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**Geospatial Quantification of Polycyclic Aromatic Hydrocarbons in the Wetlands in Egbeoma and Environs (Oil Bearing Communities) Warri North Delta for Pen Aquaculture Adoption as Innovative Technology for Sustainable Development in Nigeria**

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**Abstract**

Oil exploitation often leave on their trails wetlands degradation from products or effluents discharges. This study investigated the polycyclic aromatic hydrocarbons content in the wetlands in Egbeoma, Aleima, Bear-Town, Odububa and Brohimi oil bearing communities for their suitability for the adoption of pen aquaculture as innovative technology for sustainable development in Nigeria. The study answered 5 research questions and tested a hypothesis. In achieving these, the wetlands in each settlement was mapped into 5 research grids and water samples were collected from 5 spots in each grid bulked, composites drawn were fixed with HNO<sub>4</sub> and stored in ice-cooled flasks for analysis. The analytical standards adopted was EU 1881/2014 and the analytical instrument used for determination was Agilent Triple Quadrupole 7000. The mean results obtained were; pyrene, 0.76±0.11µg/l, chrysene, 0.73±0.01 µg/l, BaP, 0.71±0.10 µg/l, BaA, 0.72±0.01 µg/l and BbF, 0.72±0.02 µg/l. The mean results

were further subjected to test of significance using ANOVA deploying SPSS IBM model 29 at 0.05 level of significance and the *p*-value was 0.062 thus accepting H<sub>0</sub>. The study thus concluded that the wetlands in Egbeoma and environs are not polluted with PAHs above the 1881/2014 stipulated concentration thus pen aquaculture can be adopted and deployed as innovative technology for sustainable development. The study recommended that the oil companies operating in Egbeoma and environs should continue to operate with high ethical standards and with the world best practices for oil industry; furthermore, the monitoring agencies NESREA and NOSDRA should continue with their surveillance to ensure that the oil companies keep up with their operation standards for pristine wetlands in Egbeoma and environs for the adoption of pen aquaculture as innovative technology for sustainable development in Nigeria.

**Keywords:** Wetlands, Polycyclic Aromatic Hydrocarbons, Pen Aquaculture, Sustainable Development

**Introduction**

The aspiration of nations is to achieve developments that are sustainable as enshrined in the United Nations Sustainable Development Goals: 2015 to 2030. Sustainable development is the development that takes place without diminishing natural resources (Tedwell, 2017, Jones, 2018, Abraham, 2019) [59, 13, 1]. It is the development that satisfies the needs of the present generation without compromising the capacity of the future generation to meet their needs (Samuel, 2018, Palmek, 2019, Johnson, 2019) [48, 12]. Sustainable development is the development that guarantees long-term protection of the environmental variables by ensuring equilibrium between economic growth, social development and protection of the environment (Sabastine, 2019 [41], Mcdoff, 2020, Petterson, 2020). It means the way we live today if you want to ensure a better tomorrow for the next generation (Perkins, 2017, Anthony, 2018, Sajim, 2019) [32, 4, 44]. Sustainable development is meeting today's needs without compromising the chances of the future generation to meet their own needs (Christopher, 2017, Dell, 2017, Soul, 2018) [8, 9, 58]. It is the ability to meet many present needs while contributing to sustaining resources availability for the future

generation (Bradson, 2019, Samson, 2020 [47], Bradwell, 2020).

Sustainable development entails conducting economic and industrial activities without undermining environmental health (John, 2018, Truddy, 2020) [11, 60], thus requires extractive industries carrying out their activities without contaminating and polluting their operational environments (Okonkwo, 2021, Ogwu *et al.*, 2021, Ogwu *et al.*, 2022) [30, 18, 17].

Nigeria is an oil producing country with oil contributing 94.00 percent to the Nigeria Gross Domestic Product (GDP) in 2023 (Nigeria Upstream Petroleum Regulatory Commission 2024 [16], National Bureau of Statistics (NBS) 2024 [15], Ruwani, 2024 [40], Ojikutu, 2024) and 80.0 percent to its foreign exchange earnings (NBS, 2024, Ruwani, 2024) [15, 40]. Oil extraction activities are associated with spillages through equipment failure, pipe ruptures, wellheads blowout, sabotage, loading, ballast waters (Ogwu *et al.*, 2022, Ogwu *et al.*, 2021, Adaigho, 2023). Petroleum is composed of carbon, hydrogen, oxygen, nitrogen, sulphur, heavy metals and polycyclic aromatic hydrocarbons (PAHs). PAHs are organic compounds containing multiple aromatic benzene rings (Rojo-Nieto *et al.*, 2014, Santana *et al.*, 2015 [49], Ramagnah *et al.*, 2014). Bioavailability of PAHs in wetland environments result in bioaccumulation and biotransformation of the compound in aquatic organisms (Sariyannis *et al.*, 2015 [50], Rose *et al.*, 2015 [38], Rotola *et al.*, 2013). Health effects resulting from ingestion and prolonged exposure to of PAHs are, renal failure, liver degeneration, jaundice, cataract, lung cancer, osteoporosis (Sacchi *et al.*, 2023, Sarria-Villa *et al.*, 2016, Sauret *et al.*, 2015, Saxena *et al.*, 2016) [42, 51, 52, 53]. Wetlands are ecosystems where the land is covered by water, fresh marine or brackish permanently or seasonally (Sazakli *et al.*, 2015, 2015 [54], Sadeghi *et al.*, 2016 [43] Sakulthaew *et al.*, 2014 [45], Salvo *et al.*, 2016 [46]). Wetlands provide habitat for thousand species of fish, other aquatic and amphibious animals and also suitable site for earth ponds, cage and pen aquaculture deployment (Ogwu *et al.*, 2022, Ogwu *et al.*, 2021, Scheurer *et al.* 2014 [55]). Pen aquaculture is the act of raising fish in a pen made on the bed of a natural body of water (Ogwu *et al.*, 2022, Bamgboye, 2023 [5], Afolabi, 2023 [2]). Egbeoma, Aleima, Bear-Town, Brhimi and Odubaba are oil bearing wetland settlements in Warri North Local government area, Delta state, Nigeria. The focus of this study is the analysis of the wetland waters in of Egbeoma and its environs for the contents of PAHs for adoption of pen aquaculture as innovative technology for the achievement of sustainable development in Nigeria.

The PAHs investigated were pyrene, chrysene, benzo(a)pyrene (BaP), benzo(a)anthracene (BaA) and benzo(b)fluorathene (BbF).

The study was guided by research question as:

1. what are the concentrations of pyrene, chrysene, BaP, BaA and BbF in the wetlands in Egbeoma and its environs?
2. are the concentrations of the PAHs within the maximum permissible concentrations (MPC) for PAHs in wetland water of 1.00 µg/l stipulated by European Union code 1881/2014?
3. will the produce from the wetlands be suitable for human consumption?
4. will the produce from the wetlands be suitable for compounding animal feeds?

5. Can the produce from the wetlands scale Codex Alimentarius Commission 1963 standard for agricultural produce export?

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

H<sub>0</sub>: there is no significant difference between the concentrations of the PAHs in the wetlands of Egbeoma and environs and EU 1881/2014 MPC for PAHs in wetlands.

## Study Area

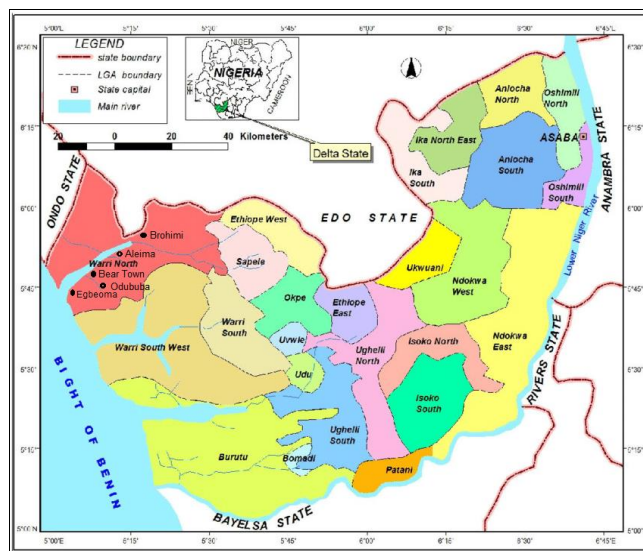


Fig 1: Map of the study area

Adapted from: Igben, J. L., Ihayere, A. C. and Igun, E. (2022) [10].

Egbeoma, Aleima, Bear Town, Brohimi and Odubaba located within the geographical positioning system of longitude 5.8824 and latitude 5.2 57 are wetland oil bearing settlements in Warri North local government area Delta Nigeria. The inhabitants of these settlements are mainly fishermen and farmers. Some are petty traders while others are artisans. Few of the people work as civil servants and a few work with the oil companies operating in the areas. The wetlands are the recipients of the effluents and spillages emanating from oil exploitation activities.

## Materials and Methods

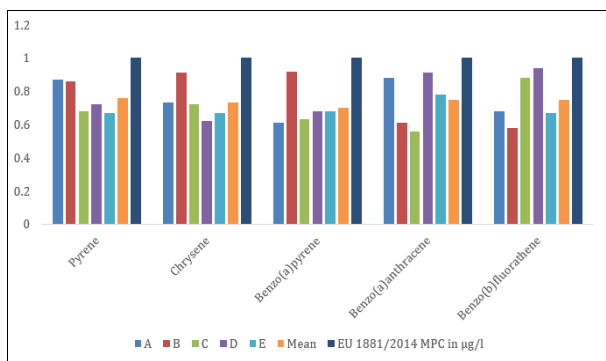
This study was conducted between December 2023 to May 2024. 5 research assistants were engaged for the study one from each of the settlements: Wetlands in each settlement was mapped into 5 research sampling grids and water samples were collected with clean plastic 125mL sampling bottles. from 5 spots adopting grab sampling techniques as described in (Seemann *et al.*, 2015, Semedo *et al.*, 2014) [56, 57], bulked and composites taken, fixed with nitric acid and stored in ice-cooled flasks for analysis. 125 samples were collected for the study.

Analysis: The analytical standard adopted for this study was EU 1881/2014 for wetland water as described in (Verma *et al.*, 2015 [61], Vieira *et al.*, 2015). 5ml of the water samples were measured into beakers and 2g of anhydrous sodium sulphate added into the beakers and were vigorously agitated for effective mixing. The mixtures were transferred

into extraction beakers with very tight caps and allowed 30 minutes to 1 hour to settle. Dicaflurobiphenyl (25g) were introduced into the mixture followed by the addition of sodium hydrosulphate and again vigorously agitated to a point when the slurry flowed freely. The flasks were allowed to settle for 1 hour. The effluents were fed into Agilent Triple Quadrupole gas chromatography coupled with mass spectrometry model 7000. For the determination of pyrene, chrysene, BaP, BaA and BbF.

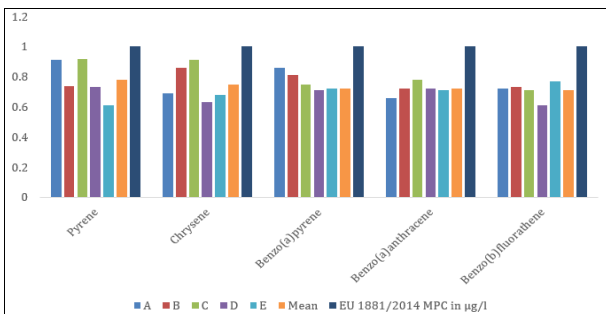
**Results**

The results of the PAHs content in the wetlands in Egbeoma and environs were as in Figure 2 to 7. The results of the PAHs content in the wetlands in Egbeoma were as in Fig 2.



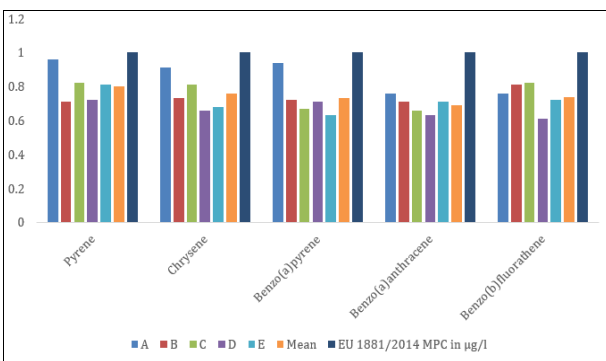
**Fig 2:** Results of the PAHs content in the wetlands in Egbeoma and EU1881/2014 MPC for PAHs in wetland in µg/l

The results of the PAHs content in Aleima wetlands are as in Fig 3.



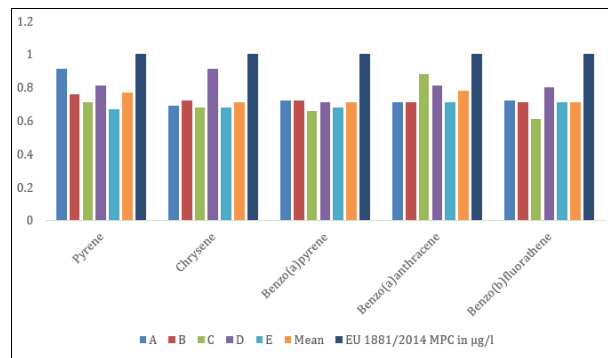
**Fig 3:** Results of the PAHs in wetlands in Aleima and the EU 1881/2014 MPC for PAHs in wetlands in µg/l

The results of the PAHs content in the wetlands in Bear-Town were as in Fig 4.



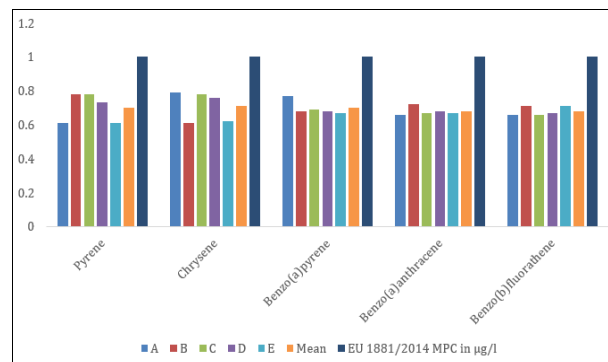
**Fig 4:** Results of the PAHs in the wetlands in Bear-Town and EU 1881/2014 MPC for PAHs in wetlands in µg/l

The results of the PAHs content in Brohimi wetlands were as in Fig 5.



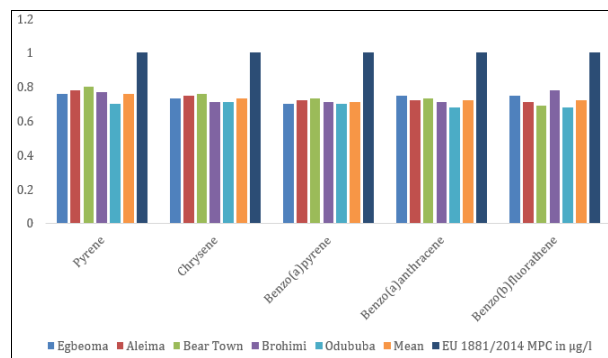
**Fig 5:** Results of the PAHs content in the wetlands in Brohimi and EU 1881/2014 MPC for PAHs in wetlands in µg/l

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



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

The comparative mean results of the PAHs in the wetlands in Egbeoma and environs were as in Fig 7.



**Fig 7:** Comparative means results of the PAHs in Egbeoma and environs and EU 1881/2014 MPC for PAHs in wetlands in µg/l

The means of the PAHs in the wetlands in Egbeoma and environs were subjected to test of significance using analysis of variance (ANOVA) deploying special package for social science IBM Model 29 at 0.05 level of significance and the *p*-value was 0.062 thus accepting Ho

**Discussion of Findings**

The analysis of the wetlands in Egbeoma Aleima, Bear-Town, Brohimi and Odububa presented varying concentrations of the PAHs investigated. The analysis of

wetlands water in Egbeoma and environs revealed that the concentrations of pyrene vary from 0.70 µg/l in Odububa to 0.80 µg/l in Bear-Town with a group mean of 0.76 µg/l. This concentration is within the EU 1881/2014 acceptable limit for pyrene in wetland water. This finding is at variance with reports in (Wang *et al.*, 2022). Health complications arising from prolonged exposure to pyrene include cataract, lung cancer, skin irritation (Walker *et al.*, 2015, Veses *et al.*, 2014<sup>[62]</sup>, Vieira de Souza *et al.*, 2015).

Wetland water analysis of Egbema and environs showed that the concentration of chrysene range between 0.71 µg/l in Brohimi and Odububa to 0.76 µg/l in Bear-Town with a group mean of 0.73 µg/l. These concentrations are within the limits espoused in EU 1881/2014 as acceptable. This report is in agreement with the reports in (Vignet *et al.*, 2015, Wei *et al.*, 2015)<sup>[65, 74]</sup> but dissimilar to the reports in (West *et al.*, 2014<sup>[75]</sup>, Villanueva *et al.*, 2014). Chrysene has been fingered in cancer of the bone, osteoporosis (Wilson *et al.*, 2016).

The analysis of the wetlands in Egbeoma and environs for the content of BaP presented the concentration to be between 0.70 µg/l in Egbeoma and Odububa to 0.73 µg/l in Bear-Town with a mean of 0.71 µg/l. This report is in tandem with the reports in (Ogwu *et al.*, 2022, Wang *et al.*, 2014). Epidemiological studies revealed BaP to be responsible for obstructive lung diseases, renal failure, liver degeneration (Wirasmita *et al.*, 2016<sup>[76]</sup>, Xu *et al.*, 2016, Ogwu *et al.*, 2022).

Wetlands water in Egbema and environs analysis for the content of BaA gave a range of the concentrations from 0.68 µg/l in Odububa to 0.75 µg/l in Egbeoma with a mean of 0.72 µg/l. These contents are within acceptable units. A similar report was in (Wu *et al.*, 2014, Xiao, 2015<sup>[78]</sup>, Vu *et al.*, 2015). Health complications associated with exposure to BaA are skin disorder, cancer of the brain (Vu *et al.*, 2015, Yan *et al.*, 2015<sup>[79]</sup>, Yang *et al.*, 2016).

The wetlands water in Egbeoma and environs on analysis for the concentrations of BbF presented a concentration of 0.68 µg/l in Odububa to 0.78 µg/l in Brohimi with a group mean of 0.72 µg/l. This report is in corroboration of the reports in (Walker & MacAskill, 2014, Wang *et al.*, 2014) but in disagreement with the reports in (Vukovic *et al.*, 2014, Waigi *et al.*, 2015). Human health complications traceable to ingestion of BbF or long exposure are gastrointestinal cancer, mutation (Vojtisek *et al.*, 2015<sup>[67]</sup>, Wang *et al.*, 2015), cancer of the bone marrow, osteoporosis (Ruiz-Fernandez *et al.*, 2016<sup>[39]</sup>, Romagnoli *et al.*, 2014<sup>[37]</sup>, Rojo-Neito *et al.*, 2014).

### Conclusion and Recommendations

Wetlands contamination emanating from oil extraction activities is replete in literature, however the results of the analysis of the wetlands in Egbeoma and environs showed a departure as that the concentrations of the PAHs investigated were within the acceptable stipulated limits by EU 1881/2014. The results showed that the wetland are not contaminated above MPC by PAHs which is a testament that the oil companies operating in the area are doing so with the world best practices which means that their activities upheld the mantra of sustainable development. The wetlands are thus healthy for the adoption and deployment of pen aquaculture and the produce will be fit for human consumption. The produce will also be suitable for animal feed compounding and are will equally be exportable for

meeting Codex Alimentarius 1963 conditions for produce exports.

Consequent upon this result, the study recommended that; the oil companies operating in Egbeoma and environs should continue with environmental best ethical practices; the environmental monitoring agencies: National Environmental Standards and Enforcement Agency (NESREA) and National Oil Spills Detection and Response Agency (NOSDRA) should continue with their strict surveillance to ensure the protection of the wetlands ecosystems for the adoption of pen aquaculture as innovation technology for sustainable development in Nigeria.

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