

Comparative Study of Organic Parameters of Soils from Three Selected Universities in Port Harcourt Metropolis, Nigeria

¹Iyama, William Azuka, ²Edori, Onisogen Simeon

¹Department of General Studies, Rivers State College of Health Science and Management Technology, Port Harcourt, Nigeria, P.M.B. 5039

²Department of Chemistry, Ignatius Ajuru University of Education, Rumuolumeni, PMB 5047 Port Harcourt, Rivers State.

willy4a@yahoo.com; onisogen.edori@yahoo.com

ABSTRACT

This research study was based on the comparative analysis of hydrocarbon content of soil samples from the 3-selected university campuses of Uniport, RSU and IAUE. Samples were collected from three different points to establish the composite samples within spaces of 500m apart as to obtain representative samples. The parameters for the determination of the hydrocarbon content were measured using the following methods, THC (ASTM D3921), PAHs (USEPA 8270D), TOG (ASTM D3921), TOC (Walkely-Black) and TOM (Walkely-Black). The hydrocarbon content analysis was done using THC (mg/kg), PAHs, TOG, TOC and TOM. The mean results of THC in soils of Uniport, RSU and IAUE were 6139 ± 146 , 6075 ± 191 , 6823 ± 337 ; PAHs were 16.36 ± 0.14 , 16.43 ± 0.09 and 16.88 ± 0.23 ; for TOG were 10777 ± 6.36 , 10689 ± 55.86 , and 10839 ± 50.20 ; for TOC (%) were 5.11 ± 0.50 , 4.75 ± 0.25 , and 3.33 ± 0.76 , whereas TOM recorded 8.81 ± 0.86 , 8.18 ± 0.42 and 5.78 ± 1.28 respectively. The analysis of variance (ANOVA) showed that there was no significant difference in the soil hydrocarbon content for Uniport, RSU and IAUE mostly due to the similar soil structure, texture and geology but most importantly similar kinds of activities on campuses ($p < 0.05$). These results are prompt indications of hydrocarbon pollution and hence adequate monitoring and control of deleterious anthropogenic inputs be put in place to sustain the already degraded soil.

KEYWORDS: Hydrocarbon, soil, PAHs, THC, anthropogenic, pyrogenic, TOG

1 Introduction

Hydrocarbons are organic chemical compounds consisting of carbon and hydrogen atoms only. Hydrocarbons are naturally-occurring compounds and form the basis of petroleum (crude oil), natural gas, coal, and other related energy sources. The four major classes are alkanes, alkenes, alkynes and the aromatics. Hydrocarbons are basically divided into two types of aliphatic hydrocarbons and aromatic hydrocarbons (David & Jessie, 2014).

Most hydrocarbons exist naturally in petroleum and natural gas as crude oil is made of decomposed organic matter. They are also present in different trees and plants, and form a natural pigment called carotene, that can be found in carrots and green leaves. This means that hydrocarbons can naturally find their ways in soils. The majority of natural crude rubber, 98%, is made of a hydrocarbon polymer which is formed when a chainlike, molecule forms, consisting of many units linked together. Hydrocarbons are the most applied organic compound in the world, and the main component of volatile organic compounds (VOCs) (Chad, 2018).

DOI: 10.14738/aivp.91.9114

Publication Date: 20th November, 2020

URL: <http://dx.doi.org/10.14738/aivp.91.9114>

Soil contamination by petroleum hydrocarbons causes severe and abrupt variations in the microbiological, chemical, and physical properties of soil. Microbial activities occur in soils due to removal of atmospheric surface oxygen by the action of natural gas or crude oil which lead to increase of substances in a chemically reduced state. According to Idisi and Uguru (2020), Petroleum hydrocarbons contaminated soils can lead to terrible environmental challenges which can lead to carcinogenic, mutagenic and neurotoxic complications in life (Freitag *et al.*, 1985; DEC, 1992; Ribes *et al.*, 2003; Denys *et al.*, 2006; Das & Chandran, 2011). Akpokodje *et al.*, (2019) observed that the ecosystem can be contaminated with hydrocarbons through the process of petroleum extraction, spills, consumption, illegal refining method, and indiscriminate disposal of petroleum waste products.

Total petroleum hydrocarbons (TPH) are a large family of several hundred chemical compounds primarily from crude oil. Most petroleum products are made from Crude oil which can become contaminants to the environment (ATSDR, 1999). The complex nature of petroleum has inhibited individual component analysis. Hence it is easier and better to measure the total amount of TPH at any given site. Research has shown that TPH can be divided into groups of petroleum hydrocarbons which act alike in soil or water and called petroleum hydrocarbon fractions (each fraction containing many individual chemicals). According to ATSDR (1999), these individual chemicals include hexane, jet fuels, mineral oils, benzene, toluene, xylenes, naphthalene, and fluorene as well as other petroleum products and gasoline components. However, samples of TPH may contain only some or a mixture of these chemicals.

Total petroleum hydrocarbons (TPH) is a commonly used gross parameter for quantifying environmental contamination originated by various petroleum hydrocarbons (PHC) products such as fuels, oils, lubricants, waxes, and others (ESD, 1993). Traditional wet chemistry methods for determining TPH level in soil samples is based on extracting the contaminant from the soil sample. The TPH level in the extracted solution is then determined by a gravimetric, FTIR, or GC measurement calibrated by an EPA calibration standard.

The TPH gross parameter is in use worldwide and facilitates an important stage of contaminated sites investigation; therefore, it is important to examine the effects of hydrocarbon type and soil properties on the extraction efficiency, as well as cross-lab repeatability. The concentrations of petroleum hydrocarbon in waste dump sites are comparatively high and represent elevated concentrations above background levels found in unpolluted soils (Iwegbue *et al.*, 2008; Ekpote *et al.*, 2019). Similarly, the levels of petroleum hydrocarbon decreases with depth of profiles (Iwegbue *et al.*, 2008). Soil sediments from the Azuabie creek recorded spatial significant difference in TPH (Moslen & Miebaka, 2019).

The common method for assessing TPH in soil samples is based on a modified version of EPA method 418.1. This method is based on extraction with 1, 1, 2-Trichlorotrifluoroethane (Freon 113, GC 99.9%), although other extracting solvents are available (*i.e.* Carbon tetrachloride, N-Hexane, etc.). This method was originally introduced in 1978 by the USEPA in order to assess TPH in waste water but was later adjusted in 1983 for the assessment of TPH in soil samples. Newer methods are available for determining TPH in soil samples; these methods are based on extraction with other solvents and are usually followed by gas chromatograph analysis for TPH determination. As these methods are more expensive, the EPA method 418.1 is in vast use as a screening tool (ESD, 1993; Schwartz *et al.*, 2011).

Some of the TPH compounds can affect the central nervous system. Some TPH compounds can cause headaches and dizziness at high levels in the air while others can cause a nerve disorder called

"peripheral neuropathy," consisting of numbness in the feet and legs. Other TPH compounds can cause effects on the blood, immune system, lungs, skin, and eyes (ATSDR, 1999). Petroleum hydrocarbons contamination of the ecosystems has become a global challenge because of their toxicity and refractory nature (Ite & Semple, 2012). Animal studies have shown effects on the lungs, central nervous system, liver, and kidney from exposure to TPH compounds. Some TPH compounds have also been shown to affect reproduction and the developing fetus in animals.

Total organic carbon (TOC) refers to the carbon content in soil organic matter (SOM) as stored and gets into the soil through the decomposition of plants and animals residues, root exudates, living and dead microbes and soil biota (Edwards *et al.*, 1999). An increase in SOM, and therefore total carbon, leads to greater biological diversity in the soil, thus increasing biological control of plant diseases and pests (Edwards *et al.*, 1999). Total oil and grease (TOG) refers to fats, oils and waxes and can be determined using Standard testing methods (ASTM) of infrared spectroscopy. The most current method is use the of S-316 extraction solvent (ASTM method D7066-04) instead of the environmentally unfriendly Freon for ASTM D3921 (Edwards *et al.*, 1999). Soil texture has significant impact on SOM and TOC in decomposition models and organic matter formation (Rastetter *et al.*, 1991; Raich *et al.*, 1991). Clay content is comparatively relevant determinant of SOM or TOC level in soils (Azlan *et al.*, 2012).

2 Materials and Methods

2.1 Site Description

This study was conducted basically in Port Harcourt and Obio-Akpor local government areas of Rivers State, Nigeria. Port Harcourt is known as port town and capital of Rivers State, Niger Delta, Southern Nigeria. It lies along the Bonny River (eastern tributary of the Niger River) 41 miles (66 Km) upstream from the Gulf of Guinea. Port Harcourt was founded in 1912 in an area traditionally occupied by the Ijo (Ijaw), Okrikans, and Ikwerre people. It began to serve as a port (named for Lewis Harcourt, then colonial secretary) after the opening of the rail link to the Enugu coalfields in 1916. Now one of the nation's largest ports, its deepwater (23 feet which is 7 metres) facilities handle the export of palm oil, palm kernels, and timber from the surrounding area, coal from Anambra state, tin and columbite from the Jos Plateau, and, since 1958, petroleum from fields in the eastern Niger River delta. Port Harcourt has bulk storage facilities for both palm oil and petroleum. In the 1970s the port was enlarged with new facilities at nearby Onne. Today, Port Harcourt is made up of two large local governments of Port Harcourt City and Obio-Akpor to which the study locations are located primarily though Uniport extends into Ikwerre Local Government.

This study is to compare the hydrocarbon contents of the three Universities in Port Harcourt. The research study was carried out in three campuses of the Universities of Port Harcourt (UNIPORT), the Rivers State University (RSU), and the Ignatius Ajuru University of Education (IAUE). The UNIPORT is of three campuses Choba, Delta and Abuja, all located in Obio-Akpor and Ikwerre Local Government and located on latitude 4°53' 14"N through 4°54' 42"N and longitude 6°54' 00"E through 6°55'50"E (Ijeomah, Chima & Okagbare, 2013). This is within the coordinates of 4.9069°N and 6.9170°E. The University has three campuses namely: Abuja, Delta and Choba. The three campuses are separated by road networks, although, Abuja and Delta Campuses are closer to each other in terms of distance. Figure 1 is the map of University of Port Harcourt showing the threeas. This study only collected samples from the Choba campus. Soil samples were taken at three distances of A, B, C within Choba Park.

Similarly, Rivers State University (RSU) is located in Port Harcourt City Council, the hub of the capital city. Rivers State University (RVSU or RSU), formerly Rivers State University of Science and Technology (UST) is a university located in the [Diobu](#) area of [Port Harcourt, Rivers State, Nigeria](#). Rivers state university was established as a College in 1972 but transformed into full-fledged University in 1980. It is located within latitude $4^{\circ}47'58''$ N through $4^{\circ}48'8''$ N and longitude $6^{\circ}58'37''$ E through $6^{\circ}59'3''$ E (coordinates of 4.7974° N and 6.9803° E). Samples here were collected at same three points of A, B, C at old site, convocation area and faculty of engineering respectively.

Finally, soil samples were also collected from the Ignatius Ajuru University of Education (IAUE) located at Rumuolumeni in Obio-Akpor local government of Rivers State, Nigeria. Ignatius Ajuru University of Education (formerly Rivers State University of Education) is a Nigerian university based in Rumuolumeni [Port Harcourt, Rivers State](#). Founded in 2010, Ignatius Ajuru University of Education is a non-profit public higher education institution located in the metropolis of Port Harcourt (population range of 1,000,000-5,000,000 inhabitants), Rivers and officially accredited by the National Universities Commission, Nigeria. Ignatius Ajuru University of Education (IAUE) is a coeducational higher education institution and offers courses and programs leading to officially recognized higher education degrees such as bachelor degrees, master degrees, and doctorate degrees in several areas of study. IAUE lies within the geographical coordinates of 4.8045° N and 6.9324° E. Figures 1 and 2 gives the map of Unipor and RSU study areas.

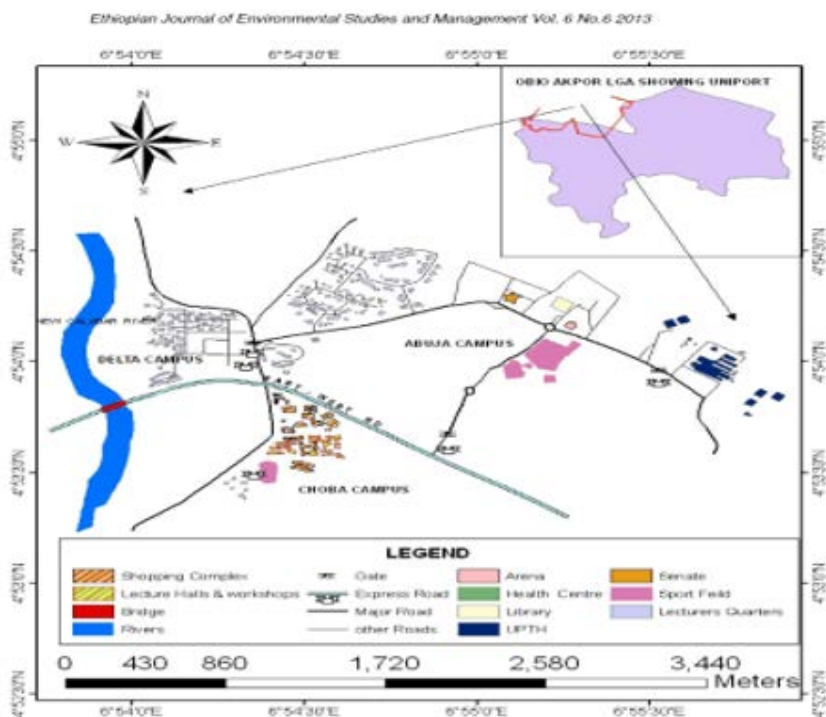


Figure 1 Map of University of Port Harcourt
Source: Department of Geography and Environmental Management, University of Port Harcourt.

Figure 1: Map of the University of Port Harcourt

Source: Department of Geography and Environment Management, University of Port Harcourt

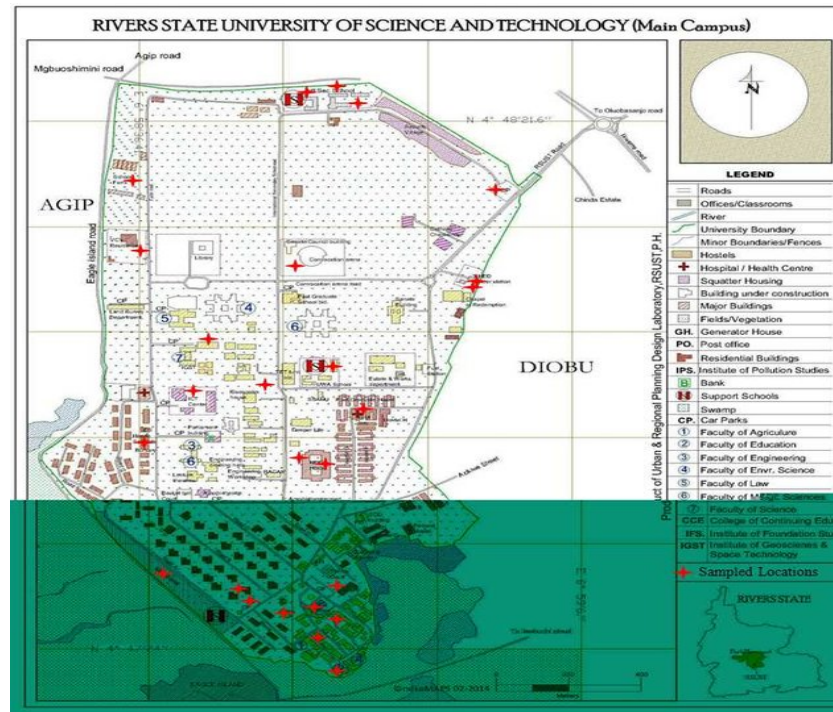


Figure 2: Map of Rivers State University (main campus)

Source: Ideriah and Ikoro (2015)

2.2 Soil Sample Collection

Soil samples were collected using soil from the top soil at 0-5cm depth (top soil) at randomly selected points within each university campus to make up a composite sample. Each points were labelled A, B and C for three (3) sample locations within each university study station. These points were collected at approximate distances of 500m apart.

Three soils from three Institutions in River State, Nigeria were selected for this study as defined according USDA key to soil taxonomy [Staff, 2010]. These soils represent a wide range of soil properties as their sites are far from each though within the Niger Delta and may significantly differ from each other. The collected soils were properly handled, preserved and transported to the Jaros base Laboratory in Port Harcourt, Nigeria. Tables 1, 2 and 3 gives summary of the hydrocarbon parameter and the method of determination for Total hydrocarbon content (THC), Polycyclic aromatic hydrocarbons (PAHs), Total oil and grease (TOG), Total organic carbon (TOG), Total organic carbon (TOC), Total organic matter (TOM) using ASTM D3921, USEPA 8270D, ASTM D3921, Walkely and Black, Walkely and Black (though modified by Mebius, 1960) respectively. All the laboratory procedures were carried out under ambient temperature of about $34 \pm 4^{\circ}\text{C}$ as earlier reported (Idisi & Uguru, 2020; ASTM, 2000; Walkely & Black, 1934; Carter, Mortland & Kemper, 1986).

2.3 Statistical Analysis

Data obtained from this study were analyzed using a one way ANOVA to compare hydrocarbon content of the soil samples. Similarly, histogram was used to show the trend around the three campuses of UNIPORT, RSU and IAUE, Port Harcourt.

Table 1: Hydrocarbon Concentrations in Unipor Top Soil Samples

Parameters	Stations			Analytical Methods
	A	B	C	
THC (mg/Kg)	6138 ± 0.71	6139 ± 0.00	6140 ± 0.71	ASTM D3921
PAHs (mg/Kg)	16.40±0.03	16.36±0.00	16.32± 0.03	USEPA 8270D
TOG (mg/Kg)	10775± 1.41	10778 ± 0.71	10779 ± 1.41	ASTM D3921
TOC (%)	5.11 ± 0.00	5.21± 0.07	5.00± 0.08	Walkely & Black (1934)
TOM (%)	8.86±0.04	8.82±0.00	8.75±0.04	Walkely & Black (1934)

Table 2: Hydrocarbon Concentrations in IAUE Top Soil Samples

Parameters	Stations			Analytical Methods
	A	B	C	
THC (mg/Kg)	6823±0.00	6813±7.07	6832±6.32	ASTM D3921
PAHs (mg/Kg)	16.86±0.00	16.78±0.07	16.98±0.07	USEPA 8270D
TOG (mg/Kg)	10839± 0.00	10842±2.12	10835±2.83	ASTM D3921
TOC (%)	3.36±0.02	3.46±0.09	3.26±0.05	Walkely & Black (1934)
TOM (%)	5.80±0.04	5.76±0.01	5.78±0.00	Walkely & Black (1934)

Table 3: Hydrocarbon Concentrations in RSU Top Soil Samples

Parameters	Stations			Analytical Methods
	A	B	C	
THC (mg/Kg)	6070 ± 3.54	6076 ± 0.71	6080± 3.54	ASTM D3921
PAHs (mg/Kg)	16.43±0.00	16.46±0.00	16.40± 0.02	USEPA 8270D
TOG (mg/Kg)	10692± 2.12	10680± 6.36	10696 ± 4.95	ASTM D3921
TOC (%)	4.74 ± 0.00	4.78± 0.02	4.72± 0.02	Walkely & Black (1934)
TOM (%)	8.17± 0.00	8.17 ± 0.00	8.19 ± 0.00	Walkely & Black (1934)

Table 4: Mean Hydrocarbon Concentrations of Unipor, RSU and IAUE Top Soil Samples

Parameters	Stations			Analytical Methods
	Unipor	RSU	IAUE	
THC (mg/Kg)	6139± 146	6075 ± 191	6823± 337	ASTM D3921
PAHs (mg/Kg)	16.36±0.14	16.43±0.09	16.88± 0.23	USEPA 8270D
TOG (mg/Kg)	10777± 6.36	10689± 55.86	10839 ±50.20	ASTM D3921
TOC (%)	5.11± 0.50	4.75± 0.25	3.33± 0.76	Walkely & Black (1934)
TOM (%)	8.81± 0.86	8.18 ± 0.42	5.78 ± 1.28	Walkely & Black (1934)

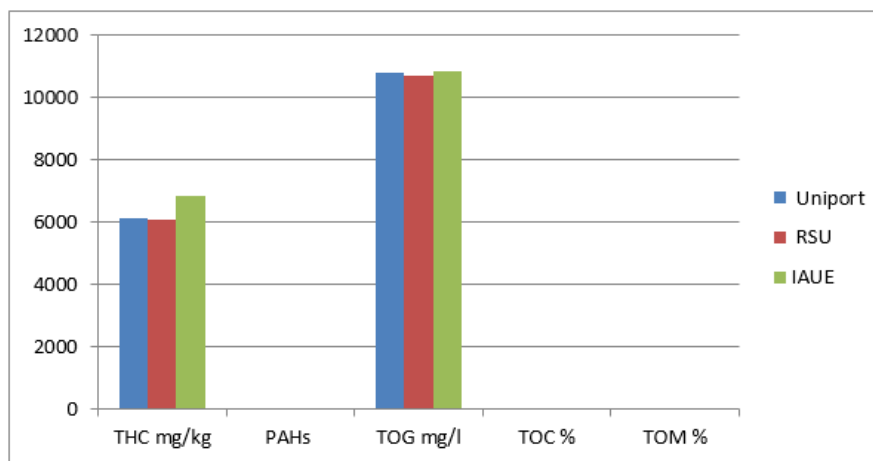


Figure 3: Variation of hydrocarbon content in the study stations

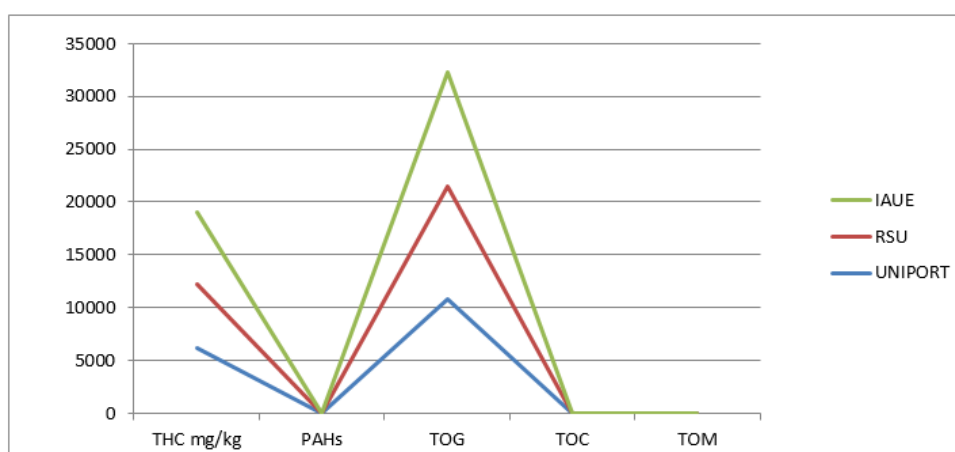


Figure 4: Trend of hydrocarbon content in the 3-study stations

3 Result and Discussion of Findings

The results of the top soil samples from the three points A, B, C for the Uniport study stations for THC (mg/kg), PAHs, TOG, TOC (%/ 100g), TOM respectively were 6138 ± 0.71 , 6139 ± 0.00 , 6140 ± 0.71 ; 16.40 ± 0.00 , 16.36 ± 0.00 , 16.32 ± 0.03 ; 10775 ± 1.41 , 10778 ± 0.71 , 10779 ± 1.41 ; 5.11 ± 0.00 , 5.21 ± 0.07 , 5.00 ± 0.08 ; 8.86 ± 0.04 , 8.82 ± 0.00 , 8.75 ± 0.04 . Similarly, RSU recorded in stations A, B, C for THC (6070 ± 3.54 , 6076 ± 0.71 , 6080 ± 3.54), PAHs (16.43 ± 0.00 , 16.46 ± 0.02 , 16.40 ± 0.02), TOG (10692 ± 2.12 , 10680 ± 6.36 , 10696 ± 4.95), TOC (4.74 ± 0.00 , 4.78 ± 0.02 , 4.72 ± 0.02), TOM (8.17 ± 0.00 , 8.17 ± 0.00 , 8.19 ± 0.00) respectively. The results for top soil analysis of the IAUE study station showed that in sampling points A, B, and C, the hydrocarbon parameters of THC, PAHs, TOG, TOC and TOM were respectively 6823 ± 0.00 , 6813 ± 7.07 , 6832 ± 6.36 ; 16.86 ± 0.00 , 16.78 ± 0.07 , 16.98 ± 0.07 ; 10839 ± 2.12 , 10842 ± 2.12 , 10835 ± 2.83 ; 3.36 ± 0.02 , 3.46 ± 0.09 , 3.26 ± 0.05 ; 5.80 ± 0.01 , 5.76 ± 0.01 , 5.78 ± 0.00 .

The THC concentration was relatively higher in IAUE compared to the other two institutions with RSU exhibiting the least. These values were higher than those obtained for soil sediments with range of 0.01-1.43mg/kg according to Ighariemu, Belonwu & Wegwu, (2019) and 2.71-3.48 (Osuji & Adesiyan, 2005). Earlier studies showed in Port Harcourt that THC concentrations were higher at near surface levels more than deeper zones (Aigberua, Ekubo, Inengite & Izah, 2016). Similar results showed elevated levels of total hydrocarbon contents (THC) when compared with the reference sites though far smaller than those of this study (Okop & Ekpo, 2012). Regulation on the assessment of

environmental pollution gave guide values for total oil hydrocarbons content (THC) in soil as normal being less than 100 mg/kg; alert values for sensitive soils, 200 mg/kg; and alert values for less sensitive soils being 1000 mg/kg and etc (Dumitru & Vladimirescu, 2017). The results showed that they were even above the alert values being less sensitive soils (less than 100mg/kg) and those of intervention values (2000mg/kg). This may be due to the soil texture, structure and anthropogenic inputs over time such as being farm lands over long period hence pyrogenic activities. This relative variation may be due to the temporary waste dump which has been abandoned for some years now compared to the other institutions without such dumps. Figures 3 and 4 gives graphical trend and variations of the hydrocarbon content of the soils of the three selected university campuses (Unipor, RSU and IAUE).

Similar concentrations of Total petroleum hydrocarbons (TPH) were recorded in soils as high as 1516.66mg/kg (Alinor & Nwachukwu, 2013). Moslen and Miebaka (2017) recorded a range of TPH of 5.7-819.5 mg/kg while THC had 7.9-1144.6mg/kg for sediment samples of the Azuabie creek. It was found that total petroleum hydrocarbon concentrations varied from 9-289 mg/kg-1 (Okop & Ekpo, 2012). Conversely, THC concentration was higher than those earlier obtained in similar research studies (Adesuyi, Ngwoke, Akinola, Njoku & Jolaoso, 2016). Some of the TPH compounds are carcinogenic and poses health hazards [Ibigoni, Gabriel & Horsfall, 2009].

There were higher levels of PAHs at the IAUE campus compared to the others. Polycyclic aromatic hydrocarbons concentration (PAHs) recorded in this study were relatively higher than those of earlier researches within ranges of 24-331 mg/kg within the region (Moslen & Miebaka, 2017; DPR, 2002]. According to WHO (2010) metropolitan areas usually have higher PAH concentrations than forest and agricultural areas because of the many sources of fossil fuel combustion. The majority of urban soil concentrations fall in the 600–3000-µg/kg range (Menzie, Potocki, & Santodonato, 1992; Trapido, 1999; Mielke *et al.*, 2001). Higher values near areas of heavy transportation and industrialization range from 8 to 336 mg/kg (Menzie, Potocki, & Santodonato, 1992; Harrison, *et al.*, 1997). Similarly, values within the range of 1000–3000 µg/kg are regarded as being in the upper limits to which the results of this study falls. The higher concentration for IAUE was probably due to higher combustion of heavy duty vehicles because it near to industrial areas such as the Dangote Cement, marine transport and tank farms. Concentration of PAH reported in sediment around the world range from nd–102,000 ng/g [Sojinu, Wang, Sonibared & Zeng, 2010; Woodhead, Law & Matthiessen, 1999; Ruchaya, Gullaya & Ayako, 2006]. Generally, sediments are classified into three: low, moderate and high with respect to hydrocarbon content [Lyons *et al.*, 2015]. According to Edori and Iyama (2019), PAHs are identified in water bodies and hence may also be in soils due to the flow patterns and soil-water geology. Based on the findings of this study, the hydrocarbon content of sediments of Azuabie creek could be rated as moderate- high pollution status. High concentrations of petroleum hydrocarbons have been reported in sediments of estuaries, harbours, bays and in coastal areas receiving industrial and urban discharges [Goldberg, 1976; Abu-Hilal & Khordagui, 1994]. These levels of PAHs can cause biological complexities to living organisms and plants (Moslen & Miebaka, 2017). The relatively higher concentration of PAHs recorded in the IAUE can be traced to pyrogenic origin as the study station was an abandoned state waste dump as earlier observed by Moslen and Miebaka (2017) in sediments of Azuabie creek. The values obtained in this study for PAHs exceed the DPR target value (0.1mg/kg) and WHO limit (1mg/kg). Onianwa (1995) observed low concentrations of total hydrocarbons in soils around Ibadan except areas of deliberate anthropogenic inputs of spent oils such as mechanic workshops. In a contaminated soil PAHs and THC concentrations were higher at near surface levels

more than deeper zones (Aigberua, Ekubo, Inengite & Izah, 2016). Polycyclic aromatic hydrocarbons (PAH) are byproducts of combustion (pyrogenic) and are common in the urban environment as could be found in industrial chemical wastes. This makes PAHs are chemicals of concern at many waste sites. Risk assessment methods yield risk based cleanup levels for PAHs that range from 0.1 to 0.7 mg/kg (Bradley, Magee & Allen, 2008). Similarly, level of THC in oil contaminated soils is higher than that of non-spill sites, hence the presence of hydrocarbon which has caused the pollution of the soil (Chukwu Okeah, Ushe & Oyegun, 2019). The toxicity of petroleum hydrocarbon oil in soil has been established at concentration range greater than 1000 mg/kg (DPR, 2002).

Carbon Content (TOC) in wetland soils is mainly products of plants that fix the carbon in the atmosphere through photosynthesis which is an important factor affecting greenhouse gas emission [Jauss, Sullivan, Lehmann, Sanderman & Daub, 2017]. Therefore, determining the contents of soil organic matter (SOM) and total carbon (TOC) in wetland soil is of great significance for protecting the wetland ecological environment [Lu *et al.*, 2018]. TOC concentration for the study stations showed that Uniport had a relatively higher concentration compared to IAUE and RSU stations. Organic matter content of soils also shows that the non-polluted sites have more organic content than the sampled communities. Studies have shown that organic parameters (TOC, PAHs, and THC) are usually different as they are relatively lower in control non-oil contaminated soil sites (Onyejekwe, Osuji, & Nwaichi, 2019). Total organic carbon (TOC) remains one of the most important components of sediments and soils as they can be used to distinguish marine and terrestrial sources of organic matter, environmental depositional conditions, pollution indices and soil quality and productivity indicators (Avramidis, Nikolaou & Bekiari, 2015).

There were also higher levels of TOG at the IAUE campus compared to the others. The least value of TOG concentration was recorded at the RSU campus of mean value 10689 %. Total Oil and Grease (TOG) contaminants are defined as materials extracted in the form of organic solvent from a samples, and are composed mainly of fatty matter from animal and vegetable sources, hydrocarbons of petroleum origin, sulfur compounds, certain organic dyes, and chlorophyll (Terese, Slawomir, Zenon & Oloyede, 2011). Total petroleum hydrocarbon fraction (TPH) accounted for oil and grease (TOG) and the ratio of [TPH] / [O/G] ranges from 12% to 50% (Pawlak, Rauckyte & Oloyede, 2008). TOG was higher at the IAUE study station primarily because of the existence of waste dumps previously abandoned without any treatment hence organic processes of decomposition, acetogenic and methanogenic actions occurring at different times within the zone. The high content of oil and grease can only be traced to anthropogenic inputs. Adewuyi, Etchie and Etchie (2012) recorded mean values for TOG of 1064.90 ± 7.70 which was far lower than the concentration recorded in the soils of the study areas of Uniport, RSU and IAUE. These sharp differences may be attributed to soil type and nature of previous anthropogenic inputs. These values exceeded the standard regulatory limits for both WHO and USEPA (WHO, 1971; USEPA, 2010).

Total organic matter (TOM) recorded was higher in Uniport study station but least at the IAUE study station (8.18 ± 0.86 and 5.78 ± 1.28 respectively). Conversely, in another study around Isiokpo Southeast of Niger Delta, the TOC and TOM contents of the polluted soils did not show any significant increase in concentration probably due to natural rehabilitation of the affected material layer of soils (Osuji & Adesiyun, 2005). Analogously, Uniport recorded the highest concentration of TOM (8.81) while IAUE had the least (5.78%). This could be attributed to the level of plants and organic decomposition around the study stations. Soil organic matter contributes to soil productivity in many different ways. The easiest method used to estimate the amount of organic matter in a soil sample is by measuring the weight lost by an oven-drying to 105°C.

4 Conclusion

The result of this study reveals that the soils of the three institutions (Uniport, RSU, IAUE) are polluted by THC, PAHs, TOG but comparatively the IAUE study station was obviously more affected which was attributed to its proximity to an abandoned dumpsite (Iyama & Edori, 2019). The most striking feature of this study is the high levels of the parameters especially THC, PAHs and TOG which were ordinarily supposed to be low risk areas due to absence of any major petroleum exploration activities. They were all above the standard limits by WHO, DPR and USEPA. This is a potential threat to plants, soil microorganisms, animals and man due to their deleterious effects as the study stations remain areas of human inhabitation. There is therefore an ardent need to monitor anthropogenic activities especially kinds of waste deposited around the campuses. Though a one way ANOVA showed no significant relationship amongst the results of soil samples from the three campuses, there is the need to thread with caution because of their arbitrary high relative concentrations.

REFERENCES

- [1] Abu-Hilal, A.H. & Khordagui, H.K. (1994). Petroleum hydrocarbons in the nearshore marine sediments of the United Arab Emirates. *Environ. Pollut.*, 85: 315–319.
- [2] Adesuyi1, A., Ngwoke, M.O. ,Akinola, M.O., Njoku, K.L. & Jolaoso, A.O.(2016). Assessment of Physicochemical Characteristics of Sediment from Nwaja Creek, Niger Delta, Nigeria. *Journal of Geoscience and Environment Protection*, 4: 16-27.
- [3] Adewuyi, G.O., Etchie, A.T.& Etchie, O.T. (2012). Evaluation of Total Petroleum Hydrocarbons (TPH) and Some Related Heavy Metals in Soils and Groundwater of Ubeji Settlement, Warri Metropolis, Nigeria. *Terrestrial and Aquatic Environmental Toxicology*, 6 (1):61-65.
- [4] Aigberua, A.O., Ekubo, A.T., Inengite, A.K. & Izah, S.C. (2016). Evaluation of Total Hydrocarbon Content and Polycyclic Aromatic Hydrocarbon in an Oil Spill Contaminated Soil in Rumuolukwu Community in Niger Delta. *Journal of Environmental Treatment Techniques*, 4, (4):130-142
- [5] Akpokodje, O.I., Uguru, H. & Esegbuyota, D. (2019). Evaluation of phytoremediation potentials of different plants' varieties in petroleum products polluted soil. *Global Journal of Earth and Environmental Science*, 4(3):41-46.
- [6] Alinnor I. J. & Nwachukwu M. A. (2013). Determination of total petroleum hydrocarbon in soil and groundwater samples in some communities in Rivers State, Nigeria. *Journal of Environmental Chemistry and Ecotoxicology*, 5(11), 292-297.
- [7] Avramidis, P., Nikolaou, K. & Bekiari, V. (2015). Total Organic Carbon and Total Nitrogen in Sediments and Soils: A Comparison of the Wet Oxidation – Titration Method with the Combustion-infrared Method. *Agriculture and Agricultural Science Procedia*, 4: 425-430
- [8] ASTM (2000). Standard test methods for moisture, ash, and organic matter of peat and other organic soils. Method D 2974-00. American Society for Testing and Materials. West Conshohocken, PA.

- [9] ATSDR (1999). Agency for Toxic Substances and Disease Registry. [Toxicological Profile for total petroleum hydrocarbons \(TPH\)](#). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.
- [10] Azlan, A., Aweng, E.R., Ibrahim, C.O. & Noorhaidah, A. (2012). Correlation between Soil Organic Matter, Total Organic Matter and Water Content with Climate and Depths of Soil at Different Land use in Kelantan, Malaysia. *J. Appl. Sci. Environ. Manage.*, 16 (4) :353-358
- [11] Bradley, L.J.N., Magee, B.H. & Allen, S.L. (1994). Background Levels of Polycyclic Aromatic Hydrocarbons (PAH) and Selected Metals in New England Urban Soils. *Journal of Soil Contamination*, 3 (4): 349-361.
- [12] Carter, D.L., Mortland, M.M. & Kemper, D.W. (1986). "Specific surface," in *Methods of Soil Analysis Part I. Soil Science*, A. Klute, Ed., 413–422, Society of America, Madison, Wis, USA.
- [13] Chad, C. (2018). What are Hydrocarbons? Gulf Coast Environmental Systems.
- [14] Chukwu Okeah, G. O., Ushe, L. & Oyegun, C.U. (2019). Analysis of Soil Quality in a Deltaic Hydrocarbon Polluted Environment Niger Delta Nigeria. *South Asian Research Journal of Natural Products*, 2(4), 1-9.
- [15] Das, N. & Chandran, P. (2011). Microbial degradation of petroleum hydrocarbon contaminants: An overview. *Biotechnology Research International Journal*, 1-13.
- [16] David, W.B. and Jessie, A.K. (2014). Introductory Chemistry (1st Canadian Edition). Pressbooks, Canada.
- [17] DEC(1992). Department of Environmental Conservation - DEC, Petroleum- contaminated soil guidance policy. Spills technology and related series (STARS). Revised. New York State.
- [18] Denys, S., Rollin C., Guillot, F. & Baroudi, H. (2006). In-situ phytoremediation of PAHs contaminated soils following a bioremediation treatment. *Water Air Soil Pollution*, 6: 299- 315.
- [19] DPR (2002). Department of Petroleum Resources —EGASPIN soil/sediment target and intervention values for Mineral oil (or TPH) in *Environmental Guidelines and Standards for the Petroleum Industry in Nigeria*, 2, 1–415, Lagos, Nigeria.
- [20] Dumitru, M. & Vladimirescu, A. (2017). Loads Limits Values of Soils with Petroleum Hydrocarbons. *19th EGU General Assembly, EGU2017, proceedings from the conference held 23-28 April, 2017 in Vienna, Austria.*, p.12351
- [21] Edori, O.S. & Iyama, W.A. (2019). Source Identification of Polycyclic Aromatic Hydrocarbons in Water at Point of Effluent Discharge into the New Calabar River, Port Harcourt, Rivers State, Nigeria. *International Journal of Environment and Climate Change*, 9 (6): 343-349.
- [22] Edwards J.H., Wood, C.W., Thurlow, D.L. & Ruf, M.E. (1999). Tillage and crop rotation effects on fertility status of a Hapludalf soil. *Soil Sci. Soc. Am. J.* 56:1577-1582.
- [23] Ekpete, O. A., Edori, O. S. & Iyama, W. A. (2019). Concentrations of Polycyclic Aromatic Hydrocarbons from Selected Dumpsites within Port Harcourt Metropolis, Rivers State, Niger Delta, Nigeria. *International Journal of Environmental Sciences & Natural Resources*, 21 (4): 01-06, 556066 DOI: 19080/ IJESNR. 2019.21.556066

- [24] ESD (1993). Environmental Sciences Division. Use of Gross Parameters for Assessment of Hydrocarbon Contamination of Soils in Alberta, Oxford, UK.
- [25] Freitag, D., Ballhorn, L., Geyer, H. & Korte, F (1985). "Environmental Hazard profile of Organic Chemicals. *Chemosphere*," 14:1589-1616.
- [26] Goldberg, E.D. (1976). The Health of the Ocean, UNESCO Press, Paris.
- [27] Harrison, R.M. *et al.* (1997). Comparative receptor modelling study of airborne particulate pollutants in Birmingham (United Kingdom), Coimbra (Portugal) and Lahore (Pakistan). *Atmospheric Environment*, 31:3309–3321.
- [28] Ibigoni, C.H., Gabriel Snr, U.U. & Horsfall, Jnr., M. (2009). Evaluation of total hydrocarbon levels in some aquatic media in an oil polluted mangrove wetland in the Niger Delta. *Applied Ecology and Environmental Research*, 7(2):111–120.
- [29] Ideriah, T.J.K. & Ikoro, U.J. (2015). Hydrogeochemical Characteristics and Quality Assessment of Groundwater in University of Science and Technology Port Harcourt. *International Journal of Environmental Monitoring and Analysis*, 3(4):221-232
- [30] Idisi, J. & Uguru, H. (2020). Petroleum hydrocarbons content in the soil and its accumulation in grasses from oil spill site at Isoko North LGA of Delta State, Nigeria. *Direct Research Journal of Agriculture and Food Science*, 8 (5): 144-150.
- [31] Ighariemu, V., Belonwu, D.C. & Wegwu, M.O. (2019). Level of Petroleum Hydrocarbons in Water and Sediment of Ikoli Creek, Bayelsa State, Nigeria. *Toxicology and Environmental Health Sciences*, 11: 114-119.
- [32] Ijeomah, H.M., Chima, U.D. & Okagbare, O. H. (2013). Ecological Survey of Avifaunal Resources in University of Port Harcourt, Nigeria. *Ethiopian Journal of Environmental Studies and Management*, 6(6): 648-660.
- [33] Iyama, W.A. & Edori, O.S. (2019). Determination of Chemical and Gross Organic Pollutant Levels in Leachates from Approved Waste Dumpsites, Port Harcourt Metropolis, Rivers State, Nigeria. *Journal of Global Ecology and Environment*, 9(1): 29-38.
- [34] Ite, A. E. & Semple, K. T. (2012). Biodegradation of petroleum hydrocarbons in contaminated soils. In Arora R (ed). *Microbial Biotechnology: Energy and Environment*, Wallingford, Oxfordshire: CAB International.
- [35] Iwegbue, C.M.A., Williams, E.S & Nwajei, G.E. (2008). Characteristic Levels of Total Petroleum Hydrocarbon in Soil Profiles of Automobile Mechanic Waste Dumps. *International Journal of Soil Science*, 3: 48-51.
- [36] Jauss, V., Sullivan, P., Lehmann, J., Sanderman, J. & Daub, M. (2017). Alternative modelling approaches for estimating pyrogenic carbon, soil organic carbon and total nitrogen in contrasting ecoregions within the United States. *Geophys. Res. Abstr.*, 19, 497.
- [37] Lu, X., Lin, Y.L., Wu, Y.N., Gu, Y., Zhao, Q. & Zhang, X. (2018). Spatial Distribution Characteristics of Soil Physical and Chemical Properties in Milu National Nature Reserve of Coastal Wetland. *Trans. Oceanol. Limnol.*, 4, 74–81.

- [38] Lyons, B.P., Barber, J.L., Rumney, H.S., Bolam, T.P.C., Bersuder, P., Law, R.J., Mason, C., Smith, A.J., Morris, S., Devlin, M.J., AlEnezi, M., Massoud, M.S., Al-Zaid, A.S. & Al-Sarawi, H.A. (2015). Baseline survey of marine sediments collected from the State of Kuwait: PAHs, PCBs, brominated flame retardants and metal contamination. *Marine Pollution Bulletin* 100: 629–636.
- [39] Mebius, L.J. (1960). A rapid method for the determination of organic carbon in soil. *Anal Chim. Acta*. 22:120-124.
- [40] Menzie, C.A., Potocki, B.B. & Santodonato, J. (1992). Exposure to carcinogenic PAHs in the environment. *Environmental Science and Technology*, 26:1278–1284.
- [41] Mielke, H.W. *et al.* (2001). PAH and metal mixtures in New Orleans soils and sediments. *Science of the Total Environment*, 281: 217–227.
- [42] Moslen, M. & Miebaka, C.A. (2019). Hydrocarbon Contamination of Sediments in the Niger Delta Region: a case study of the Azuabie Creek, upper reaches of the Bonny Estuary, Nigeria. *IOSR Journal of Environmental Science, Toxicology and Food Technology* (IOSR-JESTFT), 11 (9):26-32
- [43] Okop, I.J. & Ekpo, A.P. (2012). Determination of Total Hydrocarbon Content in Soil after Petroleum Spillage. *Proceedings of the World Congress on Engineering*, Vol III WCE 2012, July 4 - 6, 2012, London, U.K.
- [44] Onianwa, P.C. (1995). Petroleum hydrocarbon pollution of urban topsoil in Ibadan City, Nigeria. *Environment International*, 21 (3): 341-343.
- [45] Onyejekwe, I. M., Osuji, L. C., & Nwaichi, E. O. (2019). Physico-chemical Alterations and Hydrocarbon Characteristics of Kom-Kom Oil Spill Soils. *Journal of Scientific Research and Reports*, 25(2), 1-8.
- [46] Osuji, L.C. & Adesiyun, S.O. (2005). The Isiokpo Oil-Pipeline Leakage: Total Organic Carbon/Organic Matter Contents of Affected Soils. *Chemistry and Biodiversity*, 2 (8): 1079-1085 Pawlak, Z., Rauckyte, T. & Oloyede, A. (2008). Oil, grease and used petroleum oil management and environmental economic issues. *Journal of Achievements in Materials and Manufacturing Engineering*, 26 (1): 11-17.
- [47] Ruchaya, B. W., Gullaya, T. & Ayako, H. (2006). Takada, Distribution and origins of polycyclic aromatic hydrocarbons (PAHs) in riverine, estuarine, and marine sediments in Thailand. *Mar. Pollut. Bull.* 52, 942–956.
- [48] Raich, J.W., Rastetter, E.B., Melillo, J.M., Kicklighter, D.W., Steudler, P.A., Peterson, B.J., Grace, A.L., Moore III, B. & VoËroËsmarty, C.J. (1991). Potential net primary productivity in South America: Application of a global model. *Ecological Applications*, 1: 399-429.
- [49] Rastetter, E.B., Ryan, M.G., Shaver, G.R., Melillo, J.M., Nadelhoffer, K.J., Hobbie, J. & Aber, J.D. (1991). A general biogeochemistry model describing the responses of the C and N cycles in terrestrial ecosystems to changes in CO₂, climate and N deposition. *Tree Physiology*, 9: 101-126.
- [50] Ribes, A., Grimalt, J.O., Torres, C.J. & Cuevas, E. (2003). "Polycyclic aromatic hydrocarbons in mountain soils of the subtropical Atlantic". *Journal of Environ. Qual.*, 32:977-987.
- [51] Schwartz, G., Eshel, G. & Ben-Dor, E. (2011). "Reflectance spectroscopy as a tool for monitoring contaminated soils". In *Soil Contamination*, Intech, Web of Science, Croatia. Staff, S.S. (2010). *Keys to Soil Taxonomy*, Government Printing Office.

- [52] Soil Survey Staff (2010) Keys to Soil Taxonomy. 11th Edition, USDA-NRCS, Washington DC.
- [53] Sojinu, O.S.S., Wang, J.Z., Sonibared, O.O.& Zeng E.Y. (2010). Polycyclic aromatic hydrocarbons in sediments and soils from oil exploration areas of the Niger Delta, Nigeria. *Journal of Hazardous Materials*, 174: 641- 647.
- [54] Terese, R., Slawomir, Z., Zenon, P.& Oloyede, A. (2011). Determination of oil and grease, total petroleum hydrocarbons and volatile aromatic compounds in soil and sediment samples. *Journal of Environmental Engineering and Landscape Management*, 18(3):163-169.
- [55] Trapido, M. (1999). Polycyclic aromatic hydrocarbons in Estonian soil: contamination and profiles. *Environmental Pollution*, 105: 67–74.
- [56] USEPA (2010). United States Environmental Protection Agency. Drinking Water Contaminants. National Primary Drinking Water Regulations.
- [57] Walkley, A. & Black, I.A. (1934). An examination of the Degtjareff method for determining organic carbon in soils: Effect of variations in digestion conditions and of inorganic soil constituents. *Soil Sci.*, 63:251-263.
- [58] WHO (1971). World Health Organization. International Standards for Drinking Water (3rd Edn.), Geneva, 70pp. WHO (2010). World Health Organization. Polycyclic Aromatic Hydrocarbon. *WHO guidelines for Indoor Air Quality: Selected Pollutants*.
- [59] Woodhead, R.J., Law, R.J. & Matthiessen, P. (1999). Polycyclic aromatic hydrocarbons in surface sediments around England and Wales, and their possible biological significance. *Mar. Pollut. Bull.*, 38, 773–790.