ANALYSIS OF THE POLYCYCLIC AROMATIC HYDROCARBONS (PAHS) IN THE WETLANDS IN OKPAI OIL BEARING COMMUNITY FOR CAGE AQUACULTURE ADOPTION AS A RECIPE FOR UNLEASHING SCIENCE FOR ECONOMIC DIVERSIFICATION IN NIGERIA

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ABSTRACT

This study investigated the concentrations of PAHs in the wetlands of Okpai oil bearing community. Five research questions were answered with a hypothesis tested. To implement these, Okpai wetlands were mapped into grids corresponding to Okpai component parts and samples were collected from 5 spots in each adopting grab technique and composite drawn in 125 mL bottles were stored for analysis. The analytical standard was EU 1881/2014 and the instrument of determination was Agilent GC-UV/DAD model 6890G. The mean results obtained were pyrene; 160±0.11 µg/l, chrysene; 1.52±0.13 µg/l, BaP, 1.64±0.12 µg/l, BaA; 1.64±0.13 µg/l and BbF; 1.59±0.12 µg/l. The results were further subjected to test of significance with ANOVA using SPSS model 29 (IBM) at 0.05 level of significance. The p. value was 0.48 thus rejecting the null hypothesis (H0). The study revealed that the wetland was polluted by PAHs above the maximum permissible concentrations, thus making the wetland not suitable for cage aquaculture adoption for economic diversification. The oil companies are thus enjoined to adopt best practices in their operations. Furthermore, environmental pollution monitoring agencies National Oil Spill Detection and Response Agency (NOSDRA) and National Environmental Standards Regulation and Enforcement Agencies (NESREA) should increase their surveillance on the oil exploration and exploitation activities in Nigeria particularly in Okpai, and the impacted wetlands should be remediated and mitigation mechanism be put in place to restore the ecosystem to encourage the adoption of cage aquaculture for in Okpai wetlands in particular and the entire country in general for economic diversification.

Keywords: oil production, PAHs contamination, wetlands pollution, cage aquaculture, economic diversification.

INTRODUCTION

The dream, yearning and aspiration of any country is to achieve economic growth and stability and these goals are predicated on economic diversification. Economic diversification is the utilization of broad range of economic activities in achieving economic growth and development (Smith, 2015, Samuelson, 2017, Betrand, 2019). It is the practice of moving the economy away from mono income source to variable sources (Jones, 2018, MacDolf, 2019, Donald, 2019). Economic diversification is the principle of transiting from sole dependence in one or few products or commodities to variable sources for the sustenance of the economy (Dawodu, 2019, Augustus, 2020). It is the process of shifting an economy away from single income source towards multiple, and growing range of sectors and markets (United Nations, 2015, World Trade Organisation, 2016). Economic diversification involves developing and implementing varying economic streams to ensure the sustenance of the economy in the event of any shock or glut (Solomon, 2018, Dickson, 2019). It ensures economic stability and resilience against any adverse situation in a particular sector (Shaw, 2019, Dell, 2019).

A monocultural economy has been identified as is the bane of many developing countries thus making them susceptible to economic recession. (UNO, 2015, WTO, 2016) and Countries devoid of economic diversity are prone to poor standards of living (Stone, 2018, Neil, 2019, Bolt, 2020).

Nigeria has been a monocultural economy depending solely on oil production for its foreign exchange earnings and Gross Domestic Product (GDP) in recent time (Ruwani, 2019, Akintola, 2021, Tahir, 2021). Nigeria has experienced recession in several instances due to glut in oil market the last two instances were in 2016 and 2020 (Osawuru, 2021, Ogwu *et al*., 2021, Ogwu *et al*., 2022). The antidote to incessant recession and continued economic instability is economic diversification (Ogwu *et al*., 2020, Bamgboye, 2022, Adeoye, 2022). Several economic diversification models have been advocated but agriculture production in variable enterprises, crops production animal (Livestock) and fish (aquaculture) have been highly favoured (Ogwu *et al*., 2020, Afolabi, 2020, Betiku, 2022). Nigeria should diversify its economy by going back to its hitherto strong base; agriculture, and aquaculture (Egwu, 2023). Aquaculture involving cage aquaculture have been in various fora (Babatunde, 2020, Ogwu, 2020, Ogwu *et al*., 2022).

Cage aquaculture is the practice of raising fish in a cage anchored in the floor of the natural body of water (Ogwu *et al*., 2020, Atshana & Atshana, 2012). Adoption of cage aquaculture requires that water analysis be conducted for presence of water pollutants (Eromosele, 2019, Ojerinde, 2019, Ioyem, 2020). Probable water toxicants include pesticides, heavy metals, microplastics, detergents and polycyclic aromatic hydrocarbons (PAHs) (Adiele, 2018, Saliu, 2019).

Polycyclic hydrocarbons are class of organic compounds that are composed of multiple aromatic rings (Sundt *et al*., 2012, Tang, *et al*., 2013) and sources of PAHs in the environment include, gasoline, coal, crude oil (Geni *et al*., 2021, Ozaki *et al*., 2015, USEPA, 2012, Pierre *et al*., 2012. Okpai as an oil bearing community has witnessed oil spill incidences into the terrestrial and aquatic ecosystem (Ogwu, 2020, Eromosele, 2019). Bioavailability of PAHs in wetlands will result in bioaccumulation and biomagnification in the aquatic organisms (Adekoya, 2016, Shobowale, 2017, Ogwu *et al*., 2021). PAHs have been implicated in varying health complications including skin irritation, bladder and lung cancer (United State Environmetal Protection Agency 2012, Agency for Toxic Substances and Disease Registry 2012). Gene mutation and tetragenic damages (Geni *et al*., 2021, Pierre *et al*., 2012).

The focus of this study was the assessment of the PAHs in the wetlands in Okpai an oil and gas bearing community for adoption of cage aquaculture as a recipe for unleashing science for economic diversification in Nigeria. The PAHs investigated were pyrene, chrysene, benz(a)pyrene (BaP), benz(a)anthracene (BaA) and benz(b)fluorathane (BbF). The study was guided by research question as follow:

1. what are the concentrations of pyrene, chrysene, BaP, BaA and BbF in the wetland waters in Okpai oil bearing community?
2. are the concentrations of the PAHs within the maximum permissible concentrations of 1.00 µg/l for PAHs in wetland water stipulated by EU regulations 1881 2014?
3. can cage aquaculture be implemented on the wetlands in Okpai?
4. are the fishes raised in the wetlands fit for human consumption and can they be used as concentrates for animal feed formulation.
5. can the produce be exported considering Codex Allimentarius conditions for produce export?

Area of the Study

Figure 1: Map of Okpai (Source: Google Map, 2023)

Okpai community is littoral, settlement community in Ndokwa East local government area Delta state, Nigeria. It is located within the geographical coordinates of latitude 5°.717'N and longitude 6°.600'E with a land area of approximately 27 kmsq and a population of 41320 (National Population Commission, 2006). Okpai is an oil bearing community playing host to ENI-AGIP of Italy and the largest gas plant in West Africa, is the Okpai gas plant. Okpai people are predominantly fishermen and farmers, the trades they carry out on the numerous wetlands doting the community landscape and on the alluvial deposits that are left behind after yearly denudation.

MATERIALS AND METHODS

Samples collection

This study lasted for 6 months March to August, 2023. The wetlands were mapped out into sampling grids based on the quarters that makeup Okpai, randomly selected for the study and these were Oluchi, Obeze, Ashaka, Anieze and Umuagwulu. Clean plastic sampling bottles that were thoroughly washed and rinsed 3 times with the wetlands water were used as samples containers. Direct sampling technique was adopted (Olenycz *et al*., 2012, Ojerinde, 2019) and samples were collected from 5 spots in each sampling grid, at 10cm depth bulked into grab and composite drawn and stored in 125 mL containers labeled properly and stored in ice cooled boxes for analysis. A total of 125 bulked samples were collected for analysis.

Analysis of the samples

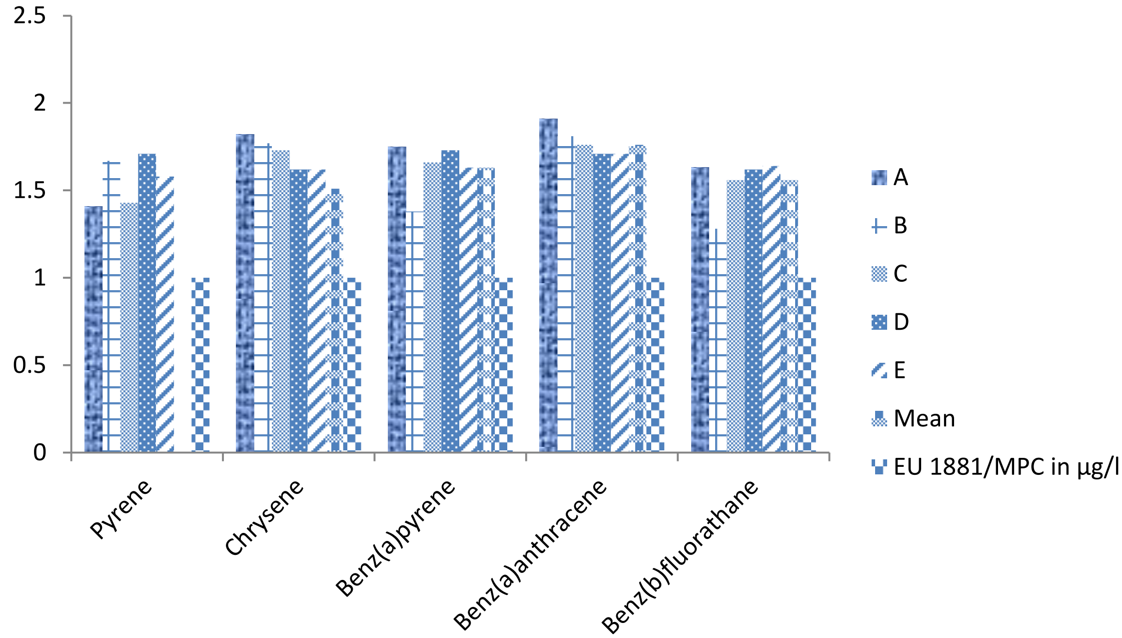
The analytical standards adopted was European union 1881/2014 as described in (Nguyen *et al*., 2014, Ortuna *et al*., 2014). 2ml of the wetland water samples were measured into 15mL centrifuge tube made of polypropylene and into this 15ml of ethylene acetate 1:1v/v was introduced. Vortexing for 1 minute was carried out followed by sonication of centrifugation and this was operated at 4500r/minute for 5 minutes. 5 ml vial was used to collect the upper phase and the samples were then injected into Agilent gas chromatography (AC) coupled to ultraviolet absorption diode-array detector (DAD) (GC-UV/DAD) model 6890Gmtt. Column purification was with 200 mm ×25mn styrene divinylbenzene copolymer gels. The mobile phase was ethylene acetates cyclohaxane calibrated at 5 ml/minute. The eluents were used in the determination of the concentrations of the PAHs.

Statistics and Data processing

The statistical instrument deployed for data analysis was analysis of variance (ANOVA) using special package for social sciences model 29 IBM at 0.05 level of significance and the p. value obtained was 0.48 thus rejecting H0.

RESULTS

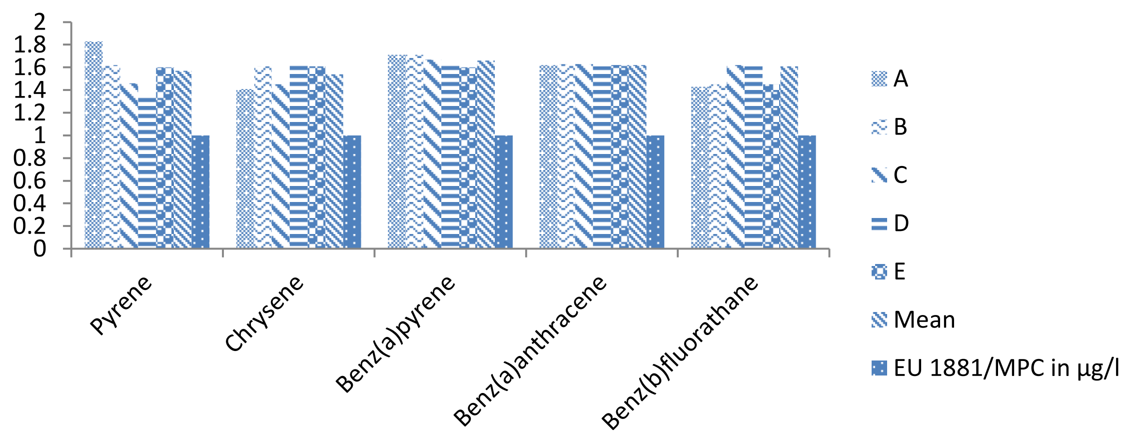
The results of the analysis of polycyclic aromatic hydrocarbons (PAHs) the wetland water in Okpai were as in Figures 2 to 6 and the comparative mean results as in Figure 7. The results of the PAHs in the wetlands in Okpai Oluchi were as in Figure 2.



A – E: samples collection sites

Figure 2: results of the PAHs content in Oluchi wetlands and EU/1881/2014 standard for PAH in wetland water in µg/l

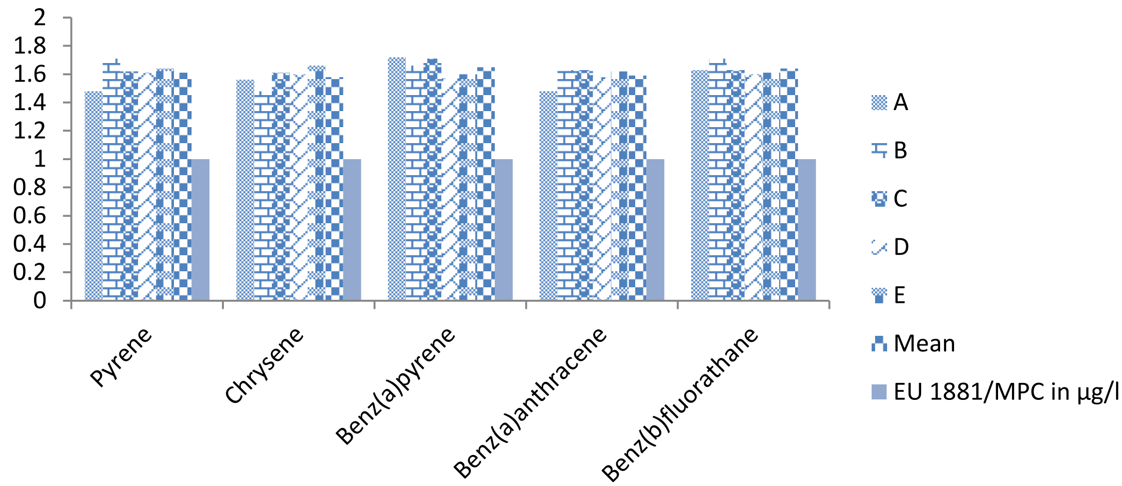
The results of the PAHs concentrations in Okpai Ashaka wetlands were as in Figure 3



A – E: samples collection sites

Figure 3: results of the PAHs content in the wetlands in Okpai Ashaka and the EU 1881/2014 MPC for PAHs in wetland water in µg/l

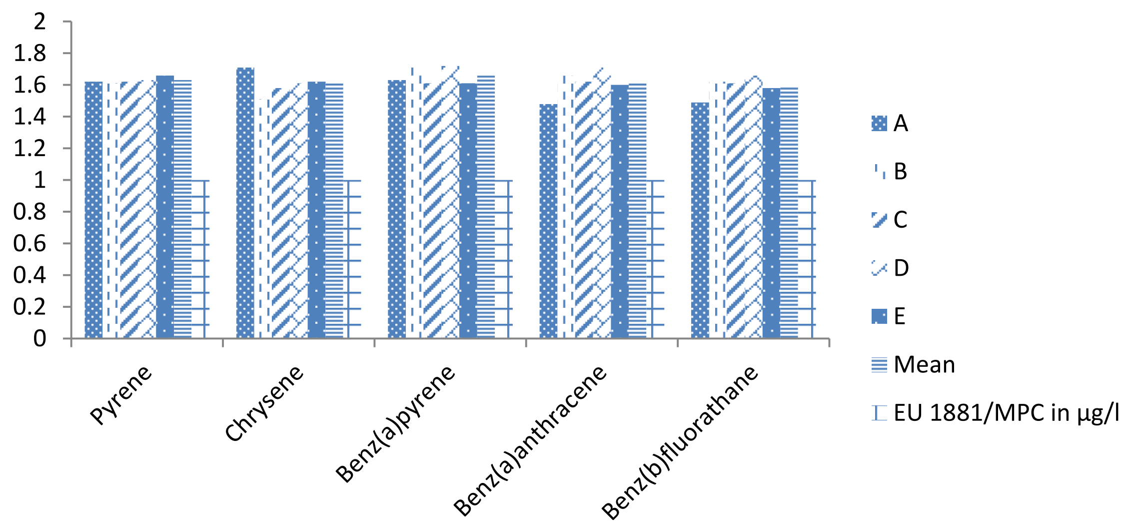
The results of the PAHs in the wetlands water in Obeze were as in Figure 4.



A – E: samples collection sites

Figure 4 results of the PAHs in the wetland water in Okpai Obeze and EU 181/2014 MPC for PAHs in water µg/L

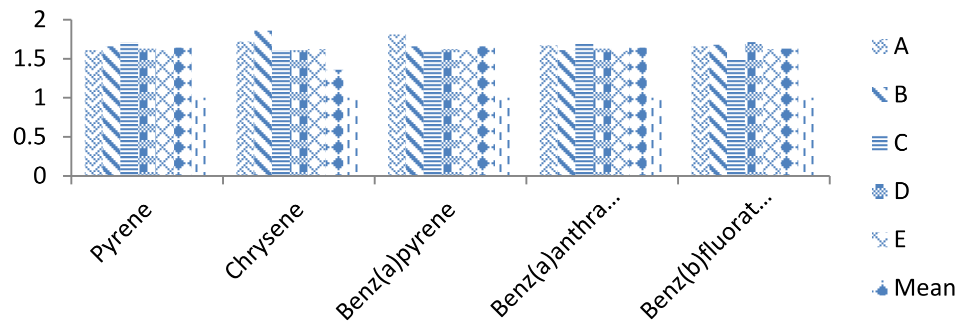
The results of the PAHs content of the wetland water in Okpai Anieze were as in Figure 5.



A – E: samples collection sites

Figure 5: results of the PAHs content of wetland water in Okpai Anieze and EU 1881/2014 MPC for PAHs in wetland water in µg/l.

The results of the PAHs content of the wetland water in Okpai Umuagwulu were as in Figure 6.

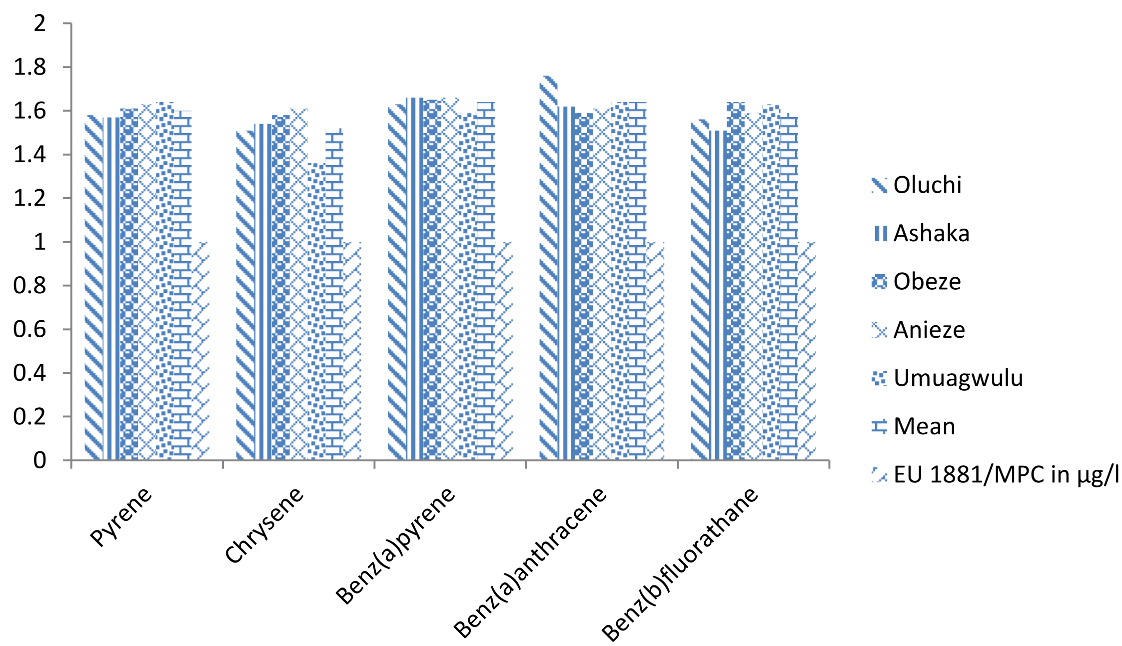


A – E: samples collection sites

Figure 6: results of the PAHs content of wetland water in Okpai Umuagwulu and EU 1881/2014 MPC for PAHs in wetland water in µg/l.

The group mean comparison of the PAHs in the wetlands in Okpai were as in Figure 7

Figure 7: results of the comparative means of the PAHs in the wetlands of Okpai oil bearing community and EU 1881/2014 MPC for PAHs in wetland water in µg/l



The groups mean results were subjected to test of significance using analysis of variance (ANOVA) deploying special package for social sciences model 29 (IBM) at 0.05 level of significance. The p. value was 0.48 thus rejecting H_0.

DISCUSSION

Myriad of researches exist on PAHs pollution and contamination of wetlands emanating predominantly from industrial activities (Tansel *et al*., 2013, Karaca *et al*., 2015, Shukla, 2010), but researches on the PAHs pollution of the environment of oil producing area of Okpai remain largely unavailable and that underpins this study.

Pyrene

The concentrations of pyrene in the wetland waters of Okpai oil producing communities was between 1.57 µg/l in Ashaka to 1.64 µg/l in Umuagwulu with a group mean of 1.60 µg/l. This report of increased pyrene above EU 1881 MPC is similar to the report in (Paoli *et al*., 2015, Ozaki *et al*., 2015, Nisha *et al*., 2015). Human health implications of prolonged exposure to pyrene include skin irritation, lung cancer (Nordin *et al*., 2015, Pharm *et al*., 2015, Pergal *et al*., 2015). The presence of pyrene above maximum permissible limit will counterproductive as it will negate the adoption of cage aquaculture in Okpai wetland due to health complications (Adekoya, 2015, Afolabi, 2020).

Chrysene

The study has shown that the content of chrysene in the wetland waters of Okpai oil bearing communities ranged from 1.36 µg/l in Umuagwulu to 1.58 µg/l in Obeze with a mean of 1.52µg/kg. This report of high content of chrysene in wetland water is similar to the reports in (Pena *et al*., 2015, Pere, 2011, Papa *et al*., 2012). Chrysene in man has been implicated in cardiovascular problems (Peru 2011, Shamipur *et al*., 2015), gene mutation (Shen, 2014, Song, 2013). Presence of contaminant and pollutants in wetlands reduces the utility of such wetland for cage aquaculture due to the toxicity consumers of produce from such wetland will experience (Adeoye, 2012, Akintola, 2020).

BaP content

The analysis of the wetlands water in Okpai presented variable concentrations BaP, from 1.59 µg/l in Umuagwulu to 1.66 µg/l in Okpai Ashaka and Anieze with a group mean of 1.64 µg/l. A similar report of high content of BaP was in (Zhi *et al*., 2015, Zheng *et al*., 2012, Obrist *et al*., 2015). Ingestion of BaA contaminated food results in gastrointestinal disorder, endocrine disruption (Otte *et al*., 2013, Oyo-Ita *et al*., 2016), deoxyribonucleic acid mutation (Obuekwe & Semple 2013). Contaminations of wetlands due to industrial effluents discharges have always resulted to lack of adoption of cage or pen aquaculture (Ogwu *et al*., 2023).

BaA Concentrations

The results from the wetlands water in Okpai oil bearing communities showed that the content of BaA was between 1.59 µg/l in Obeze to 1.76 µg/l in Oluchi with a group mean of 1.64 µg/l. This report of high content of BaA in the wetland water of Okpai is in consonance with the repots in (Ohura *et* *al*., 2015, Okenyez *et al*., 2012, Orechio *et al*., 2016). Human health implications associated with human prolonged exposure to BaA include respiratory disease, cancer of the lungs and liver (Pazos *et al*., 2010, Patil *et al*., 2014, Shih *et al*., 2016). Marine and other wetlands contamination by PAHs and other contaminants have become setbacks to adoption of happa aquaculture, pen culture, cage culture in most developing countries (Babattuade, 2020).

BbF Concentrations

This Okpai oil bearing communities wetland waters study has revealed that BbF concentrations ranged between 1.51 µg/l in Okpai Ashaka to 1.54 µg/l in Okpai Obeze with a group mean concentration of 1.59 µg/l. This report of BbF content higher than the established critical point is in tandem with the reports in (Oliva *et al*., 2012, Olsson *et al*. 2010, Paulve *et al*., 2015). Health complications caused by prolonged exposure to BbF are kidney cancer, cancer of the liver (Obinaju *et al*., 2015, Plaza-Bolanes *et al*., 2010) DNA oxidative damages (Soliman *et al*., 2014). Health hazards associated with consumption of produce harvested from heavy metals, pesticides and PAHs contaminated wetlands have been setbacks on adoption of cage aquaculture in various wetlands in Nigeria (Akintola, 2020, Bamgboye, 2012).

CONCLUSION

This study has affirmed environmental contamination of various wetlands by PAHs consequence of industrial activities of oil exploitation. The analysis of the wetland waters in Okpai oil bearing communities revealed that the content of the PAHs investigated were above the maximum permissible limit enunciated in EU 1881/2014. The study thus concluded that the wetlands have been polluted. The produces are therefore neither fit for human consumption nor for compounding animal feeds. They are equally not suitable for export because of failure to scale agriculture produce standards established by Codex Allimentarius Commission of World Health Organisation established in 1963.

The study thus recommended that oil companies operating in Okpai should be made to adopt world best practices in their operation to avoid wetland contamination, and the monitoring agencies should step up regular environmental surveillance in the area. The impacted areas should be remediated for vibrant economic activities and wetlands ecosystem services which could includes the adoption and deployment of cage aquaculture as a model for unleashing science for economic diversification in Nigeria.

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