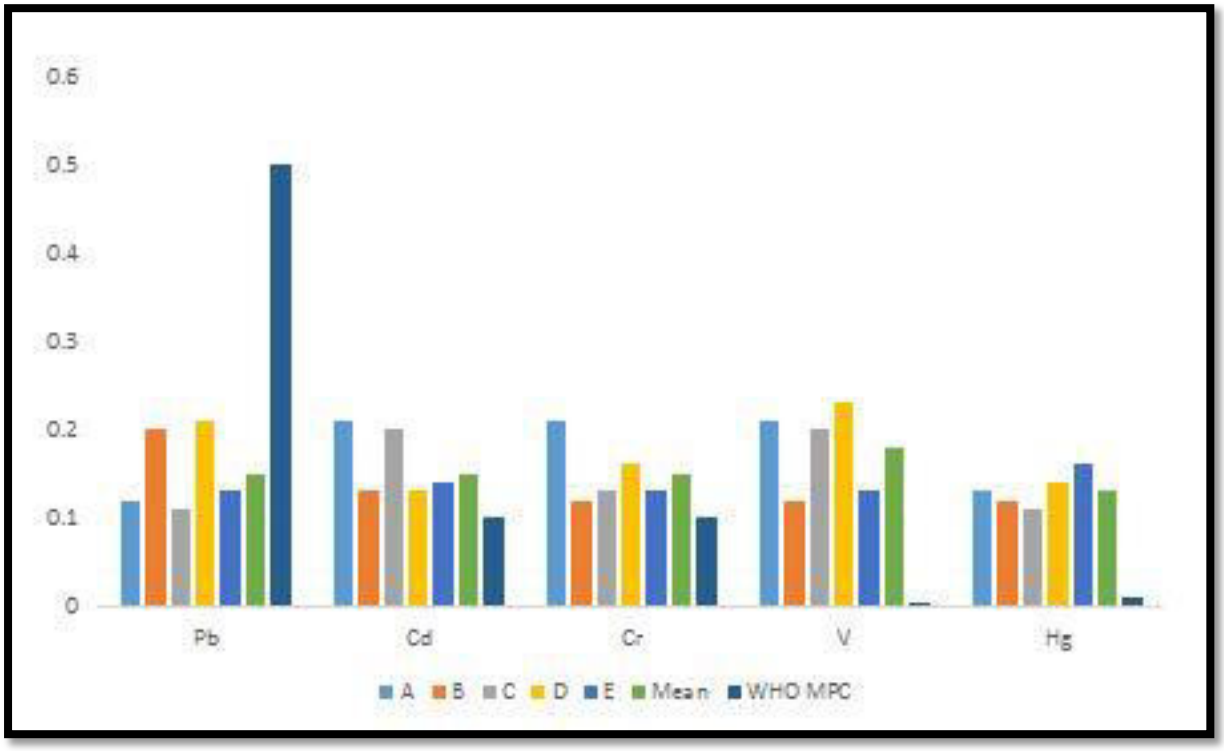
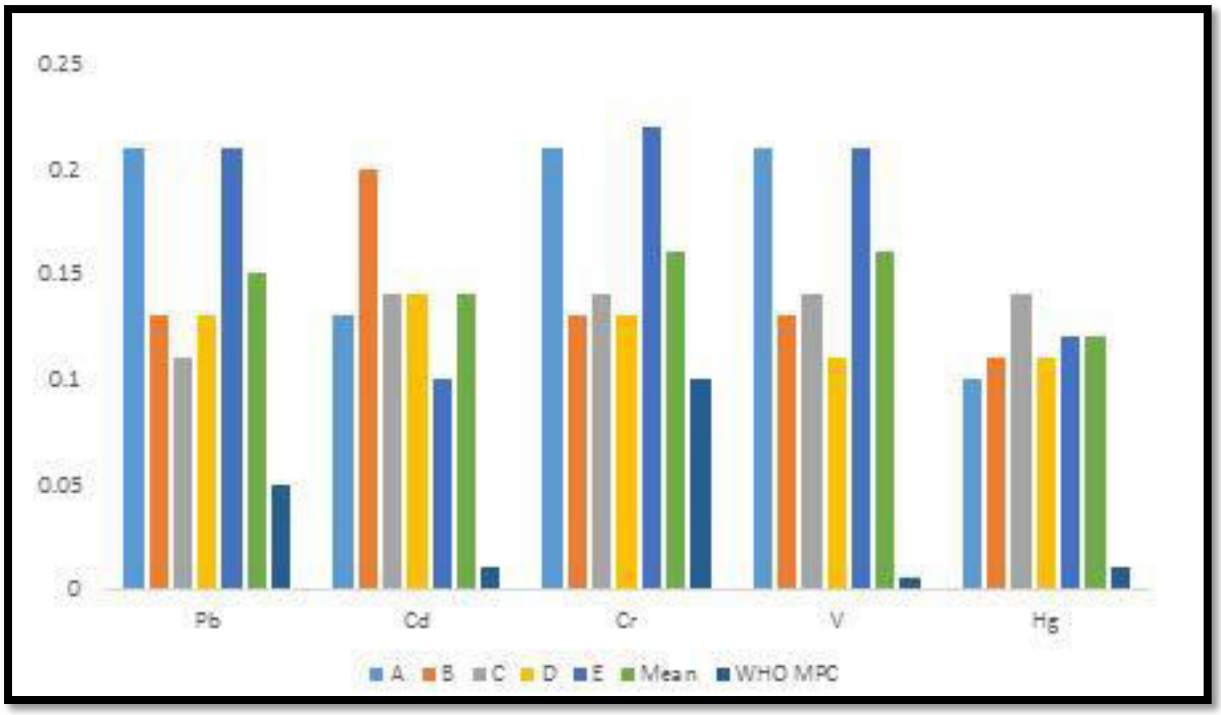
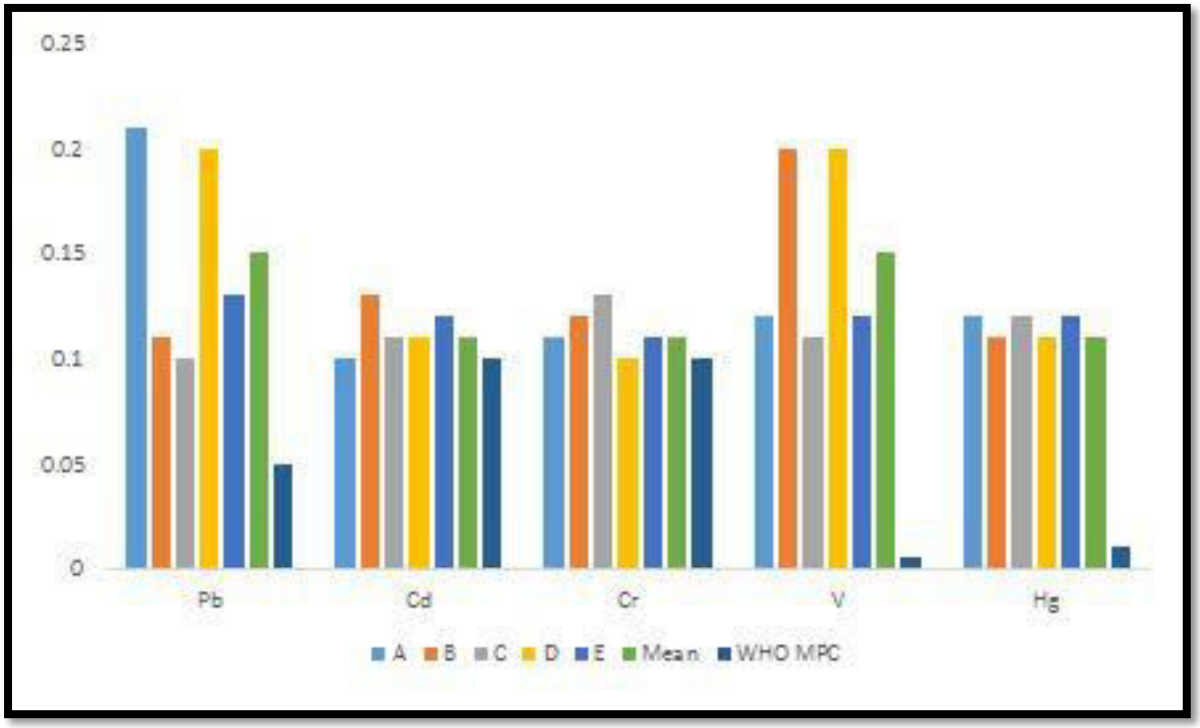


Figure 3: Results of heavy metal content in fish species in Kirikiri wetland and WHO MPC in mg/kg



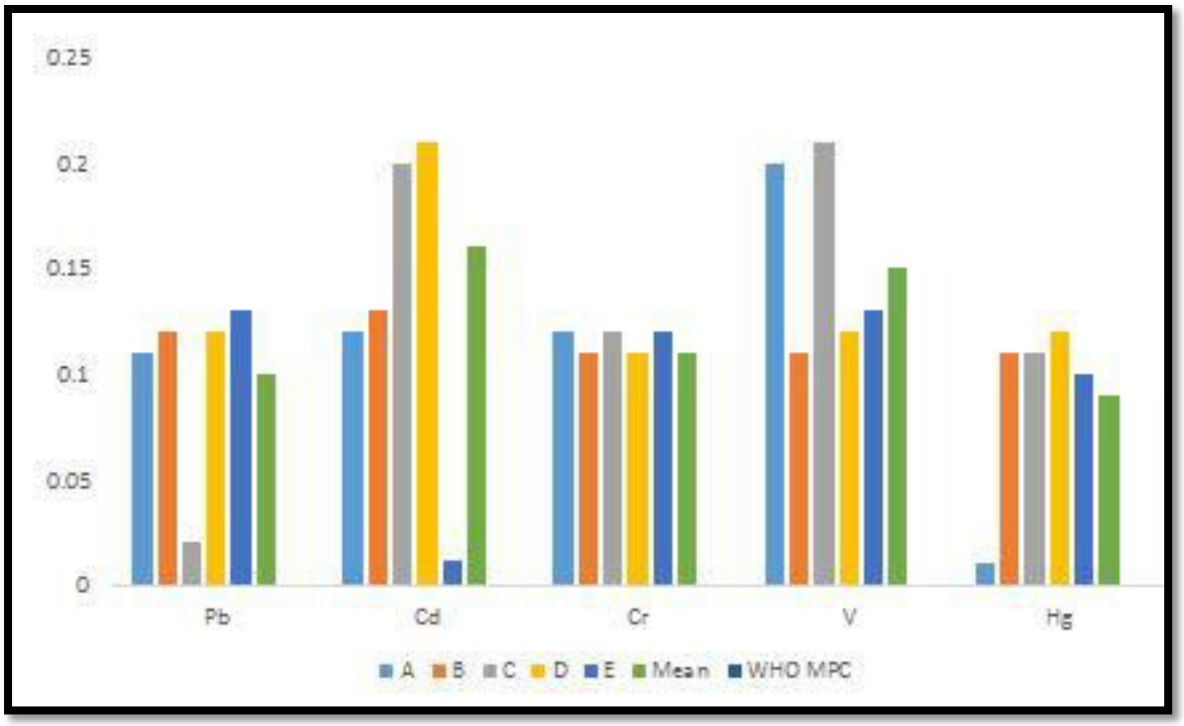
The results of the heavy metals in fish species in Ebuta-Meta wetland are as in Figure 4

Figure 4: Results of the heavy metals in fish species in Ebuta Meta wetland and WHO MPC in mg/kg



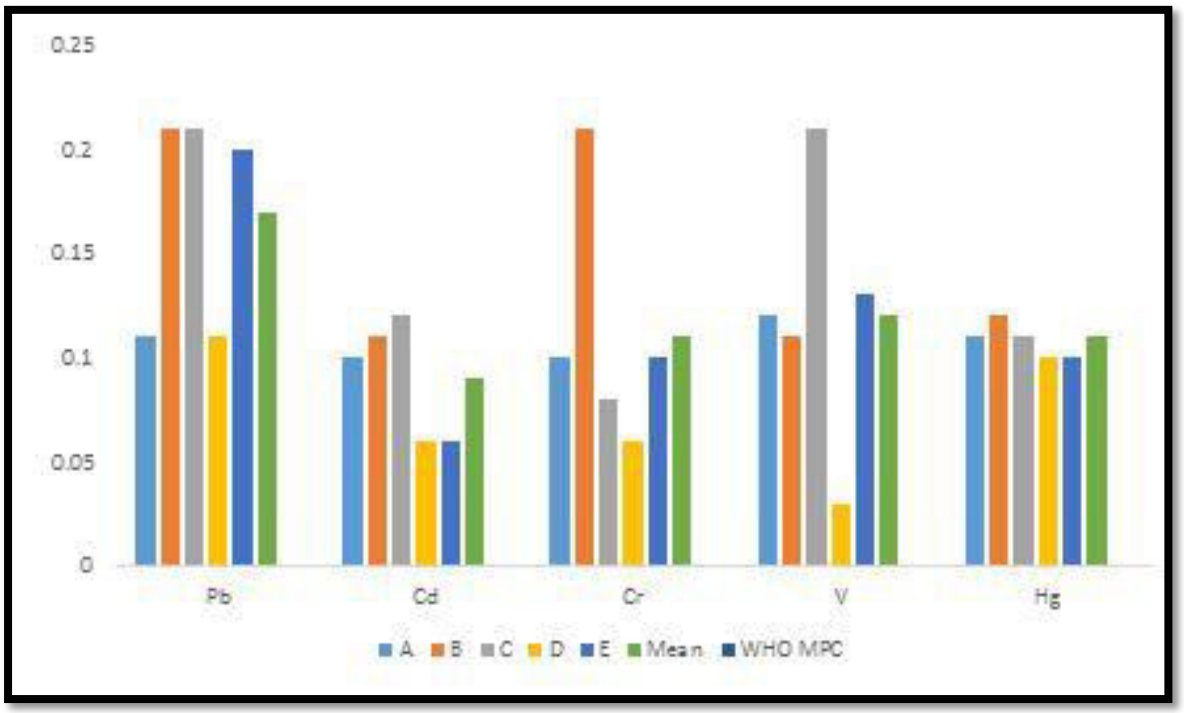
The results of the heavy metals in fish species in Iba wetland are as in Figure 5

Figure 5: results of heavy metals in fish species in Iba wetland and WHO MPC in mg/kg



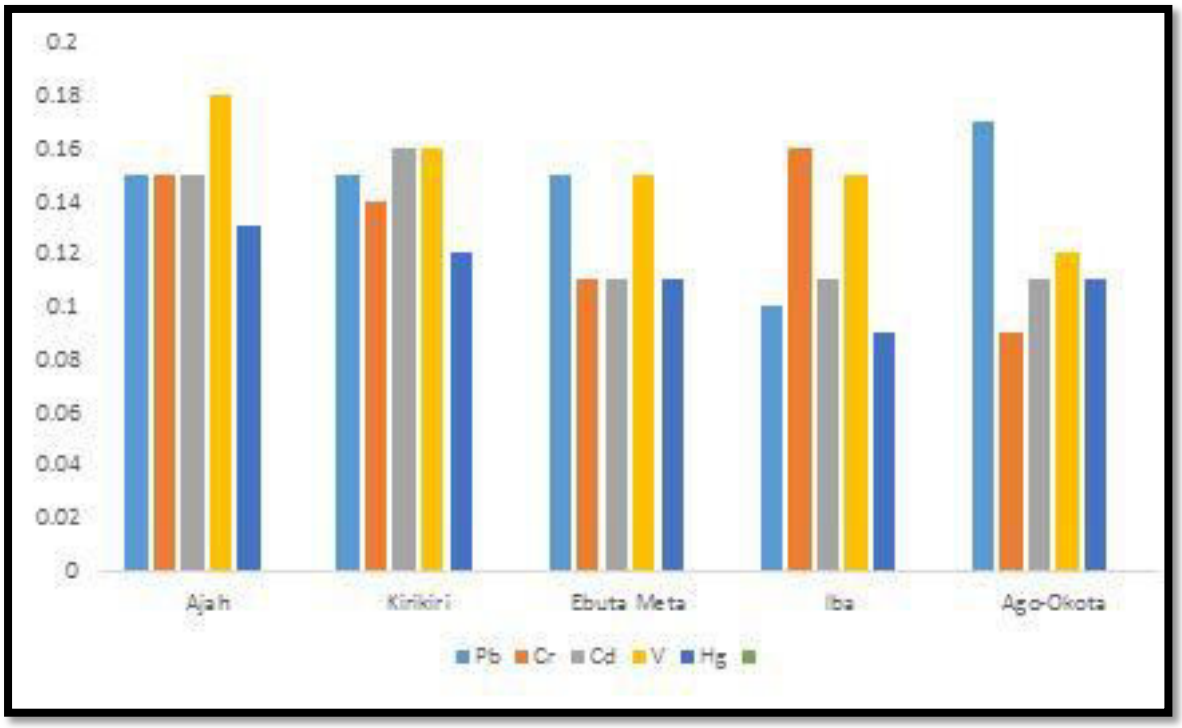
The results of the heavy metals content in fish species in Ago-Okota wetland are as in Figure 6

Figure 6: results of the heavy metals in fish species in Ago-Okota wetland and WHO MPC in mg/kg.



The grand means of the heavy metals in the fish species in the wetlands in Lagos are as inFigure 7

Figure 7: Results of grand mean of the heavy metals in fish species in wetlands in Lagos and WHO MPC in mg/kg.



The grand means results of the heavy metals in the wetlands were subjected to test of significance deploying special package for social science (SPSS) model 29at 0.05 level of significance. The p-value is 0.34 thus rejecting H_0.

Discussion

Analysis of the heavy metals in fish species in selected wetlands in Lagos presented varying mean concentrations of the metals investigated.

Mean concentrations of Pbis 0.15mg/g in Ajah wetlands Kirikiri and Ebuta-melta wetland to 0.01 mg/kg in Ago-Okota wetland, with a grand mean of 0.14mg/kg while WHO MPC for Pb is 0.05 mg/kg. The increased concentration of Pb in fishes in the wetlands is the concomitant effect of effluent discharges into the wetlands. High content of Pb in fishes in wetlands was in the reports of (Zhang *et al*., 2015, Sekitar, *et al*., 2015). Human exposure to Pb leads to high blood pressure, abdominal pain, lack of concentration (Luczynska*et al*., 2016), damage to the brain, hearing and speech problems and slow growth and development (Datha*et al*., 2013Gupta *et al*., 2011, Ogwu*et al*., 2023c).

The analysis of fish species harvested in some wetlands in Lagos also revealed mean concentrations of 0.09 mg/kg in Ago-Okota wetlands to 0.15mg/kg in Ajah wetlands with grand mean concentration of 0.13 mg/kg. WHO MPC for Cr in fishes is 0.05 mg/kg. The elevated concentrations found in the fishes are the effects of industrial wastes discharges into the wetlands. High content of Cr in fishes tissues have been reported(Wei *et al*., 2014, Traina*et al*., 2019, Vu *et al*., 2017, Ogwu*et al*., 2023d). Prolonged human exposure to Cr results in human health problems such as renal damage, asthma, respiratory problems (Abtani*et al*., 2017, Rahmani*et al*., 2018), cancer irritation to the linnings of the nose and nose ulcers (Heshmati*et al*., 2018, Vi *et al*., 2011, Xiao, 2018).

The analysis of the fishes tissues harvested in wetlands in Lagos for their Cd bioaccumulation revealed means varying from 0.11mg/kg in Ebuta meta, Iba and Ago-Okota to 0.16mg/kg in Kirikiri wetland with grand mean of 0.13 mg/kg. The WHO maximum permissible concentration for Cd in fish is 0.005 mg/kg. The high content of Cd in the fishes are the effect of industrial effluent disposal into the wetlands and environ. Similar report of high Cd in fish tissue were reported in (Dadar, *et al*., 2017, Fakhri, 2017, Ogwu,

2023a). The health effects of Cd include lung diseases, kidney problems, bone degeneration (Fantke*et al*., 2017, Peper*et al*., 2012, Yin *et al*., 2015, Hu *et al*., 2013), cardiovascular diseases, osteoporosis, cancer (Cao *et al*., 2014, Vielra*et al*., 2011).

The laboratory analysis of fish tissues from selected wetlands in Lagos showed that the V mean content vary between 0.12 mg/kg in Ago-Okota wetland to 0.18mg/kg in Ajah wetlands with a grand mean concentration of 0.15mg/kg. WHO MPC for V in fish is 0.05 mg/kg.Increased V in the fishes tissues is due to bioavailability of V in the wetlands ecosystem. Increased content of V in fishes tissues have been reported (Raknuzzaman*et al*., 2016, Kumar *et al*., 2012, Mutra*et al*., 2012). Human effects of exposure to V include damage to liver and kidney (Kwork*et al*., 2014, Rajeshkumar, 2018), irritation of the nose, throat and lungs (Ogunsola*et al*., 2017).

Analysis of fish tissues harvested in wetlands in Lagos for Hg also presented varying mean concentrations ranging from 0.09 mg/kg in Iba wetlands to 0.13 mg/kg in Ajah wetlands with an grand mean of 0.11 mg/kg. WHO MPC for Hg in fish tissues in 0.001 mg/kg. The high concentration of Hg in fishes is the result of poor effluents management which resulted in the bioaccumulation. High concentration of Hg in fishes harvest in wetlands were in the reports of (weber *et al*., 2013, Bing *et al*., 2011, Liu *et al*., 2019). Effects of Hg on human health include lack of coordination, hearing loss and speech difficulties, muscle weakness (Sanyal*et al*., 2015, Zatarzadeh, 2018, Tvermoes*et al*., 2014), damage to gastrointestinal tracts, kidney and nervous system (Okogwu*et al*., 2019, fakhri*et al*., 2018).

Conclusion and recommendation

Industrialization and industrial activities are for the betterment of life and for improved stand ards of living. However, such industrial activities should be carried out with utmost concern for all indices of the environment, air, soil, fauna flora water and wetland ecosystems. Thus best practices in all activities of industries should be the mantra of operation. The results of the analysis of fish species harvested in wetlands in Lagos revealed that the fishes are contaminated with heavy metals thus making them unhealthy for human consumption and also not able to scale Codex Alimentan us conditions for export of fish products.

Consequent upon the results of the analysis, the study therefore recommends the followings:

- Fishes in the wetlands should not be consumed.
- Industries operating in Lagos city should adopt the standards of operation spelt out by National Environmental Standards Regulation and Enforcement Agency (NESREA) Act 2007
- NESREA should step up their surveillance on all the industries operating in Lagos state.
- Impacted wetlands should be remediated immediately for the wetlands to continue to provide their ecosystem services.

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