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Determination of The Polycyclic Aromatic Hydrocarbons (Pahs) In *Telfairia Occidentalis* (Fluted Pumpkin) Cultivated In Okpai Oil Bearing Community For Sustainable Economic Growth In Nigeria

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Abstract
This study was an ex-post-facto research that investigated the content of PAHs in T. occidentaliscultivated in Okpai oil producing community for its suitability for human consumption. The study answered 3 research questions and tested a hypothesis. In achieving these T. occidentalist samples were collected from 5 farms/gardens in 5 quarters of Okpai bulked in each case, wrapped in alluminium foil and stored in ice cool boxes for analysis. The analytical standard adopted was EU 1255/2020 and the instrument for determination deployed was HPLC shimadzu LC 2050 series pressure resistance 50 MPa. The results obtained were pyrene; 2.72±0.11µg/kg, chrysere; 2.70±0.12 µg/kg, BaP; 2.74 µg/kg±0.11 µg/kg, BaA; 2.72±0.10 µg/kg and BbF, 2.73±0.12 µg/kg. The mean results of the PAHs in the T. occidentalis 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 Ho. The study concluded that the T. occidentalis were contaminated above the established critical points. It recommended that the cultivation of T. occidentalisshouldbe suspended in Okpai and mitigation of the effect of oil activities should be embarked upon. The oil companies in Okpai should be mandated to adopt world best practices in their operations while the monitoring agencies NOSDRA and NESREA should be compelled to improve on their surveillance on the activities of the oil firms.
Keywords: *oil extraction, PAHs bioavailability, T. occidentalis, Human health,sustainable economic growth.*

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I. Introduction

The aspiration of nations world over is to achieve sustainable economic growth in all facets of its economy for good standards of living of its citizens. Sustainable economic growth is an economic growth that is devoid of economic problems (Johnson, 2017 Jonah, 2018, Spiff, 2018). It is the process or practice of creating an economic growth trajectory that supports long-term economic improvement without jeopardizing, decreasing or depleting existing resources (Branson 2018, Tedwell 2019, Cornell 2019). Economic growth is the measure of real growth that can be maintained without visibly creating any significant economic problem (Humphrey 2018 Samson 2019 Betrand 2019). It is the growth of a nation that satisfy the need of the present without altering, compromising and endangering the ability of generation yet to come to harness and utilize the same resources (Peterson 2020, Richard 2020, Sunil 2020). Sustainable economic growth also include the practice of exploring and the natural resources of a nation for the satisfaction of the present without compromising the ability of the future generation to use and enjoy the same resources for their satisfaction in future (Ogwu, 2020, Ochu, 2021, Abdulwaheed, 2020). Extracting oil deposits for the satisfaction of the present generation without denigrating and degrading the environment to deprive the future generation of the opportunity of utilising same resources is sustainable economic growth (Ogwu*et al*., 2021, Ogwu*et al*., 2022, Ioryem, 2022).

Nigeria is a major oil producing country ranking 11th globally and 7th in gas deposit. (Organisation of Petroleum Exporting Countries 2023, Nigeria Bureau of Statistics, 2022, Ruwani, 2023). Nigeria has witnessed 822 cases of oil spills between 2020 and 2022 spewing 28003 barrels into the terrestrial and aquatic environment (Natural Oil Spills Detection and Response Agency (NORDRA), 2023, Nigeria Environmental Standard Regulation and Enforcement Agency. In addition, it flares 10% of its gas making it rank the 10th gas flaring nation in the world and in 2018 flared 7.4 billion cubic feet of gas into the atmosphere (NOSDRA, 2023,

NESREA, 2023, Tondo, 2022). Oil spillage on the land contaminates the soil with varying toxicants such as heavy metals, nitrogen oxides, sulphur oxide and polycyclic aromatic hydrocarbons (Wang, 2015, Wilson 2014, Yate *et al*., 2011) while flaring into the atmosphere results in particulates foliar contaminations with heavy metals NO_2, SO_2, PAHs in the soil and in the air result in bioaccumulation and biomagnification of the toxicants in annual, perennial and vegetable crops physiology (Ogwu et al., 2022) and prolonged exposure of human to PAHs have been implicated in many health complications such as cancer of the lung and throat (Zhao, 2014, Vigret*et al*., 2015, Walker *et al*., 2015) cardiovascular diseases, mutation and tetragenic disorders (Wang et al., 2015, Islam et al., 2013, Sayara et al., 2011).

Telfairiaoccidentalis (fluted pumpkin) is the commonest vegetable consumed in Delta state (Ojowhe, 2018, Ossai, 2018, Ogwu*et al*., 2022). The focus of this study thus the assessment of the polycyclic aromatic hydrocarbons in the *T. occidentalis* grown in Okpai oil bearing community for sustainable economic growth in Nigeria. The PAHs investigated were pyrene, chrysene, benz(a)pyreneBaP, benz(a)anthraceneBaA, benz(b) fluorathane (BbF).

The study was guided by research questions as follows;

i. what are the concentrations of pyrene, chrysene BaP, BaA and BaF in *T. occidentalis* grown in Okpai oil bearing community.

ii. are the concentrations of the PAHs within the maximum permissible concentrations stipulated by European Union Regulation 1255/2020 for PAHs in vegetables?

iii. are the *T. occidentalis* grown in Okpai suitable for human and animal consumption considering the concentration of PAHs?

iv. can the *T. occidentalis* scale Codex Allimentarius huddles for produce export

The study was guided by a hypothesis as follows:

H_0: there is no significant difference between the concentrations of the PAHs investigated in *T. occidentalis* cultivated in Okpai oil-bearing community and EU regulation 1255/2020 for PAHs in vegetables.

Study Area

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

Okpai is a wetland settlement in Ndokwa east local government area of Delta state. It lies within geographical coordinates of 5.723°N and 6.5990°E with a land area of 1805 Km^2 and a population of 4020 inhabitants (National Population Commission, 2006). Okpai people are predominantly fishermen and farmers with notable crops being yam, cassava and *T. occidentalis*as the major vegetable grown in alluvial deposits that result from annual denudation (Ogwu, 2023, Ariwe, 2023, Izah, 2022). Okpai plays host to ENI-AGIP Oil Company and the biggest gas plant in West Africa, the Okpai gas plant.

II. Material and Methods

Ethical consideration: the samples collection were made from home gardens and farms from the 5 quarters. Permission of the owners of the crops were sought before samples were collected. There was no approval sought from the government authorities because the crops were not under prohibition listbecause they were not endangered.

Sampling

5 out of the total 7 quarters of Okpai community constituted the sampling grid (SG). The 5 quarters randomly selected were Oluchi, Anieze, Ashaka, Obeze and Obodoyibo. From each of these quarters, *T. occidentalis* samples were randomly collected from 5 gardens and farms, bulked, labeled, wrapped with alluminium foil and stored in ice cool boxes for analysis.

Samples Preparation

The vegetables (*T. occidentalis*) samples were thoroughly washed with double distilled water and later rinsed with deionized water. They were shredded with shimadizu laboratory blender model M620 and homogenized with Agilent homogenizer model A1240MC.

The analytical standard adopted for the analysis was European Union Regulation 1255/2020 as described in (Lin 2016, Semedo, 2014). The analysis was conducted deploying ion motoring on a high performance liquid chromatography Schimadzu model 2050 series (pressure resistance 50 MPA) that has HP-6MS(shimodzu) model 2506 installed with a fused silica of 0.25µm film thickness. The carrier used was ultra helium gas with flow rate of 1ml/minute. Extract of the samples were injected into high performance liquid chromatography with electron impact mode 70eV. The injector temperature was programmed at 200°C/mm and 260°/minute.

III. Results

The results of the PAHs in the *T. occidentalis* grown in Okpai oil bearing communities were as in Figure 2 to 6 and the comparative means result as in Figure 7.

The result of the PAHs content of *T. occidentalis*cultivated in Oluchi were as in Figure 2

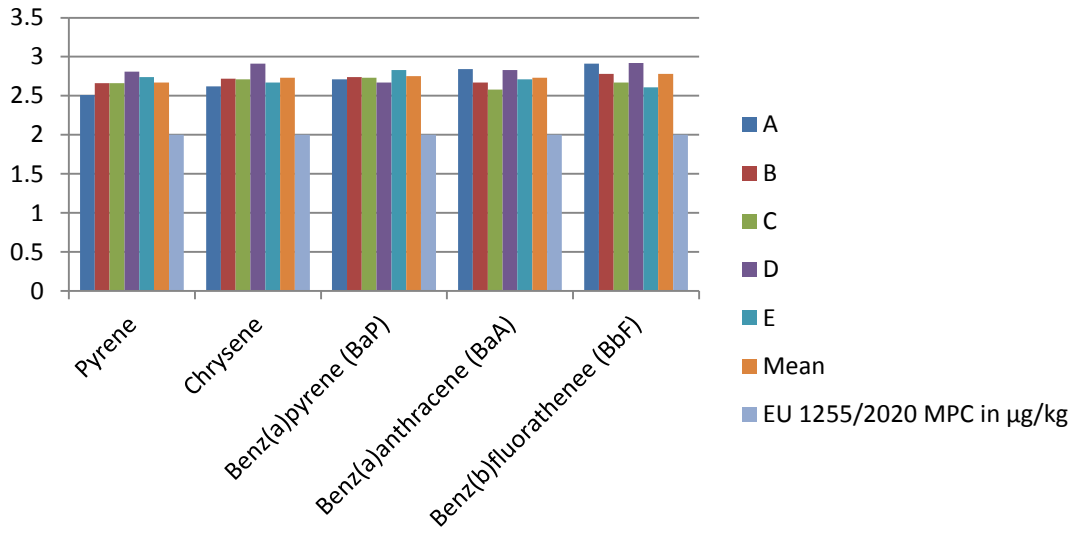

Figure 2: results of the PAHs in *T. occidentalis* grown in OkpaiOluchi and EU 1255/2020 MPC for PAHs in vegetables in µg/kg.

The results of the PAHs content of *T. occidentalis* grown in Aniezewere as in figure 3

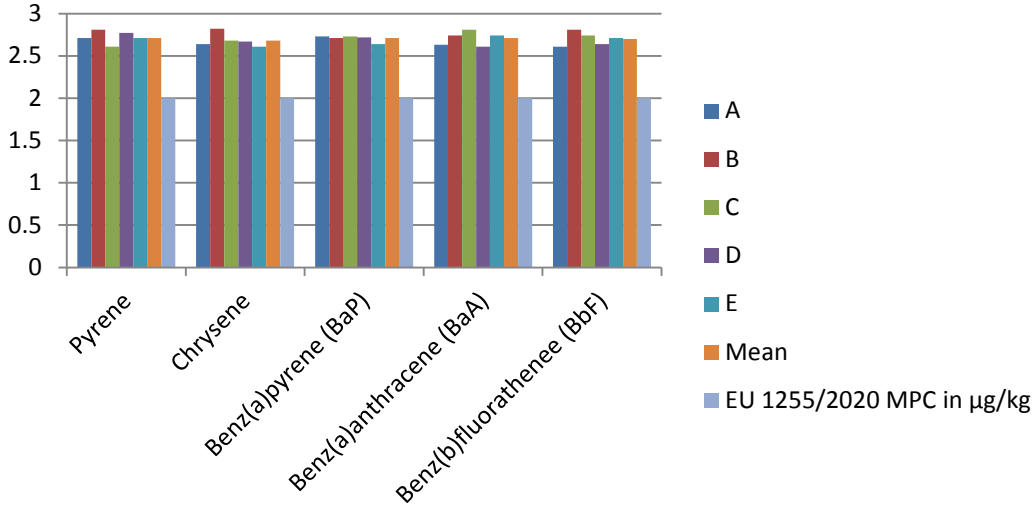

Figure 3: results of the PAHs content in *T. occidentalis* cultivated in OkpaiAnieze and EU regulation 1255/2020 MPC for PAHs in vegetables in µg/kg

The results of the PAHs content in *T. occidentalis* cultivated in OkpaiAshaka were as in Figure 4

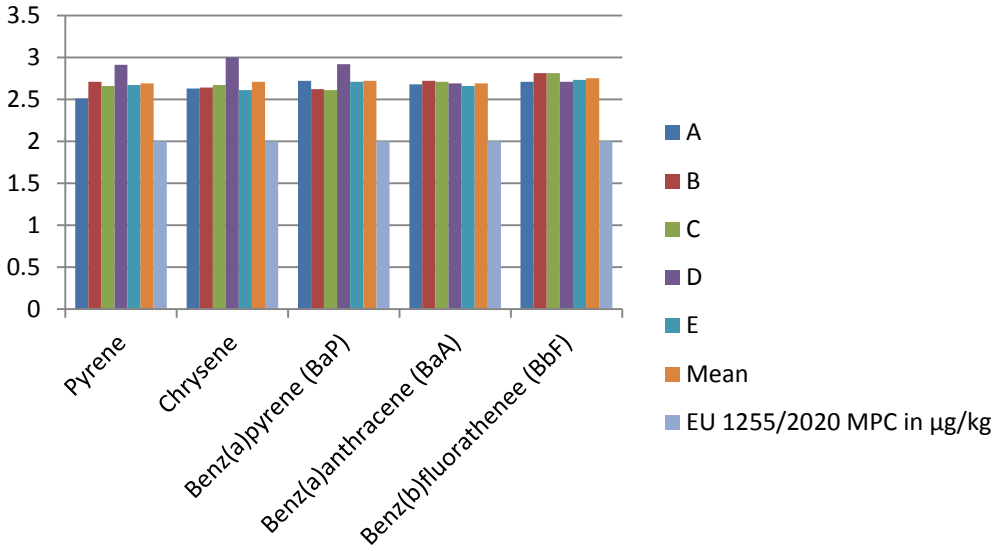

Figure 4: results of the concentration of PAHs in *T. occidentalis* grown in OkpaiAshaka and the EU regulation 12550/2020 MPC on PAHs in vegetables in µg/kg

The results of the PAHs in *T. occidentalis*cultivated in Obeze were as in Figure 5

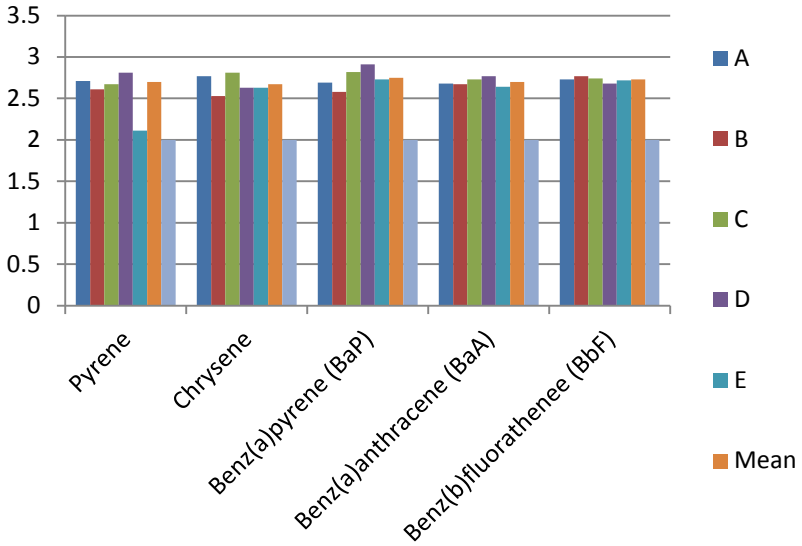

Figure 5: results of the PAHs cultivated in Okpai-Obeze and the EU regulation 1255/2020 MPC for PAHs in vegetables in µg/kg.

The results of the PAHs in *T. occidentalis* cultivated in OkpaiObodoyibo were as in Figure 6

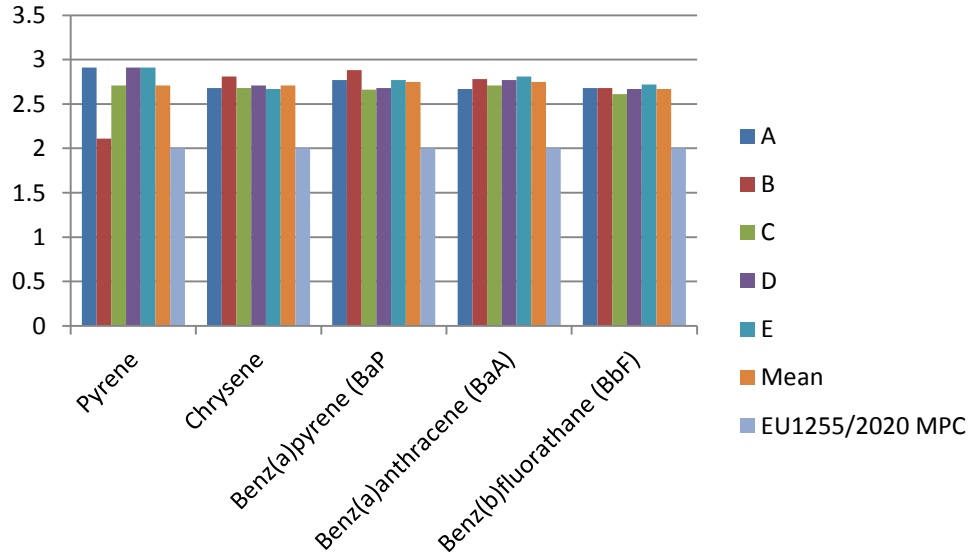

Figure 6: results of the PAHs content in *T. occidentalis*cultivated in Okpai-Obodoyibo and EU regulation 1255/2020 MPC for PAHs in vegetables in µg/kg

The mean content of the PAHs in *T. occidentalis*vegetables cultivated in Okpai oil producing community were presented comparative means as in Figure 7.

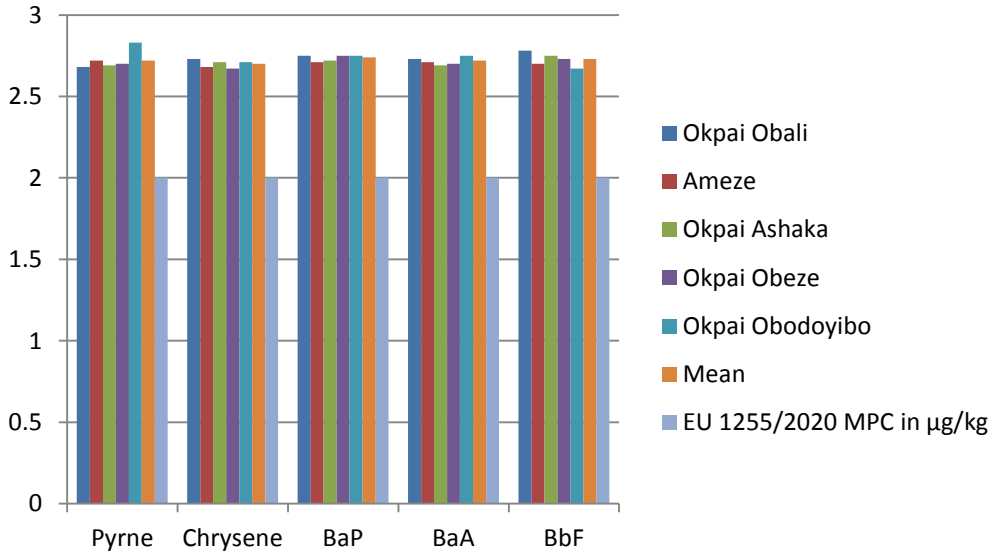

Figure 7 comparative mean results of the PAHs in the *T.occidentalis*cultivated in Okpai oil producing community and EU regulation 1255/2020 MPC for PAHs in vegetables in µg/kg

The means results of the PAHs in *T. occidentalis*were further subjected to test of significance using special package for social sciences (SPSS) model 29 (IBM) at 0.05 level of significance. The *p*. value was 0.48 thus rejecting Ho.

IV. Discussion

Polycyclic aromatic hydrocarbons ontamination of foods, fruits and vegetables have been reported in several researches (Jeng*et al*., 2013, Iwegbu*et al*. 2013, Islam, *et al*., 2013),however, researches on PAHs contamination levels in crops cultivated in oil producing areas of Niger Delta in general and Okpai in Delta state oil producing community in particular remainlargely scanty and that mandated this study. The analysis of *T. occidentalis* grown in Okpai oil bearing communities present varying concentrations of the PAHs measured and these were predicated on EU 1255/2020 bench mark for PAHs in fruits and vegetables.

The concentrations of the pyrene in the *T. occidentalis* in Okpaiol bearing community range from 2.22 µg/kg in Anieze to 2.83 mg/kg in Obodoyibo with a mean concentration of 2.72µg/kg. The elevated content of pyrene is anthropogenic. This report is in agreement with the reports in (Radriquez*et al*., 2015, Ranjagarajan, 2015, Seemann, 2015.).

Chrysene content in the *T. occidentalis* samples from Okpai was between 2.68µg/kg in Anieze to 2.73 µg/kg in Oluchi with a mean of 2.70 µg/kg. This increased content of chrysene is associated with human interaction with the environment and is in tandem with the reports in (Martinse*et al*., 2013, Meng*et al*., 2015, Ogwu*et al*., 2021, Miao *et al*., 2015).

The concentrations of BaP in the *T. occidentalis* grown in Okpai community vary from 2.71 µg/kg in Anieze to 2.75µg/kg in Oluchi, Obeze and Obodoyibo and the mean concentration recorded was 2.74 µg/kg. This level of BaP above critical point established by EU 1255/2020 is associated to the impact of oil activities in the environment. This result is in corroboration of (Sayara*et al*., 2011, Rosales *et al*., 2013, Ogwu*et al*., 2022), however, it is at variance with (Kalwa*et al*., 2014, Ivan *et al*., 2014).

The analysis of BaA in *T. occidentalis* grown in Okpai community revealed also the contents of BaA to be between 2.69µg/kg in Okpa-Ashaka to 2.75µg/kg in Obodoyibo with a mean concentration of 2.72 µg/kg. Oil exploration and exploitation are the culprits for this increase in BaA recorded in the *T. occidentalis*. This report is similar to the reports in (Jin *et al*., 2014, Iwegbue*et al*., 2014, Ogwu*et al*., 2020, Ogwu*et al*., 2020).

BbF content in the*T. occidentalis*i presented a concentration range of 2.67 µg/kg in Obodoyibo to 2.78 µg/kg in Oluchi with a group mean of 2.73 µg/kg. This content of BbF higher than the MPC established by EU 1255/2020 is the concomitant effect of oil activities in Okpai. A similar report was recorded in (Meng*et al*., 2015, Ogwu*et al*., 2021, Seemann*et al*., 2015, Islam *et al*., 2013).

V. Conclusion

This study has confirmed several research reports on the environmental contamination effect of industrial activities in Nigeria such as oil activities. Oil exploitation activities resulting in bioavailability of PAHs in the soil and the air through particulate droplets bioaccumulation have been further affirmed. The results of this investigation has shown that the PAHs content of the *T. occidentalis* in Okpaiis above the levels recommended by EU for vegetables and therefore not fit for human and animal consumption, it is also not fit for exported as Codex Allimentarius conditions for produce export has not been fulfilled.

Consequent upon the result of this investigation, the study recommended that:

1. cultivation of *T. occidentalis* in Okpai oil producing community should be suspended forthwith.
2. The oil company or companies operating in Okpai should be mandated to adopt world best practices in their operations in line with the mantra of sustainable development and for the achievement of sustainable economic growth in Nigeria.
3. The monitoring agencies NOSDRA AND NESREA are enjoined to step up their surveillance on the oil companies activity in Okpai.

REFERENCES

[1]. Abdulwaheed, B. Q. (2020). Adoption of cage aquaculture in Niger state for sustainable economic growth in Nigeria. Journal of Agriculture 12(2), 102-108.
[2]. Betrand, M. (2019). Stimulating sustainable economic growth. https://www.enterprisedevelopment.org
[3]. Brandson, C. (2018). Sustainable economic development. Httpss://www.elibrary.imf.rg
[4]. Friends of the Earth (2022). Oil spills and Nigeria environment. Friends of the Earth publication. Washington DC United States of America
[5]. Ioryem, P. A. (2022). Adoption of bees production in senior secondary schools in Benue state: a recipe for achieving sustainable growth in Nigeria. Nigeria journal of Extension Agriculture 20(3), 124-130
[6]. Johnson, P. (2017). Sustainable economic growth. https://www.indeed.com
[7]. Jonah, H. (2018). What is sustainable economic growth https://www.study.com/academy
[8]. Kara, G., & Aydin, M. E. (2015). Risk Assessment of 26 Polycyclic Aromatic Hydrocarbon (PAH) Compounds in Parkıng Garages. Environmental Forensics,16, 205–216.
[9]. Karimi, P., Peters, K. O., Bidad, K., & Strickland, P. T. (2015). Polycyclic aromatic hydrocarbons and childhood asthma. European Journal of Epidemiology,30, 91–101.
[10]. Klein, S. J. (2014). Acenaphthene. In P. Wexler (Ed.), Encyclopedia of Toxicology (Third Edition) (pp. 17–19). Oxford: Academic Press.
[11]. Mafiana, B. C. (2018). Effect of oil spillage on roots and yield response of Manihotspp in the Niger Delta. Quest Journal of Agriculture 12(3), 98-104.
[12]. National Bureau of Statistics (NBC) (2022). Nigeria oil production volume in 2021. A NBS publication, Abuja, Nigeria.
[13]. National Oil Spills Detection and Response Agency (NOSDRA) (2020). Oil spill cases in Nigeria 2020-2021. NOSDRA Bulletin, Abuja, Nigeria
[14]. Nigeria Environmental Standards Regulation and Enforcement Agency (2022) Oil spill cases in Nigeria. A NESREA publication, Abuja, Nigeria.
[15]. Nøst, T. H., Halse, A. K., Randall, S., Borgen, A. R., Schlabach, M., Paul, A., ... Breivik, K. (2015). High Concentrations of Organic Contaminants in Air from Ship Breaking Activities in Chittagong, Bangladesh. Environmental Science and Technology,49, 11372–11380.
[16]. Nwaichi, E. O., Wegwu, M. O., &Nwosu, U. L. (2014). Distribution of selected carcinogenic hydrocarbon and heavy metals in an oil-polluted agriculture zone. Environmental Monitoring and Assessment,186, 8697–8706.
[17]. Obinaju, B. E., Graf, C., Halsall, C., & Martin, F. L. (2015). Linking biochemical perturbations in tissues of the African catfish to the presence of polycyclic aromatic hydrocarbons in Ovia River, Niger Delta region. Environmental Pollution,201, 42–49.
[18]. Obrist, D., Zielinska, B., &Perlinger, J. A. (2015). Accumulation of polycyclic aromatic hydrocarbons (PAHs) and oxygenated PAHs (OPAHs) in organic and mineral soil horizons from four U.S. remote forests. Chemosphere,134, 98–105.
[19]. Obuekwe, I. S., &Semple, K. T. (2013). Impact of Al and Fe on the development of phenanthrene catabolism in soil. Journal of Soils and Sediments,13, 1589–1599.
[20]. Ochu, M. A. 2021). Achieving sustainable economic growth through technical and vocational education and training. Journal of Vocational and Technical Education 12(3), 91-96.
[21]. Odabasi, M., Vardar, N., Sofuoglu, A., Tasdemir, Y., &Holsen, T. M. (1999). Polycyclic aromatic hydrocarbons (PAHs) in Chicago air. Science of The Total Environment,227, 57–67.
[22]. Ohura, T., Sakakibara, H., Watanabe, I., Shim, W. J., Manage, P. M., &Guruge, K. S. (2015). Spatial and vertical distributions of sedimentary halogenated polycyclic aromatic hydrocarbons in moderately polluted areas of Asia. Environmental Pollution,196, 331–340.
[23]. Ojamede, F. T. (2018). The biological effects of oil exploitation in the Niger Delta. Journal of Environmental Monitoring 30(3), 114-120.
[24]. Ojowhe, V. C. (2018). Vegetable cultivation and oil production in the Niger Delta. Journal of Horticulture Science 16(3), 202-208.
[25]. Okelie, J. P. (2017). Oil spillage and vegetable production in Obocha oil prodcing community River state Nigeria. Journal of Agricultural Education Teachers of Nigeria 6(3), 90-96
[26]. Okonkwo, S. S. (2016). Vegetable production and rural economic of Egbema people of the River state Nigeria. Journal of Crop Science Society of Nigeria 13(2), 88-94.
[27]. Oleszczuk, P., Zielińska, A., &Cornelissen, G. (2014). Stabilization of sewage sludge by different biochars towards reducing freely dissolved polycyclic aromatic hydrocarbons (PAHs) content. Bioresource Technology,156, 139–145.
[28]. Oliva, M., Perales, J. A., Gravato, C., Guilhermino, L., & Galindo-Riaño, M. D. (2012). Biomarkers responses in muscle of Senegal sole (Soleasenegalensis) from a heavy metals and PAHs polluted estuary. Marine Pollution Bulletin,64, 2097–2108.
[29]. Orecchio, S., Amorello, D., Barreca, S., &Valenti, A. (2016). Wood pellets for home heating can be considered environmentally friendly fuels? Polycyclic aromatic hydrocarbons (PAHs) in their ashes. Microchemical Journal,124, 267–271.

[30]. Organisation of Petroleum Exporting Countries (OPEC) (2020). Oil production quota in Nigeria. OPEC bulletin 122, Geneva Switzerland.
[31]. Osfai, J. C. (2018). Feifairaoccidentalis cultivation in the alluvial deposits of orashi. Journal of Agriculture 18(3), 52-57.
[32]. Osugo, F. A. (2018). Effect of oil spills on no nodule formation of Arachuhypogia. Journal of Biological Sciences 4(2), 101-108.
[33]. Oteriba, B. (2020). Oil production in Nigeria. Lagos: Oteriba Economic Consultancy.
[34]. Oteriba, S. (2023). The problem with oil wealth. Lagos: Oteriba Economic consultancy
[35]. Otte, J. C., Keiter, S., Faßbender, C., Higley, E. B., Rocha, P. S., Brinkmann, M., ... Hollert, H. (2013). Contribution of Priority PAHs and POPs to Ah Receptor-Mediated Activities in Sediment Samples from the River Elbe Estuary, Germany. PLoS ONE,8, e75596.
[36]. Oyo-Ita, I. O., Oyo-Ita, O. E., Dosunmu, M. I., Domínguez, C., Bayona, J. M., &Albaigés, J. (2016). Distribution and Sources of Petroleum Hydrocarbons in Recent Sediments of the Imo River, SE Nigeria. Archives of Environmental Contamination and Toxicology,70, 372–382.
[37]. Ozaki, N., Takamura, Y., Kojima, K., &Kindaichi, T. (2015). Loading and removal of PAHs in a wastewater treatment plant in a separated sewer system. Water Research,80, 337–345.
[38]. Paoli, L., Munzi, S., Guttová, A., Senko, D., Sardella, G., &Loppi, S. (2015). Lichens as suitable indicators of the biological effects of atmospheric pollutants around a municipal solid waste incinerator (S Italy). Ecological Indicators,52, 362–370.
[39]. Papa, S., Bartoli, G., Nacca, F., D'Abrosca, B., Cembrola, E., Pellegrino, A., ... Fioretto, A. (2012). Trace metals, peroxidase activity, PAHs contents and ecophysiological changes in Quercus ilex leaves in the urban area of Caserta (Italy). Journal of Environmental Management,113, 501–509.
[40]. Patrolecco, L., Ademollo, N., Capri, S., Pagnotta, R., &Polesello, S. (2010). Occurrence of priority hazardous PAHs in water, suspended particulate matter, sediment and common eels (Anguilla anguilla) in the urban stretch of the River Tiber (Italy). Chemosphere,81, 1386–1392.
[41]. Pesch, B., Spickenheuer, A., Kendzia, B., Schindler, B. K., Welge, P., Marczynski, B., ... Brüning, T. (2011). Urinary metabolites of polycyclic aromatic hydrocarbons in workers exposed to vapours and aerosols of bitumen. Archives of Toxicology,85(SUPPL. 1), S29–S39.
[42]. Petterson, F. (2020). Way to make growth sustainable. https://weforum.org/
[43]. Polanska, K., Hanke, W., Dettbarn, G., Sobala, W., Gromadzinska, J., Magnus, P., & Seidel, A. (2014). The determination of polycyclic aromatic hydrocarbons in the urine of non-smoking Polish pregnant women. Science of the Total Environment,487, 102–109.
[44]. Pozo, K., Estellano, V. H., Harner, T., Diaz-Robles, L., Cereceda-Balic, F., Etcharren, P., ... Vergara-Fernández, A. (2015). Assessing Polycyclic Aromatic Hydrocarbons (PAHs) using passive air sampling in the atmosphere of one of the most wood-smoke-polluted cities in Chile: The case study of Temuco. Chemosphere,134, 475–481.
[45]. Richard, E. F. (2018). Sustainable economic development. https://ent.org sustainable economic development.
[46]. Ruwani, B. (2022). Nigeria oil economy in 20221. Lagos: Financial Derivatives.
[47]. Ruwani, B. (2023). Oil production and Nigeria economy in 2022. Lagos. Financial Derivatives
[48]. Sanusi, L. (2021.). Oil wealth and Nigeria economic stability. A keynote address Economist Society of Nigeria annual international conference, Abuja, Nigeria.
[49]. Shen, G., Zhang, Y., Wei, S., Chen, Y., Yang, C., Lin, P., ... Tao, S. (2014). Indoor/outdoor pollution level and personal inhalation exposure of polycyclic aromatic hydrocarbons through biomass fuelled cooking. Air Quality, Atmosphere & Health,7, 449–458.
[50]. Soliman, Y. S., Al Ansari, E. M. S., & Wade, T. L. (2014). Concentration, composition and sources of PAHs in the coastal sediments of the exclusive economic zone (EEZ) of Qatar, Arabian Gulf. Marine Pollution Bulletin,85, 542–548.
[51]. Song, X. F., Chen, Z. Y., Zang, Z. J., Zhang, Y. N., Zeng, F., Peng, Y. P., & Yang, C. (2013). Investigation of polycyclic aromatic hydrocarbon level in blood and semen quality for residents in Pearl River Delta Region in China. Environment International,60, 97–105.
[52]. Spiff, S. S. (2018). Economic growth. https://www.un-org/economic-growth
[53]. Studabaker, W. B., Krupa, S., Jayanty, R. K. M., &Raymer, J. H. (2012). Measurement of polynuclear aromatic hydrocarbons (PAHs) in epiphytic lichens for receptor modeling in the athabasca oil sands region (AOSR): A Pilot study. Developments in Environmental Science,11, 391–425.
[54]. Sun, H., Wang, W., Guo, S., & Zhang, Y. (2016). In situ investigation into surfactant effects on the clearance of polycyclic aromatic hydrocarbons adsorbed onto soybean leaf surfaces. Environmental Pollution,210, 330–337.
[55]. Sun, Y., Zhou, Q., Xu, Y., Wang, L., & Liang, X. (2011). Phytoremediation for co-contaminated soils of benzo[a]pyrene (B[a]P) and heavy metals using ornamental plant Tagetespatula. Journal of Hazardous Materials,186, 2075–2082.
[56]. Sunil, S. (2021). Steps to ensure sustainable economic growth. https://www.serial.uk
[57]. Taghvaee, Z., Piravivanak, Z., Rezaei, K., &Faraji, M. (2015). Determination of Polycyclic Aromatic Hydrocarbons (PAHs) in Olive and Refined Pomace Olive Oils with Modified Low Temperature and Ultrasound-Assisted Liquid-Liquid Extraction Method Followed by the HPLC/FLD. Food Analytical Methods,9, 1220–1227.
[58]. Tai, C., Zhang, K., Zhou, T., Zhao, T., Xiao, C., & Wu, L. (2012). Distribution characteristics of polycyclic aromatic hydrocarbons in the soil from the middle line source area of the south-to-north water diversion project. HuanjingKexueXuebao/Acta Scientiae Circumstantiae,32, 402–409.
[59]. Talaska, G., Thoroman, J., Schuman, B., &Käfferlein, H. U. (2014). Biomarkers of polycyclic aromatic hydrocarbon exposure in European coke oven workers. Toxicology Letters,231, 213–216.
[60]. Tauler, M., Vila, J., Nieto, J. M., &Grifoll, M. (2015). Key high molecular weight PAH-degrading bacteria in a soil consortium enriched using a sand-in-liquid microcosm system. Applied Microbiology and Biotechnology, 1–16.
[61]. Tedwell, T. (2019). Sustainable development. https://www.britainica.com?topic
[62]. Teixeira, E. C., Pra, D., Idalgo, D., Henriques, J. A. P., &Wiegand, F. (2012). DNA-damage effect of polycyclic aromatic hydrocarbons from urban area, evaluated in lung fibroblast cultures. Environmental Pollution,162, 430–438.
[63]. Tomashuk, T. A., Truong, T. M., Mantha, M., &McGowin, A. E. (2012). Atmospheric polycyclic aromatic hydrocarbon profiles and sources in pine needles and particulate matter in Dayton, Ohio, USA. Atmospheric Environment,51, 196–202.
[64]. Tripathy, V., Basak, B. B., Varghese, T. S., &Saha, A. (2015). Residues and contaminants in medicinal herbs - A review. Phytochemistry Letters,14, 67–78.
[65]. 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. Environmental Science and Pollution Research,23, 1371–1380.
[66]. Van Metre, P. C., & Mahler, B. J. (2014). PAH concentrations in lake sediment decline following ban on coal-tar-based pavement sealants in Austin, Texas. Environmental Science and Technology,48, 7222–7228.

[67]. Verma, R., Patel, K. S., &Verma, S. K. (2015). Indoor polycyclic aromatic hydrocarbon concentration in Central India. Polycyclic Aromatic Compounds.
[68]. Ogwu C, Imobighe M, Okofu S, Attamah F (2022), Speciation of heavy metals in fish species in the wetlands of oilbearing communities of the Niger Delta; IJB, V21, N2, August, P169-178.
[69]. Ogwu C. (2021). Heavy metals loadings of Telfairiaoccidentalis (Fluted pumpkin) grown in Ekpan (Host community of Warri Refinery and Petrochemical) Nigeria. Quest Journals: Journal of Research in Agriculture and Animal Science. 8(1), 16-20
[70]. Ogwu C., Azonuche J E and Okumebo V. O. (2021). Heavy metals content of Telfairiaoccidentalis (fluted pumpkin; order: Violales, Family: Cucurbitacea) grown in Ebedei (An oil and gas bearing community) Niger Delta, Nigeria. Quest Journals: Journal of Research in Humanities and Social Science. 9(4), 74-78 [29].
[71]. Ogwu C., Azonuche J., and Achuba F (2021). Heavy metals quantification of Telfairiaoccidentalis (Fluted pumpkin, Order: Violales, family: Cucurbitaceae) grown in Niger Delta oil producing areas. International Journal of Biosciences. 13(2) 170-179.
[72]. Ogwu C., Ideh Victor, Imobighe Mabel (2022), Bioaccumulation of heavy metals in some pelagic and benthic fish species in selected wetlands in oil-bearing communities of the Niger Delta; International Journal of Biosciences. 20 (6), 128-139.
[73]. Ogwu C.,Azonuche J. E and Okeke, M. (2020). Heavy metals contamination status of Telfairiaoccidentalis (Fluted pumpkin) grown in Uzere oil rich community, Niger Delta. Quest Journal: Journal of Research in Agriculture and Animal Science. 7(7), 12-17
[74]. Ogwu, C., Abvbunudiogba, R. E., Ogune, P., Aloamaka, T. A. (2023). Analysis of the heavy metals content of Lagos Lagoon Lagos Nigeria. International Journal of Recent Research in Physics and Chemical Sciences, 10(1), 1-6.
[75]. Ogwu, C., Obi-Okolie, F. and bvbunudiogba, R. E. (2023). Quantification of the heavy metals in the groundwater of Ikeja industrial estate, Ikeja Lagos. Quest Journal of Research in Environmental and Earth Science 9(3), 69-73.
[76]. Ogwu, C., Ossai, A. C., Ejemeyovwi, D. O. &Unuafe, S. E. (2023). Characterisation of the heavy metals in the aquifer of Matori Industrial estate Lagos Nigeria. Quest Journal of Research in Environmental and Earth Science 9(3), 20-26.
[77]. Ogwu, C., Ossai, A. C., Ejemeyovwi, D. O. and Unuafe, S. E. (2023). IOSR Journal of Environmental Science, Toxicology and Food Technology. 17(issue 3, sir 1), 01-06.
[78]. Ogwu, C., Ukpene, A. O., Ekpe, I. N. and Aregbor, O. (2023). Bioaccumulation of heavy metals in the tissues of some fishes species in selected wetlands in Lagos Nigeria. Journal of Innovation 72, 1407- 1418.
[79]. Ogwu, C., Ukpene, A. O., Ekpe, I. N., Umukoro B. O. J. and Onuelu, J. E. (2023). Quantification of heavy metals and metalloid in cassava roots (manihotesculentacrantz; family: Euphorbiaceae) grown in oil bearing communities of the Niger Delta. Innovation Journal, 73, 89-101.