PRINT ISSN 1119-8362
Electronic ISSN 2659-1499

Full-text Available Online at
https://www.ajol.info/index.php/jasem
https://www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 28 (12B Supplementary) 4293-4297 Dec. 2024

Quantification of Polycyclic Aromatic Hydrocarbons in Wetlands in Aja-Pessu and Environs (Oil Bearing Communities) Warri South Delta, Nigeria

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ABSTRACT: Oil production in Nigeria is synonymous with wetland degradation resulting in most times in youth's restiveness and unrests in oil bearing Niger Delta. Hence, the objective of this paper is to evaluate the quantification of polycyclic aromatic hydrocarbons in wetlands in Aja-Pessu and environs (oil bearing communities) Warri South Delta in Nigeria using appropriate standard methods. The mean results obtained were: pyrene 1.06±0.11 µg/l, chrysene 1.05±0.00 µg/l , BaP; 1.05±0.10 µg/l, BaA; 1.05±0.01 µg/l and BbF 1.06±0.11 µg/l. The results obtained were subjected to test of significance with ANOVA deploying SPSS IBM model 29 at 0.05 level of significance and the p value was 0.045, thus rejecting H_0. The study concluded that the wetlands in Aja-Pessu and environs are polluted with PAHs investigated higher than EU 1881/2014 MPC, thus the produce will neither be fit for human nor animal consumption and will equally not be fit for export. The study recommended that oil companies operating in the settlement should adopt world best practices in their operations, the monitoring agencies NESREA and NOSDRA should be made to carry out their assignment expeditiously and the impacted wetlands should be remediated and restored for adoption of pen aquaculture for job creation in Nigeria.

DOI: https://dx.doi.org/10.4314/jasem.v28i12.43

Cite this Article as: OGWU, C, IDEH, V; OGANA, J; ADINKWU, O. (2024). Quantification Of Polycyclic Aromatic Hydrocarbons In Wetlands In Aja-Pessu And Environs (Oil Bearing Communities) Warri South Delta, Nigeria. *J. Appl. Sci. Environ. Manage.* 28 (12B Supplementary) 4293-4297

Dates: Received: 22 October 2024; Revised: 20 November 2024; Accepted: 08 December 2024; Published: 31 December 2024

Keywords: polycyclic aromatic hydrocarbons; wetland contamination; pen aquaculture; adoption; job creation

A cardinal responsibility of government of any country is to ensure a good standard of living for its citizens and this is predicated on job creation which translates to income. Job creation is making opportunities available for paid employment for those not gainfully employed (Stevenson, 2018, Jones, 2019, Dulex, 2019). It is the provision of opportunity for people that are without jobs in a society to get new jobs to eke living (Perkins, 2020, Zack, 2021, Bathlomew, 2022). Job creation is the process through which the number of job openings in a given profession or area is increased to absorb all who are interested in being employed (Thompson, 2020, Shedrack, 2020, Jackson, 2023). It is the process of providing job for those who were previously inactive and not engaged. Job creation is the process of generating new job placement for individuals not previously employed in an economy (Petterson, 2019, Noel, 2020, Brandson, 2021, Anthony, 2021). It is a systematic way of absorbing those not

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employed and those underemployed into productive cycle of the economy (Benson, 2022, Salim, 2022, Jacobson, 2023), the process of increasing the number of job opening in an economy (MacDoff, 2020, Johnson, 2021). It includes policies of government intended to reduce unemployment (Patrick, 2020, Jewal, 2021, Sampson, 2022). Job creation stimulates economic growth and engenders good standard of living (Christian 2022, Samuel 2022) and ensures economic stability (Betrand, 2020). It creates employment which crystalizes into good living standards in a country. Nigeria Unemployment in 2024 is 5.3 percent (National Bureau of Statistics, 2024, Ruwani, 2024) and the under unemployment rate stands at 10.6 percent (NBS, 2024, Oteriba, 2024, Ruwani, 2024). Nigeria high unemployment rate can be reduced by creating jobs in agriculture (Ogwu *et al*., 2024, Ogwu *et al*., 2023, Ojugo, 2023). Youths are enjoined to venture into aquaculture agriculture for jobs and wealth creation (Ogwu *et al*., 2021, Ogwu *et al*., 2022, Afolabi, 2023). Provision of enabling environment for youths to venture into aquaculture adopting and deploying pen aquaculture due to its low capital outlay will lead to increase in job creation and wealth creation in Nigeria (Bakre, 2023, Ogwu *et al*., 2024, Bedeke and Ojo, 2024). Nigeria annual fish demand is 3 million metric tons while the local production is 850,000 metric tons the difference is bridged through importation (NBS 2024, Ruwani, 2022 (Ogwu *et al*., 2021, Afolabi, 2023). Pen aquaculture is the art of culturing fishes in a pen built in a natural body of water (Banjoko, 2018, Adekoya, 2019, Audu, 2020). Water analysis is imperative before deploying pen aquaculture because of possible presence of toxicants to avoid bioaccumulation and biomagnification (Ochu, 2020, Okonkwo 2022, World Health Organisation, 2020). Bioaccumulation is the tendency of toxicants within aquatic ecosystem to penetrate the tissues of aquatic organisms while biomagnification is the propensity of toxicants within organism tissue to multiply in geometry as they progresses into higher trophic levels (Ogwu *et al*., 2023, USEPA, Bamgboye, 2012). Possible water pollutants include heavy metals, pesticides, microplastic, petroleum, hydrocarbons, styrofoams, polycyclic aromatic hydrocarbons (PAHs) (Atshana and Atshana, 2012, USEPA, 2012, Ojikutu, 2023, Ogwu *et al*., 2023). PAHs are large group of organic compounds possessing two or more benzene rings (USEPA, 2020, Ogwu *et al*., 2023). PAHs have been implicated in epidemiological studies as being responsible for cancer of the lungs, bone marrow, (Chen *et al*., 2016, Cheng *et al*., 2013), Obstructive gastroenteritis (Diggs *et al*., 2011, Colak *et al*., 2013) and sources of PAHs in the environment are coal, gasoline and petroleum (Duan *et al*., 2016, Eriksson *et al*., 2014, Feng *et al*., 2016). Nigeria is an oil producing country ranking 11th in the world (Organisation of Petroleum Exporting countries, 2023, NBS, 2024). Oil accounts for 90 percent of Nigeria export value and 6.33 percent of its Gross Domestic Product (NBS, 2024, Oteriba 2024, Ruwani, 2024) and Delta state is the second oil producing state in Nigeria contributing 21.56 percent of Nigeria oil production (NBS, 2024, Oteriba, 2024, Ruwani, 2024) with Warri South hosting over 350 wells (Ogwu *et al* 2021, Afolabi 2023) of Delta state production. Oil spills into the wetland environment occur through wellheads blowout, pipe vandalism, equipment failures, and through loading (Ogwu *et al*., 2023, Ogwu *et al*., 2024, Nwachukwu, 2024, Abubakar, 2024). A wetland is an ecosystem that can habour water for 3 – 6 months in a year or all year round (Ramsar Conference of Parties, 2018, Ramsar Conference of Parties, 2022). Aja-Pessu, Aja-Dediare, Aja-Enetsemi, Aja-Mami and Aja-Moore are oil bearing wetland settlements in the Warri South local government of Delta Nigeria. The focus of this study is the analysis of polycyclic aromatic hydrocarbons content in the wetlands of Aja-Pessu and environs for adoption and deployment of pen aquaculture for job creation in Nigeria. The PAHs investigated were pyrene, chrysene, benzo(a)pyrene (BaP), benzo(a)anthracene (BaA) and benzo(b)fluorathane (BbF). The objective of this paper is to evaluate the quantification of polycyclic aromatic hydrocarbons in wetlands in Aja-Pessu and environs (Oil Bearing Communities) Warri South Delta for in Nigeria.

MATERIALS AND METHOD

Study Area: Aja-Pessu, Aja-Dediare, Aja-Enetsemi, Aja-Mami and Aja-Moore are oil producing wetlands settlements in Warri South local government area Delta Nigeria. Located with the coordinates of 5.5172°N and 5.7415°E, the people of Aja-Pessu and environs are predominantly fishermen and farmers some are artisans while some are petty traders with a few working with the oil companies mainly as lower cadre staff (janitors and messengers). The wetlands are the recipient of the spillage that occur in the process of oil extraction in the environment. This study was conducted between January 2024 to July 2024. Six research assistants were recruited for sampling one in each settlement. The wetlands in each settlement were mapped into 5 sampling grids as described (Fadiel *et al*., 2013, Eskandary *et al*., 2014). Water samples were collected with clean plastic bottles with fitting caps from 5 spots at the depth of 10cm and covered subsurface (Gao et a., 2015) adopting grab sampling techniques (Gavina *et*

al., 2014). The samples from each grid were bulked and composites drawn were fixed with nitric acid and stored in ice-cooled flask for analysis.

Fig 1: Map showing the study area
Adapted from: https://en.wikipedia.org/wiki/Uvwie#/media/File:Uvwie,_Delta_State.jpg

Analysis: The analytical standard adopted for this study was European Union 1881/2014 as described in EU1881/2014 (Hao *et al*., 2016, Dang *et al*., 2015). The samples were analysed with gas chromatography coupled with mass spectrometry (GC/MS) using Agilent Quadrupole model 7000. 5g of the wetland water samples were measured into beakers and anhydrous sodium sulphate 2g added and agitated vigorously. The mixtures were then transferred into other beakers (extraction beaker) and allowed to settle for 1 hour, 20 g of dicafluobiphinyl and 2g of sodium sulphate were added to the beakers thesis were again vigorously agitated to the point when slurry began to flow freely. The resulting eluents were fed into the chambers of Agilent GS/MS 7000 for the determination of the PAHs of interest.

RESULTS AND DISCUSSION

The results of the analysis of the wetlands in Aja-Pessu and environs were as in Figure 2 – 6 and the comparative means result of the PAHs in Aja-Pessu as in Figure 7. The results of the content of PAHs in Aja-Pessu and environs were as in Figure 2. The results of the PAHS content in the wetlands in Aja-Dediare were as in Figure 3. The results of the PAHs content in the wetlands in Aja-Enetsemi were as in Figure 4. The results of the PAHs in the wetlands in Aja-Moore were as in Figure 5. The result of the PAHs in wetlands in Aja-Mami were as in Figure 5. The comparative means results of the PAHs content of the wetlands in Aja-Pessu and environs were as in Figure 6.

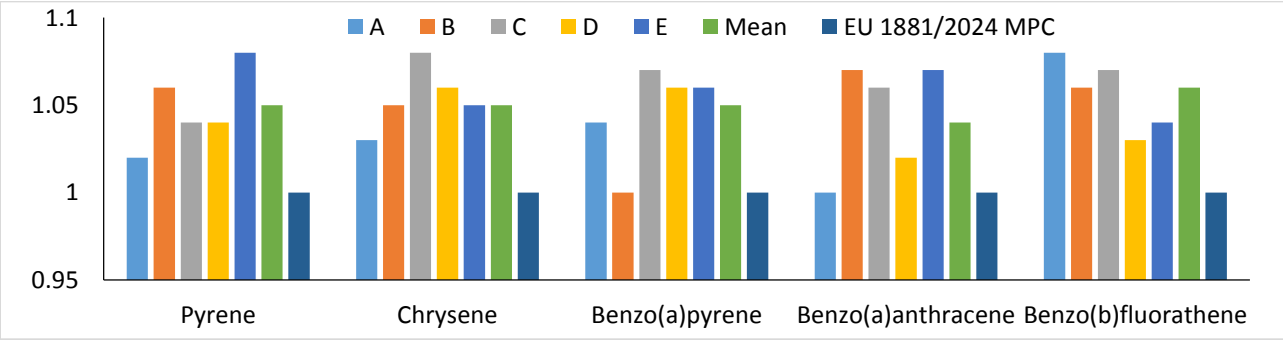

Fig 2: results of the contents of PAHs in the wetlands in Aja-Pessu and EU 1881/2014 MPC for PAHs in wetlands in µg/l.

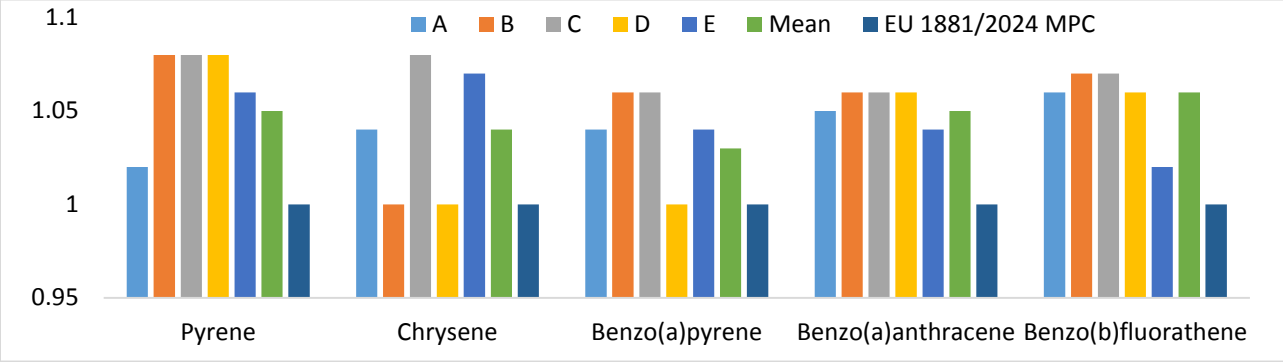

Fig 3: results of the PAHs content in the wetlands in Aja-Dediare and EU1881/2014 MPC for PAHs in wetland in µg/l.

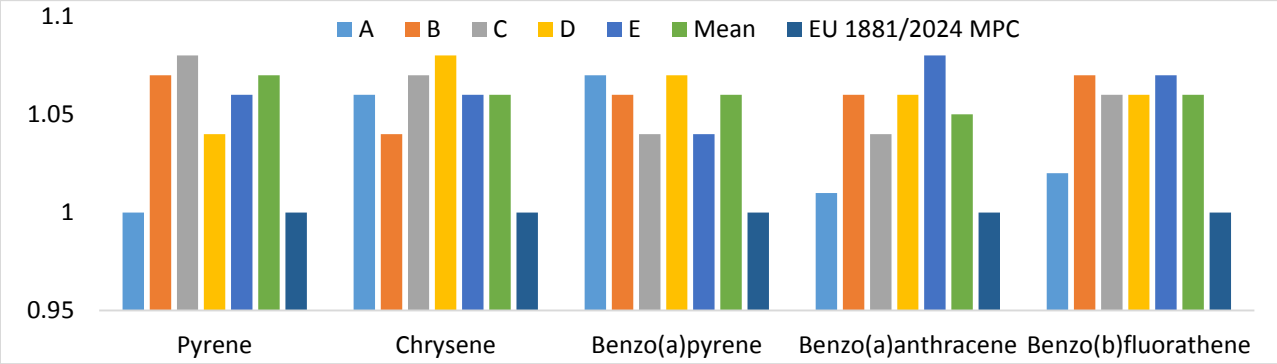

Fig 4: results of the PAHs content in the wetlands in Aja-Moore and EU 1881/2014 MPC for PAHs in wetlands in µg/l..

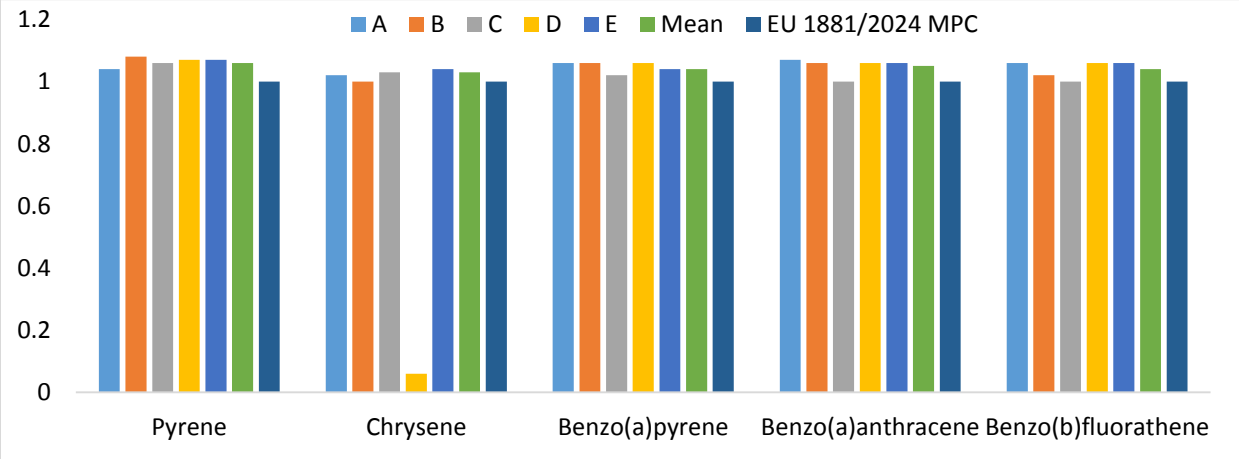

Fig 5: results of the PAHs in the weltands in Aja-Enetsemi and the EU 1881/2014 MPC for PAHs in wetlands in µg/l.

The mean results of the PAHs concentrations in Aja-Pessu and environs were subjected to test of significance with analysis of variance (ANOVA) using special package for social science (SPSS) IBM model 29 and the *p*-value was 0.045 thus rejecting H_0. The analysis of the water of the wetlands in Aja-Pessu and environs presented varying results of concentration of the PAHs investigated. The concentration of pyrene in the wetlands in Aja-Pessu and environs ranged from 1.05 µg/l in Aja-Pessu, Aja-Dediare to 1.07 µg/l in Aja-Moore with group mean concentrations of 1.06 µg/l. The high concnetrations of pyrene is anthropogenic. This result is in tandem with the reports in (Hung *et al*., 2014, Hussain *et al*., 2014). Pyrene has been reported to be responsible for health complications such as obstructive lung disease, renal failure (De-la *et al*., 2016, Colak *et al*., 2016).

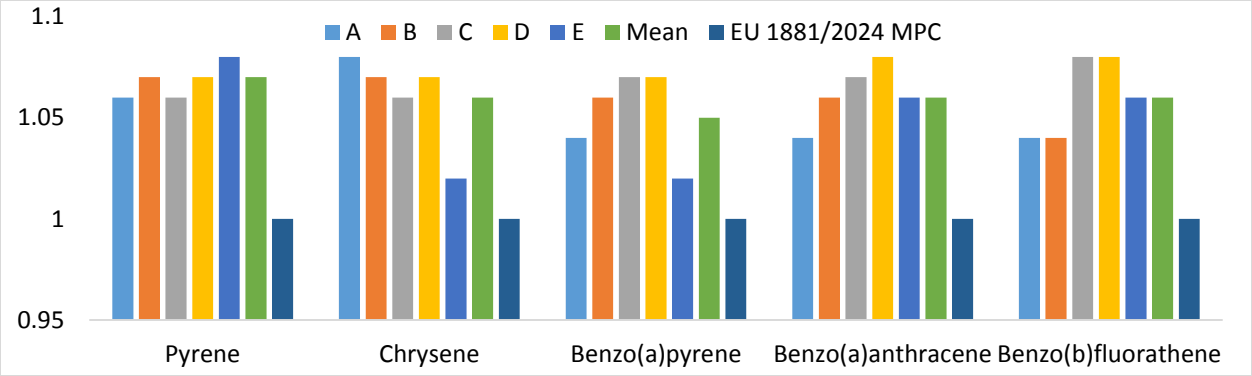

Fig 6: results of the PAHs contents in the wetlands in Aja-Mami and EU 1881/2014 MPC for PAHs in wetlands in µg/l.

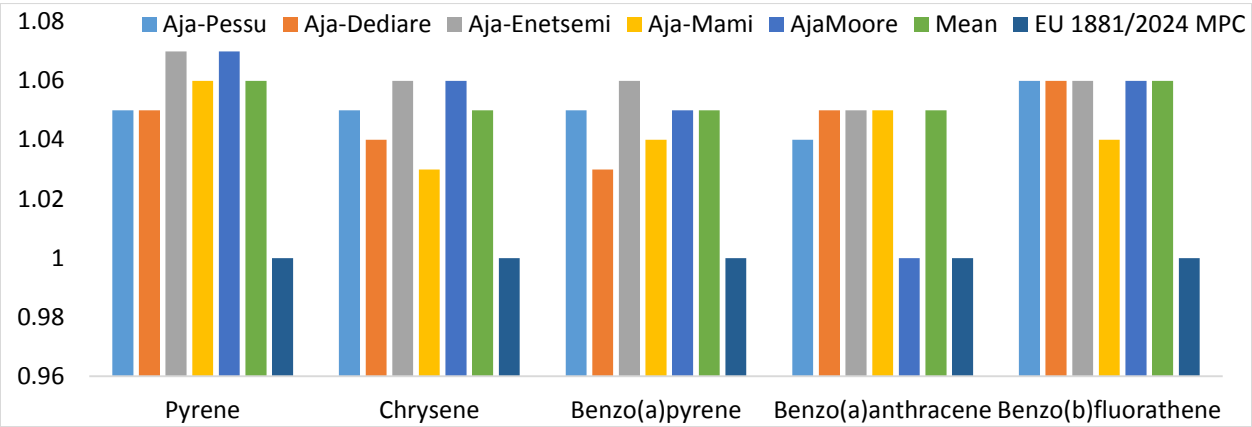

Fig 7: results of the mean results of the concentrations of PAHs in the wetlands in Aja-Pessu and environs and the EU 1881/2014 MPC for PAHs in wetlands in µg/l.

Wetland water analysis in Aja-Pessu and environs for the content of chrysene revealed the concentrations of chrysene to be between 1.03 µg/l in Aja-Mami to 1.06 µg/l in Aja-Enetsemi and Aja-Moore with a group mean concentration of 1.05 µg/l. The elevated content of chrysene is traceable to the oil production activities in the wetlands. This report is in agreement with the report in (Dong *et al*., 2015, Ogwu *et al*., 2024). Human long exposure to chrysene has been associated with osteoporosis, liver problems (Chang *et al*., 2016, Ogwu *et al*., 2024), cancer of the lungs (Cheng *et al*., 2013). BaP content analysis in the wetlands in Aja-Pessu and environs showed that the concentration was between 1.03 µg/l in Aja-Dediare to 1.06 µg/l in Aja-Enetsemi with group mean concentration of 1.05 µg/l. This high content of BaP is the wetlands is the concomitant effective of oil mining. A similar report of high concentration of BaP in wetlands was in (Byth *et al*., 2015, Gao *et al*., 2015). Ingestion of BaA contaminated food or long exposure has been known to cause mutation of DNA, brain cancer (Eskandary *et al*., 2014, Batello *et al*., 2015), renal failure (Ogwu et a., 2024, Ogwu *et al*., 2024). The analysis of the wetlands in Aja-Pessu and environs for the assessment of the concentrations of BaA, presented varying concentration ranging from 1.04 µg/l in Aja-Pessu to 1.06 µg/l in Aja-Enetsemi with a mean of 1.05 µg/l. The increased concentration of BaA in the wetland settlement is a result of oil production activities. This report is in corroboration of the reports in (Zhao *et al*., 2014, Usman *et al*., 2015), but at variance with the reports in (Vander-Wat *et al*., 2015). Prolonged exposure to BaA results in tetratogenic problem (Verma *et al*., 2015, Tauler *et al*., 2015), skin irritations (Thomas *et al*., 2016). The results of the analysis of BbF in the wetlands of Aja-Pessu and environs showed that the concentration was from 1.04 µg/l in Aja Mami to 1.06 µg/l in Aja-Pessu, Aja-Dediare, Aja-Enetsemi and Aja-Moore with a group mean of 1.06 µg/l. This high concentration of BbF is the effect of oil extraction in the wetland. This report is in consonance with the reports in (Tungal and Uslu, 2015, Theo *et al*., 2016, Sigh *et al*., 2016), but dissimilar with the reports in (Zeno *et al*., 2015, Storey *et al*., 2014, Singh *et al*., 2016). Health complications arising from exposure to BbF include gastrointestinal disorder (Shati *et al*., 2016, Sherma *et al*., 2014), renal Failure (Song *et al*., 2015, Sherestha *et al*., 2015).

Conclusion: Wetland pollution propensity of oil production activities is plenary and replete in literature in academic cyber space. The result of the analysis of the wetlands in Aja-Pessu and environs has further lend credence to already existing information, thus an affirmation of environmental degradation arising from oil activities. The analysis of the wetlands in Aja-Pessu and environs revealed that the concentrations of the PAHs investigated are higher than the maximum permissible concentration stipulated in EU 1881/2014 thus the produce will neither be fit for human nor animal consumption. The produce cannot also be exported due to the failure to satisfy Codex Alimentarius standards for produce export. Consequence upon these findings, the study recommended that oil companies operating in Aja-Pessu and environs should be made to adhere to the world best practices in oil industries operations, oil activities monitoring agencies National Environmental Standards Regulation and Enforcement Agency (NESREA) and National Oil Spills Detection and Response Agency (NOSDRA) should be mandated to carry out their assignments expeditiously, the impacted wetlands should be remediated and restored for the adoption of pen aquaculture for job creation in Nigeria.

Declaration of Conflict of Interest: The authors declare that there is no conflict of interest as no part of this work has been submitted to any journal for consideration or publication.

Data Availability Statement: Data collected are in compliance with ethical standards. No permission was sought from Wildlife Conservation Department because no animal was used. However, permits were sought from the community heads whose wetlands were sampled for this study

REFERENCES

Abubakar, QT (2024). Oil spills and the rural economy of the Niger Delta litoral communities. *J. Agric. Edu. Teach. Nig.* 6(2): 91-96

Adekoya, JN (2019). Assessment of the adoption of pen aquaculture in Kwara state. *Asia J. Mar. Sci.* 28(3): 302-308.

Anthony, I (20210. Job creation. https://www.quara.com retrieved February, 2024.

Atshana DC; Atshana LA (2012). *Environmental Chemistry*. New Delhi: Chand Book Ltd.

Audu, Q (2020 19 August). Youths should adopt pen aquaculture in fish production. Vanguard news pp. 46 – economy.

Bakre, J (2023 17 October). Youths Agriculture: The Antidote for Unemployment in Nigeria. Vangaurd News Ppp. 42 – Economy.

Bamgboye, TK (2022). Polycyclic aromatic hydrocarbons content of Olomoge lagoon Lagos Nigeria. *Discov. Environ.* 23(2): 102-108.

Banjoko, JC (2018 17 June). Youths should adopt pen aquaculture for easy venture into agriculture. Guardian News pp. 48.

Bathlomey, C (2022). Employment creation. Https://www.usip.org

Bedeke, C; Ojo, MN (2024). Agriculture and Youths Unemployment in Nigeria. A Review J. Vocat. Technol. Educ. Train. 18(2): 196-201.

Benson, C (2022). Job creation. Https://www.oxford.com Retrieved January 2024.

Betrand, NJ (2020). What is job creation. Https://www.jobtechchalence.com Retrieved April.

Blyth, W; Shahsavari, E; Morrison, PD; Ball, AS (2015). Biosurfactant from red ash trees enhances the bioremediation of PAH contaminated soil at a former gasworks site. J. Environ. Manage. 162: 30-36.

Brandson, L (2021). Employment creation. https://www.sciencedirect.org. Retrieved March, 2024.

Chang, YT; Lee, JF; Liu, KH; Liao, YF; Yang, V (2016). Immobilization of fungal laccase onto a nonionic surfactant-modified clay material: application to PAH degradation. Environ. Sci. Pollut. Res. 23: 4024-4035.

Chen, CF; Chen, CW; Ju, YR; Dong, CD (2016). Vertical profile, source apportionment, and toxicity of PAHs in sediment cores of a wharf near the coal-based steel refining industrial zone in Kaohsiung, *Taiwan Environ. Sci. Pollut. Res.* 23: 4786-4796.

Cheng, YJ; Huang, SH; Chiu, JY; Liu, WL; Huang, HY (2013). Analyses of polycyclic aromatic hydrocarbonas in seafood by capillary

electrochromatography-atmospheric pressure chemical ionization/mass spectrometry. *J. Chromatogr.* 1313: 132-138.

Christian, O (2022). Role of job creation. https://www.researchgate.net. Retrieved February 2024.

De la Rosa, JM; Paneque, M; Hilber, I; Blum, F; Knicker, HE; Bucheli, TD (2016). Assessment of polycyclic aromatic hydrocarbons in biochar and biochar-amended agricultural soil from Southern *Spain J. Soils Sediments.* 16: 557-565.

Dellex, S (2019). Job creation. Definition. Https://www.erofound.europa.eu. Retrieved January, 2024.

Diggs, DL; Huderson, AC; Harris, KL; Myers, JN; Banks, LD; Rekhadevi, PV (2011). Polycyclic aromatic hydrocarbons and digestive tract cancers: a perspective. *J Environ Sci Health C Environ Carcinog Ecotoxicol Rev*, 29: 324-357.

Dong, C; Bai, X; Sheng, H; Jiao, L; Zhou, H; Shao, Z (2015). Distribution of PAHs and the PAH-degrading bacteria in the deep-sea sediments of the high-latitude Arctic Ocean. *Biogeosciences*, 12: 2163–2177.

Duan, X; Shen, G; Yang, H; Tian, J; Wei, F; Gong, J; Zhang, J (2016). Dietary intake polycyclic aromatic hydrocarbons (PAHs) and associated cancer risk in a cohort of Chinese urban adults: Inter-and intra-individua variability. *Chemosphere*, 144: 2469-2475.

Eriksson, AC; Nordin, EZ; Nyström, R; Pettersson, E; Swietlicki, E; Bergvall, C; Pagels, JH (2014). Particulate PAH emissions from residential biomass combustion: Time-resolved analysis with aerosol mass spectrometry. *Environ. Sci. Technol.* 48: 7143-7150.

Eskandary, S; Hoodaji, M; Tahmourespour, A; Abdollahi, A (2014). Bioremediation of PAHs from contaminated soils by Festuca aroundiacea in the presence of Bacillus licheniformis and Bacillus mojavensis. *J. Residuals Sci. Technol.* 11: 99–105.

Eskandary, S; Hoodaji, M; Tahmourespour, A; Abdollahi, A (2014). Bioremediation of PAHs from contaminated soils by Festuca aroundiacea in the presence of Bacillus licheniformis and Bacillus mojavensis. *J. Residuals Sci. Technol.* 11: 99-105.

Fadiel, A; Epperson, B; Shaw, MI; Hamza, A; Petito, J; Naftolin, F (2013). Bioinformatic analysis of benzo-α-pyrene-induced damage to the human placental insulin-like growth factor-1 gene. *Reprod. Sci.* 20: 917-928.

Feng, J; Hu, P; Zhang, F; Wu, Y; Liu, S; Sun, J (2016). Ecological risk assessment of polycyclic aromatic hydrocarbons in surface sediments from the middle and lower reaches of the Yellow River, China. *Hum. Ecol. Risk Assess.* 22: 532-542.

Gao, B; Du, X; Wang, X; Tang, J; Ding, X; Zhang, Y; Zhang, G (2015). Parent, Alkylated, and Sulfur/Oxygen-Containing Polycyclic Aromatic Hydrocarbons in Mainstream Smoke from 13 Brands of Chinese Cigarettes. *Environ. Sci. Technol.* 49: 9012–9019.

Gao, B; Du, X; Wang, X; Tang, J; Ding, X; Zhang, Y; Zhang, G (2015). Parent, Alkylated, and Sulfur/Oxygen-Containing Polycyclic Aromatic Hydrocarbons in Mainstream Smoke from 13 Brands of Chinese *Cigarettes. Environ. Sci. Technol.* 49: 9012-9019.

Gao, B; Wang, XM; Zhao, XY; Ding, X; Fu, XX; Zhang, YL; Guo, H (2015). Source apportionment of atmospheric PAHs and their toxicity using PMF: Impact of gas/particle partitioning. *Atmos. Environ.* 103; 114-120.

Gavina, JMA; Yao, C; Feng, Y-L (2014). Recent developments in DNA adduct analysis by mass spectrometry: A tool for exposure biomonitoring and identification of hazard for environmental pollutants. *Talanta*, 130; 475-494.

Hao, X; Li, J; Yao, Z (2016). Changes in PAHs levels in edible oils during deep-frying process. *Food Control*, 66: 233-240.

Haruna, J; Loyerm, AC. (2022). Bioaccumulation of heavy metals in *Tilapia zelli* cropped in Taraba River. *J. Total Environ.* 19(2): 80-86.

Hung, CV; Cam, BD, Mai, PTN; Dzung, BQ (2014). Heavy metals and polycyclic aromatic hydrocarbons in municipal sewage sludge from a river in highly urbanized metropolitan area in Hanoi, Vietnam: levels, accumulation pattern and assessment of land application. *Environ. Geochem. Health.* 37: 133-146.

Hussain, K; Balachandran, S; Hoque, RR (2015).Sources of polycyclic aromatic hydrocarbons in sediments of the Bharalu River, a tributary of the River Brahmaputra in Guwahati, India. *Ecotoxicol. Environ. Saf.* 122: 61-67.

Jackson, AN (2022). Creating job for African's growing population. https://www.worldbang.org. retrieved March, 2024.

Jacobson, A (2022). Job creation. Https://www.com Retrieved January 2024.

Jewel, MA (2021). Job creation in small and medium size enterprises. https://www.ilo.org.dyn

Johnson, K (2021). Job creation scheme, definition and meaning. https://www.collinsdictionary.com. Retrieved April.com

Jones, M (2019). What are the concepts of job creation. https://www.quru.com retrieved January 2024.

Mac-Doff, J (2022). Job creation and youths empowerment in Nigeria. Https://www.researchgate.net Retrieved February, 2024.

National Bureau of Statistics (2024). Unemployment in Nigeria. https://www.nigeriastat.gov.ng Retrieved June 2024.

Noel, N (2020). Job creation strategies for Nigeria. https://www.researchgate.net retrieved April, 2024.

Nwachukwu, PC (2024). Oil exploration and the delima of the wetlands ecosystem in the Nigeria Delta. *J. Environ. Conserv.* 22(3): 141-147.

Oclu, JA (2020). Water chemistry of Katsina Ma River. *J. Environ. Monit.* 12(2): 202-208

Ogugo, AS (2023 16 March). Solve Youths Unemployment With Agriculture. Punch News Pp. 52 – Economy.

Ogwu C; Atima, I; Aghana, SO (2023). Organochlorine pesticides determination of Iselegu-wetlands for cage aquaculture in secondary schools as a recipe for remodeling education in Nigeria. *Int. J. Recent Res. Phys. Chem. Sci.* 10(2): 76-80.

Ogwu, C; Avbnudiogba, E; Ogune, P; Aloamaka, TA (2023). Analysis of the heavy metals content of Lagos lagoon, Lagoss, Nigeria. *Int. J. Recent Res. Phys. Chem. Sci.*, 10(1): 1-6

Ogwu, C; Onuelu, JE; Awowede, MA; Agbe, E (2023). 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. *Niger. J. Sci. Environ.*, 21(3): 91-106.

Ogwu, C; Onuelo, JE; Awowede, MA (2023). Assessment of the heavy metals and metalloids in cassava roots grown in Ebdei (an oil bearing community) Delta State Nigeria. *Int. J. Novel Res. Phys. Chem. Math.* 10(2): 43-48.

Ogwu, C; Ukpene, AO; Ekpe, IN; Umukoro, BO; Onuelu, JE (2023). Quantification of heavy metals and metalloid in cassava roots grown in oil bearing communities of the Niger Delta. *Innov. J.* 73: 89-101.

Ojikutu, SO (2023). Analysis of the polycyclic aromatic hydrocarbons in Ogun River by Kara Bridge Lagos. *J. Environ. Manag.* 16(3): 40-45.

Okokwo, CC (2022). Contaminants in Omambala River. *J. Ecol.* 17(1): 90-96.

Oteriba, S (2024). Nigeria unemployment rate 2023 Lagos: Oteriba Economic Consultants.

Oteriba, S (2024). Oil production in Nigeria. Lagos: Oteriba Economic Consultants.

Patrick, JP (2020). Creating jobs what does it really mean? https://www.florida.edu.org.

Perkins, J (2020). Employment creation. https://www.dictionarycambridge.org. retrieved February, 2024.

Petterson, S (2019). What leads to global job creation. https://www.technoserve.org. retrieved April, 2024.

Ramsa Conference of Parties (2018). Convention on wetland Festival Arena Dubai United Arab Emirate 21-29 October 2018.

Ramsar Conference of Parties (2022). Convention on wetlands. Wuhan China November 5 to 13 2022.

Ruwani, B (2024). Nigeria oil production 2023. Lagos: Financial Derivatives.

Ruwani, B (2024). Unemployment in Nigeria Lagos: Oteriba and Associates.

Salim, SI (2022). Job creation. https://www.ideoconline.com Retrieved January 2024.

Sampson, A (2022). Job creation. https://www.wikilabori.org. Retrieved February 2024.

Samuel, JP (2022). Job creation: a means or an end. https://www.includeplatform.net. Retrieved January 2024.

Shedrack, AT (2020). Employment creation poverty and the structure of job market in Nigeria. Https://www.nigeriaeconomicsociety.org.ng

Shedrack, F (2020). The challenges of job creation in Nigeria. https://www.afdb.org. Retrieved February 2024.

Singh, A; Chandrasekharan Nair, K; Kamal, R; Bihari, V; Gupta, MK; Mudiam, MKR; Srivastava, AK (2016). Assessing hazardous risks of indoor airborne polycyclic aromatic hydrocarbons in the kitchen and its association with lung functions and urinary PAH metabolites in kitchen workers. *Clin. Chim. Acta***.** 452: 204–213.

Singh, L; Varshney, JG; Agarwal, T (2016). Polycyclic aromatic hydrocarbons' formation and occurrence in processed food. *Food Chem.* 199: 768–781

.

Stevenson, A (2018). Job creation. https://www.collinsdictionary.com. Retrieved January 2024.

Storey, S; Ashaari, MM; McCabe, G; Harty, M; Dempsey, R; Doyle, O; Doyle, EM (2014). Microbial community structure during fluoranthene degradation in the presence of plants. *J. Appl. Microbiol.* 117: 74–84.

Tauler, M; Vila, J; Nieto, JM; Grifoll, M (2015). Key high molecular weight PAH-degrading bacteria in a soil consortium enriched using a sand-in-liquid microcosm system. *Appl. Microbiol. Biotechnol.* 1–16.

Thea, AE; Ferreira, D; Brumovsky, LA; Schmalko, ME (2016). Polycyclic aromatic hydrocarbons (PAHs) in yerba maté (Ilex paraguariensis St. Hil) traditional infusions (mate and tereré). Food Control, 60: 215–220.

Thomas, F; Lorgeoux, C; Faure, P; Billet, D; Cébron, A (2016). Isolation and substrate screening of polycyclic aromatic hydrocarbon degrading bacteria from soil with long history of contamination. *Int. Biodeterior. Biodegrad.* 107: 1–9.

Thompson, J (2020). What is job creation. Https://www.rigiglobal.com retrieved January 2024.

Tunçal, T; Uslu, O (2015). Industrial sludge remediation with photonic treatment using Ti-Ag nano-composite thin films: Persistent organic pollutant removal from sludge matrix. *J. Environ. Manage.* 149: 37–45.

United State Environmental Protection Agency (2020). Polyaromatic hydrocarbons https://www.achive.epa.gov.pdf retrieved May, 2024.

United State Environmental Protection Agency ERA Terminology. https://www.epa.gov retrieved June, 2024.

Usman, M; Chaudhary, A; Biache, C; Faure, P; Hanna, K (2015). Effect of thermal pre-treatment on the availability of PAHs for successive chemical oxidation in contaminated soils. *Environ. Sci. Pollut. Res.* 23: 1371–1380.

Verma, R; Patel, KS; Verma, SK (2016). Indoor polycyclic aromatic hydrocarbon concentration in Central India. *Polycycl. Aromat. Compd.* 36: 152–168.

Zhao, Z; Zhang, L; Cai, Y; Chen, Y (2014). Distribution of polycyclic aromatic hydrocarbon (PAH) residues in several tissues of edible fishes from the largest freshwater lake in China, Poyang Lake, and associated human health risk assessment. *Ecotoxicol. Environ. Saf.* 104: 323–331.