**INVESTIGATION OF TOTAL HYDROCARBON CONTENTS AND HEAVY METALS IN TERMITARIA WITHIN AKWA IBOM STATE UNIVERSITY, IKOT AKPADEN, NIGERIA.**

 **ABSTRACT**

*This study investigates the concentrations of Total Hydrocarbon Content (THC) and Heavy Metals in termitaria within Akwa Ibom State University Ikot Akpaden, Nigeria. Samples of five different soils and Core of the termitaria were collected in triplicate using standard sampling analytical methods. The samples were analyzed for Heavy metals and Total Hydrocarbon Content by Atomic Absorption Spectrophotometry and Gas Chromatograph fitted with flame ionization detector (GC-FID) respectively. The pH, salinity, electrical conductivity and moisture content were also assessed. The results obtained were subjected to statistical analysis such as mean, standard deviation and standard error. The concentration range of the heavy metals of both soils and Cores in the termitaria was 0.0.13 – 54.103 mg/Kg. These values are above the World Health Organization and National Environmental Standard and Regulations Enforcement Agency (WHO/NESREA) (0.001 – 5.0 mg/Kg). The THC results in both soils and cores of the termitaria varied from 21.087 – 632.191 mg/Kg. These results were higher than the (0.6 mg/Kg) limit of THC by the Department of Petroleum Resources, implying that the termitaria are contaminated with THC which might be attributed to anthropogenic activities on campus and its environs through atmospheric deposition. Hence, there is need for routine assessment and remediation for a cleaner and healthier environment. This study has provided baseline information within Akwa Ibom State University main campus, Ikot Akpaden, on the levels of heavy metals and total hydrocarbon content in soils and cores of termitaria.*

 ***Keywords****: Total Hydrocarbon Content, Soils, Termitaria, Heavy Metals, Gas Chromatography*

 **1.0** **INTRODUCTION**

Contamination of environment by hydrocarbons is becoming prevalent across the globe. This is probably due to heavy dependence on petroleum as a major source of energy throughout the world, rapid industrialization, population growth and complete disregard for the environmental health. The implication of heavy metals, as well as polycyclic aromatic hydrocarbons (PAHs) and petroleum hydrocarbons (PHs) in the environment, is increasingly becoming an issue of global concern especially as the soil makes up an important aspect of the rural and urban environment. Contamination of environment by hydrocarbons is spreading widely in our country Nigeria (Ikpe *et al.,* 2023).

The amount of natural crude oil seepage was estimated to be 600,000 metric tons per year with a range of uncertainty of 200,000 metric tons per year (Kvenvolden and Cooper 2003). The release of hydrocarbons into the environment whether accidentally or due to human activities is the main causes of water and soil pollution, these hydrocarbon pollutants usually caused disruptions of natural equilibrium between the living species and their natural environment. Hydrocarbon components have been known to belong to the family of carcinogens and neurotoxic organic pollutants (Das and Chandran, 2011).

Ikot Akpaden is one of the fast-growing areas in Akwa Ibom State, a Niger Delta region in Nigeria which is surrounded by areas where oil drilling and other anthropogenic activities are carried out; this shows the possibility of soil contamination and other environmental degradation. In recent times Ikpe *et al* (2023) reported that auto-mobile mechanic worships had high concentration of total petroleum hydrocarbons and total hydrocarbon content in three stations including Akwa Ibom State University, Ikot Akpaden campus. Soils may become contaminated by the accumulation of heavy metals and metalloids through atmospheric emissions from the rapidly expanding industrial areas, mining, disposal of high metal wastes, leaded gasoline and paints, land application of fertilizers, animal manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, spillage of petrochemicals, and atmospheric deposition (Khan, *et al.,* 2008). Consequently, concentration of heavy metal is rising in the soil as a result of human activities. Heavy metals enter the environment by natural and anthropogenic means that includes: natural weathering of the earth's crust, mining, soil destruction, industrial expulsion, city overflow, sewages, and pesticide applications to plants and air pollution fallout (Ming, 2005).

Heavy metals in soil have been attracting considerable attention lately owing to their non– degradability relative to organic pollutants. These metals may vary in importance and roles as some are essential to plants at low concentrations and others may become toxic even at low concentration when consume over time (Ikpe *et al.,* 2023). Some edible mushrooms are also intimately associated with various termite species thereby becoming sources from which metals may be taken up (Nyeko and Olubayo, 2005).

It has been established that termite species are agents of soil denudation due to their feeding on soil as well as construction of their nests (Kaschuk *et al.,* 2006; Musa *et al.,* 2014), and in the process accumulate large amount of metals in their bodies, resulting in physiological toxicity (Hsu *et al.,* 2006; Heckel and Keener, 2007).

Furthermore, heavy metals could be transported to organisms on the higher position from insects along food chains resulting in bioaccumulation and eventual toxicity (Zheng *et al.,* 2008). Recent studies that monitored the fate of heavy metals in the environment, made use of some predatory insects as bio–indicators due to their high abilities to accumulate metals from their environment. Termites may also serve as bio-indicators of metals in the environment (Nummelin *et al.,* 2007).

Another issue of concern is that bioaccumulation of heavy metals in terrestrial food chains is considered the most important source of non – occupational human exposure to the elements; just as most heavy metals are highly toxic and persistent. It follows that consumption of termite species by man would be a veritable source of metal transfer and accumulation in the food chain. Anomalous environmental levels of metal concentration from such insects warrant concern. It is hence pertinent to know the presence or absence of metals in these insects’ habitats. It is on the foregoing that this study is predicated.

Termitaria, also known as termites’ mounds are a common feature in the forest and savannah zones of Nigeria. They vary greatly in size even in the same ecological zone ranging from about 2-5m in basal circumference and 1-3m in height (Momah and Okieimen, 2019). Termite mound density can be very high and is estimated to cover up to 10% of the land area of the African continent and could thereby limit the area available for cultivation (Momah and Okieimen, 2019). It has been suggested that mound building activities of termites involve the upward transfer of clay, silt, sand and fine-grained particles, to the surface leading to the modification of the physical and textural properties, mineral nutrient content, etc. of the soil and insignificant mobilization and dispersal of trace elements (Chatupa and Dieng, 2000). These modifications have been exploited in the use of termitaria sampling in geochemical exploration (Petts *et al.,* 2009) and in the use of termitaria as mineral nutrient supplement in agriculture (Momah and Okieimen, 2019)

Micro-organisms can modify the properties of soils either in reversible or irreversible forms. Through their actions they deeply modify their immediate environment by increasing the content of fine particles and organic matter of the soil and consequently stimulate microbial activity. Termite can be a major agricultural pest, particularly in Africa where crop losses can be severe (Mbah *et al.,* 2014).

Researches on termite mounds have concentrated on its beneficial effects with no attention on its possible adverse effect on soil and crop production. Similarly, little or no research on termite mound has been carried out in the study area Akwa Ibom State, South-South, Nigeria. Therefore, this research would be investigating the level of total hydrocarbon content and heavy metals in termitaria soil and core in the Akwa Ibom State University main campus, Ikot Akpaden.

**2.0** **MATERIALS AND METHODS**

**2.1 Study Area**

The study Area was Akwa Ibom State University, Ikot Akpaden. It is a rural region in Mkpat Enin Local Government Area of Akwa Ibom State, Nigeria. It is bounded by Oruk Anam Local Government Area in the West, Eastern Obolo Local Government Area in the East, Ikot Abasi Local Government Area in the North and Onna Local Government in South. Figure1 illustrate the map of the sampling stations .The study area, provides an ideal setting for researching various environmental aspects. Its lies between the latitude of 4.6214° N, and longitude of 7.7639° E. It covers a vast campus with diverse vegetation, including trees, shrubs, and grassland areas. The gate area is the main entrance to the University, where vehicular and human activities are prominent. These activities can contribute to the release of pollutants such as hydrocarbons and heavy metals, which have detrimental effects on the environment and human health.

Fig.1: Locations of Sampling Stations in Akwa Ibom State University.

**2.2** **Sample Collection**

The samples of the soil and the core of the termitaria within the main campus of the Akwa Ibom State University were collected in triplicate using standard analytical methods described by Ikpe *et al.,* 2023. The samples were collected from five different coordinate’s stations as indicated in Table 1. The samples collected for the evaluation of total hydrocarbon content (THC) were well labelled in an amber glass container while that of the heavy metals were in polythene bags, in order to avoid photo degradation and gross contamination of the samples. All the Sampling was carried out on the same day and the coordinates of all the sampling sites were recorded using Global Positioning System (GPS). The samples were later transported in an ice cooler to the laboratory for analysis.

**2.3 Preparation of Total Hydrocarbon content (THC) extraction mixture**

The THC extraction mixture was prepared using acetone and dichloromethane (ratio 1:1). Six hundred (600 ml) millilitre was measured into a 1000 ml volumetric flask and properly mixed by swirling the mixture (Ikpe *et al.,* 2023)**.**

**2.3.1 Determination of THC from the soil and core of the Termitaria**

 Total Hydrocarbon content (THC) were determined from the soil and core of the termitariausing gas Chorography fitted with flame ionization detector (GC-FID) as reported by Ikpe *et al,*2023. Each of the samples was pulverized using porcelain mortar. 10g of each of the crushed samples were weighed into a 100 ml beaker and 60 ml of THC extraction mixture was then added. The beaker with its content was placed on a magnetic stirrer (with thermostatic heater) and shaken for about 15 mins at 700c (Schwab *et al*., 1999). The extract was later decanted into a clean round-bottom flask. 30 ml of flesh extraction solvent was added and the process of shaking on the magnetic stirrer repeated. 5g of anhydrous sodium sulphate was used to remove water from the extract. The extract was concentrated to 3 ml with rotary evaporator maintained at 200c (Ikpe *et al*., 2023).

1.5 ml of the concentrated extract was loaded on silica gel column. The silica gel column was prepared by loading a 2 g glass wool followed by a 30 g chromatography silica gel, onto a chromatography column (2cm internal diameter and 10 cm long). Each of the bed was conditioned with 40 ml HPLC-hexane to remove any contaminant.

The 1.5 ml concentrated extract was loaded and eluted with 30 ml HPLC hexane into a well labelled 100 ml beaker to get aliphatic hydrocarbon components in the sample. 2 g of anhydrous sodium sulphate was added to remove any traces of water left in the extract. The extract were re-concentrated using rotary evaporator to about 2 ml. and 0.01ml of the extract was taken and transferred into a well labelled chromatography vial ready for gas chromatography analysis. The samples were stored at a temperature of -40c until GC analysis.

**2.3.2 Instrumentation**

The process begins with a solvent blank followed by performance/calibration verification standard(s) , then method blank and finally sample extract analyses. 100 µl extract was introduced into the injector port (LVI) trace GC-2000 with GC-PAL-AS. GC oven temperature is as follows; 5 mins, isotherm at 60oC, with 50oC/min heating ratio to 330oC. Hydrogen carrier gas was used with a constant flow of 3 ml/ min. Analyte were detected with the aid of Flame Ionization Detector (FID) at a temperature of 350oC. A verification standard was used at the end of each analytical batch. The process ends when the entire set of samples has been injected. All sample analyses were performed using reference standard calibration with emphasis on calibration and retention time criteria.

**2.4 Determination of Heavy Metals**

The soil and core were digested separately after drying at a temperature of 1050c for 24 hrs according to Association of Analytical Chemist (AOAC) (2000) methods. The levels of Pb, Cd, Ni, Cu, and Fe was determined using buck scientific model 210 VGP (Variable Giant Pulse) atomic absorption spectrophotometer with different hollow Cathode lamp at different wavelength. The modified method by Adewuyi *et al*., 2011 and Ikpe *et al*., 2019 was used for sample digestion. The samples were grinded using prewashed (with 3m nitric acid) mortar and pestle, sieved into a well labelled transparent plastic containers by passing them through 1mm mesh, 1g of each of the sieved samples were accurately weighed into different digestion flask, well clamp to a retort stand. 10 ml of ratio 10:1 mixture of Nitric (HNO3) and perchloric (HCIO4) acid were added to the sample in each of the clamped digestion flask, swirled and allowed for some minutes for any reaction to subside. The digestion flasks were mounted on a heating mantle and heating began gradually until appearance of whitish dense fumes where a clear solution is obtained. The digestion flask was removed and allowed to cool. 50 ml deionized water was added to the digest filtered (using Whatman’s filter paper) and made up to mark of 100 ml standard volumetric flask with deionized water. Each of the standard volumetric flasks of the digest were corked, labelled and refrigerated ready for AAS analysis. Before the instrumental analysis stock solutions were prepared from which serial dilutions were made for working standards. Calibration curve for each metal was plotted. The working standards were analyzed first followed by the blank before the samples. The results were subjected to descriptive statistics.

**2.5: Determination of Physico - chemical parameters**

The properties evaluated for physicochemical determination in the samples were; Moisture content, pH. , Temperature, Electrical conductivity and Salinity;

**2.5.1 Moisture content determination**

 Water or moisture in the soil and core samples was determined electronically through the use of moisture Analyser (XY- 105 MW). One (1 g) of each of the fresh ground samples was inserted into the cell of the Analyzer, at the end of every determination the value was displayed on the screen display unit as the moisture content of the samples (Okiemen *et al,* 2015)

**2.5.2 Determination of pH**

The pH analysis was done using Jenway digital pH meter, based on the difference in activity of hydrogen ion in and out of the electrode. The pH meter was calibrated with buffer solution of pH 4.0, 7.0 and 9.0 respectively.

20 ml of deionized water was added to 1 g of ground fresh samples and stirred in a 100 ml beaker. After allowing standing for equilibration, the pH was taken by immersing the meter electrode into the mixture and reading taken (Tsai *et al*, .2012).

**2.5.3** **Evaluation of Temperature**

Temperature was Evaluated electronically in the laboratory using (DDSJ 308A) conductivity meter fitted with thermometer. The probe was rinsed with deionized water before immersing in the sample and the reading was taken (Ikpe *et al*, 2023)

**2.5.4 Evaluation of Electrical Conductivity (EC)**

 One gram (1 g) of each of the soil and core samples was weighed separately. They were later pulverized thoroughly to obtain a homogenized sample mixture of each sample respectively; the samples were later transferred into a well labelled beaker. Twenty ml (20 ml) of deionized water was added to every one gram of the sample (ratio 1:20) and allowed for 30 minutes equilibration. Multi- purpose conductivity meter (DDSJ 308A) was used to determine the Electrical conductivity. The evaluation was done electronically and the probe was rinsed with deionized water after each determination, according to standard analytical procedure described by Ikpe *et al*., 2023 and the readings were recorded.

**2.5.5 Test for Salinity**

The salt content of the samples was detected with the help of multipurpose conductivity meter (DDSJ 308A). The procedure for determination follows as stated for the electrical conductivity above. The only difference is turning the reading knob to salinity before taking readings. The probe was rinsed with deionized water before and after each reading in the sample and the readings was recorded. (Ogbeifun *et al*., 2018)

**Table .1: Coordinates of the Sampling Locations**

|  |  |  |  |
| --- | --- | --- | --- |
| SAMPLESTATIONS  |  LATITUDE |  LONGITUDE |  |
|  1. Back of Statistics Department |  **N04° 35' 48.2"** |  **E007° 49' 56.3"** |  |
|  2. Close to Bursary.  |  **N04° 37' 29.8"** |  **E007° 45' 37.3"** |  |
|  3. Close to Administrative Block |  **N04° 37' 56.5"** |  **E007° 45' 39.3"** |  |
|  4. Close to Student’s Affairs |  **N04° 37' 28.2"** |  **E007° 45' 49.4"** |  |
|  5. Close to Obong Akanimo Udofia Hostel |  **N04° 37' 18.1"** |  **E007° 46' 22.9"** |  |

**3.0 RESULTS AND DISCUSSION**

**3.1 Results**

The results obtained from the analysis of physicochemical properties of the soil and core samples of the study area are shown in Table 2 and 3 respectively. Table 4 and Table 5 shows the concentrations of the total hydrocarbon content in the soil and the core samples respectively. Analysis of the heavy metals of the extract from the soil and core samples is reported in Table 6 and 7 respectively.

**3.2 Discussion**

**3.2.1 Temperature**

There were significant differences in the temperature of the five sampling stations of the core and the soil respectively as shown in Table 2-3. The temperature were lower than that of a similar study conducted by Ikpe *et al.* (2023) and below the Federal Environmental Protection Agency( FEPA) standard of 40 oC these could be attributed to seasonal variation, which implies that the soil could be suitable for agricultural purposes. Moreso, the variation in temperature could be attributed to solar radiation as a result of daily weather condition (Olubokola *et al.,* 2015; Ikpe *et al.,* 2019), and the activity of termites in the termitaria.

**3.2.2 Electrical Conductivity (EC)**

The electrical conductivity of the soil and core samples obtained from different sample stations were higher than the FEPA(1999) standard of 4.0 µS/cm with the ranges of 127.5 – 336 µS/cm for the soil and 48.5 – 925 µS/cm for the core higher (Table 2-3). Sample station 1 of the core recorded 925 µS/cm which was higher than the sample point 1 of the soil, which recorded 336 µS/cm. The results were higher than 4 µS/cm from FEPA standard (FEPA, 1999) and result obtained by Ogbeifun *et al.* (2019) for a similar study. The reason could be attributed to Edaphic factors, as supported by Okuo, (2015).

**3.2.3 Salinity**

The salinity values of the soil and the core samples of the termitaria were 0.08% and 0.00% respectively indicating low salinity status of the soil and core. High salinity decreases plant growth and water quality resulting in lower crop yields. It kills plants, leaving bare soil that is prone to erosion (Etesin *et al.,* 2017).

**3.2.4 pH**

The pH of the soil samples ranged from 4.3 to 6.4 , and the pH of the core samples ranged from 4.6 to 5.9 which is mildly acidic in both samples respectively. The pH values obtained in this study were more acidic than those reported by Ubong *et al.,* (2023) and Ikpe *et al.,* (2023) who researched on a similar study area. This result is slightly high and does not meet the FEPA limit which is neutral (7) for soil. Therefore, because of the high value of hydrogen ion concentration (pH) in the termiteria, the soil is rendered unsuitable for agricultural purposes.

**3.2.5 Moisture**

Moisture content of samples is of great importance as a number of biochemical, chemical and physiological changes in food and other related substances depends very much on moisture content. The result of the percentage moisture in core samples analyzed in this study is 22.9% and is lower than 59.99 ± 0.310 % of the studies of Ikpe *et al.,* (2022) in a similar study.

**Table 2: Result of Physicochemical Analysis in Termitaria Soil**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SampleStations | Temperature(oC) | pH | Salinity(%) | Electrical Conductivity(µS/cm) |
|  1 | **25.8 ± 0.01** | **5.78±0.02** | **0.02±0.00** |  **336 ±0.00** |
| 2 | **25.8 ± 0.00** | **6.43±0.07** | **0.01±0.02** |  **220 ±0.003** |
| 3 | **25.7 ±0.01** | **6.45±0.00** | **0.01±0.00** |  **127.5 ±0.00** |
| 4 | **25.7 ±0.04** | **5.70±0.01** | **0.01±0.00**  |  **277 ±0.01** |
|  5 | **26.2 ±0.00** | **4.30±0.00** | **0.08±0,02** | **161.4 ±0.00** |
| FEPA (1999) | **40** | **7.00** | **-** | **4.00** |

**Table 3.: Result of Physicochemical Analysis in Termitaria Core**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SampleStations | Temperature(oC) | pH | Salinity(%) | Electrical Conductivity(µS/cm) |
|  1 | **25.6 ± 0.01** | **4.62 ± 0.04** | **0.05 ±0.01** | **925 ± 0.01** |
| 2 | **26.0 ± 0.01** | **5.70±0.01** | **0.00±0.00** | **90.2 ±0.04** |
| 3 | **25.4 ± 0.03** | **5.99±0.00** | **0.00±0.00** | **48.5 ± 0.06** |
| 4 | **25.6 ± 0.04** | **4.8±0.00** | **0.03±0.08** | **509 ±0.00** |
| 5 | **25.5 ± 0.00** | **4.±0.03** | **0.02±0.08** | **397 ±0.03** |
| FEPA (1999) | **40** | **7.00** | **-** | **4.00** |

**3.2.6 Total hydrocarbon content (THC)**

The result of THC in the soil and core of the Termitaria obtained in this study are represented in Table 4 and Table 5 respectively. The THC of the five termitaria under study varied from 0.126 ±0.001 ppm to 0.023 ±0.001 ppm for the soil and 0.606 ±0.001 ppm to 0.086 ± .001 ppm for the core respectively. The concentration was observed in the order; P5>P4>P3>P2>P1for the soil samples and P3>P4>P5>P1>P2 for the core samples respectively. According to DPR (2002), contaminations of soil is said to have occurred when their concentration exceeds a given limit.The concentration of THC obtained in the five stations of both the soil and the core samples are within than the 0.6 ppm permissible limit of total hydrocarbons content allowed by the Department of Petroleum Resources (DPR, 2002), and are less than the value of THC obtained by Ikpe *et al*. (2023) in the same study area. The moderately observed level of THC in the five termitaria sites could be attributed to the anthropogenic activities going on at the university campus, which include but are not limited to the activities from the mechanical workshop and from the university generator house, improper disposal of hydrocarbon products during the construction of buildings in the sampling sites and washing of contaminated soil by erosion to the study area. According to Jouquet *et al.* (2015), it is stated that, while constructing the mounds, termites improve the soil physical and chemical characteristics by excavating and breaking down organic materials, therefore, the high level of THC concentration in the core of the termitaria could be attributed to the activities of the termites in the mound.

**Table 4: Concentrations of Total Hydrocarbon Content** **in the Soil**

|  |  |  |
| --- | --- | --- |
| Sample Stations | THC (ppm) | DPR LIMIT (2002) |
|  1 | **0.023 ±0.001** | **0.6 ppm** |
|  2 | **0.024 ±0.001** | **0.6 ppm** |
|  3 | **0.062 ±0.001** | **0.6 ppm** |
|  4 | **0.063 ±0.001** | **0.6 ppm** |
|  5 | **0.126 ±0.001** | **0.6 ppm** |

**Table 5: Concentrations of Total Hydrocarbon Content** **in the Core**

|  |  |  |
| --- | --- | --- |
| Sample Stations. | THC (ppm) | DPR LIMIT (2002) |
| Point 1 | **0.114 ±0.001** | **0.6 ppm** |
| Point 2 | **0.086 ±0.001** | **0.6 ppm** |
| Point 3 | **0.606 ±0.001** | **0.6 ppm** |
| Point 4 | **0.186 ±0.001** | **0.6 ppm** |
| Point 5 | **0.115 ±0.002** | **0.6 ppm** |

**3.2.7 Heavy Metals Concentration**

Table 6 and Table 7 indicates Mean concentration, Standard Deviation and (S.D) and Standard Error (S.E) of heavy metals in the soil and the core samples obtained from the five sampling stations of the Termitaria in Akwa Ibom State University, Ikot Akpaden campus.

**3.2.7.1 Lead**

Lead was detected in all the samples shown in Table 6 and Table 7Their concentration ranged from 0.38 – 1.06 mg/kg for soil and 0.28 – 1.09 mg/kg for core. Station 1 has a highest mean concentration of 1.06 and 1.09 mg/kg lead for both soil and core respectively. Concentration of lead (Pb) in all the soil and core samples is higher than the permissible limit (0.01 mg/l) of USEPA and NESREA. The level of Pb in soil and Core samples could be from indiscriminate disposal of waste from lead acid batteries, lead-based solder; metallic alloy, lead-based paints, used oil, waste incineration, scrap and junk part of automobile (Nkansah *et al.,* 2011).

**3.2.7.2 Cadmium**

Cadmium was detected in all the samples shown in Table 6 of the soil and Table 7 of the core. Their mean concentration ranged from 0.02 – 1.00 mg/kg in the soil and 0.01 – 0.87 mg/kg in the Core. Station 4 (Close **to Student’s Affairs**) has the highest concentration of Cadmium of 1.00 mg/kg in soil and 0.87 mg/kg in core. Both the soil and the core samples had cadmium concentrations and were higher than the 0.003 mg/kg allowed by WHO/ NESREA. Cadmium presence could be attributed to dumping of Cadmium related waste over time, combustion and burning of fossil fuels. They are also mobile in soil, generally more bio available and tend to bio accumulate. Long-term exposure to Cadmium can lead to Cancer and organ system toxicity such as skeletal, urinary, reproductive and respiratory system.

**3.2.7.3 Copper**

The Mean Concentrations of Copper in the Termitaria varied from 15.11 to 21.03 mg/kg for the soil and 15.03 to 19.02 mg/kg for the core as shown in Table 6 and Table 7 respectively. Station 2 has the highest Mean concentration of 21.03 mg/kg in soil and station 1 has the highest Mean concentration of 19.02 mg/kg in the core. Cu concentration for all the samples collected are all below the USEPA and NESREA (50 mg/kg and 100) Standards..

**3.2.7.4 Nickel**

Nickel was detected in all the samples shown in Table 6 of the soil and Table 7 of the core. Their mean concentration ranged from 0.10 – 0.83 mg/kg for soil and 0.12 – 0.64 mg/kg for core. Station 2 has the highest concentration of nickel of 0.83 mg/kg in soil and 0.64 mg/kg in core respectively. The obtained range is higher than 0.4 – 2.3 mg/kg reported by Vincent-Akpu *et al.* (2015) in their studies which shows that the region is not contaminated. However, the mean value obtained is recommended (0.02 mg/kg) for unpolluted sediment by the World Health Organization (WHO 2013).

**3.2.7.5 Iron**

The Mean concentrations of iron in the studied Termitaria varied from 14.08 to 54.10 mg/kg for the soil and 12.46 to 51.67 mg/kg for the core as shown in Table 6 and Table 7respectively. Station 1 has the highest concentration of iron of 54.10 mg/kg in soil and 51.67 mg/kg in core respectively. The obtained range is lower than 6914.0 – 7543.0 µg/g reported in sediments by Howard and Olulu, (2012). The mean obtained is higher than 30.0 mg/kg recommended for Fe in unpolluted sediment by the World Health Organization (WHO 2013). Consequently, Fe may pose serious risk in the studied ecosystem as high levels of the metal could be released into the environment. The high level of iron and other metals in the Termitaria could be attributed to the diverse natural and anthropogenic activities which may include: natural weathering of the earth's crust, soil destruction, industrial expulsion, city overflow, washing of contaminated soil by erosion to the study area and pesticide applications to plants and air pollution fallout.

**Table 6: Result of Analysis of Heavy Metals in Termitaria Soil**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sample Stations |  | Pb(mg/kg)  | Cd (mg/kg) | Ni (mg/kg) | Cu (mg/kg) | Fe (mg/kg) |
|  1 | MeanS.DS.E | 1.060.010.006 | 0.030.020.01 | 0.340.030.02 | 18.10.050.03 | 54.100.030.02 |
|  2 | MeanS.DS.E | 0.380.020.01 | 0.020.020.01 | 0.830.020.01 | 21.030.020.01 | 31.430.040.02 |
| 3 | MeanS.DS.E | 0.710.020.01 | 0.110.020.01 | 0.100.030.02 | 17.30.010.006 | 14.080.010.006 |
| 4 | MeanS.DS.E | 0.870.010.006 | 1.000.0070.004 | 0.310.010.006 | 15.110.020.01 | 21.040.030.02 |
|  5 | MeanS.DS.E | 0.410.020.01 | 0.970.010.006 | 0.720.020.01 | 20.200.020.01 | 20.720.020.01 |
| NESREA (2011) |  | 0.01 | 0.003 | 0.02 | < 1.0 | 30.0 |

**Table 7: Result of Analysis of Heavy Metals in Termitaria Core**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sample Site |  | Pb(mg/kg)  | Cd (mg/kg) | Ni (mg/kg) | Cu (mg/kg) | Fe (mg/kg) |
|  1 | MeanS.DS.E | 1.090.090.2 | 0.010.0070.004 | 0.390.0070.004 | 19.020.020.01 | 51.671.070.98 |
|  2 | MeanS.DS.E | 0.260.020.01 | 0.020.010.006 | 0.640.030.02 | 16.100.060.03 | 27.060.030.02 |
| 3 | MeanS.DS.E | 0.540.020.01 | 0.060.020.01 | 0.120.010.006 | 15.340.050.03 | 12.460.040.02 |
|  4 | MeanS.DS.E | 0.680.0070.004 | 0.870.010.006 | 0.260.010.006 | 15.030.0070.004 | 17.470.020.01 |
|  5 | MeanS.DS.E | 0.280.030.02 | 0.640.020.01 | 0.430.010.006 | 16.990.020.01 | 19.300.020.01 |
| NESREA (2011) |  | 0.01 | 0.03 | 0.02 | < 1.0 | 30.0 |

**3.28: The Pearson Correlation Analysis of Heavy Metals in Soil and Core of Termitaria**

The result of the Analysis presented in Table 8, statistically revealed that when the P-value is less than the significant level of 0.01,its an indication that the result is significant which means that the sources of Heavy metal enrichment in soil and core of the termitaria are the same whereas when the P-value is greater than 0.01 it means that the results are not significant implying that the soil and the core of the termiteria derived its sources of heavy metals enrichment from different sources

Table 9: Summary of Pearson Correlation Analysis of Heavy Metal sources of Enrichment.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Stations | Metals | N | r-calculated | p-value | **Decision at P ≤ 0.01** |
| 1. Back of statistics Department | Pb SoilPb Core | 55 | .974 | .005 | \*\* |
| 2.Close to Bursary  | Cd SoilCd Core | 55 | .983 | .003 | \*\* |
| 3.Close to Admin. Block | Ni SoilNi Core | 55 | .926 | .024 | NS |
| 4.Close to Students Affairs | Cu SoilCu Core | 55 | .306 | .616 | NS |
| 5.Close to Obong Akanimo Udofia Hostel | Fe SoilFe Core | 55 | .997 | .000 | \*\* |

NS – Not Significant

\*\* - Significant

**4.0 Conclusion**

This study provides up-to-date information on the Analysis and concentration of Total Hydrocarbon Content (THC) and Heavy Metals in soils and cores from Termitaria found in Akwa Ibom State University, Ikot Akpaden. The results obtained showed the presence of THC and heavy metals in the samples analyzed. It was found that the concentration of THC in the samples were within the permissible limit, and the concentration of heavy metals were lower than the permissible limit of WHO/ NESREA with exception of iron, and the sources of some of the heavy metal enrichment in the samples were significant, likelihood of deriving its pollutant from the same sources. The provided data will assist the health officials, Agriculturist and the university management for creation of awareness and a holistic and sustainable monitoring and remediation of the environment.

 **REFERENCES**

Abioye, O. P. (2011). Biological Remediation of Hydrocarbon and Heavy Metals Contaminated Soil, *Institute of Biological Sciences, University of Malaya, Kuala Lumpur Malaysia* ISBN: 978-953-307-647-8. <https://www.intechopen.com/books/soil-contamination/biological-remediation-of-hydrocarbon-and-heavy-metals-contaminated-soil>

Adams, G. O., Tawari-Fufeyin, P., Igelenyah, E., and Odukoya, E. (2014). Assessment of heavy metals bioremediation potential of microbial consortia from poultry litter and spent oil contaminated site. *Int. J. Env. Bioremed. & Biodegr.* *2(2)*: 84-92.

Adeniji, A., Okoh, O., and Okoh, A. (2019). Levels of polycyclic aromatic hydrocarbons in the water and sediment of Buffalo River Estuary, South Africa and their health risk assessment. *Arch. Environ. Con. Tox. 76*:657–669

Agency for Toxic Substances and Disease Registry (ATSDR). (1999). Toxicological profile for total petroleum hydrocarbons (TPH). *Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.*

Ahmed, F., and Anm, F. (2018) A review on environmental contamination of petroleum hydrocarbons and its biodegradation. *International Journal of Environmental Science and Natural Resources 11(3)*: 63-69.

Aigberua, A. O., Ekubo, A. T., Inengite, A. K., and 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

Akomah, O., and Osayande, A. (2017). Evaluation of hydrocarbons level and identification of indigenous bacteria in soil from auto-mechanic workshops along Ikokwu Mechanic Village, Port Harcourt, Nigeria, *Journals of Appl. Sci. Environ. Manage*. 22 (1) 115-118.

Atagana, H. (2010). Bioremediation of co-contamination of crude oil and heavy metals in soil by phytoremediation using Chromolaena odorata (L) King and H.E. *Robinson. Earth and Environ. Sc., 215*: 261-271.

Balasubramaniam, A., Boyle, A., and Voulvoulis, N. (2007). Improving petroleum contaminated land remediation decision making through the MCA weighting process. *Chemosphere*, *66*: 791-798.

Banfalvi, G. (2011). Cellular Effects of Heavy Metals. *Netherlands, London, New York:* Springer.

Castro, G., and Méndez, A. (2008). Heavy metals: Implications associated to fish consumption. *Environ. Toxic. and Pharm.*, 26:263-271

Chatupa, J. C., and Dieng, B. B. (2000). Distribution of trace and major elements in the -180 + 75µm fractions of the sand veld regolitt in northwest Ngami land, Botswana. *J. Afr. Earth Sci.,* 30(3): 515-553.

Clemente, A., Anazawa, T., and Durrant, L. (2001). Biodegradation of polycyclic aromatic hydrocarbons by soil fungi. *Brazilian Journal of Microbiology,* *32*:255-261.

Das, N., and Chandran, P. (2011). Microbial degradation of petroleum hydrocarbon contaminants: an overview. Biotechnol Res Int., 9: 1–11. <https://doi:10.4061/2011/941810>

Daraei, H., Mittal, A., and Noorisepehr, F. (2013). Kinetic and equilibrium studies of adsorptive removal of phenol onto eggshell waste. *Environmental Science and Pollution Research* 20: 4603-4611.

Department for Environment, Food and Rural Affairs (DEFRA). (2009) Soil strategy for England supporting evidence paper.

Department of Petroleum Resources (DPR), (2002). Soil/Sediment target and intervention values for Mineral oil (or TPH), Environmental Guidelines and Standards for the Petroleum Industry in Nigeria, (EGASPIN). Lagos, Nigeria. 2(1): 1415.

Edori, E. S., Edori, O. S., and Wodi, C. (2020). Assessment of Total Petroleum Hydrocarbons Content of Soils Within Estate and Works Departments of Three Universities in Port Harcourt Housing Heavy-Duty Generators. *Biomedical Journal of Science & Technology Research*; 30 (1). <https://DOI:10.26717/BJSTR.2020.30.004894>

Ekanem, A., Ikpe, E., and Ekwere, I. (2019). Assessment of Polycyclic Aromatic Hydrocarbons Levels in Soil around Automobile Repair Workshops within Eket Metropolis, Akwa Ibom State, Nigeria. *International Journal of Research and Scientific Innovation (IJRSI);* ISSN 2321–2705 6:102

Etesin, U. M., Ite, A. E., Ukpong, E. J., Ikpe, E. E., Ubong, U. U., and Isotuk, I. J. (2017). Comparative assessment of iodine content of commercial table salt brands available in Nigerian market. *American Journal of Hypertension Research*. 4(1):9-14.

Federal Environmental Protection Agency (FEPA), (1999). National Guidelines and Standards for Soil Quality in Nigeria. FEPA, Rivers State Ministry of Environment and Natural Resources, Port Harcourt.

Gan, S., Lau, E., and Ng, H. (2009). Remediation of soils contaminated with polycyclic aromatic hydrocarbons (PAHs). *J. Hazard. Mater.* 172:532–549.

Gitipour, S., Sorial, G. A., Ghasemi, S., and Bazyari, M. (2018). Treatment technologies for PAH-contaminated sites: a critical review. *Environ. Monit. Assess. 190*, 1–17

Gupte, A., Tripathi, A., Patel, H., Rudakiya, D., and Gupte, S. (2016). Bioremediation of polycyclic aromatic hydrocarbon (PAHs). *Open Biotechnol. J*. 10:363–378.

He, Z. L., Yang, X. E., and StofStoffel, P. J. (2005). Trace elements in agroecosystems and impacts on the environment. *Journal of Trace Elements in Medicine and Biology.19 (2–3)*:125-140

Heckel, P. F. and Keener, T. C. (2007). Sex differences noted in mercury bioceomolation in Magicicada casini. *Chemosphere*, 69: 78 – 81.

Herawati, N., Suzuki, S., Hayashi, K., Rivai, I. F., and Koyoma, H. (2000). Cadmium, copper and zinc levels in rice and soil of Japan, Indonesia and China by soil type. *Bulletin of Environmental Contamination and Toxicology. 64:33*-39

Howard, I. C., and Olulu, B. A. (2012). Metal Pollution Indices of Surface Sediment and Water from the Upper Reaches of Sombriero River, Niger Delta, Nigeria. *Our Nature*; 10: 206 -216.

Husaini, A., Roslan, H. A., Hii, K. S. Y., and Ang, C. H. (2008). Biodegradation of aliphatic hydrocarbon by indigenous fungi isolated from used motor oil contaminated sites. *World Journal of Microbiology and Biotechnology 24*: 2789 – 2797

Hsu, M. J., Selvaraj, K. and Agoramoorthy, G. (2006). Taiwan’s industrial heavy metal pollution threatens terrestrial biota. *Environmental Pollution, 143*(2): 327 – 334.

Ikpe, E., Ubong, U., Uwanta, E., Oku, U., and E Akpan, E. (2023). Investigation of Petroleum Hydrocarbons in Soil from Auto-mobile Mechanic Workshops within Ikot Akpaden, Mkpat Enin L.G.A., Akwa Ibom State, Nigeria. *Chemical Science International Journal; 32*(2): 22-29.

Ikpe, E. E., Ekwere, I. O., Ukpong, E. G., Effiong, J. O., and Okon E. O. (2019). Evaluation of the levels of heavy metals, total petroleum hydrocarbon and total hydrocarbon content in *tympanotomus fuscatus* and Sediment, Qua Iboe River, Akwa Ibom State, Nigeria, *Chemical Science International Journal*; 27(4): 1-17.

IUPAC (2010). Goldbook. <https://en.wikipedia.org/wiki/Hydrocarbon>

Johnsen, A. R., and Karlson, U. (2007). Diffuse PAH contamination of surface soils: environmental occurrence, bioavailability, and microbial degradation. *Appl. Microbiol. Biotechnol. 76*:533–543

Jouquet, P., Guilleux, N., Shanbhag, R., and Subramanian, S. (2015). Influence of soil type on the properties of termite mound nests in Southern India. *Applied Soil Ecology*. 96:282-287

Kamaludeen, S., Arunkumar, K., Avudainayagam, S., and Ramasamy, K. (2003). Bioremediation of chromium contaminated environments. *Indust. J. Exper. Biol., 41*:972-985

Kaschuk, G., Pires-Santos, P. C., Almeida, J. A., Sinhorati, D. C. and Berton-Junior, J. F. (2006). Termite activity in relation to natural grassland soil attributes. *Scientia Agricola,* 63(6): 583 – 588.

Khan, S., Cao, Q., Zheng, Y. M., Huang, Y. Z., and Zhu, Y. G. (2008). Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, China, *Environmental Pollution, 152*(3). 686–692.

Kim, G. B., Maruya, K. A., Lee, R. F., Lee, J. H., Koh, C. H., & Tanabe, S. (1999). Distribution and sources of polycyclic aromatic hydrocarbons in sediments from Gyeonggi Bay, Korea. *Marine Pollution Bulletin.* 38:7-15.

Kuppusamy, S., Thavamani, P., Venkateswarlu, K., Lee, Y. B., Naidu, R., and Megharaj, M. (2017). Remediation approaches for polycyclic aromatic hydrocarbons (PAHs) contaminated soils: technological constraints, emerging trends and future directions. *Chemosphere* 168, 944–968.

Kvenvolden, K. A., and Cooper, C. K. (2003). Natural seepage of crude oil into the marine environment. *Geo-Marine Letters, 23*(3-4):140–146.

Malla, M. A., Dubey, A., Yadav, S., Kumar, A., Hashem, A., and Abd\_Allah, E. F. (2018). Understanding and designing the strategies for the microbe-mediated remediation of environmental contaminants using omics approaches. *Front. Microbiol.* 9:1132.

Manish, S., Anamika, S., Anjali, Y., and Varun, R. (2019). Source and Control of Hydrocarbon Pollution, *Hydrocarbon Pollution and its Effect on the Environment,* <https://DOI:10.5772/intechopen.86487>

Masindi, V., and Muedi, K. L. (2018). Environmental Contamination by Heavy Metals Error! Hyperlink reference not valid.

Mbah, C., Ukpa, C., Attoe, E., Ojikpong, T.,and Idike, F. (2014). Physicochemical Properties and Heavy Metal Content of Termite Mound in Relation to No-Mound and its Implication in Agriculture. *European Journal of Academic Essays 1*(9): 24-29, 2014

Meagher, R. B. (2000). Phytoremediation of toxic elemental and organic pollutants. *Current Opinion in Plant Biology.* 3:153-162

Mehetre, G. T., Dastager, S. G., and Dharne, M. S. (2019). Biodegradation of mixed polycyclic aromatic hydrocarbons by pure and mixed cultures of biosurfactant producing thermophilic and thermo-tolerant bacteria. *Sci. Total Environ*. 679, 52–60

Meindinyo, R. K., and Agbalabga, F. O. (2012). Radioactivity concentration and heavy metal assessment of soil and water in and around Imirigin oil field, Bayelsa State, Nigeria. *Journal of Environmental Chemistry and Ecotoxicology* 4(2): 29-34.

Miura, K., Shimada, K., Sugiyama, T., Sato, K., Takami, A., and Chan, C. K. (2019). Seasonal and annual changes in PAH concentrations in a remote site in the Pacific Ocean. *Sci. Rep*. 9: 1–10

Ming-Ho, Y. (2005). Biological and Health Effects of Pollutants, *Environmental Toxicology: Boca Raton, USA.* (2) 12, ISBN 1-56670-670-2

Mojiri, A., Zhou, J. L., Ohashi, A., Ozaki, N., and Kindaichi, T. (2019). Comprehensive review of polycyclic aromatic hydrocarbons in water sources, their effects and treatments. *Sci. Total Environ.* 1(1):133971

Momah, M., and OkieimenF., (2019). Composition of Termite Mound Soils in the Ika Area of Delta state in Comparison with Surrounding Top-Soil Samples. *J. Chem Soc. Nigeria.* 44(7):1250 -1258

Musa, M. B., Ajayi, F. A. and Abdulhadi, B. J. (2014). Denudation effect of termitaria and characterization of associated termite species in Laffia, Nasarawa State, Nigeria. *European Scientific Journal, 10*(30): 186 – 195.

NESREA (2011). National Environment Standard and Regulations Enforcement Agency, Lagos, Nigeria.

Nkansah, M. A., Christy, A. A., and Barth, T. (2011) The use of anthracene as a model compound in a comparative study of hydrous pyrolysis methods for industrial waste remediation. *Chemosphere*, 84(4):403-408

Nummelin, M., Lodenius, M., and Tulisalo (2007). Predatory insects as bioindicators of heavy metal pollution. *Journal of Environmental Pollution, 145*: 1339 – 1347.

Nyeko, N. and Oludayo, F. M. (2005). The Participatory Assessment of Farmers Experiences of Termites Problems in Agroforestry in Tororo District, Uganda. *Agricultural Research and Extension Network Papers*, *Overseas Development Institute, London, United Kingdom*. 143:1

Nwankwo, I. L., Ekeocha, N. E., and Ikoro, D. O. (2015). Evaluation of deviation of some soil contamination indicators due to oil spill in Akinima, Rivers State. *Scientific Research Journal* 3(7): 19-24.

Ogboi, E. (2012). Heavy metal movement in crude oil polluted soil in Niger Delta Region. *Journal of Agriculture and Veterinary Sciences 4*: 71-78.

Okop, I. J., and Ekpo, S. C. (2012). Determination of total hydrocarbon content in soil after petroleum spillage. *Proceedings of the World Congress on Engineering* 1(3): 1-3

Ojimba, T. P., and Iyagba, A. G. (2012). Effects of crude oil pollution on horticultural crops in Rivers State, Nigeria. *Global Journal of Science Frotier Research Agriculture and Biology 12(4):* 37-44.

Olubokola, T. I., Doris, F. O., Felix, E. O., and Bull, G. (2015). Consideration of the groundwater quality in Effurun Metropolis, *Environmental and climate change adaptation research*; 4:1-40

Peng, T., Luo, A., Kan, J., Liang, L., Huang, T., and Hu, Z. (2018). Identification of a ring-hydroxylating dioxygenases capable of anthracene and benz anthracene oxidization from *Rhodococcus s*p., *J. Mol. Microbiol. Biotechnol. 28*: 183–189.

Petts, A. E., Hill, S. M., and Worall, L. (2009). Termite species variations and their importance for termitaria geochemistry: towards a robust media approach for mineral exploration. *Geochem.Explor. Environ. Anal.,* 9: 257-266.

Plohl, K., Leskovsek, H., and Bricelj, M. (2002) Biological degradation of motor oil in water. *Acta Chim Slov 49:*279–289

Prince, R. C., McFarlin, K. M., Butler, J. D., and Nedwed, T. J. (2013). The primary biodegradation of dispersed crude oil in the sea. *Chemosphere*; 90(2):521-526. <https://DOI:10.1016/j.chemosphere.2012.08.020>

Ravindra, K., Sokhi, R., and Van-Grieken, R. (2008). Atmospheric polycyclic aromatic hydrocarbons: source attribution, emission factors and regulation. *Atmos. Environ*. 42:2895–2921

Sally, G. & Donald, N. (2002). Bioremediation: an innovative solution for soil contamination. *Aventis Biotech, challenge competition Halifax, Nova Scotia* 1-18

Srogi, K. (2007). Monitoring of environmental exposure to polycyclic aromatic hydrocarbons*. Environ. Chem. Lett. 5*, 169–195.

Thenmozhi, R., Arumugam, K., Nagasathya, A., Thajuddin, N., and Paneerselvam, A. (2013). Studies on Mycoremedation of used engine oil contaminated soil samples. *Adv. in Applied Sc. Res., 4(2)*:110-118

Ubong, U. U., Ikpe, E. E., Ekwere, I. O., and Uwanta, E. J. (2023). Physicochemical and Polycyclic Aromatic Hydrocarbons (PAHs) Analysis in Soil and Sediment from Vicinity of Ikot Akpaden, Akwa Ibom State, Nigeria. *Asian Journal of Biology* 19(1): 16-24.

Uchimiya, M., and Masunaga, S. (2007). Time trend in sources and dechlorination pathways of dioxins in agrochemically contaminated sediments. *Environmental Science and Technology*. 41: 2703-2710. <https://DOI:10.1021/es0627444>

US Environmental Protection Agency (USEPA). (2011). Crude and petroleum products.

Vincent-Akpu, I. F., Tylerb, A. N., Wilson, C., and Mackinnon, G. (2015). Assessment of physico-chemical properties and metal contents of water and sediments of Bodo Creek, Niger Delta, Nigeria. *Toxicological & Environmental Chemistry*; 97(2): 135144.

WHO (2013). (World Health Organization). World Health Organization meetings on the guidelines for drinking-water quality, 2–5, Geneva, Switzerland. 2013.

Wuana, R. A., and Okieimen, F. E., (2011). Heavy Metals in Contaminated Soils: A Review of Sources, Chemistry, Risks and Best Available Strategies for Remediation. *International Scholarly Research Network ISRN Ecology*. <https://doi:10.5402/2011/402647>

Xu, X., Liu, W., Tian, S., Wang, W., and Jiang, P. (2018). Petroleum hydrocarbon-degrading bacteria for the remediation of oil pollution under aerobic conditions. *Frontiers in Microbiology*; 9: 1–11. <https://DOI:10.3389/fmicb.2018.02885>

Zheng, D. M., Wang, Q. C., Zhang, Z. S., Zhang, N. and Zhang, X. W. (2008). Bioaccumulation of total and methyl mercury by arthropods. *Bulletin of Environmental Contamination and Toxicology, 81*: 95 – 100.