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Polycyclic Aromatic Hydrocarbon, Physio-Chemical Properties, and Culturable Microbial Flora of Human Urine-Impacted Topsoils at Commercial Tricycle Parks Along Benin-Sapele Expressway, Benin City, Nigeria.

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Abstract

This study presents an evaluation of the microbiological, physiochemical, and poly aromatic hydrocarbon (PAH) properties of human urine-impacted topsoils from a commercial tricycle park located along Benin-Sapele expressway in Benin City. Several analytical procedures (pour plate method, spectrophotometry, atomic absorbance spectrophotometry, and gas chromatography) were utilized in the determination of the heterotrophic microbial flora, physiochemistry, heavy metal and PAH profiles of the topsoils. The heterotrophic bacterial and fungal counts for the urine-contaminated soils ranged from 8.1×10^4cfu/g to 18.9×10^4cfu/g and 4.4×10^4cfu/g to 8.0×10^4cfu/g, respectively. The heterotrophic bacterial and fungal counts for the control soils were 5.0×10^4cfu/g and 3.1×10^4cfu/g, respectively. The predominant bacterial and fungal genera were Bacillus sp., Klebsiella sp., Alcaligenes sp., Acinetobacter sp, Enterobacter sp., Micrococcus sp., Staphylococcus sp., Aspergillus sp., Penicillium sp., Trichoderma sp., and Candida sp. All the soils were acidic and sandy. The conductivity and organic carbon values for the urine-contaminated soils ranged from 960 µs/cm to 3240 µs/cm and from 3.58 % to 5.39 %. The potassium values for the contaminated soils ranged from 0.05 meq/100g to 0.12 meq/100g. Iron had the highest heavy metal concentration (788.0 mg/kg). The highest concentration of total hydrocarbon content was 43.6 mg/kg. The PAH values of the contaminated soils ranged from 1.47 mg/kg to 2.12 mg/kg. Considering the bio-magnification potentials of these chemical constituents within the ecological food webs and the disgusting stench and unhygienic nature of the urine-impacted environment, there is a need for increasing public awareness to discourage this low-esteemed human behaviour.

Keywords: Microbiological, physiochemical, poly aromatic hydrocarbon, human-urine, topsoils

1. Introduction

A soil environment refers to the weathered geological materials and biological residues that come into contact with the earth's atmosphere (Wilson and Artiola, 2004). The soil environment includes viable plants (roots), animals, and microorganisms that reside in the pore spaces, and are attached to the geological materials. According to Dada and Aruwa (2014), soil organic and inorganic matters are determinants of soil fertility, and they also aid the proliferation of various soil micro flora which in-turn play vital roles in the maintenance of the nutritional balance and geochemical cycles of the soil. The topsoil has the highest concentration of organic matter and microorganisms; it is where most of the Earth's biological soil activity occurs. The majority of microbial population is found in the topsoil and the number decreases as depth increases (Bridge and Spooner, 2001). The microbial population and types of biota found in soils depends on the Physiochemical quality of the soil. Different bacterial and fungal species thrive on various food sources and in different microenvironments in the soil (Dada and Aruwa, 2014).

Heavy metals have a great ecological significance due to their toxicity and accumulative behavior. Polycyclic Aromatic Hydrocarbons (PAHs) result from pyrolytic processes and originate mainly from anthropogenic processes, particularly from any incomplete combustion of organic fuels (matter) at high temperatures (Suchanová et al., 2008). Considering their carcinogenic and mutagenic properties, sixteen PAHs have been classified as priority pollutants by both the U.S. Environmental Protection Agency and the European Environment Agency, in addition to the fact that their health effects have been widely studied (Safo-Adu1 et al., 2014). Although air and drinking water may be responsible for some human exposure, the highest PAH intake is typically associated with their occurrence in diet (food) (Suchanová et al., 2008).

The basic urine constituents are urea, uric acid, minerals, chloride, nitrogen, sulphur, ammonia, copper, iron, phosphate, sodium, potassium, manganese, carbolic acid, calcium, salts, vitamins A, B, C, and E, enzymes, hippuric acid, creatinine, as well as lactose (Dada and Aruwa, 2014). Some possible effects of indiscriminate urination include disgust, damages to property value, impacting the quality of life for the people who have to live with the stench, and spreading diseases (Hoglund et al., 2002). Dada and Aruwa (2014) maintained that the proper disposal of human waste is important to avoid pollution and minimize the possibility of spreading diseases.

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The aim of this study is to evaluate the culturable microbial flora as well as the polycyclic aromatic hydrocarbon levels of human urine-impacted topsoils.

2. Materials And Methods

2.1 Collection of Soil Samples

Samples of topsoils contaminated with human urine were collected from different commercial tricycle parks sited along the Benin-Sapele-Warri expressway, Benin City, Edo State. The topsoil samples were collected with the aid of a standard soil auger at the depths of 0-20 cm; and were dispensed into a labelled sterile polythene bags. Also, a soil sample free of human urine contamination was collected from a sampling point 100 m away from contaminated vicinity along the Benin-Sapele-Warri expressway. The soil samples were immediately transported to the laboratory for analysis. Geographical Position System (GPS) coordinates of the sampling locations were N:06.29174, E005:63277^{o}; N:06.28186, E005:63396^{o}; N: 06.27500, E005:63277^{o}; N: 06.24243, E005:63761^{o}; N: 06.25882, E005:63667^{o} (control).

2.2 Enumeration and Isolation of Heterotrophic Bacteria and Fungi Using General Purpose Media

Ten grams of the respective soil samples were suspended in ninety millilitres (90 ml) of a sterilized nutrient broth in a conical flask. The soil suspension was thoroughly mixed and serially diluted using tenfold dilution. Appropriate dilutions were plated in duplicates on a sterile nutrient agar and potato dextrose agar for total heterotrophic bacterial counts and total heterotrophic fungal counts, respectively. The plates for the total heterotrophic bacterial counts were incubated aerobically at 35 ^{o}C for eighty-four hours; while one millilitre of antibiotic solution (chloramphenicol) was added to the potato dextrose agar plates to inhibit any possible growth of bacterial isolates on the fungal incubated plates at room temperature (28^{o}C ± 5^{o}C) for five days. After incubation, the counts obtained from the culture plates were recorded and expressed as the colony-forming unit per gram (cfu/g) of the original sample. The various isolates were further identified and characterized (Barnett and Hunter, 1975; Cullimore, 2000; Collins et al., 2004; Cheesbrough, 2006).

2.3 Determination of Polycyclic Aromatic Hydrocarbons (PAHs)

Ten grams of the soil samples were weighed into a solvent-rinsed beaker and 50 ml of 50:50 mixtures of acetone and dichloromethane (DCM) was added. The samples were spiked with 1ml of a surrogate mixture (orthoterphenyl-OTP) and placed in a sonicator for fifteen minutes at 20 ^{0}C. Ten grams of anhydrous sodium sulphate was then added to the sample and allowed to stand until a clear extract developed and was decanted. One milliliter (1ml) of the extracted samples was dissolved in n-hexane (HPLC grade) in order to elute the aliphatic hydrocarbons. The eluted samples were concentrated using a rotatory evaporator to about 3 ml, and was transferred into a teflone lined screwed vial and labeled for gas chromatography (GC) for the PAH analysis using Gas Chromatography (Agilent, Hewlett Packard 6890 series).

2.4 pH and Electrical Conductivity

Twenty grams of the air-dried soil samples was dispensed into a sterile beaker. Twenty millilitres (20 ml) of distilled water was added, and the mixture was stirred vigorously. The mixture was, then, allowed to stand for ten minutes before the pH was read using a calibrated pH meter. Also, a digital conductivity meter was used in determining the soil conductivity by dipping the sensitive rod into the mixture and a steady reading was taken.

2.5 Total Organic Carbon

Prior to analysis, 50 g of the soil was air-dried and sieved using a 2 mm metallic sieve. The soil was then ground to a fine consistency and re-sieved using a 0.5 mm metallic sieve. Approximately 0.5 g of the sieved soil was dispensed into a clean 250 ml conical flask and 10 ml of N $K_2Cr_2O_7$ and 10 ml of Conc. H_2SO_4 were, respectively, added to the flask. The mixture was shaken for one minute and allowed to cool. 60 ml of distilled water was added to the cooled solution to make the volume up to 150 ml, and the mixture was shaken and allowed to settle. Five millilitres (5 ml) of phosphoric acid and 8-10 drops of 1% diphenylamine solution were added, making the solution assume a dark violet color. This solution was titrated against 0.4 N ferron ammonium sulphur solution until a color change from violet to green was observed (Onyeonwu, 2000).

Calculation

%C = Titre × 0.24
%C = Bk – Titre × 0.24
Total Organic Carbon = (Bk – Titre) × 1.72.

2.6 Particle-Size Distribution

Fifty grams of the fine textured air-dried soil samples was transferred into a one-litre dispersion cup. One-hundred millilitres of freshly 0.1M sodium hydroxide solution was added to the dispersion cup. After thorough mixing, the mixture was placed on a mechanical shaker for four hours. The mixture was thereafter transferred to a (1 L) measuring cylinder, and the volume was made up to one litre with distilled water. The mixed solution inside the cylinder was shaken by inversion, and the time was noted. After forty seconds, a hydrometer was inserted into the cylinder, and at five minutes, the hydrometer scale was read and the temperature of the mixture was also noted. The hydrometer was withdrawn and the process was repeated three hours later (Onyeonwu, 2000).

Calculation

$$\text{(a) Silt + Clay\%} = \frac{\text{corrected hydrometer reading at 40 seconds}}{\text{Sample weight (g)}} \times 100\%$$

$$\text{(b) Clay\%} = \frac{\text{corrected hydrometer reading at 5 hours}}{\text{Sample weight (g)}} \times 100\%$$

(c) Sand (%) = 100 – (a) - (b).

2.7 Exchangeable Acidity

Five grams of air-dried soil was weighed and dispensed into a 150 ml plastic bottle. Fifty millilitres (50 ml) of potassium chloride was added and shaken mechanically for one hour. The mixture was filtered with the aid of Whatman filter paper No.1 into 250 ml conical flask. Thereafter, three to five drops of phenolphthalein indicator were added and titrated against the 0.05M NaOH until the colourless solution turned to pink (Onyeonwu, 2000).

Calculation

Exchangeble Acidity = 0.05M ×Titre × 20 meq/100g soil

2.8 Ammonium-Nitrogen

Prior to the estimation of the NH_4-N value of the soil samples, a filtered extract of the soil was prepared by weighing 10 g of the soil into 150 ml conical flask. Forty

(40 ml) millilitres of the extracting solution was added and shaken for thirty minutes. The solution was then filtered using a Whatman filter paper No 1. Five millilitres (5 ml) of the extract was pipetted into a clean beaker after which 2.5 ml of alkaline phenol, 1 ml of sodium potassium tartrate and 2.5 ml of sodium hypochlorite were added, respectively. The solution was shaken vigorously in between each addition, and the resultant solution was read at 636 nm (Onyeonwu, 2000).

Calculation

$$NH_4N \text{ (ppm as } \alpha/g \text{ for soil)} = \frac{IR \times SR \times Vol.}{Wt. \text{ of sample} \times Aliquot \text{ taken}}$$

IR: instrumental reading
SR: slope reciprocal
Vol: volume
Wt. of sample: weight of sample

2.9 Nitrate

Ten millilitres (10 ml) of the sodium acetate soil extract filtrate was pipetted into a 50 ml flask. Two millilitres (2 ml) of brucine and 10 ml of conc. H_2SO_4 were added sequentially. The resultant solution was mixed and allowed to stand for ten minutes. The solution was read spectrophotometerically at 470 nm (Onyeonwu, 2000).

Calculation

$$NO_3 \text{ (ppm as } \alpha/g \text{ for soil)} = \frac{IR \times SR \times Vol}{Wt. \text{ of sample} \times Aliquot \text{ taken}}$$

IR: instrumental reading
SR: slope reciprocal
Vol: volume
Wt. of sample: weight of sample

2.10 Sulphate

Ten millilitres (10 ml) of the sodium acetate soil extract filtrate was transferred into 50 ml conical flask. The volume of the filtrate was made up to 20 ml by the addition of 10 ml of distilled water. One millilitre (1 ml) of gelatine – $BaCl_2$ reagent was added, and the mixture was shaken and allowed to stand for thirty minutes. The solution was read at 420 nm (Onyeonwu, 2000).

Calculation

$$SO_2 \text{ (ppm as } \alpha/g \text{ for soil)} = \frac{IR \times SR \times Colour\ Vol. \times Extra.\ Vol.}{Wt. \text{ of sample} \times Aliquot \text{ taken}}$$

IR: instrumental reading
SR: slope reciprocal
Vol: volume
Wt. of sample: weight of sample

2.11 Chloride

Ten millilitres (10 ml) of the sodium acetate soil extract filtrate was transferred into a 250 ml conical flask. Three drops of K_2CrO_4 were added, and the solution was titrated against 0.05 M silver nitrate until the formation of slight red precipitate (Onyeonwu, 2000).

Calculation

$$Cl^- \text{ (}\alpha/g \text{ for soil)} = \frac{Molarity \times Titre \times Vol. \times 1000}{Wt \text{ of sample} \times Aliquot \text{ taken}}$$

Vol: volume
Wt. of sample: weight of sample

2.12 Cation Exchangeable Bases (Na, K, Ca, Mg)

Five grams of the air-dried soil was weighed into a conical flask. One-hundred milliliters (100 ml) of neutral 1 M ammonium acetate was then added to the soil, and the mixture was shaken with the aid of a mechanical shaker for thirty minutes. The mixture was filtered using a Whatman filter paper No 42 into a 100 ml volumetric flask. The filtrate was made up to mark with acetate. Stock working standards 0, 2, 4, 6, 8, and 10 ppm were prepared for sodium, potassium, calcium, and magnesium, and the concentration of the exchangeable cations (Na, Ca, K and Mg) in the filtrate was determined using a flame photometer. The utilized blank was ammonium acetate (Onyeonwu 2000).

Calculation

$$Ca \text{ (Meq/100g)} = \frac{Instrument\ reading}{Weight \text{ of sample} \times Eq.\ wt.} \times 100\%$$

$$K \text{ (Meq/ 100g)} = \frac{Instrument\ reading}{Weight \text{ of sample} \times Eq.\ wt.} \times 100\%$$

$$Mg \text{ (Meq/ 100 g)} = \frac{Instrument\ reading}{Weight \text{ of sample} \times Eq.\ wt.} \times 100\%$$

$$Na \text{ (Meq/ 100 g)} = \frac{Instrument\ reading}{Weight \text{ of sample} \times Eq.\ wt.} \times 100\%$$

2.13 Determination of Heavy Metals:

The soil was sieved, and 5 g of the soil samples was taken from the sieved soil and dispensed into a beaker. Ten milliliters (10 ml) of nitric acid was added to the sample. The sample was digested at 105°C for forty-five minutes after which it was allowed to cool to room temperature. The cooled digest was washed into a standard volumetric flask, and was made up to the mark with distilled water (Onyeonwu, 2000). The heavy metals (Pb, Cd, Mn Fe, Cu, Cr, Ni, V, and Zn) levels were analyzed using an Atomic Absorbance Spectrophotometer (AAS) (MODEL-SOLAAR 969 UNICAM SERIES).

2.14 Determination of Total Hydrocarbon Content

One gram of the air-dried soil samples was dissolved in 10 ml of hexane and shaken for ten minutes using a mechanical shaker. The solution was filtered using a Whatman filter paper No. 42, and absorbance was read at 460 nm (Akpoveta et al., 2011).

$$THC \text{ (mg/Kg)} = \frac{OD\ reading \times Volume\ of\ Solvent\ Used}{Weight\ of\ soil\ sample\ (Kg)}$$

3. Results

The results of heterotrophic bacterial and fungal counts were in the order of 10^4 cfu/g for both (table 1 A). The heterotrophic bacterial and fungal counts for the control were 5.0×10^4cfu/g and 3.1×10^4cfu/g, respectively (Table 1). The heterotrophic bacterial counts and heterotrophic fungal counts for the urine-contaminated soils ranged from 8.1×10^4cfu/g for sample 4 to 18.9×10^4cfu/g for sample 2, and from 4.4×10^4cfu/g for sample 4 to 8.0×10^4cfu/g for sample 3, respectively. The culturable microbial isolates were: Bacillus sp., Klebsiella sp., Alcaligenes sp., Acinetobacter sp., Enterobacter sp., Micrococcus sp., Staphylococcus sp., Aspergillus sp., Penicillium sp., Trichoderma sp., and Candida sp. The most dominant bacterial isolates were Bacillus sp., Enterobacter sp.. Micrococcus sp. was isolated from all the soils, whilst Aspergillus sp. and Penicillium sp. were the dominant fungal isolates (table 1B).

The results of the physiochemical analysis are shown in table 2. All the soils were acidic (pH ranging from 4.28 to 5.82) and sandy (ranging from 91.1 % to 92.4 %). The conductivity and organic carbon values for the urine-contaminated soils ranged from 960 µs/cm for sample 3 to 3240 µs/cm for sample 1, and from 3.58 % for sample 3 to 5.39 % for sample 1. The sodium and potassium values for the contaminated soils ranged from 1.09 meq/100g for sample 3 to 1.84 meq/100g for sample 1, and from 0.05 meq/100g for sample 2 to 0.12 meq/100g for sample 3. The

calcium, magnesiumm and chloride values for the urine-contaminated soils ranged from 2.85 meq/100g for sample 3 to 3.95 meq/100g for sample 1, 0.74 meq/100g for sample 1 to 1.20 meq/100g, and from 89.4 mg/kg for sample 3 to 177.7 mg/kg for sample 1. The ammonia-nitrogen and nitrate content of the urine-contaminated soils ranged from 8.48 mg/kg for sample 3 to 15.6 mg/kg for sample 1, and from 10.4 mg/kg for sample 3 to 15.2 mg/kg for sample 1. The sulphate and exchangeable acidity values for the contaminated soils ranged from 7.4 mg/kg for sample 3 to 17.0 mg/kg for sample 1, and from 0.6 meq/100g for sample 4 to 1.3 meq/100g for sample 2.

The results of the heavy-metal analysis of the soils are presented in table 3. Iron had the highest concentration, which ranged from 162.2 mg/kg (control) to 788.0 mg/kg (sample 1). This was followed by manganese with a range of 12.4 mg/kg (control) to 67.7 mg/kg (sample 1). The PAHs values for the soils are shown in table 4. The total concentration of PAHs ranged from 0.10 mg/kg (control) to 2.05 mg/kg (sample 2).

Table 1A. The heterotrophic microbial counts of the urine-contaminated and control soils

Soil samples	Total Heterotrophic Bacterial count ($\times 10^4$cfu/g)	Total heterotrophic fungal count ($\times 10^4$cfu/g)
Control	5.0	3.1
Location 1	16.8	7.5
Location 2	18.9	7.1
Location 3	17.2	8.0
Location 4	8.1	4.4

Table 1B. Occurrence of the microbial isolates in the soils

Sample Code	Bacterial isolates present	Fungal isolates present
Control	Bacillus sp., Enterobacter sp., Micrococcus sp., Alcaligenes sp.	Aspergillus sp., Penicillium sp.
Location 1	Bacillus sp., Staphylococcus sp., Enterobacter sp., Micrococcus sp.	Aspergillus sp., Penicillium sp., Candida sp.
Location 2	Bacillus sp., Acinetobacter sp., Micrococcus sp.	Aspergillus sp., Penicillium sp.
Location 3	Bacillus sp., Klebsiella sp., Enterobacter sp., Micrococcus sp.	Aspergillus sp., Trichoderma sp., Penicillium sp., Candida sp.
Location 4	Bacillus sp., Enterobacter sp., Micrococcus sp., Staphylococcus sp.	Aspergillus sp., Penicillium sp., Candida sp.

Table 2. Physiochemical values of the urine-contaminated and control soils

Soils	pH	EC	Org.C	EA	Na	K	Ca	Mg	Cl	THC	NH_4N	NO_3	SO_4	Clay	Silt	Sand
		(µS/cm)	(%)	(meq/100g)						(mg/kg)					(%)	
Control	5.82	270	1.51	0.4	0.63	0.12	0.96	0.50	37.5	2.17	2.28	3.36	1.62	5.9	2.5	91.6
Location 1	4.28	3240	5.39	1.1	1.84	0.09	3.95	0.74	177.7	43.6	15.6	15.2	17.0	6.9	1.8	91.3
Location 2	4.36	2950	4.22	1.3	1.29	0.05	3.11	0.88	143.6	35.2	11.9	13.5	14.8	5.4	2.2	92.4
Location 3	4.93	960	3.58	0.9	1.09	0.12	2.85	0.91	89.4	25.3	8.48	10.4	7.4	6.1	2.5	91.4
Location 4	5.20	1210	4.18	0.6	1.36	0.10	3.07	1.20	125.2	17.0	9.47	12.3	9.1	5.8	3.1	91.1

KEY: EC; Electrical conductivity, T. N; Total nitrogen, Org. C; Organic Carbon, EA; Exchangeable acidity, THC: Total Hydrocarbon content

Table 3. Heavy-metal values of the urine-contaminated and control soils

Code	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	Cr (mg/kg)	Cd (mg/kg)	Pb (mg/kg)	Ni (mg/kg)	V (mg/kg)
Control	162.2	12.4	1.0	0.0	0.0	0.0	0.03	0.03	0.0
Location 1	788.0	67.7	5.1	0.0	0.0	0.0	3.0	1.0	0.0
Location 2	729.1	54.2	2.0	0.0	0.0	0.0	2.5	1.0	0.0
Location 3	531.3	28.4	5.9	0.0	0.0	0.0	2.0	0.1	0.0
Location 4	685.1	32.6	4.2	0.0	0.0	0.0	1.1	0.7	0.0

Table 4. Poly aromatic hydrocarbon values of the urine-contaminated and control soils

Sample Code	Control	Location 1	Location 2	Location 3	Location 4
COMPONENT					
Naphthalene	0	0	0	0.07	0
Acenaphthylene	0	0	0	0.30	0
Acenaphthene	0	0	0	0	0
Fluorene	0	0	0.27	0.17	0
Phenanthrene	0	0	0.19	0.08	0.32
Anthracene	0	0	0	0	0
Fluoranthene	0	0.18	0.40	0	0
Pyrene	0	0.15	0	0	0.35
1,2-Benzothracene	0	0	0.30	0.11	0
Chysene	0	0	0	0	0
Benzo(b)fluoranthene	0	0.45	0	0	0
Benzo(k)fluoranthene	0	0	0	0	0.36
Benzo(a)pyrene	0	0.08	0.23	0.18	0.35
Dibenzo(a,h)anthracene	0	0.53	0.22	0.41	0.04
Benzo(g,h.i) perylene	0.04	0.10	0.21	0.08	0.06
Indeno(1,2,3-cd)pyrene	0.06	0.04	0.30	0.07	0.06
Total mg/kg	**0.10**	**1.53**	**2.12**	**1.21**	**1.54**

4. Discussion

Expectedly, the culturable microbial flora of the human-urine-impacted soil samples was comparatively higher than the counts recorded for the control soil (table 1). This trend was collaborated by the higher conductivity, total hydrocarbons, and macro nutritional values of the contaminated soils in comparison with the control soil (table 2). These trends suggest possible characteristic changes on the microbial diversity and physiochemical status of the exposed soil as a result of continuous urine contamination. The microbial isolates identified from the examined soils were similar to the isolates reported by Dada and Aruwa (2014) who investigated the culturable microbial flora of human urine-impacted soils collected from around lecture theatres within the Federal University of Technology, Akure. The isolation of gram-positive bacterial cultures such as Bacillus sp. and Micrococcus sp. (table 1B) was not surprising, given the fact that these organisms are normally present in tropical soils and are also known to withstand adverse environmental conditions. Dada and Aruwa (2014) reported that the micrococci are known to grow well in environments with little water or high salt concentrations. They also described the Bacillus species as versatile chemo-heterotrophs capable of respiration using a variety of simple organic compounds (sugars, amino acids, organic acids). Also, expectedly, Aspergillus sp. and Penicillium sp. were isolated from all the studied soils (table 1B). These filamentous micro fungi are known to be ubiquitously distributed in the environment especially in the soil and air niches. The pH values of the urine-polluted soils were comparatively lower than the values indicated by the control soil (table 2). This phenomenon might be ascribed directly to the effect of the urine on the topsoil. Dada and Aruwa (2014) reported the same trend and stated that fungal growth favours low pH more than a bacterial growth in the urine-contaminated soils.

The presence of heavy metals and poly cyclic aromatic hydrocarbon in the studied soil samples (tables 3 and 4) may be attributed to the impact of anthropogenic activities or practices in the area. Examples of some of these practices include: vehicular emissions and indiscriminate disposal of refined petroleum products and used batteries. The heavy-metal concentrations in the control soil were comparatively lower than levels recorded in the urine-contaminated soils (table 3). This trend might also be attributed to natural factors such as the elemental composition of the underlying parent rock material from which the soil was formed. The possible source of the PAHs in the soils can be attributed to the deposition of refined petroleum products on the soils over time. The detection of PAHs in both the control and the urine-impacted soils could be a reflection of the ubiquitous distribution of these compounds in the soils. However, this trend is relevant to public health because these compounds

are known to have a lipophilic nature, and because heavy metals and PAHs have a high potential for biomagnification through trophic transfers (Clements et al., 1994). From the results of this study, dibenzo (a, h) anthracene, benzo (b) fluoranthene, benzo (k) fluoranthene, benzo (a) pyrene, pyrene and phenanthrene were generally observed to be high among the PAH tractions.

5. Conclusions

Considering the bio-magnification potentials of these chemical constituents within the ecological food webs, the chemical contents of primary producers, such as plants growing around urine- impacted soils, should be investigated. The disgusting-stench and unhygienic nature of the urine impacted environments also call for the need to increase public awareness for the sake of discouraging this low-esteemed human behaviour.

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