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Geospartial Quantification of the Polycyclic Aromatic Hydrocarbons (PAHS) In the Wetlands of Koko and Environs (Oil Bearing Communities) Warri North Delta for Cage Aquaculture Adoption for Sustainable Economic Development in Nigeria

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Abstract
The study investigated the concentration of PAHs in the wetlands of Koko, Agbegbrodo, Ajamogha, Arunologbo and Bresibi oil producing communities in Warri North LGA for their suitability for adoption of cage aquaculture for sustainable economic development in Nigeria. The study answered 5 research questions and tested a hypothesis. In accomplishing these, each of the wetlands was mapped out into 5 research grids, and water samples were collected from 5 spots in each grid adopting grab hydrology sampling technique using 125ml plastic sampling bottle at 10cm depth. The samples collected in each grid were bulked and composites were drawn, fixed with HNO_4 and stored in ice cool boxes. The analytical standard adopted was EU code 1881/2014 and the instrument for determination deployed was Agilent GC/MS Tripple Quadrupole model 7000. The mean results obtained were; pyrene 1.23±0.11 µg/l, chrysene; 1.26±0.01 µg/l, BaP; 1.25±0.01 µg/l, BaA; 1.25±0.02, and BbF; 1.25±0.11 µg/l. The mean results were further subjected to test of significance using SPSS model 29 IBM at 0.05 level of significance and the p. value was 0.43 thus rejecting H_0. The study concluded that the wetlands in Koko and environ were contaminated with PAHs above EU 1881/2014 MPC, Thus are not suitable for cage aquaculture adoption as the produce will neither be fit for human or animal consumption. The produce will equally not be suitable for export. The study recommended that oil companies operating in Koko and environs should be compelled to adopt the world best practices in their operations, the monitoring agencies; NESREA and NOSDRA should be more studious in their supervision and the impacted wetlands should be remediated to return them to hitherto pristine status for improved ecosystem services.

Keywords: *oil production, wetlands, PAHs, contamination, cage aquaculture, sustainable economic development.*

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I. Introduction

The aspiration of every nation is to attain economic development trajectory That is enduring and viable and that is sustainable economic development. Sustainable economic development is a national economic blueprint predicated on local economics unique capitals to solve their national and individual challenges that will provide measurable real world of benefits now and in future (Jone, 2018, Pedro 2019, Sandwell, 2020). It is the process in which the national resources trajectory of investments, the direction of technological developments and institutional reforms architecture are engineered to enhance both immediate and future potential for meeting human needs (Tedwell, 2018, Thompson 2020, Spencer 2022, Way, 2023). Sustainable economic development entails the development in the present that does not predispose future resource utility jeopardy (Way, 2023, Jones 2018, Bell, 2020). It is the development that satisfies the needs of the present generation without compromising the ability of future generation to meet their needs (Bell, 2020, Spear, 2022). Sustainable economic development is only achievable when the economic base of a nation is not monocultural (Brooks, 2023, Sheffield, 2023). Monocultural economy increases a Nation's susceptibility to global economic shocks and recessions (Frederick 2019, Oteriba, 2022, Hansen, 2020). The bane of most developing countries is

dependency on a single stream economy which reduces their resilience to glut in the international market (Owolabi, 2018, Brandon, 2019). A single stream economy is prone to over exploitation and product pressure (Thordike, 2018, Surreal, 2019).

Nigeria is an oil producing country with oil accounting for 90 per cent of gross domestic products and 80% of foreign exchange earnings (Oteriba, 2022, Rewani, 2023, National Bureau of Statistics, 2023). Nigeria with oil as its mainstay of her economy has experienced several recessions with the last two occasions in 2016 and 2022 due to gluts in international oil market (Adewale, 2023, Haruna, 2023, Lawal, 2023).

Nigeria should go back to agriculture to build in resistance to oil shocks and to enthrone diversification in her economy for a sustainable economic development (Nwankwo, 2022, Ovie, 2022, Ochu, 2023). Nigeria should take to agriculture especially aquaculture for diversification of her economy and the high demand for fish (Ozor, 2017, Ogwu *et al*., 2020). Nigeria annual fish demand is 3.6 million but it produces 850,000 metric tons of leaving a deficiet of 2.15 million metric tons (NBS, 2022, Oteriba, 2022, Ruwani, 2023) Fish importation is synonymous with creating jobs in source country while widening the gap of unemployment in Nigeria (Audu, 2024, Ogwu *et al*., 2020, Ogwu *et al*., 2021, Ogwu *et al*., 2022). Venturing into aquaculture adopting cage is more plausible due to its initial financial out lay (Ogwu 2022, Afolabi, 2022, Oderi, 2022). Cage aquaculture is the process of raising fish in a cage placed and anchored in a natural body of water (Ogwu *et al*., 2021, Adegboye, 2022). Analysis should be conducted on the natural body of water to be utilized for cage aquaculture for possible presence of toxicants to avoid bioaccumulation and biomagnification (Bamgboye 2016, Ogwu *et al*., 2021). Probable toxicants in water include pesticides, microplastics, detergent, Styrofoam, heavy metals and polycyclic aromatic hydrocarbons (United State Environmental Protection Agency (USEPA), 2014, World Health Organisation (WHO), 2014). Polycyclic aromatic Hydrocarbon are class of hydrocarbons (PAHs) with two or multiple benzene rings (Atshana and Atshana, 2012, USEPA, 2014). PAHs occur naturally in coal, gasoline crude oil (USEPA, 2014, Ogwu *et al*., 2022, European Union, 1881/2014). Health implication of consumption of PAHs contaminated fish produce include cancer, of the gastrointestinal tract, (Osaworu *et al*., 2016, Zhi *et al*., 2015, Zeng *et al*., 2014), cardiovascular disease (Benson *et al*., 2015, Berman *et al*., 2013, Betrand et a., 2015), congestion of the lungs, osteoporosis (Chang *et al*., 2016, Chen *et al*., 2016, Cu *et al*., 2014).

A wetland is an ecosystem which habours water partially or permanently in most period of the year (Ogwu *et al*., 2023, Ramsar Conference of Parties, 2018, Ramsar Cop, 2022). Oil is produced in Koko, Agbegborodo, Ajamogbo, Arunonlogbo and Bresibi oil spill into the environment occur via equipment failure, wellhead blowout, pipeline rupture, vandalism, tank wash, ballast water (Asuel, 2022, Ogo, 2023, Ogwu *et al*., 2022).

The focus of this study therefore is the analysis of the PAHs in the wetlands of the oil producing Koko and its environs for their suitability for adoption of cage aquaculture as a recipe for sustainable economic development in Nigeria.

The PAHs investigated are; pyrene, chrysene, benzo(a)pyrene (BaP), benzo(a)anthracene (BaA) and benzo(b)fluorathane (BbF).

Research Question

The study is guided by research questions as:

1. what are concentrations of pyrene, chrysene, BaP, BaA and BbF in the wetlands of Koko, Agbegbrodo, Ajamogha, Arunolugbo and Brisibi wetlands?
2. are the concentrations of the PAHs measured within the maximum permissible concentrations (MPC) for PAHs stipulated by European Union 1881/2014 of 1.00µg/l in wetland waters?
3. can cage aquaculture be adopted in the oil producing villages considering bioaccumulation and biomagnification of toxicants in aquatic organism?
4. will the produce be fit for human consumption?
5. can the produce be exported considering Codex Alimentarius commission of 1963 standards for agricultural produce export?

Hypothesis

The study was guided by hypothesis as:

H_0: there is no significant difference between the concentrations of the PAHs in the wetlands in Koko and its environs and EU 1881/2014 MPC for PAHs in wetland water of 1.00µg/l

Study Area

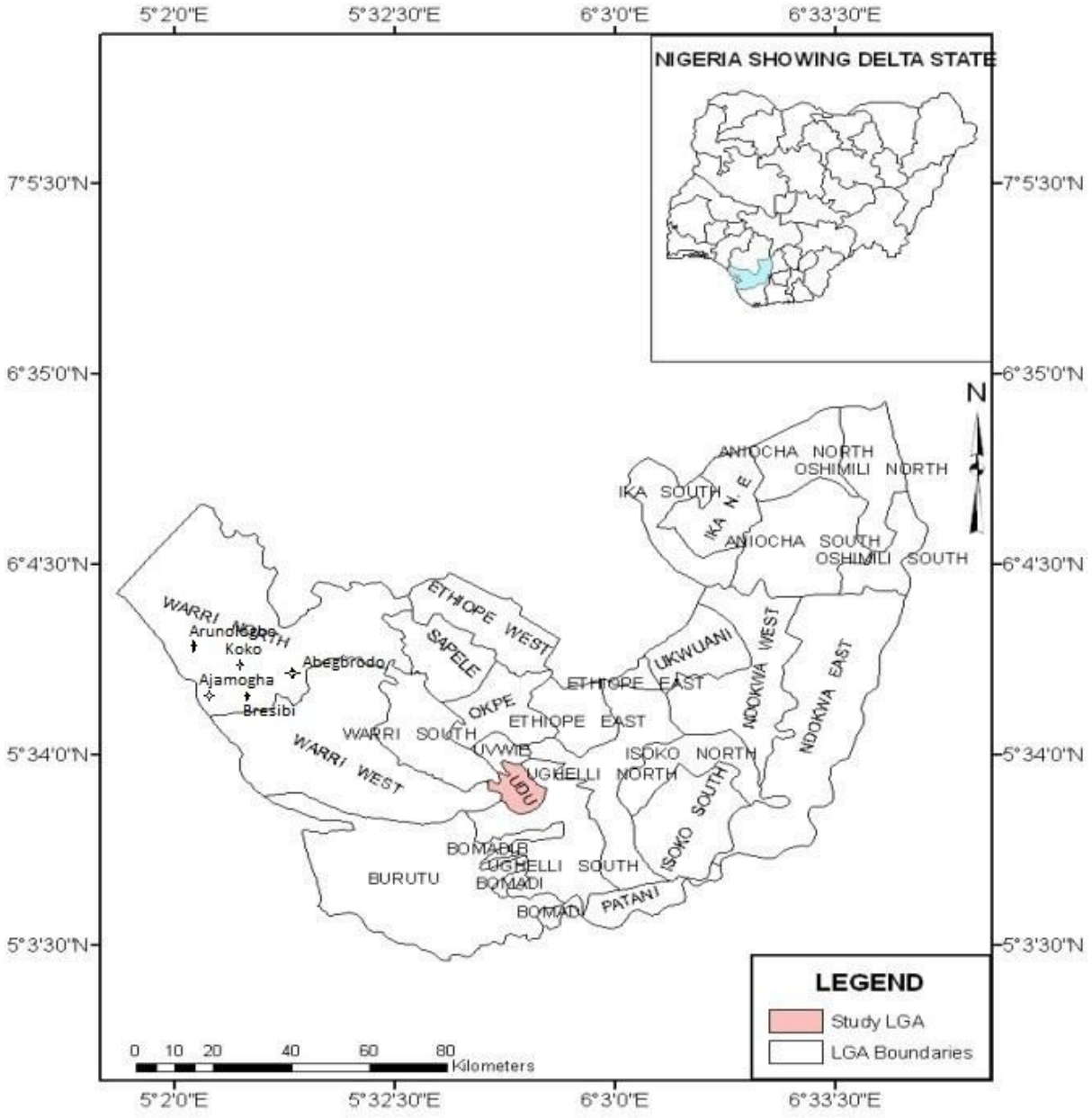


Figure 1: Map of the study area

Koko, Abegbrodo, Arunologbo Ajamogha and Bresibi are wetland oil bearing settlements in Warri north local government of Delta state Nigeria. Lying within the geographical coordinates of latitude 6°.00N and longitude 5°27' 99"E, Koko, Agbegbrodo, Arunologbo and Bresibi are settlements rich in oil. The occupation of the inhabitants are farming, fishing some are artisans others are petty traders a few work in oil companies while a very few work as civil and public servants in the public schools and council in Koko. The wetlands in these villages are the recipients of pollutants originating from oil and gas activities in the area.

II. Materials and Methods

This study was conducted between September 2023 and February 2024. Samples collection were accomplished with the assistance of 5 research assistants. Samples were collected from 5 wetlands in Koko Abegbodo, Ajamogha, Arunologbo and Bresibi. Each wetlands was mapped out into 5 sample grids and water samples were collected with clear 125mL plastic sample bottles at the depth of 10cm and covered subsurface.

The samples from each grid were bulked and composite were drawn, fixed with nitric acid to ward off oxidation and stored in ice cooled boxes. A total of 125 samples were collected for the study.

Analysis

The samples from Koko and environs were analysed using gas chromatography and mass spectrometry methods as described by (Cheng *et al*., 2013, Chiang *et al*., 2013, Calak, 2013) as in European Union code 1881/2014 for PAHs in wetlands water. 5ml of the water samples were measured into beakers and into these, 2g anhydrous sodium sulphate were added and agitated vigorously for proper mixing. The mixtures were transferred into extraction beakers and allowed to settle for 30 minutes to 1 hour. 20 gram dicafluorobiphenyl were then added into the mixtures and also sodium hydrosulphate. The tubes were vigorously agitated to a point when slurry begins to flow freely. They were then allowed to stand to settle for another 30 minutes and the effluents were then fed into gas chromatography coupled with mass spectroscopy Triple Quadrupole Agilent model 7000 for the determination of the PAHs of interest.

III. Results

The results of the PAHs in the wetlands of Koko and environs were as in Figure 2 to 6 and the mean comparative result of the PAHs as in Figure 7.

The results of the PAHs in Koko wetland were as in Figure 2

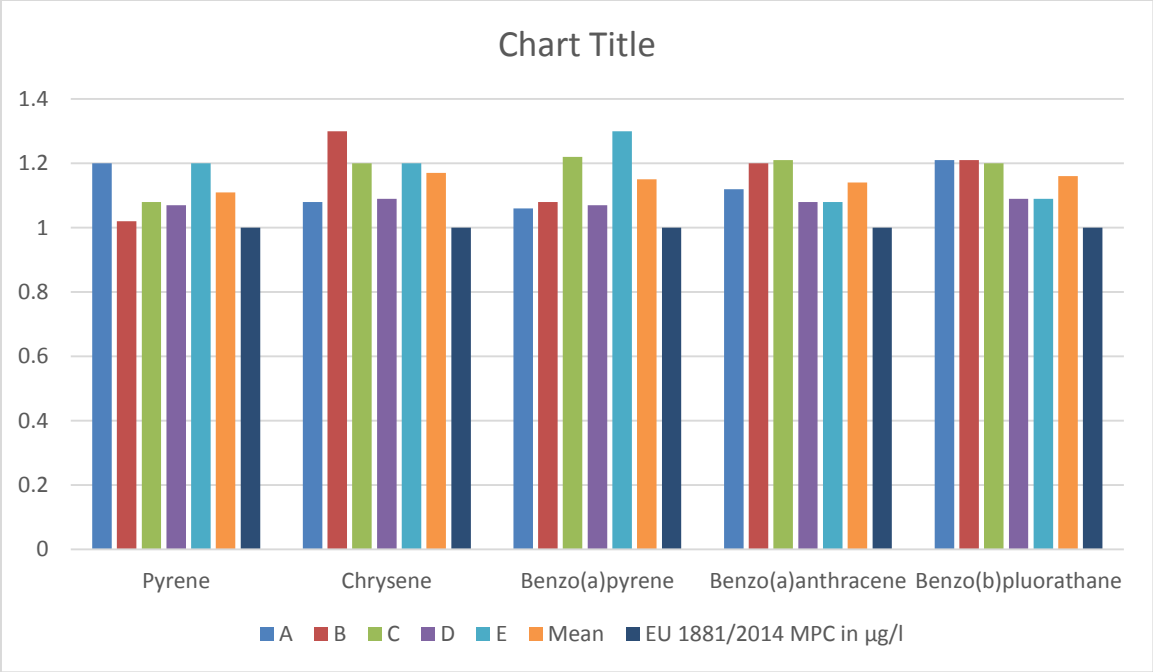
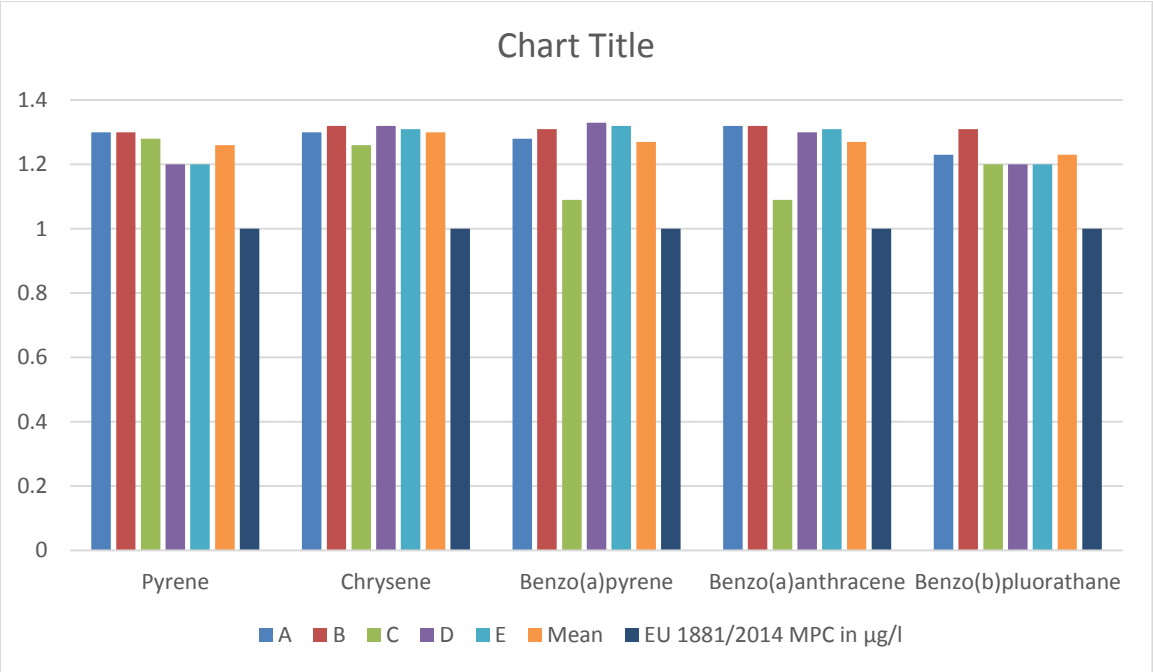


Figure 2: results of the PAHs in Koko wetlands and EU 1881/2014 MPC for PAHs in wetland in µg/l



The results of the PAHs in Arunologbo wetlands were as in Figure 3

Figure 3: results of the PAHs in Arunologbo wetlands and EU 1881/2014 MPC for PAHs in wetlands in µg/l.

The results of the PAHs in the wetlands in Agbegbrodo were as in Figure 4

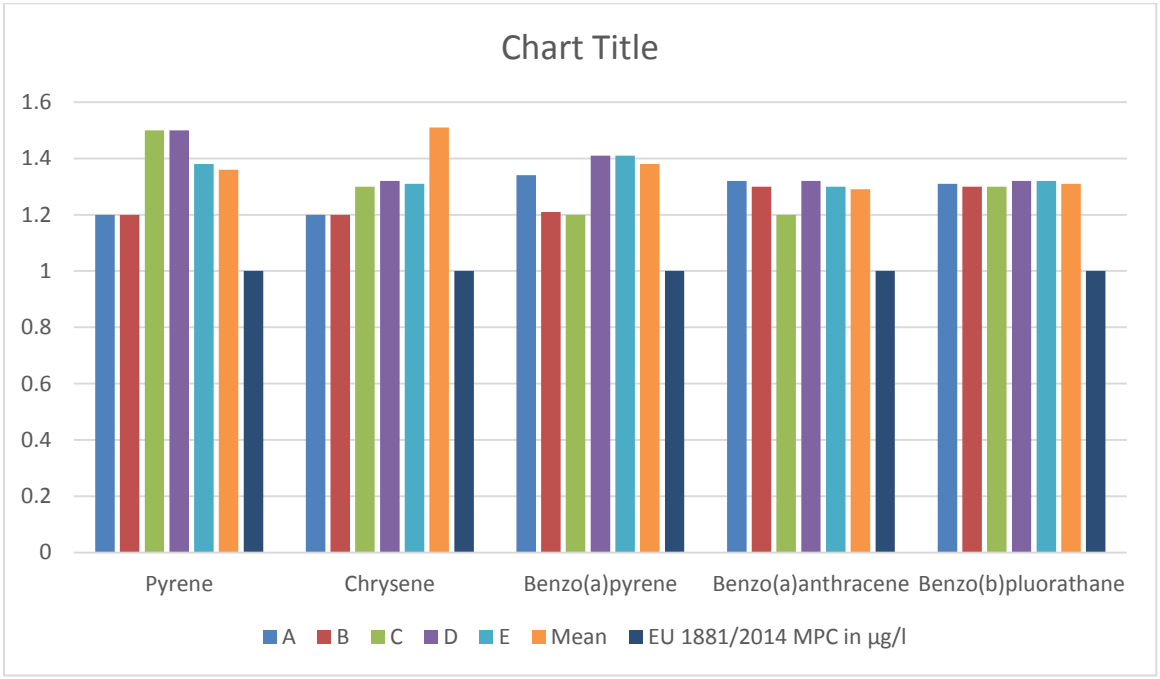


Figure 4; results of the PAHs in the wetlands in Agbegbrodo wetland and EU 1881/2014 MPC for wetlands in µg/l.

The results of the PAHs content in Ajamogha wetlands were as in Figure 5

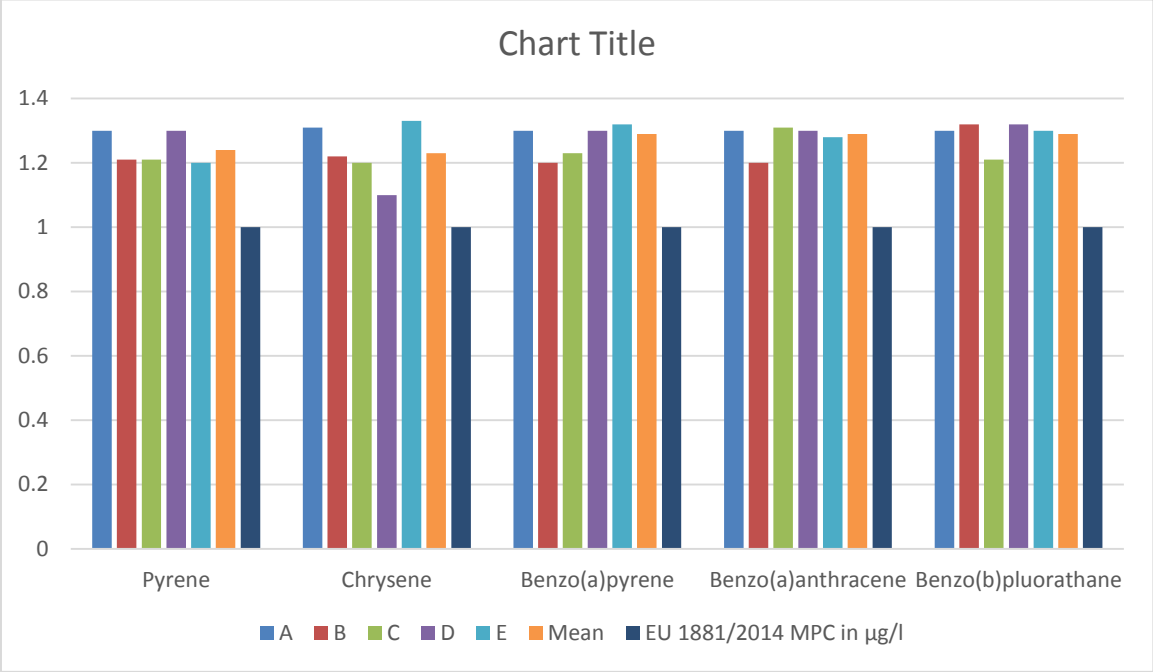


Figure 5: results of the PAHs content in Ajamogha and EU 1881/2014 MPC for PAHs in water in µg/l

The results of PAHs in the wetlands in Bresibi were as in Figure 6

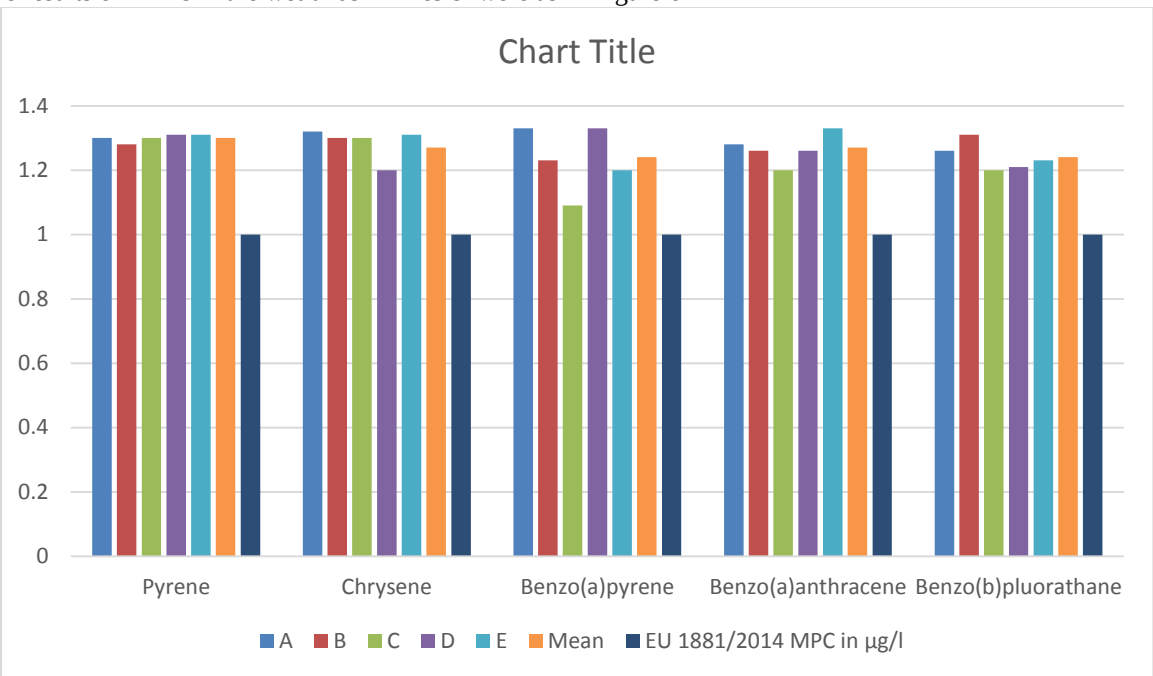


Figure 6: results of the PAHs in Bresibi wetland and EU 1881/2014 MPC for PAHs in wetlands in µg/l

The comparative mean results of the PAHs in the wetlands in Koko and environs were as in Figure 7.

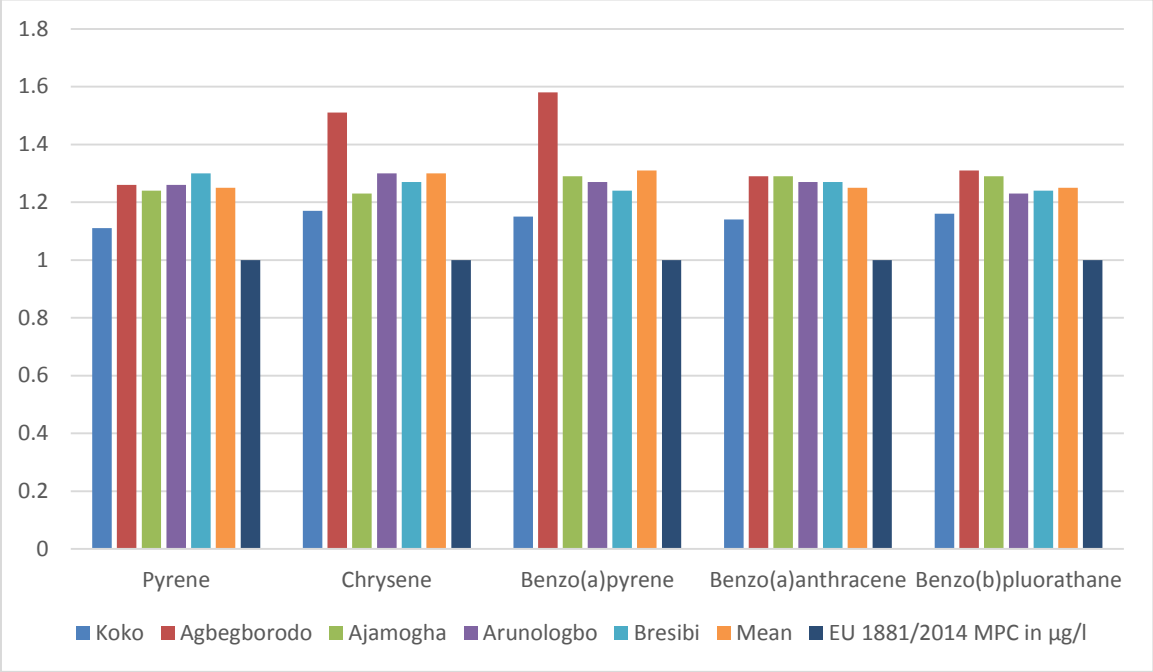


Figure 7: results of the PAHs in wetlands in Koko and environs and EU 1881/2014 MPC for PAHs in wetlands in µg/l

The means results of the PAHs in the wetlands in Koko and environs were subjected to test of significance deploying analysis of variance using special package for social sciences (SPSS) model 29 IBM at 0.05 level of significance and the p. value was 0.43 thus rejecting H_o.

IV. Discussion of Findings

Research reports on PAHs contamination of wetlands ecosystem are abound in academic cyberspace but research publications on the PAHs contamination of Koko and environs remain scarcely available. The analysis of the wetlands waters in Koko, Abregbrodo, Agamogha, Arunologbo and Bresibi presented vary concentrations of the PAHs investigated.

The concentration of pyrene were between 1.11 µg/l in Koko and 1.30 µg/l in Bresibi with a mean concentration of 1.23 µg/l. These increased concentrations are anthropogenic. This report is similar to those in (Erikson *et al*., 2014, Dilan *et al*., 2014, Ogwu *et al*., 2021). Pyrene has been implicated in lung cancer, colon cancer and osteoporosis (Eskandary *et al*., 2014, Fadiel *et al*., 2013, Diggs *et al*., 2014). High content of pyrene in wetlands of environment negates the adoption of cage aquaculture in the wetlands (Afolabi, 2022, Oderi, 2022).

Analysis of the wetland waters in Koko and environs presented the concentrations of chrysene of 1.17 µg/l in Koko wetlands to 1.30 µg/l in Arunologbo with a group mean concentration of 1.26 µg/l. The elevated content of chrysene is traceable to oil activities in the area. this report is in tandem with the reports in (Dang *et al*., 2015, Duke *et al*., 2015, Ogwu *et al*., 2020). Chrysene has been implicated in cardiovascular problems (FEng *et al*., 2015), osteoporosis (Fisher *et al*., 2016), mutation (gao *et al*., 2013). PAHs contamination of wetland reduces its utility for cage and pen aquaculture (Ogwu *et al*., 2022, Bamgboye, 2023).

The analysis of the wetlands in Koko and its environs for the content of BaP showed that the content to range from 1.15 µg/l in Koko to 1.31 µg/l in Agbegbrodo with a mean concentration of 1.25 µg/l. The high content of BaP in the area is as a result of human inference in the environment especially through oil production activities. This report is in agreement with reports in (Gavino *et al*., 2014, Ogwu *et al*., 2022, Garcia *et al*., 2015). Health problems associated with BaP contamination are tetratogenitc effects (guo *et al*., 2013, Hafner *et al*., 2015) gene mutation (Hao *et al*, 2016). Presence of BaP in wetlands reduces the possibility of the adoption of cage aor pen aquaculture due to the health implication of bioaccumulation and biomagnification to the organism (Adegbo *et al*., 2022, Zah, 2022).

BaA content analysis in the wetlands in Koko and environs presented the concentration of BaA of 1.14 µg/l in Koko to 1.30 µg/l in Arunologbo with a mean content of 1.25 µg/l. The increased content of BaA in these communities are human induced through oil production activities. This report is in corroboration with (Hu

et al., 2014, Hua *et al*., 2016, Ogwu *et al*., 2020). BaA has been reported in epidemiological studies to cause cancer of the skin and lungs (Husssain *et al*., 2015, Hung, 2015, Ogwu *et al*., 2021, Ogwu, 2021), obstructive lung disease (blyth *et al*., 2015). Toxicants contamination of wetlands decreases the ecosystem services especially for aquaculture (Ozah, 2023, Ogwu *et al*., 2022).

The analysis of wetlands in Koko and environs revealed the concentration of BbF to range from 1.16 µg/l in Koko to 1.31 µg/l in Agbegbrodo with a mean of 1.25 µg/l. The high content of BbF in the area is the effect of industrial activities of oil extraction and loading. A similar report of increased BbF in wetlands ecosystem was in (Bruns *et al*., 2016, Baltelo *et al*., 2016, De-la Nosa *et al*., 2016). Health complications arising from ingestion of BbF contaminated foods are osteoporosis, skin diseases (Gao et la., 2015, Feng *et al*., 2015, Frapiccin et la., 2015). Wetland contamination with BbF is a setback to the adoption of cage aquaculture in wetlands because of health complications (Banjo, 2021, Asuquo, 2022).

V. Conclusion and Recommendations

The study of the PAHs content of Koko and is environ has further affirmed the environmental contamination reports in several researches on oil activities and PAHs contamination of wetlands ecosystem. The analysis of the wetland in Koko, Arunologbo, Agbebrodo, Ajamogha and Bresibi has shown that the wetlands are contaminated with the PAHs investigated above the stipulated maximum permissible concentration by EU 1881/2014.

The pollution status has thus rendered the aquatic organisms in the wetland unfit for human consumption and for formulation of animal feeds. The produce from the wetland too cannot the exported because of the failure to scale through Codex (1963) standards for agricultural produce export. Consequent upon these, they study recommends that the oil companies operating in Koko and environs should be made to operate with high regards for the environment. The environmental monitoring agencies; National Environmental Standards Regulation and Enforcement Agency (NESREA) and National Oil Spills Detection and Response Agency (NOSDRA) should be made to step up their surveillance, the impacted wetlands should be remediated and restored.

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