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Characterization of the Polycyclic Aromatic Hydrocarbons in the Wetlands of Gbokoda and Environs for Pen Aquaculture Adoption as a Recipe for Achieving Zero Hunger in Nigeria

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Abstract

This was an ex-post facto research that investigated the PAHs content in the wetlands in Gbokoda and its environs for their suitability for pen aquaculture adoption for zero hunger in Nigeria. The study answered 5 research questions and tested a hypothesis. In accomplishing these, Gbokoda, Eghoro, Jakpa, Kolokola, Ogheghe and Oru-Megege wetlands were mapped into 5 research grid. Water samples were collected from 5 spots in each grid with plastic sampling bottles at the depth of 10cm using grab sampling techniques. The samples in each grid were bulked and composites drawn fixed with HNO_4 and stored in ice-cooled boxes for analysis. The analytical standards adpted was EU 1881/2014 and the instrument of determination deployed was Agilent GC/MS. Tripple Quadrupole model 7000. The mean results obtained were pyrene 1.06±0.01µg/l, chrysene, 1.07±0.11µg/l, BaP, 1.06±0.01µg/l, BaA; 1.06±0.01µg/l and BbF, 1.06±0.01µg/l. The mean results obtained were subjected to test of significance with SPSS IBM model 29 at 0.05 level of significance and the *p* value was 0.043 thus rejecting H_0. The study concluded that the wetlands were polluted with PAHs investigated above the limit of MPC established by EU 1881/2014, thus pen aquaculture cannot be adopted as the produce will not be fit for human and animal consumption. The produce also will not be exportable. The study recommended that oil companies operating in Gbokoda and environs should adopt the world best practices in oil industry, the monitoring agencies NESREA and NOSDRA should improve on their surveillance while the impacted ecosystem be remediated and restored to allow for the adoption of pen aquaculture for zero hunger in Nigeria.

Keywords: Wetlands, Polycyclic Aromatic Hydrocarbons, Wetland Contamination, Pen Aquaculture, Zero Hunger

Introduction

The United Nations Organization (UNO) in 2012 conference held in Rio de Janeiro articulated a set of 17 goals adopted in 2015 to terminate in 2030 that meet the world's urgent political, environmental and economic challenges and they were termed global or universal goals, the goal number 2 is zero hunger.

Zero hunger is to ensure that every one has unhindered access to safe, nutritious and sufficient food that meet their preferences and dietary need (Gabriel, 2018, Jones, 2019, Drake, 2019) [12, 20, 10]. It is when all people have the ability and capability to acquire the food they need without compromising in quality, quantity and in preference (Jonathan, 2019, Sajim, 2018, Paulson, 2018) [19, 49, 46]. Zero hunger is the goal that ensures that all people especially children have access to the food they want at the right quality and quantity (Samuelson, 2020, Benjamin, 2020, Hajian, 2019) [50, 9, 13]. It is creating a world that is hunger free by the year 2030 (Peterson, 2018, Soul, 2019) [47, 51]. Zero hunger is to achieve food secured nation, achieve improved nutrition through promotion of sustainable agriculture by 2030.

Nigeria was an agrarian economy with agriculture engaging 90 percent of her population, contributing 80 percent to its gross domestic product and accounting for 90 percent of its foreign earnings (Ruwani, 2016, Oteriba, 2017 [45], Lawal, 2018 [21], Ihumodu, 2020). The coming of oil wealth in the 70s dislocated the old order, changed the orientation of Nigerians and encouraged rural – urban drift causing social amenities shortage unemployment and increase social vices in the cities (Abubakar, 2018, Hassan, 2015, Halidu, 2018, Nwachukwu, 2019) [1, 15, 14, 28]. Nigeria is currently an oil powered economy

with oil accounting for 90 percent of its GDP and 80 percent of foreign exchange (National Bureau of Statistics, 2023, Lawal, 2022, Ojo, 2022) [24, 22, 43]. Nigeria has been exposed to several economic shocks and recession due to its dependence on monoeconomic product(oil) whose price is internationally modulated (Ogwu *et al*., 2022, Ogwu, 2021 [32], Asuquo, 2020, Ndem, 2018).

Nigeria has been admonished to go back to agriculture for its comparative advantage, economic diversification and resilience to global shocks and for youths empowerment (Ogwu *et al*., 2022, Ogwu *et al*., 2022b, Ndiomu 2023 [27], Agada, 2023 [4]). The unemployment rate in Nigeria is at 33.2 percent (NBS, 2024) [25]. International Monetary Fund (IMF) (2024) [18], International Labour Organisation (ILO) (2024) Nigeria youths should take into aquaculture due to its rate of return on investment and for the high national fish demand (Ogwu, 2022, Makinde, 2022 [23], Okowa, 2022 [44]). Nigeria adults and youths are enjoined to venture into aquaculture adopting pen aquaculture because of its low financial outlay (Ogwu *et al*., 2022, Odogwu, 2022 [30]).

Pen aquaculture is the art of raising fish in a pen or rectangular fence anchored on the floor of a natural body of water (Bamgboye, 2017, Abulu, 2019, Odezugo, 2018) [8, 2, 29]. Water analysis is imperative on the natural body of water to be used for pen aquaculture for the presence of toxicants (Ogwu *et al*., 2022, Afolabi, 2020 [3]). Possible water pollutants include microplastics, detergents (Ogwu *et al*., 2022), heavy metals, pesticides, Styrofoam, polycyclic aromatic hydrocarbons (PAHs) (United State Environmental Protection Agency (USEPA), 2012, Food and Agricultural Organisation (FAO), 2015, Atshana & Atshana, 2012) [11, 6]. PAHs are hydrocarbon containing multiple benzene rings (USEPA, 2012). Sources of PAHs in environment are coal, gasoline, crude oil (USEPA, 2012, FAO, 2015 [11]), (Ogwu *et al*., 2022, Babajide, 2020 [7]). Presence of PAHs in aquatic environment result in bioaccumulation and biomultiplication of PAHs in aquatic organisms (USEPA, 2012, Atshana & Atshana, 2012 [6]). PAHs have been revealed in epidemiological studies to cause cancer, mutation (Kang *et al*., 2014, Kpadon *et al*., 2014, Li *et al*., 2015, Kwon 2014).

A wetland is an ecosystem that habours water temporarily for at least 3 months or permanently for the year round (Ramsar, 1971, Ramsar, Conference of Parties (COP) 2018, Ramsar COP, 2022).

Gbokoda, Eghoro, Jakpa, Kolokolo, Ogheghe, Oru-Megege are oil producing communities in Warri North local government (NBS, 2023 [24], Nigeria Upstream Regulation Commission (UPRC), 2023). Oil spills into the environment occur through equipment failure, wellhead blowout, pipes rupture, tank wash, product loading, vandalism (Ogwu *et al*., 2022, Ogugo, 2019, Eromosele, 2019).

The focus of this study is the analysis of the wetlands water at Gbokoda and environs for the presence of PAHs for adoption of pen aquaculture for zero hunger in Nigeria. The PAHs investigated were pyrene, chrysene, benzo(a)pyrene (BaP), benzo(a)anthracene(BaA) and benzo(b)fluorathane (BbF).

The study was guided by research questions as;

1. What are the concentrations of pyrene, chrysene, BaA, BaP and BbF in the wetlands of Gbokoda and its environs?
2. Are the concentrations of the PAHs within the Maximum Permissible concentrations (MPC) stipulated by European Union code 1881 of 2014 of 1.00µg/l?
3. Can the pen aquaculture be adopted in the wetlands for zero hunger?
4. Can the produce be suitable for human consumption?
5. Can they be used for animal feed formulation
6. Can the produce from the wetlands be exported considering Codex Alimentarius 1963 standards for produce exports?

The study was guided by a null hypothesis at 0.05 level of significance as:

H_0: There is no significant difference between the concentrations of the PAHs in the wetlands in Gbokoda and environs and EU 1881/2014 MPC for PAHs in wetlands of 1.00µg/l.

Study Area

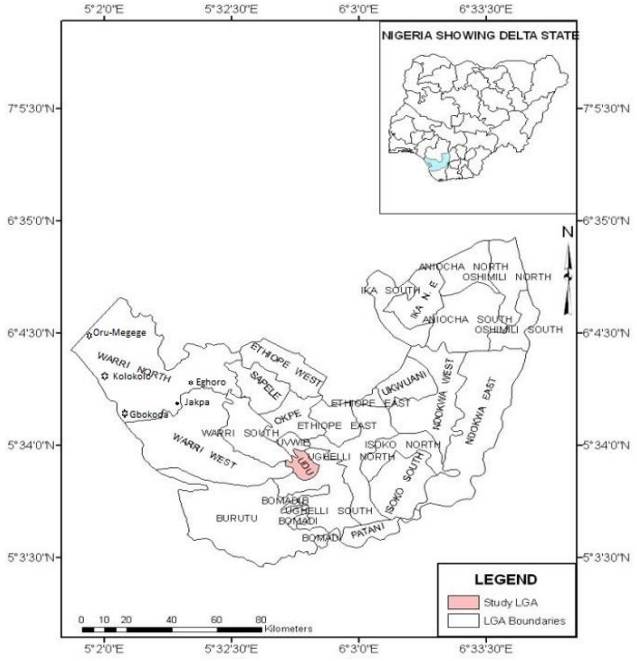

Fig 1: Map of study area

Gbokoda, Eghoro, Jakpa, Kolokolo, Ogheghe and Oru-Megege are oil rich settlements in Warri north local government area of Delta state. They are wetland settlements which made fishing and farming the mainstay of their rural economy. Some of the inhabitants are artisans and petty traders while some work in the public schools and very few work in the oil companies mainly as janitors and messengers. The wetlands are the recipients of the spills and other effluents from oil activities in the area.

Materials and Methods

This study was conducted within a period of 6 months (November 2023 to April, 2024). Each of the 6 wetland settlement was mapped out into 5 research grids and water sample were collected from 5 spots in each grid adopting grab sampling technique as described in (Kazieska *et al*., 2015, Kong *et al*., 2015, Leung, 2015). The samples from each grid were bulked and composites were drawn and fixed with nitric acid. The samples were collected at 10cm depth with 125mL plastic sampling bottles. 130 samples were collected for the study through the assistance of 6 research assistants recruited from the settlements.

Analysis

The wetland water samples from Gbokoda and environs were analysed using gas chromatograph (GC) and mass spectrometry (MS) as described in (Lee *et al*., 2016, Liang *et al*., 2016, Mao *et al*., 2016) adopting EU 1881/2014, standard. 6ml of the water samples were calibrated into beakers and 2½ g of anhydrous sodium sulphate introduced and agitated vigorously for thorough mixing. The thoroughlyagitated were introduced into extraction beakers and were allowed to settle for 30 minutes. Dicafluorobiphenyl were added into the beakers and sodium hydrosulphate was added also. The tubes were agitated vigorously again till the point where slurry appear and flow freely and they were allowed to settle for another 30 minutes. The effluents were fed into GS/MS for the determination of the PAHs under investigation.

Results

The results of the PAHs content analysis of the wetland in Gbokoda and environs were as in Figure 2 to 7 and the comparative mean content of the PAHs in Fig 8.

The result of the PAHs content in Gbokoda wetland were as in Fig 2.

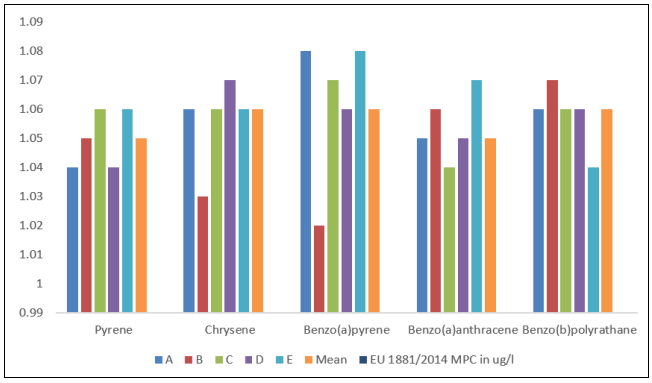

Fig 2: Results of the PAHs content in Gbokoda wetland and the EU 1881/2014 MPC for PAHs in wetland in µg/l

The result of the PAHs content in Eghoro wetlands were as in Fig 3.

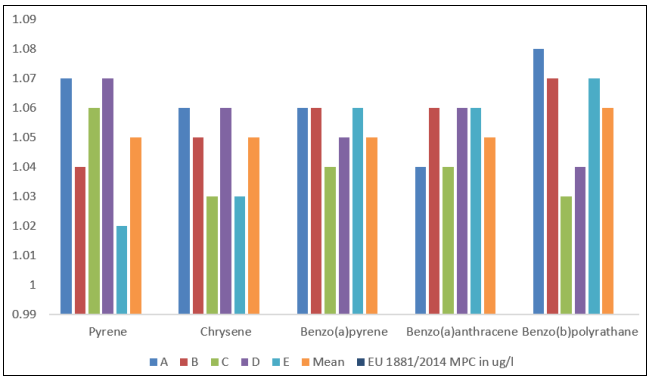

Fig 3: Results of the PAHs in Eghoro wetland and EU 1881/2014 MPC for PAHs in wetland in µg/l

The results of the PAHs content in Jakpa wetlands were as in Fig 4.

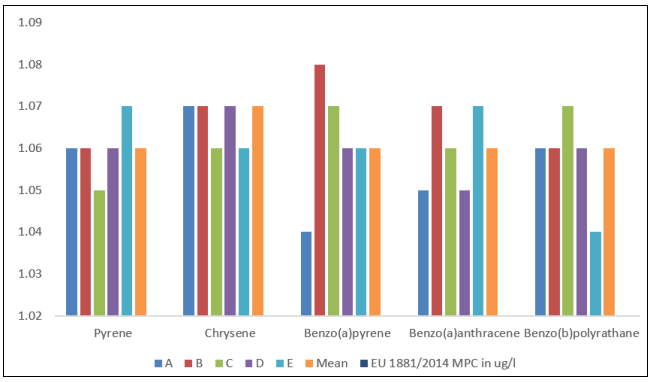

Fig 4: Results of the PAHs content in wetlands in Jakpa and EU 1881/2014 MPC for PAHs in wetland in µg/l

The result of the PAHs content in Kolokolo wetland were as in Fig 5.

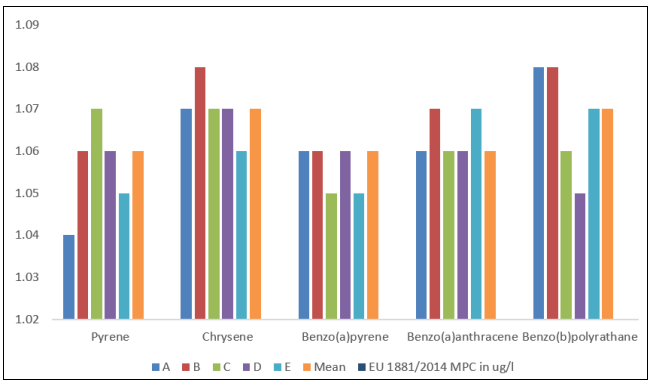

Fig 5: Results of the PAHs content in Kolokolo wetland and EU 1881/2014 MPC for PAHs in wetland in µg/l

The results of the PAHs content in the wetlands in Ogheghe were as in Fig 6.

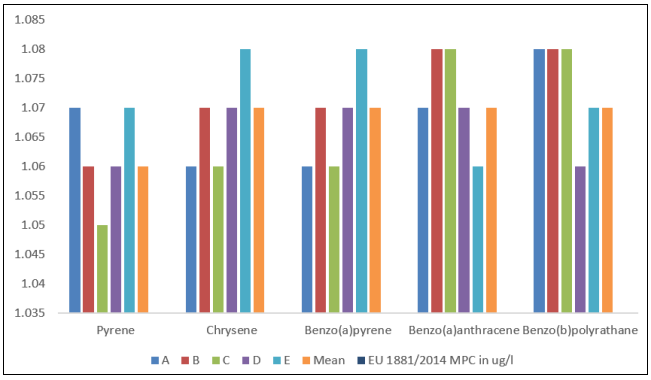

Fig 6: Results of the PAHs content in Ogheghe wetlands and EU/1881/2014 MPC for PAHs in wetland in µg/l

The results of the PAHs in Oru-Megeye wetlands were as in Fig 7.

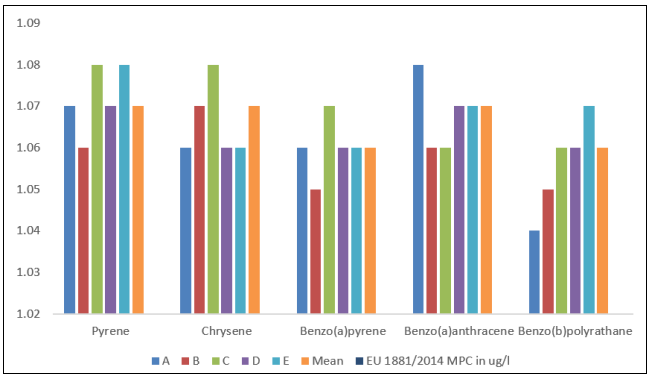

Fig 7: results of the PAHs in Oru-Megege wetlands and EU 1881/2014 MPC for PAHs in wetland in µg/l

The comparative mean results of the PAHs in the wetlands in Gbokoda and environs were as in Fig 8.

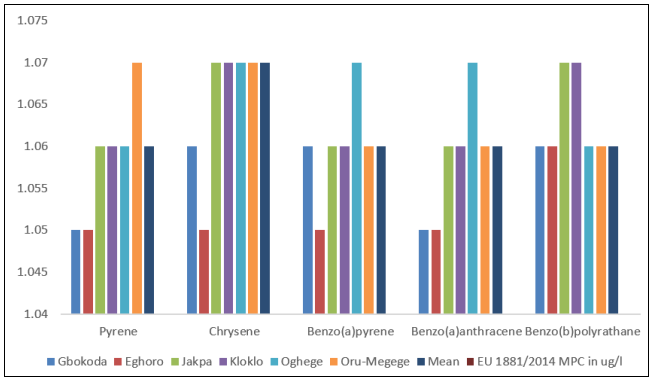

Fig 8: Results of the mean PAHs content in the wetlands in Gbokoda and environs and EU 1881/2014 MPC for PAHs in wetlands in µg/l

The mean results of the PAHs content in the wetlands in Gbokoda and environs were subjected to test of significance using special package for the social sciences (SPSS) IBM model 29 at 0.05 level of significance and the *p* value was 0.043 thus rejecting H_0.

Discussion of Findings

Wetlands contamination emanating from poor industrial activities have been highly documented in many literature, however, research reports on wetland contamination resulting from oil activities in Gbkoda wetlands and environs remain largely unavailable and that underpins this study. The results of the analysis of Gbokoda wetlands and environs presented varying results of the PAHs of interest.

The analysis of Gbokoda wetlands for the content of pyrene showed that the concentration of pyrene was between 1.05µg/l in Gbokoda and Eghoro to 1.07µg/l in Oru-Megege with a group mean of 1.08 µg/l. This increased content of pyrene in the wetlands is human induced. This report of increased pyrene in wetlands is similar to reports in (Mishra *et al*., 2014, Meng *et al*., 2015, Ogwu *et al*., 2022). Pyrene in food cause skin irritation (Miao *et al*., 2015, Masih *et al*., 2015), mutation of DNA (Macek *et al*., 2016).

Gbokoda and environs wetlands water analysis for the content of chrysene revealed a concentration range of 1.05 µg/l in Eghoro to 1.07 µg/l in Jakpa Kolokolo, Ogheghe and Oru-Megege with a mean of 1.07 µg/l. This elevated content of chrysene is anthropogenic. This report is in tandem with reports in (Nam *et al*., 2015, Net *et al*., 2015, Ogwu *et al*., 2022). Chrysene contamination has been implicated in cancer of the lungs, skin and gastrointestinal tract (Mrthy *et al*., 2015, Moreno *et al*., 2015, Muangchinda *et al*., 2015).

The analysis of Gbokoda and environs wetland for BaP concentration presented BaP content of 1.05 µg/l in Eghoro to 1.07 µg/l in Ogheghe with a group mean of 1.00 µg/l. This high content of BaP is traceable to oil activities in the area. A report similar to this was in (Margues *et al*., 2016, Lu *et al*., 2016, Lauvado *et al*., 2015). BaP has been fingered in tetratogenic problems, DNA mutation (Marquez-Bravo *et al*., 2016, Manoli *et al*., 2016), cancer of the bone marrow (Magler *et al*., 2014).

Wetlands water analysis of Gbokoda and environs for BaA revealed its content to range between 1.05 µg/l in Gbokoda and Eghoro to 1.07 µg/l in Ogheghe with a mean of 1.06 µg/l. The high content of BaA in this area is the effect of man's interaction through oil extraction and loading. This study corroborates the reports in (Mari *et al*., 2015, Mordukho *et al*., 2016, Mulder *et al*., 2015). Human health effect of BaA include cancer of the lungs, kidney failure, liver degeneration (Ngscimbere *et al*., 2014, Mugica-Alvarez *et al*., 2015), obstructive lung disease (Mareak *et al*., 2015).

Wetland analysis of the wetlands in Gbokoda and environs for the concentration of BbF showed that the mean content of BbF was between 1.06 µg/l in Gbokoda, Eghoro and Jakpa to 1.07 µg/l in Kokololo and Ogheghe with a group mean of 1.06 µg/l. The increased content of BbF is associated with oil activities. These high content of BbF is in agreement with the reports in (Nisen *et al*., 2015, Ogwu *et al*., 2022, Nordin *et al*., 2015, Nwaichi and Ntorgbo, 2015). Epidemiological studies have revealed BbF to be responsible for renal failure, liver diseases (Osaki *et al*., 2015, Poali *et al*., 2015, Ohira *et al*., 2015) gene mutation (Orisakwe *et al*., 2015).

Conclusion and recommendation

The analysis of the wetlands in Gbkoda and environs for the concentration of PAHs has further led credence to environmental contamination of wetlands through oil industrial activities. The analysis presented varying contents of the PAHs investigated with the concentrations higher than the EU 1881/2014 recommended thus revealing that the wetlands are polluted. The pollution levels of the wetlands will negate the adoption of pen aquaculture for the achievement of zero hunger in Nigeria as the produce will be unhealthy for human consumption and for animal feeds formulation. The produce will not be accepted in international markets because of the failure to scale Codex Allimentarius commission conditions for agricultural produce export.

Corollary to these findings, the study recommends as thus:

- Oil companies operating in Gbokoda and environs should adopt the world best practices in their operations.
- The monitoring agencies National Environmental Standards Regulation and Enforcement Agency (NESREA) and National Oil Spills Detection and Response Agency (NOSDRA) should increase their surveillance on the oil companies' activities.
- The impacted areas should be remediated and restored to make for the adoption of pen aquaculture for the achievement of zero hunger in Nigeria.

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