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Impact Assessment of Vehicular Poly-Aromatic Hydrocarbon Emmissions on Cassava Leaves and Tubers along Owerri – Port Harcourt Highway, Nigeria

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Abstract

Poly-aromatic hydrocarbon (PAH) effluents arising from vehicular spent petroleum products on highways were assessed. Analysis of this impact on cassava leaves and tubers on highway using the method of AOAC, 1990 revealed xylene to be of highest concentration, 0.1449 and 0.1865mm/g in leaves and roots respectively. Other PAHs analyzed were found to contain as follows: acenapthylene (0.0003 and 0.0312mm/g), phenanthlene (0.0029 and 0.0003mm/g), anthracene (0.0067 and 0.0127mm/g), 1,2-benzathracene (0.0161 and 0.0126mm/g), benzo(k)fluorine (0.0001 and 0.223mm/g) and pyrene (0.0169 and 0.0329mm/g) for leaves and roots respectively. From these findings, the concentration of PAH is highest in cassava roots than leaves and this justifies its hazardous effects on humans. Therefore, environmental monitoring of poly aromatic hydrocarbons in food is imperative in evaluating the possible toxicity of the impact as well as the carcinogenic potential of these compounds to humans via intake.

Keywords: Cassava, leaf, root, poly-aromatic hydrocarbon.

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1.0: INTRODUCTION

Cassava (Manihot esculenta Crantz) with its high source of calorie is the second staple food found in this tropical Africa, Nigeria (FAO/IFAD, 2000). It ranks with other important food crops such as sugar cane, maize, rice, wheat and potato, in terms of global annual production (FAO/STAT, 2010). Cassava, being a staple food is a widely accepted plant in Nigeria by millions of people (FAO/IFAD, 2000). Its easy acceptability as food is because it is processed into various products such as starch, tapioca, flour, garri, fufu and as food for live stocks. It is the sixth most important food annually produced globally (FAO/STAT, 2010).

Poly aromatic hydrocarbons are heterogeneous organic compounds made up of two or more aromatic fused rings composed mainly of hydrocarbon with the absence of hetero-atoms or substituent in their structures (Ossai *et al*., 2015, Ohiozebau *et al*., 2017). Poly aromatic hydrocarbons are generally lipophilic, volatile and not soluble in water but soluble in organic solvents (Paris *et al*., 2018). Poly aromatic hydrocarbons are pollutants formed when organic materials such as (coal, oil, gas, wood, garbage, tobacco, petroleum products etc) are burnt in the limited supply of oxygen. They are also released into the environment through anthropogenic activities such as engine fumes, industrial processes, mining, petroleum refining, coal-derived products, waste incineration, tobacco smoking and partly by natural means, e.g. bush burning and volcanic eruptions (Ossai *et al*., 2015). Polyaromatic hydrocarbons, with their carcinogenic and mutagenic properties are considered to be the most acute toxic component of petroleum products, (Abdulazeez *et al*., 2017). Various classes of poly aromatic hydrocarbons, however, differ substantially in their effects on biological systems and behavior in the environment (Nwaichi *et al*., 2016). For example, the lower molecular weight compounds, with two or three aromatic rings, such as the naphthalenes, anthracenes and fluoranthenes tend to be the most acutely toxic, whereas the longer poly aromatic hydrocarbons with four to seven rings, such as benzopyrenes, chrysene and coronene, are not acutely toxic but tend to be more carcinogenic.

Given the fact that food safety is increasingly becoming a global challenge has made several researchers to focus on possible dangers inherent in

ingestion of foods contaminated by toxins with unbiased prism (Omambia *et al*., 2014, Onyedikachi *et al*., 2018). The toxicity of poly aromatic hydrocarbons has gained serious interest among international regulatory bodies based on the degree of occurrence and toxicity (Pereive *et al*., 2007).

An increase in environmental poly-aromatic hydrocarbon levels is the major cause of high poly-aromatic hydrocarbon levels in food within industrialized and developing countries such as Nigeria. Humans are exposed to poly-aromatic hydrocarbons through dietary means as poly aromatic hydrocarbons are possible contaminants in fruits, vegetables, oils and dairy products. This exposure gives rise to various health challenges such as immunological, hematological, cardiological and hepatological (Pereive *et al*., 2007). Poly-aromatic hydrocarbons dispersed into the environment, i.e. air, water, soil and plants, result in the pollution of organisms in different habitats; thus, possibly exposing humans to high risk of poly-aromatic hydrocarbon levels through food supply especially to non-smokers (Paris *et al*., 2018).

Some other studies show that poly aromatic hydrocarbons play significant roles in the physiology of experimental animals as carcinogenes, mutagenes, and genotoxins (Paris *et al*., 2018). Increased human risk to various forms of cancer (lungs, skin and bladder) is associated with dietary exposure to high levels of poly aromatic hydrocarbons (Zheng *et al*., 2009). Therefore, evaluating the cancer risk level of a given area via the ingestion of poly aromatic hydrocarbons is important for effective environmental management and human risk assessment. Based on the levels of occurrence and carcinogenicity, the United States Environmental Protection Agency (USEPA) has highlighted sixteen poly aromatic hydrocarbons according to their precedence as: benzo(a)pyrene (BaP), benzo(a)anthracene (BaA), dibenzo(b)fluoranthene (BbF), chrysene (Chry), benzo(k) fluoranthene (BkF), indeno (1,2,3-cd) perylene (IndP) and dibenzo(a,h)anthracene (DahA), considered as human carcinogens, and others like of naphthalene (Nap), acenaphthene (Ace), acenaphthylene (Acy), anthracene (Ant), benzo(ghi) perylene (BghiP), fluoranthene (Flt), fluorene (Flu), phenanthrene (Phe) and pyrene (Pyr), noted as non-carcinogenic poly aromatic hydrocarbons (Pereive *et al*., 2007, Paris *et al*., 2018). Therefore, environmental monitoring of poly aromatic hydrocarbons in food is imperative in evaluating the possible toxicity of the impact as well as the carcinogenic potential of these compounds to humans via intake (Paris *et al*., 2018).

1.1: Aim and objectives

This study was aimed at substantiating the impact of poly aromatic hydrocarbons on cassava leaves and tubers along Owerri - Port-Harcourt highways, Nigeria with the following objectives.

i. To assess the impact of vehicular poly aromatic hydrocarbon (PAH) emissions on cassava tubers and leaves
ii. To analyze the concentration of (PAH) on cassava tubers and leaves

2.0: MATERIALS AND METHOD

2.1: Study Area

This study was carried out at Owerri-Port-Harcourt high way (Obinze) community, Owerri West Local Government Area of Imo State, Nigeria, with longitude 05º 24’ 55.99” N and latitude 06º57’ 59.99” E. The coastal lowland type of landscape with prevalence tropical rainy climate characteristic encourages their major occupation which is farming (Osakwe, 2012).

2.2: Sample collection

Cassava samples (leaves and tubers) were collected from farm located close to the highway in Obinze and sent to laboratory for analysis of poly aromatic hydrocarbons (PAH).

2.3: Methodology:

2.3.1: Determination of poly-aromatic hydrocarbons: extraction procedure

This was analyzed according to AOAC 1990. A ten gram homogenized sample was weighed and quantitatively transferred into a 500 ml beaker. 6g sodium sulphate was added and extracted using 300ml normal hexane.

A 10 ml of acetonitrile was added to the sample and place in a shaker for 2 minutes. An additional 10 ml portion of acetonitrile was added, and the separating funnel closed tightly and placed on a horizontal shaker. It was then set to shake continuously for 30 minutes at 300 rpm/min and finally allowed to stand for 5 minutes to sufficiently separate the phases. A 10 ml of the supernatant was carefully taken and dried over 2 g anhydrous magnesium sulphate through filter paper into 50 ml round bottom flask. This was then concentrated to about 1ml using the rotary evaporator, and made ready for silica clean up step.

2.3.2: Clean-Up of Extract (Purification Using Silica SPE Cartridge)

1ml of filtered residue was dissolved in 50ml of chloroform and transferred to a 100ml volumetric flask and diluted under room temperature. Next, 1 ml of the reagent (20% benzene and 55% methanol) was added, sealed and heated at 40ºC water bath for 10 minutes. After heating, the organic sample was extracted with hexane and water, so that the final mixture of the reagent, hexane and water, is in proportion of 1:1:1 (i.e., add 1ml each of hexane and water to the reaction mixture). The mixtures were vigorously shaken by hand for 2min and emulsion broken by centrifugation. Half of the top hexane phase was transferred to a small test tube for injection.

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2.3.3: Gas chromatographic determination

The final extracts were analyzed by Gas Chromatograph-Buck M910 scientific gas chromatography equipped with Flame ionization detector that allowed the detection of contaminants even at trace level concentrations (in the lower µg/g and µg/kg range) from the matrix to which other detectors do not respond. The GC conditions used for the analysis were capillary column coated with VF-5 (30 m + 10 m EZ guard column x 0.25 mm internal diameter, 0.25 µm film thickness). The injector and detector temperature were set at 250 ºC and 280ºC respectively. The oven temperature was programmed as follows: 120 ºC held for 4 min, ramp at 10 ºC/ min to 180 ºC, held for 2 min, and finally ramp at 5ºC/ min to 300 ºC. Helium was used as carrier gas at a flow rate of 1.0 ml/ min and detector make-up gas of 29 Ml min-1. The injection volume of the GC was 10.0 µl. The total run time for a sample was 43 min.

2.3.4. Quantification of poly aromatic hydrocarbon residues.

The residue levels of poly aromatic hydrocarbons were quantitatively determined by the external standard method using peak area. Measurement was carried out within the linear range of the detector. The peak areas whose retention times coincided with the standards were extrapolated on their corresponding calibration curves to obtain the concentration.

3.0: RESULT

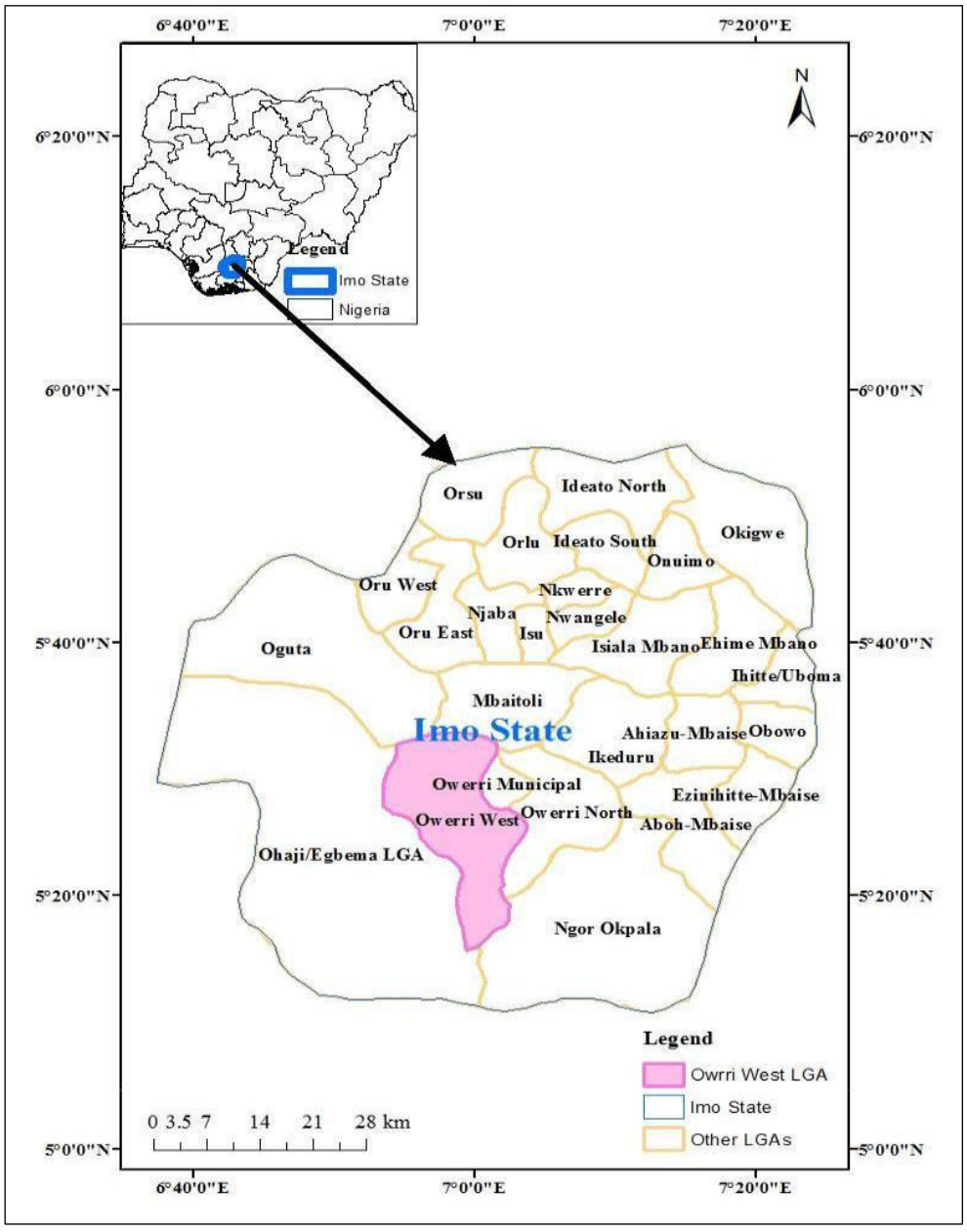


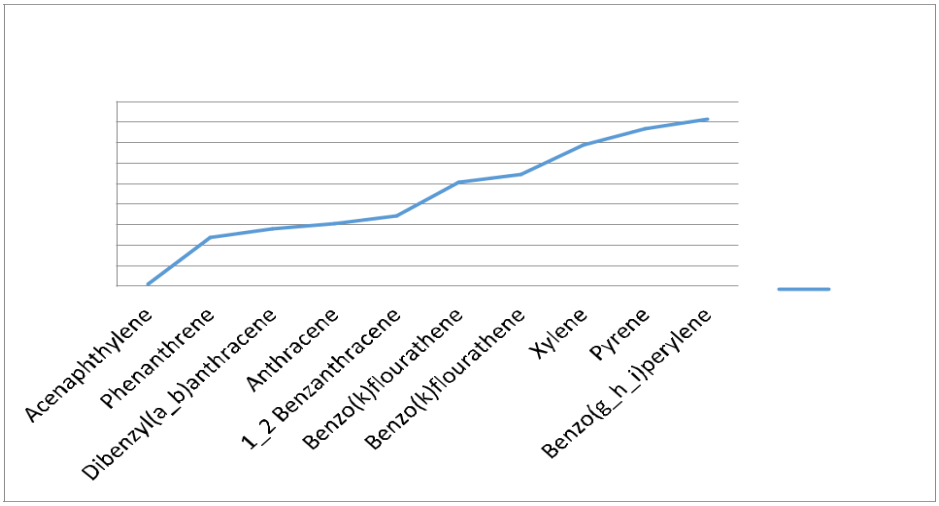
Fig 2.0: Geographical map of study area

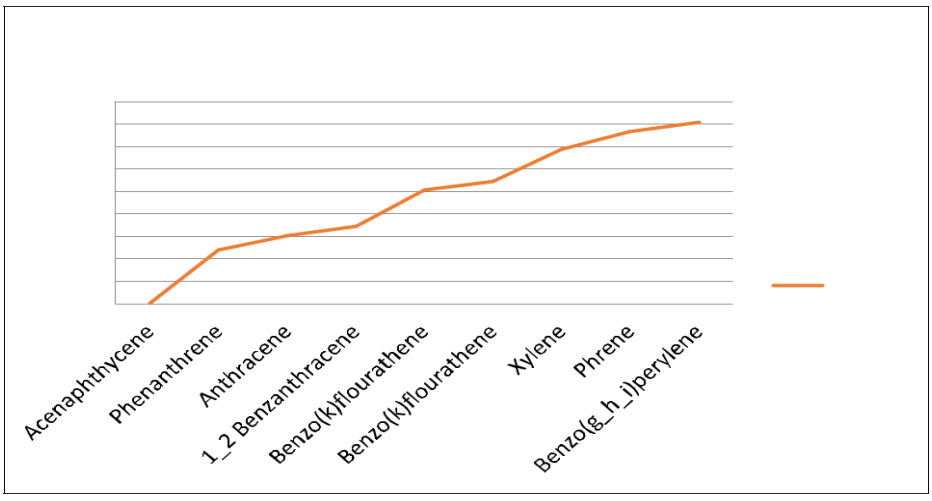
Table 3.0 Result of poly aromatic hydrocarbon analysis in cassava leaf

COMPONENTS	RETENTION	AREA	HEIGHT	EXTERNAL UNITS
Acenaphthycene	0.113	55.8904	27.265	0.0003
Phenanthrene	11.893	3945.1501	58.963	0.0029
Anthracene	15.223	13913.9478	264.582	0.0067
1_2 Benzanthracene	17.183	8946.783	132.841	0.0161
Benzo(k)flourathene	25.316	13.309	0.319	0.0001
Benzo(k)flourathene	27.27	5765.6068	85.84	0.0223
Xylene	34.333	22140.8382	326.486	0.1449
Phrene	38.29	6285.985	95.635	0.0169
Benzo(g_h_i)perylene	40.36	4533.8196	70.265	0.03224

Table 3.1: Result of poly aromatic hydrocarbon analysis in cassava tuber

COMPONENTS	RETENTION	AREA	HEIGHT	EXTERNAL UNITS
Acenaphthylene	0.473	5418.8342	188.93	0.0312
Phenanthrene	11.893	4024.2255	136.394	0.003
Dibenzyl(a_b)anthracene	13.996	67.4168	2.179	0.0002
Anthracene	15.223	13844.1276	468.816	0.0127
1_2 Benzanthracene	17.183	9013.1198	305.145	0.0126
Benzo(k)flourathene	25.32	64.7686	2.202	0
Benzo(k)flourathene	27.27	5843.7246	198.018	0.0011
Xylene	34.333	2215.6827	743.162	0.1865
Pyrene	38.29	6622.396	224.313	0.0329
Benzo(g_h_i)perylene	40.7	4905.519	166.283	0.0347





4.0: DISCUSSION

Microorganisms are endowed with the ability to degrade hazardous contaminants and this is the hallmark of remediation and soil purification processes. Poly aromatic hydrocarbons (PAH) being toxic even to microorganisms decrease their biomass and soil contaminated with PAH has lower self-purification capacity (Hreniuc *et al*., 2015). Soil particle size, organic carbon and to some extent pH are parameters that affect poly aromatic hydrocarbons discharged on soil. Magi *et al*., 2002 posited that binding of poly aromatic hydrocarbon is a function of soil particle size and clay particles with more surface area has more binding sites resulting in adsorption of poly aromatic hydrocarbons firmly on finer fraction particle of the soil. Fine particles also result in less porosity and hence lesser mobilization of adsorbed contaminants over the period of time which results in persistent toxicity and long-term effects.

In this study, xylene was found to be of highest concentration, 0.1449 and 0.1865mm/g in leaves and roots respectively. Other PAHs analyzed were found to contain as follows: acenapthylene 0.0003 and 0.0312mm/g, phenanthlene 0.0029 and 0.0003mm/g, anthracene 0.0067 and 0.0127mm/g, 1,2-benzathracene 0.0161 and 0.0126mm/g) Benzo(k)fluorine 0.0001 and 0.223mm/g, Pyrene 0.0169 and 0.0329mm/g for leaves and roots respectively. From these findings, the concentration of PAH is highest in cassava roots than leaves and this justifies its hazardous effects on humans.

Soil biological activities which involve microorganisms and microbial exudates, enzymes, and their activities are of veritable importance in mineralization of the impacted xenobiotic. Soil contamination may affect the microbial community/population and microbial activity/enzymatic activities of the soil.

Petroleum effluents (PAH) therefore exert adverse effects on plants by depleting the needed plant's minerals and making toxic minerals in the soil bio-available to plants. It adversely affects the soil ecosystem through adsorption to soil particles, providing an excess carbon that might be unavailable for use by plants and induction of a limitation in soil nitrogen and phosphorus (Atlas, 1981). This environmental toxicant, alters soil biochemistry, immobilizes nutrients and creates oxygen tension (Atuanya, 1987). This limitation in oxygen results to utilization of alternate electron acceptors by indigenous microbial communities which produces an increased reducing environment. This report is in harmony with the findings of Osuji and Opiah (2007), Ebulue (2022). The consequence is a lowered pH which adversely affects the physicochemical parameters of the soil.

Various experiments have been done under controlled environments to investigate the adverse effect of poly Aromatic Hydrocarbons contamination on soil microorganisms and metabolic activities. Microbial activity may be inhibited due to the presence of high concentration of organic contaminants (PAH). Soil contamination with crude oil (PAH) may develop anaerobic conditions in soil by blocking soil pore with consequent effects on microbial communities of soil (Ebulue, 2022).

5.0: CONCLUSION

Poly aromatic hydrocarbons, with their carcinogenic and mutagenic properties are considered to be the most acute toxic component of petroleum products. Various classes of poly aromatic hydrocarbons, however, differ substantially in their effects on biological systems and behavior in the environment. Poly-aromatic hydrocarbon effluent on cassava tubers on highways amounts to medical implications on humans. Therefore, evaluating the cancer risk level of a given area via the ingestion of poly aromatic hydrocarbons is important for effective environmental management and human risk assessment.

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