INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 21, No. 2, p. 169-178, 2022

RESEARCH PAPER OPEN ACCESS

Speciation of heavy metals in fish species in the wetlands of oil-bearing communities of the Niger Delta

Ogwu Chukwudi[1*], Imobighe Mabel[2] Okofu Sabastina[3], Attamah Fidelia[4]

[1&2]*Department of Vocational Education, Delta State University, Abraka*
[3]*Department of Marketing and Entrepreneurship Studies, Delta State University, Abraka*
[4]*Department of Agricultural Education, University of Nigeria, Nsukka*

Key words: Oil exploitation, Wetland pollution, Heavy metals, Fisheries.

http://dx.doi.org/10.12692/ijb/21.2.169-178 Article published on August 10, 2022

Abstract

This study investigated the heavy metals concentration in 3 fish species: *Tilapia zilli, Clarias* spp, and *Chana obscura* in the wetlands of oil-producing states of the Niger Delta. In carrying out this study, 5 oil-bearing communities were randomly selected from 5 randomly selected Niger Delta states and fish samples were randomly collected from the wetlands with the assistance of artisanal fishermen. The samples from each wetland were bulked and composites drawn and preserved in the ice-cooled box at -20°C and taken for laboratory analysis. The analytical standards adopted were ASTM and APHA and the analytical instruments deployed are Marek VI standard reagent Australia and Agilent ICP-MS 7900. The results obtained were: Hg range from 0.19µg/l to 0.34 µg/l with a mean of 0.29 µg/l, Cr range from 0.26 µg/l to 0.72 µg/l with a mean of 0.46 µg/l, Pb range from 0.43 µg/l to 0.49 µg/l and the mean 0.48 µg/l and the concentration of V range from 0.73 µg/l to 0.59 µg/l with a mean of 0.67 µg/l while Cd range was 0.15 µg/l to 0.50 µg/l with a mean of 0.36 µg/l. The results were subjected to a test of significance with ANOVA SPSS model 21 at a 0.05 level of significance. The p-value is 0.41, thus rejecting Ho. The study recommends that fisheries and aquaculture activities should be suspended forthwith. Clean-up and remediation should be commissioned and the Environmental Monitoring Agencies should ensure that oil companies adopt global best practices in doing their businesses in the region.

* **Corresponding Author:** Ogwu Chukwudi ✉ chukwudiogwu008@yahoo.com

Introduction

Nigeria was an agrarian country with agriculture accounting for 90 percent of its foreign exchange earnings and 95 percent of its budget revenue (Nwankwo, 2018; Oteriba, 2019; Ruwani, 2020). Agriculture accounted for education, health and all the infrastructural developments in colonial Nigeria and in the early years of independence (Awogbemi, 2017; Arinze, 2018; Tor, 2018). Nigeria's economy at that era was stable, and the currency was at par with the British pound and was stronger than the American dollar (Sarumi, 2017; Nwankwo, 2018; Ayorinde, 2018).

The discovery of oil in Nigeria in 1958 dislocated the economy's old order, pushed agriculture to the backburner, encouraged rural-urban drift and engendered exotic tastes (Adejumo, 2017; Agbalajobi, 2018; Ochu, 2019). Nigeria, with an oil production volume of 2.5 million barrels per day, is the greatest oil producer in Africa and the sixth greatest oil producer in the world (Lukman, 2012; Nigeria National Petroleum Cooperation (NNPC), 2013; Kachukwu, 2018). Crude oil is Nigeria's present viable export product and foreign exchange earner as it presently accounts for 80 percent of federal government revenue and 90 percent of foreign exchange earnings (Anyawu, 2021; National Bureau of Statistics, 2022; Oteriba, 2022). Nigeria is a notable member nation of the Organisation of Petroleum Exporting Counties (OPEC) and the immediate past OPEC secretary was a Nigerian (Adekunle, 2020; Dawodu, 2020; Aminu, 2021). The oil belt in Nigeria is the Niger Delta, as all crude oil activities in Nigeria are carried out in the Niger Delta region (Wiwa, 2019; Clarke, 2019; Ogagaoghene, 2021). Oil extraction is associated with the input of oil into the terrestrial and marine environment as a result of equipment failure, tank wash, ballast water, sabotage, pipe rupture, illegal refineries and so on (Adamu, 2020; Asuquo, 2021; Lawal, 2022). Nigeria recorded approximately 5000 cases of oil spillage in the Niger Delta in the past 6 years with an approximate total of one trillion barrels lost to the environment (Federal Ministry of Petroleum Resources, 2021; Federal Ministry of the Environment, 2022; Friends of the Earth, 2022). Crude oil is composed of an organic compound, heteroatoms (N O, S,) hydrocarbons (C, H) and varying concentrations of heavy metals (Hg, V, Fe, Na^+, Ca^+, Pb, V, Cd, Cr, As and so on) (Ogwu *et al.*, 2021; Wivwarmar and Xiaoyu, 2018; Djedjibegovic, 2020). Bioavailability of heavy metals in the aquatic environment results in bioaccumulation and biomagnification of heavy metals in the cells and tissues of fishes and other aquatic populations (United States Department of Health and Human Services, 2020; Verdade, 2010). Exposure to heavy metals a concentrations higher than the recommended limit result in varying health complications including elevated blood pressure, kidney and bone disease, lung cancer, neurobehavioral and developmental disorder and so on (Ogwu, 2020, Tyokumbur and Okorie, 2014; Petrovic *et al.*, 2013; Burger and Gochfield, 2005). And the product will fail to meet international trade standards for export stipulated for agricultural products (FAO/WHO/Codex, 1963).

Studies have been conducted on the effect of oil exploitation on the aquatic population community of some oil-producing communities, but a comprehensive and comparative study on the effects of oil exploitation on the wetland population of the oil-producing belt of Nigeria, the Niger Delta, remained largely unavailable, hence this study. The focus of this study is the determination of the concentrations of heavy metals in the tissues of three fish species; *Clarias* spp, *Talapia zilli* and *Chana obscura* ubiquitous in the wetlands of the Niger Delta oil-bearing communities. The heavy metals investigated are Hg, Cr, Pb, V and Cd.

The study is guided by research questions as follows:
What are the concentrations of Hg, Cr, Pb, V and Cd in the tissues of fish species in the wetlands of Niger Delta oil-bearing communities?
Are the concentrations of the heavy metals in the fish species within the limit stipulated by WHO (2014) and EU Regulation (1881) (2006)?

Can fisheries and aquaculture activities be continued in the wetlands?

Can the products meet consumers' standards recommended by Codex Alimentarius Commission (CAC) (1963)?

The study is guided by the hypothesis below:

Ho: there is no significant difference between the concentrations of heavy metals in the fish species in the wetlands at Niger Delta oil-producing communities and WHO/EU maximum allowable concentrations for heavy metals in fish.

Study area

The Niger Delta is the oil-bearing zone of Nigeria. It is located on the gulf of guinea at the mouth of the Atlantic Ocean lying at the geographical coordinates of latitude 5° 32" and longitude 6°459". It is fed by the sediments from the Niger River. The Niger Delta covers an area of 75,000 km² and it is noted as one of the world's major hydrocarbon belts (Awaritoma, 2011). The states that make up the Niger Delta include Delta, Edo, Akwa Ibom, Cross River, River States, Abia, Bayelsa and Ondo states. The inhabitants of Niger Delta are majorly fishermen, and some are peasant farmers, while some work in oil and gas industries. A good population of them are civil and public servants with some others prying their trades as artisans and petty traders (Obadoni, 2015, Udom, 2017, Obaduemu, 2018).

Materials and methods

Ethical statement

The fish samples were obtained from the wild; they were not threatened or endangered and were collected with the help of artisanal fishermen. There is no edict or law in place prohibiting fish harvest or cropping in the wetlands to warrant permission. Therefore no permission was sought before sample collection.

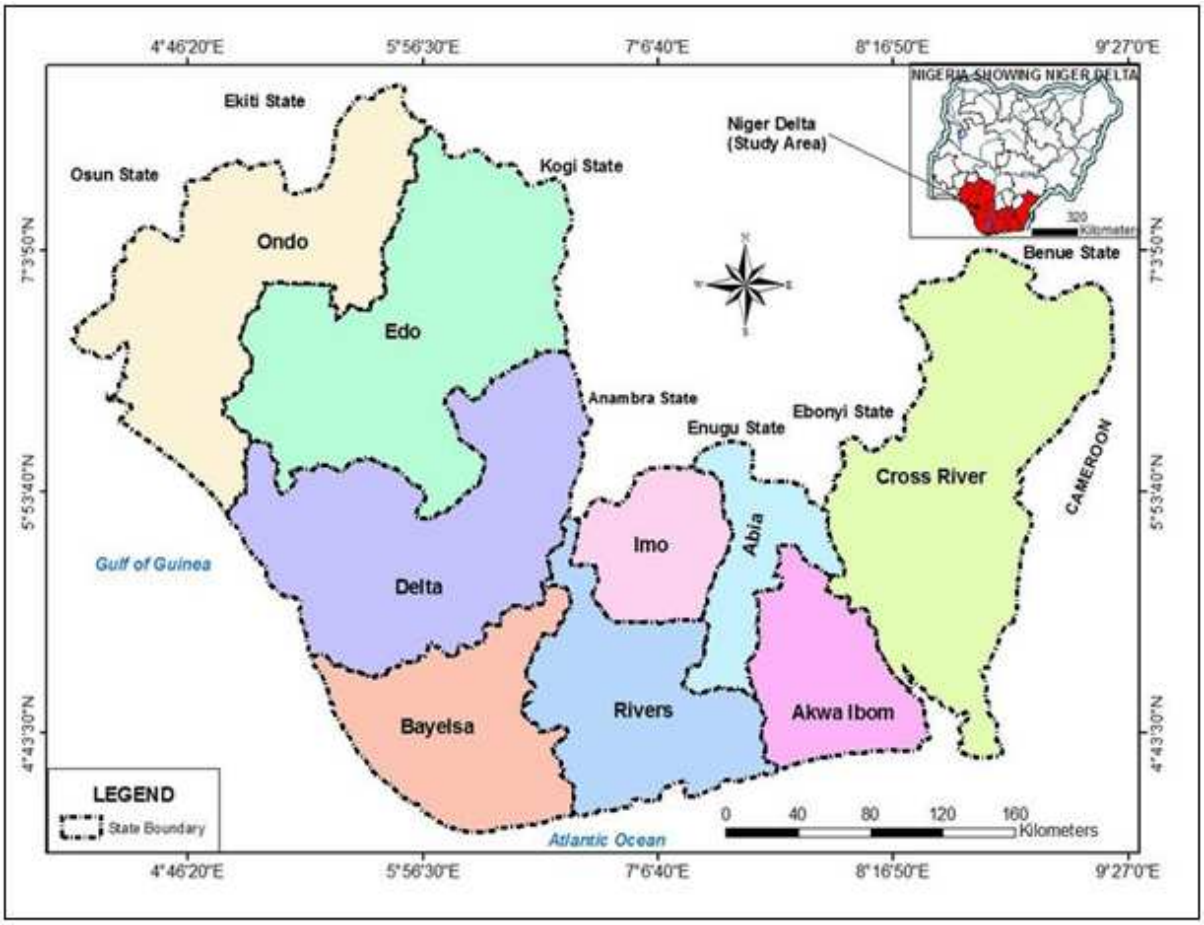

Fig. 1. Map of Niger Delta.

Source: Oweikeye, E 2017

Sampling procedure

The three fish species common in the Niger Delta wetlands viz catfish (*Clarias garipinus* and *Clarias angularis)* tilapia, *Tilapia zilli* and Snakehead *Chana obscura* were used for the study.

The Niger Delta region is comprised of 9 states; out of these, 5 states were randomly selected to make the sample, and these are Abia, Ondo, Edo, Bayelsa and Akwa Ibom. From each of the 5 states, an oil-bearing community was randomly selected to make the sampling station (SS) and from the sampling stations (SS) 5 oil-bearing villages were randomly selected for sample collection. The sampling stations in each state were Abia; Owaza oil-bearing communities and the wetlands sampled were in Obarhia, Okeikpe, Owo-Ala, Owo-Asa and Umuiku. In Ondo state, the sample station was Ugbo oil-bearing community and samples were collected from Moore, Ilode, Iremo, Okerowa and Ilare. In Edo state, the sampling station is Idogbo oil-bearing community, while the samples were collected from Evbuomodu, Umusan, Obazagbon, Agedo and Ekoja. The sampling station in Bayelsa state is Sagbama and the sampled wetlands include Abuetor, Osiko, Odoni, Agbere and Osakweni and in Akwa-Ibom, the oil-producing community that made the sampling station is Ikot-Abasi and the wetlands sampled were in Ikot Ikpo Inwa, Afa Udo Usung, Afan Eka Iko, Afan Ikpe and Essene. From each of the 5 wetlands in a state, a sample of each of the 3 fish species was collected, giving a total of 15 samples which were then bulked composites of each taken and stored in -20°C ice-cooled boxes for analysis (Dai and Sun 2001; Oliveira-Ribeiro *et al.*, 2005; Qui *et al.*, 2007). The sample collection was carried out within a period of 6 months, July to December 2021, deploying cast, seine gill nets and hood and line.

Samples preparation and determination of heavy metals

The analysis of the samples was carried out in an ultramodern laboratory at the National Institute of Oceanography and Marine Research Lagos Nigeria Laboratory. The samples were thawed of ice, tilapia and *Chana obscura* scales removed and the samples were dissected with stainless steel scalpels. They were then freeze-dried with cuddon freeze-drying machine (Australia model F23000) at 200°C for 24 hours (Shafiuddin-Ahmed, 2007). The specimen was allowed to cool to room temperature for 24 hours. 0.5g of the samples were weighted out and placed in 10ml of 100 percent nitric acid followed by sulphuric acid and heated in an oil bath with 4 drops of hydrogen peroxide (H_2O_2) added persistently until a clear mixture is obtained. The solution was then mineralized deploying LG 21 microwave digesting machine model (MC2146BG). The resulting solution was then filtered, diluted in a 50 ml tezaran tube and allowed to cool for 30 minutes (Djedjibegovic *et al.*, 2020). Merek VI standard reagent Australia was used to analyze the concentration of the various metals in the samples. The accuracy check was conducted utilizing a certified reference material CRM, 430 Merek KGaA Australia) (Islam *et al.*, 2018). The concentration of the metals Hg, Cr, Pb, V and Cd were further confirmed with Agilent inductively coupled plasma mass spectrometry (ICP-MS) 7900.

Results

The results of the heavy metals content in fish species in wetlands of the Niger Delta oil-bearing communities and the World Health Organisation (2014) and European Union Regulation 1818 (2006) are as in Figs 2 to 6 and the aggregate comparison of the concentrations of the heavy metals content in the fish samples from the Niger Delta oil-bearing states in Fig. 7.

The heavy metals content aggregate comparisons of the fish samples from the wetlands of Niger Delta oil-producing states and the WHO (2014) and EU (2006) in µg/l.

The mean concentration of the heavy metals content from the wetland of oil-bearing communities of Niger Delta States was subjected to a test of significance deploying analysis of variance (ANOVA) with a special package for social sciences model 21 at a 0.05 level of significance. The p-value obtained was 0.41, thus rejecting Ho.

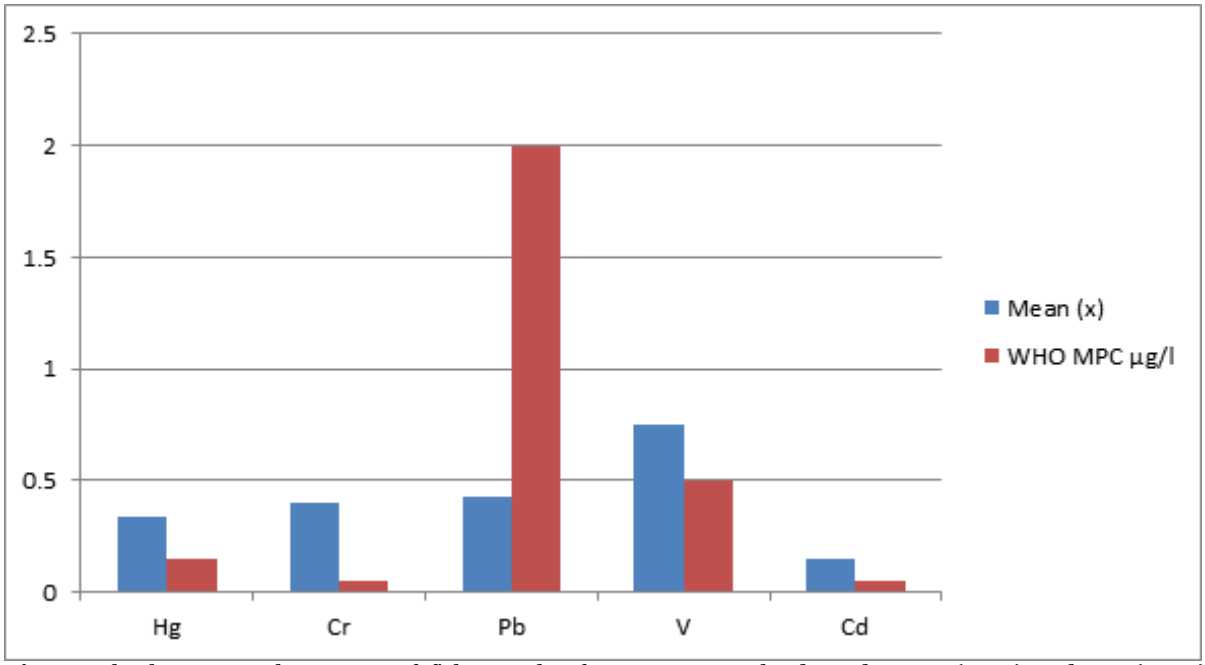

Fig. 2. The heavy metals content of fish samples from Owaza wetlands and WHO (2014) and EU (2006) maximum allowable concentration in µg/g.

The concentrations of the heavy metals in fish samples in Owaza wetlands in decreasing order are: V > Pb > Cr > Hg > Cd.

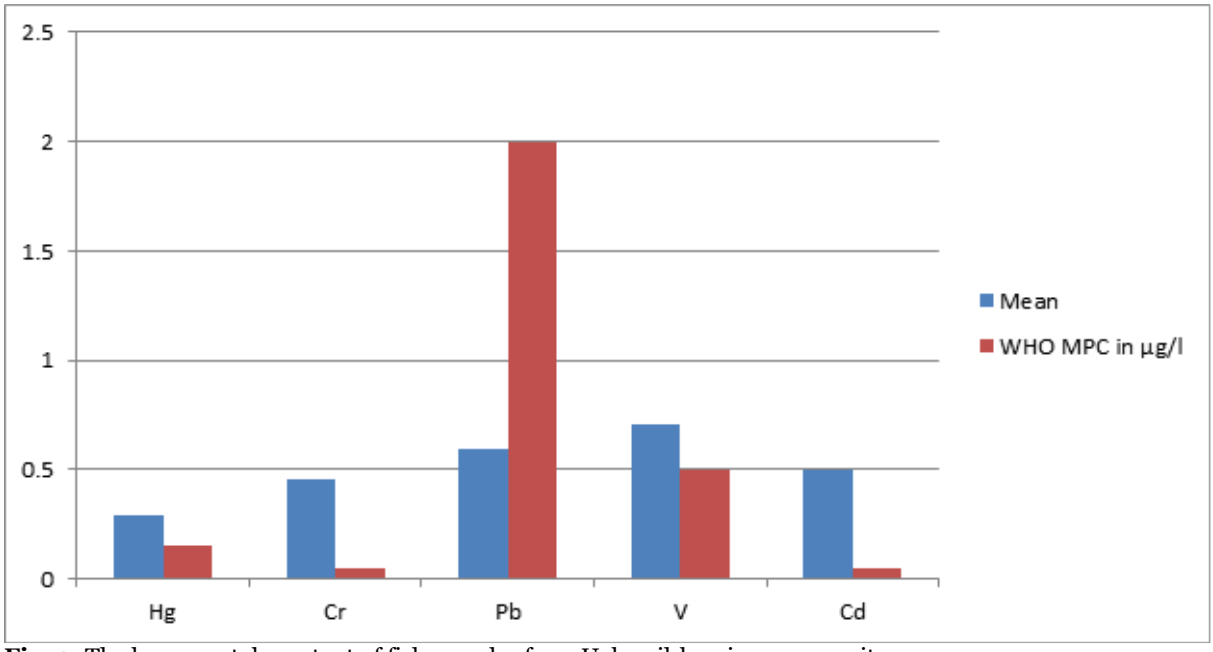

Fig. 3. The heavy metals content of fish samples from Ugbo oil-bearing community.

The concentrations of heavy metals in the fish samples in Ugbo wetland in decreasing order are: V > Pb > Cd > Cr > Hg.

Discussion

The analysis of the fish's specimen from the various wetlands in the Niger Delta oil-producing communities reveals varying concentrations of the heavy metals investigated.

The analysis of the specimens for Hg showed that the content of Hg ranges from 0.34 µg/g in Owaza to 0.19µg/g in Ikot Abasi. The presence of Hg in fish samples from the wetlands of the oil-producing communities is traceable to the degradation of crude

oil samples inputted into the ecosystem by oil exploiting companies. The presence of Hg in fish consumed by human's results in cancer of the lungs and changes in the blood vessels (Agency for Toxic Substances and Diseases Registry (ATSDR) 2018; American Environmental Protection Agency (USEPA) 2012). The high content of Hg in fish samples has been reported (Liu *et al.*, 2004; Yuan *et al.*, 2011).

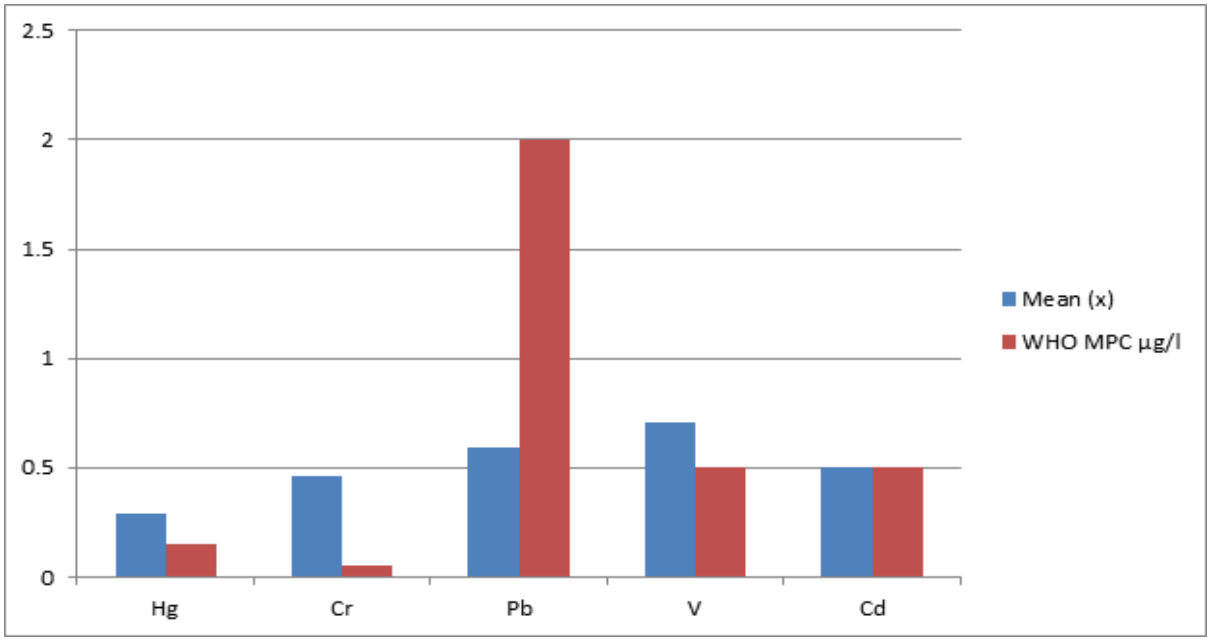

Fig. 4. Heavy metals content of fish samples in Igbodo oil-producing community wetlands.

The concentration of heavy metals in fish samples in Igbodo wetland in decreasing order are: V > Cr > Pb > Hg > Cd.

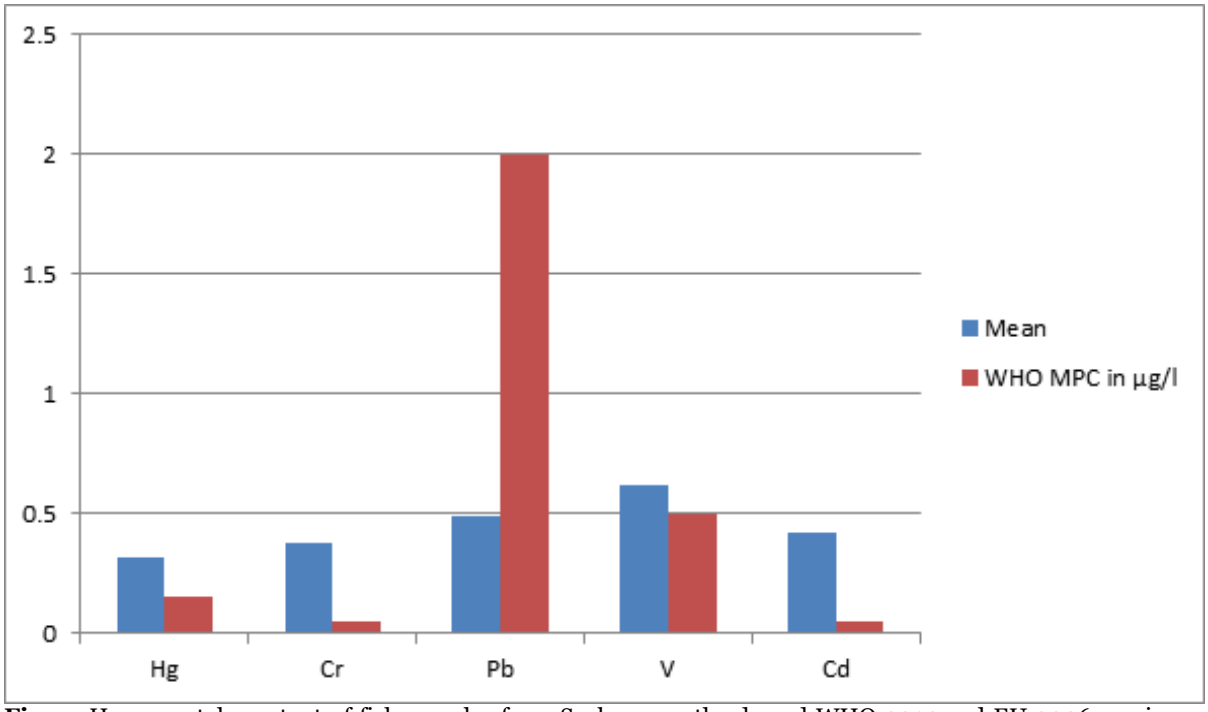

Fig. 5. Heavy metals content of fish samples from Sagbama wetlands and WHO 2014 and EU 2006 maximum allowable concentration of heavy metals in fish in µg/g.

The concentration of heavy metals in fish samples in Sagbama oil-bearing community wetland in decreasing order are: V > Pb > Cd > Cr > Hg.

The analysis of the fish's specimen from the oil-producing communities of the Niger Delta revealed that Cr content range from 0.26 µg/g in Ikot Abasi to 0.72µg/g in Ugbo community showing increased concentration above the stipulated limit in all the wetlands investigated. This elevated concentration of Cd is a resultant effect of oil extraction in the environment. The availability of Cr in humans at above acceptable limit results in health complications such as cancer of the sinus, lung and nasal (Zhang *et al.*, 2015; Wang *et al.*, 2015).

The high content of Cr in fish tissues has been reported (Hu *et al.*, 2008; Zhang *et al.*, 2010).

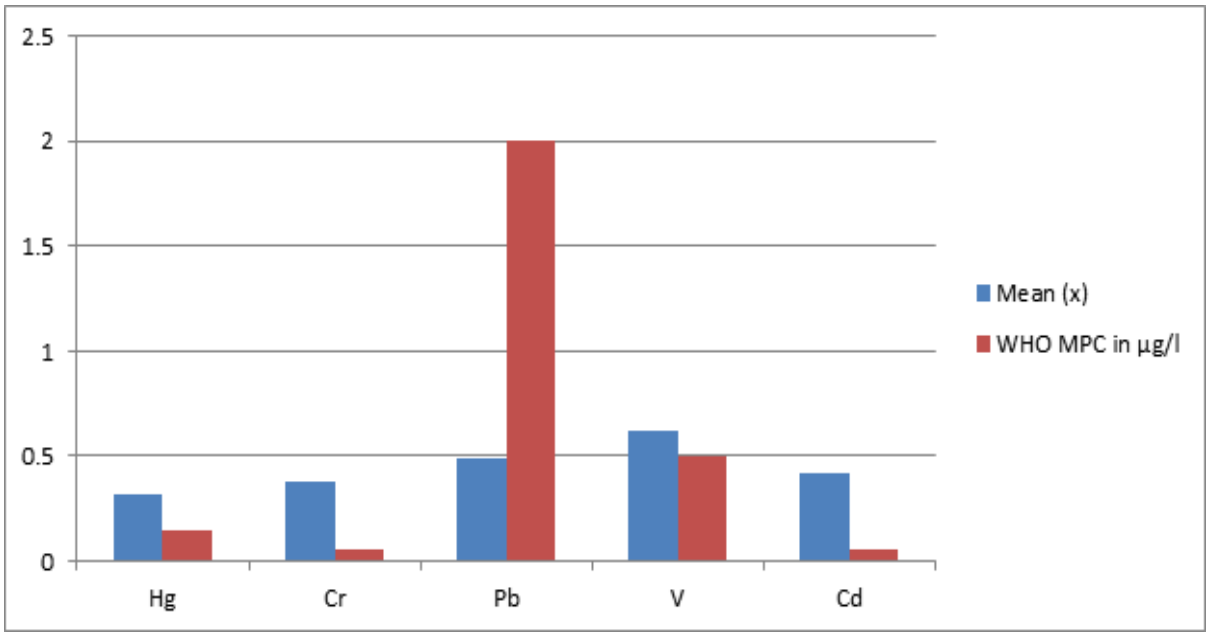

Fig. 6. Heavy metals content of fish samples in Ikot Abasi oil-bearing community wetlands.

The concentrations of heavy metals in fish samples in Ikot Abasi wetland in decreasing order are V > Pb > Cd > Cr > Hg.

The concentrations of Pb in the fish samples the investigation revealed are between 0.43 µg/g in Owaza to 0.59µg/g in Ugbo oil-bearing community. The presence of Pb in the wetlands of oil-bearing communities of the Niger Delta is the aftermath of oil activities in the region. Increased content of Pb in fish tissue has been reported by (Obasohan and Orosaryan 2006; Bao *et al.*, 2015).

The health implications of the presence of Pb above acceptable concentrations in humans are brain damage, kidney failure and osteoporosis (USEPA, 2012; ATSDR, 2018). It also causes abdominal pains, short-term memory and fatigue (Raheed, 2001; Evans, 2009). The analysis of the fish samples from Niger Delta oil-producing communities presented varying concretions of V in all the research stations investigated. The V concentrations range from 0.59µg/g in Ugbo to 0.73µg/g in Owaza. These concentrations, quite higher than the levels recommended by WHO (2014) and EU (2006) occur due to oil exploitation activities in the wetlands. High exposure to human to V results in health complications such as vomiting, nausea, abdominal pains and greenish discoloration of the tongue (Chi *et al.*, 2007; Rahman *et al.*, 2012). Increased V in fish tissues was in the reports of (Fan *et al.*, 2002; Uysal, 2008).

The content of Cd in the fish specimen from the Niger Delta wetlands the analysis revealed is in the range of 0.15µg/g in Owaza to 0.50µg/g in Ugbo.

The presence of these concentrations of Cd in the fish samples from the wetlands is the concomitant effect of crude oil mining activities going on in the region.

Presence of Cd in the human body above the threshold recommended by WHO (2014) and EU (2006) gives rise to various health implications; fragile bone, cancer and renal failure (Xu and Tao, 2004; Azeman *et al.*, 2015; ATSDR, 2018). Shortness of breath, and blurred vision (Islam *et al.*, 2018). A high concentration of Cd was reported (Idris, 2015; Hassan *et al.*, 2018; Khan, 2018).

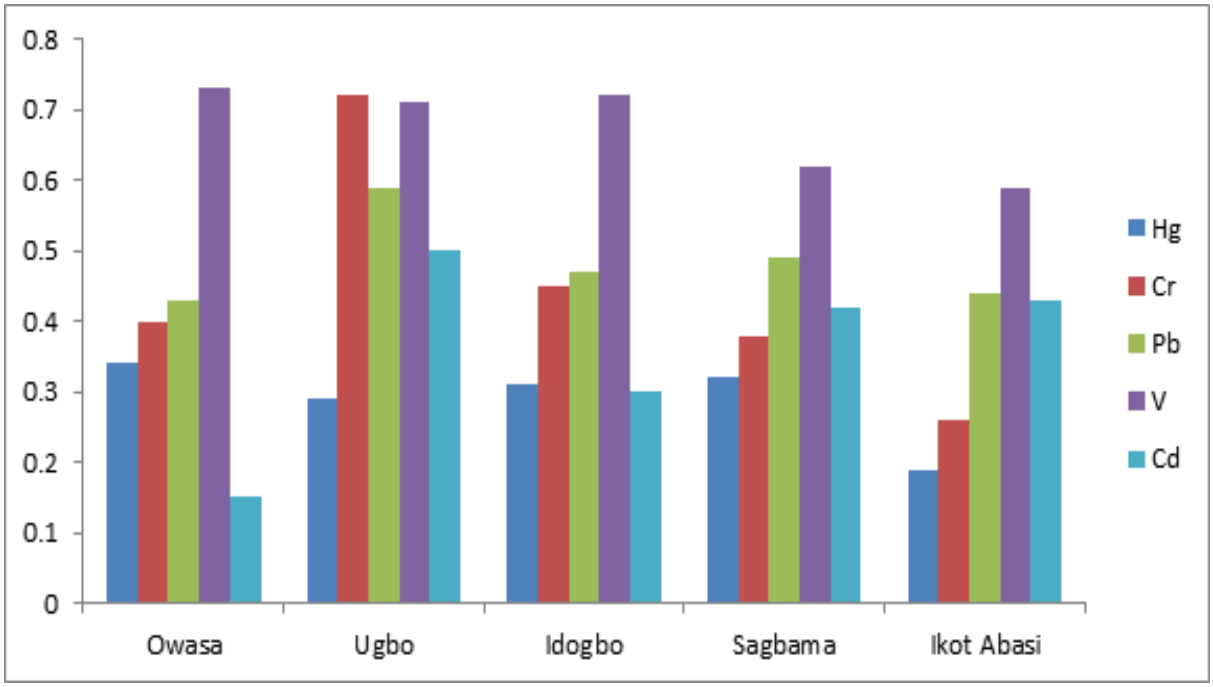

Fig. 7. Comparisons of the heavy metals content of the fish samples from the wetlands of the Niger Delta oil-producing states.

The concentration of the heavy metals in decreasing order are V > Pb > Cr > Cd > Hg.

Conclusion

Quest for economic growth and development for good standards of living result in varying economic activities with some impacting negatively on the environment and one of such is oil exploration and exploitation. The result of the analysis of the fish samples from the wetlands of the Niger Delta oil-producing communities has revealed varying degrees of heavy metals pollution resulting from the activities of the extractive industry. Economic activities are welcome developments only when they are operated within the ambit of the global best practices in the industry. Degradation of the environment to the detriment of the ecosystem service therein is counter-productive and inimical to the population of biodiversity, the health of the consumers in the host communities, wider society of Nigeria and other continents of the world who may consume the seafood harvested or raised from such heavy metal polluted wetlands.

This will make the produce unacceptable in the international market because of its inability to meet the codex 1963 minimum benchmark. Consequent to the result of this investigation, it is recommended that fisheries and aquaculture activities be suspended in these wetlands forthwith. The oil companies operating in the Niger Delta should be mandated to adopt the global best practices in the oil industry, while clean-up and remediation should be commissioned to restore the health of the ecosystem for the service of mankind.

Acknowledgement

We acknowledge the contributions of Dr. Uyimadu, J. P. of the National Institute of Oceanography and Marine Research, Lagos, Nigeria for carrying out the analysis of the specimens, Mr. Omoye Isreal the

Statitician for the statistical analysis and Mr. Ani Donatus Onyema for the computer typing and graphs plotting.

References

Ahmed A, Sultana S, Habib A, Ullah H, Musa N, Hossain M, Rahman M, Sarker S. 2019. Bioaccumulation of heavy metals in some commercially important fishes from a tropical river estuary suggests higher potential health risk in children than adults. *PLoS ONE*. **14(10),** e021933.

Ali H, Khan E. 2018. Bioaccumulation of non-essential hazardous heavy metals and metalloids in freshwater fish. Risk to human health. Environmental Chemistry Letters. **16,** 903–917. https://doi.org/10.1007/s10311-018-0734-7

Azaman F, Juahir H, Yunus K, Azid A, Kamarudin M, Toriman M. 2015. Heavy metal in fish: Analysis and human health-a review. Journal of Technology **77,** 61–69. https://doi.org/10.11113/jt.v77

Bao L, Wang D, Li T, Li Y, Zhang G, Wang C, Zhang S. 2015. Accumulation and risk assessment of heavy meals in water sediment: and aquatic organisms in rural rivers in the Taihu Lake region, China. Environmental Science Pollution Resources **22,** 6721–6731.

Burger J, Gochfeld M. 2005. Heavy metals in commercial fish in New Jersey. Environmental Resources **99,** 403–412.

Codex. 1963. WHO/FAO Codex Alimentarius Commission on Safety of Export Food Products - Animal and plant products. A Codex/WHO publication, Rome Italy.

Dai XL, Sun C. 2001. The characteristics of heavy metals distribution and pollution in sediment from Lake Taihu, Sbanghai. Environmental Science **20,** 71–74.

Evans DW, Dodoo DK, Hanson DJ. 1993. Trace elements concentrations in fish livers Implications of variations with fish size in pollution monitoring. Marine Pollution Bulletin **26,** 329–334.

Fan CX, Zhu YX, Ji ZJ. 2002. Characteristics of the pollution of heavy metals in the sediment of Yilihe River, Taihu Basin, Journal of Lake Science **14,** 235–241.

Hossain M, Ahmed A, Sarker M. 2018. Human health risks of Hg, As, Mn, and Cr through consumption of fish, Ticto barb (Puntius ticto) from a tropical river, Bangladesh. Environmental Science and Pollution Research **25,** 31727–31736. https://doi.org/10.1007/s11356-018-3158-9

Hu W, Zhai S, Zhu Z, Han H. 2008. Impacts of the Yangtze River water transfer on the phosphorus release of the sediments from different tropic areas in Taihu Lake, China, Environmental Pollution **130,** 288–295.

Idriss A, Ahmad A. 2015. Heavy metal concentrations in fishes from Juru River, estimation of the health risk. Bulletin of Environmental Contamination and Toxicology **94,** 204–208. https://doi.org/10.1007/s00128-014-1452-x

Li W, Yang Q, Liu G. 1994. Algal bloom in Lake Taihu and its control, in: Sund H., Yu X., Stabel H., Yuan K., Geller W., She F. (Eds.). Environmental Protection and Lake Ecosystem, Science and Technology Press, China, Beijing p 243–261.

Liu EF, Shen J, Ahu YX. 2004. Source analysis of heavy metals in surface sediments of Lake Taihu, Journal of Lake Science **16,** 113–119.

Meche A, Martins M, Lofrano B, Hardaway C, Merchant M, Verdade L. 2010. Determination of heavy metals by inductively coupled plasma-optical emission spectrometry in fish from the Piracicaba River in Southern Brazil, Microbiology Journal **94,** 171–174.

Obasohan EE, Oronsaye J, Obano E. 2006. Heavy metal concentrations in malapterurus electricus and chrysichthys nigrodigitatus from ogba river in Benin city, Nigeria, African Journal of Biotechnology **5,** 974–982.

Oliveira Ribeiro C, Vollaire Y, Sanchez-Chardi A, Roche H. 2005. Bioaccumulation and the effects of organochlorine pesticides PAH and heavy metals in the eel (Anguilla anguilla) at the Camargue Nature Reserve, France, Aquaculture and Toxicology **74,** 53–69.

Oweikeye E. 2017. GIS Based mapping and analysis of oil pollution in Niger Delta Coastal Environment. http://dx.doi.org/10.13140/RG.2.2. 14491.36648.

Petrovic Z, Teodrorovic V, Dimitrijevic M, Borozan S, Beukovic M, Milicevic D 2013. Environmental Cd and Zn concentration in liver and kidney of erupean hare from different Serbian region: age and tissue difference. Bulletin of Environmental Contamination and Toxicology **90,** 203–207.

Rahman MS, Molla AH, Saha N, Rahman A 2012. Study on heavy metals levels and its risk assessment in some edible fishes from Bangshi River Savar, Dhaka, Bangladesh. Food Chemistry **134,** 1847–1854.

Rajeshkumar, Sivakumar Li, Xiaoyu 2018. Bioaccumulation of heavy metals in fish species from the Meiliang Bay, Taihu Lake, China. Toxicology Reports **5,** 288-295.

Rashed M. 2001. Monitoring of environmental heavy metals in fish from Nasser Lake, Environmental International **27,** 27–33.

Tyokumbur E, Okorie T. 2014. Toxic trace metal contamination (Arsenic, cadmium, and lead) of sarotherodon melanotheron (Rupell, 1852) from alaro stream inIbadan, Journal of Food Nutritional Science. **2,** 258–261.

Uysal K, Emre Y, Köse E. 2008. The determination of heavy metal accumulation ratios in muscle, skin, and gills of some migratory fish species by inductively coupled plasma-optical emission spectrometry (ICP-OES) in Beymelek Lagoon (Antalya/ Turkey), Microchemistry Journal **90,** 67–70.

Wang C, Bi J, Ambrose Jr B. 2015. Development, and application of mathematical model to support total maximum daily load for the Taihu Lakes on fluent rivers, China, Ecology Engineering **83,** 258–267.

Xu S, Tao S. 2004. Coregionalization analysis of heavy metals in the surface soil of Inner Mongolia. Science of the total environment **320,** 73–87. https://doi.org/10.1016/S0048969703)00450-9

Yuan HZ, Shen J, Liu EF, Wang JJ, Meng XH. 2011. Assessment of nutrients and heavy metals enrichment in surface sediments from Taihu Lake: a eutrophic shallow lake in China. Environmental Geochemistry and Health **33,** 67–81.

Zhang L, Shi Z, Zhang JP, Jiang Z, Wang F, Huang X. 2015. Spatial and seasonal characteristics of dissolved heavy metals in the east and west Guangdong coastal waters, South China. Marine Pollution Bulletin **95,** 419–426.

Zhong J, Fan C, Liu G, Zhang L, Shang J, Gu X. 2010. Seasonal variation of potential denitrification rates of surface sediment from Meiliang Bay, Taihu Lake, China. Journal of Environmental S.