https://dx.doi.org/10.4314/dujopas.v10i3a.12
ISSN (Print): 2476-8316
ISSN (Online): 2635-3490
Dutse Journal of Pure and Applied Sciences (DUJOPAS), *Vol. 10 No. 3a September 2024*

Persistent Organic Pollutants (POPs) in Farmland Soils of Kumo Akko Local Government Area, Gombe State, Nigeria

[1]Usman Y. M, [2] Pantami H. A, [3]Ndahi J. A, [4]Modibbo U. U, [5] Abdullahi Z. A, [6]Yau A., [7]Baka E. F., [8]Liman I.A.

[1,2,5,6,7]Department of Chemistry,
Gombe State University
P.M.B. 127 Gombe,
Gombe State
Nigeria.

[3,4] Modibbo Adama University of Technology Yola
PMB 2076 Yola,
Adamawa State.

[8]Nigerian Army Institute of Science Education and Technology,
PMB 1410 Ilorin
Kwara State.

Email: usmanym45@gsu.edu.ng

Abstract

This work investigated the Prevalence and Impact of Persistent Organic Pollutants (POPs) In Farmland Soil within the Vicinity of Kumo, Gombe State, Nigeria. by employing a combination of field sampling and laboratory analysis. The research aimed to analyze the present of the concentrations of POPs in farmland soils using GC-MS. Samples were collected from three different locations and analyzed, their content of POPs per sample area determined the major components present. The results obtained indicated the POPs components of each soil sample. The research revealed that eight components of POPs such as naphthalene with a retention time of 5.02 minutes amounting to a highest composition of 0.004141 ppm followed by acenaphthene with a retention time of 8.82 minutes which showed 0.00395 ppm. Moreover, phenanthrene showed the least concentration of 0.000139 ppm with a retention time of 12.5 minutes. The physical parameters of the farmland soil revealed the mean pH values of sample soil investigated with S3 having the highest value of 6.01 followed by S1 with pH value of 5.95, while S2 showed the lowest pH value of 5.20. This showed that the acidity value increase in the order of S2=5.20 < S1=5.95<S3=6.01 respectively.

Keywords: Organic, pollutants, persistent, threats, components, Income

Author for Correspondence

INTRODUCTION

Persistent Organic Pollutants (POPs) are the major pollutants originating from the chemical spreading during agricultural practices; they are also toxic chemicals, initiated to prevent effects of insecticides and pesticides on crops grown. This chemicals turn to safeguard both the environment and human health required at permissible limits but eventually become pollutants as they are constantly applied on farmland soils bio-accumulated at the top of the soil.

Land, soil and water are the focal components of environmental impacts that are commonly contaminated by weathering, mining and agricultural practices which affect the existence of human civilization. These natural resources were altered from the original due to changes of human activities and natural processes such as leaching, mineralization, volcanic eruption, and anthropogenic activities such as industrial waste and many more. Changes of these essential resources leads to greater threats to the environmental components such as soil erosion, eventually emanate inadequate clean drinking water at the same time reducing agricultural output.

Natural sources of organic pollutants occurred during Precambrian era, however, activities of human development in technology and industrial revolution alter the natural composition as they pose a threats to environment and ecosystem. Bush burning of remains of vegetation is also another source of organic pollutants in the soil. Among the most harmful organic pollutants are polycyclic aromatic hydrocarbons which become toxic to human health when absorbed beyond permissible limits, hence they pose carcinogenic pathways into human bodies. Compounds of these characteristics passes into the soil as remnants of bush burning of biomass and vegetation, they are constantly absorbed in the surface of the soil and also leached into the soil water as dissolve ions by rainwater that are absorbed by plants. Organo-halogen compounds also originated in soil by to the burning of fossil fuels and dead/decayed flora and fauna that occurred due to spontaneous reactions of volcanic eruptions and other geological activities.

There are several types of pollutants including range of harmful organic compounds that are persistently utilized at higher concentrations above recommended levels, substances such as Organo Choloro Phosphates (OCPs,), Poly Chlorine bi Phynyls (PCBs), and Poly Amide Hydrazines (PAHs), that serve as fatty acids bestowed in the dermis of skin. These organic chemicals became threats to the ecosystem affecting negatively to both Plants and Animals (Mukaj *et al*., 2016). Other common POPs and PAHs such as anthracene, pyrene and fluoranthene are said to exhibit harmful effects when constantly absorbed in food substances and are possible human carcinogens as stated by Wenjing *et al*., (2019). PAHs also damage DNA, causes oxidative stress, impaired male fertility, cause to respiratory diseases, cognitive dysfunction and many effects on female youths causing breast cancer (Wenjing *et al*., 2019).

Thus, permissible limits knowledge of these POPs compounds is paramount to safeguard and to mitigate the negative impacts of these components to ecosystem and human activities in general (Begum *et al*., 2021). Environmental experts revealed that tremendous implications occurred on application of pesticides and other agricultural chemicals during farming activities affect the natural soil particles concentrations, thereby releasing contaminants as residues, posing a threat to ecological health. Qualitative and quantitative determination of these pollutants impacts on the environment are the focus concerns of researchers nowadays leading to qualitative human health and the ecosystem in general. (Mukaj *et al*., 2016).

Elaborated research with ideas on the environmental impacts and human health risks effect are very important to detect these sources of POPs and threats on the ecosystem, significantly mitigate consequences of these pollutants on ecosystem. (Begum *et al.*, 2021). This research focused the excess of amount of POPs deposited as pollutants in Kumo soil due constant agricultural activities conceded.

MATERIALS AND METHODS

Study Area

This study was carried out in Kumo, Akko local government area of Gombe State, Nigeria which was located on the A345 highway approximately 40 kms south of Gombe. Kumo town existed on coordinate's points of 10.0496° N, -11.1997° E. It serves as an Agricultural and commercial center collecting point for vegetables, peanuts (groundnuts), cotton, and corn (maize) and also a commercial center for sorghum, millet, cowpeas, cassava (manioc), goats, sheep, cattle, fowl, and cotton raised by the Fulani, Tangale, and Hausa people of the surrounding area.

MAP OF STUDY AREA

10.0496° N, -11.1997° E

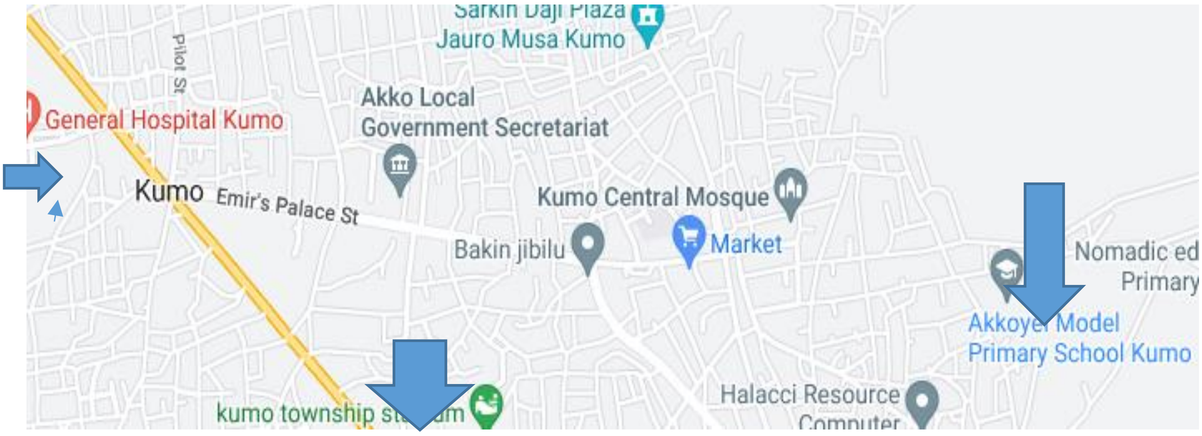

Figure 1. Map of Area of Study. Source; Google maps

Sample Collection

Three different samples locations each with two alternative samples of soils were collected from different locations at an interval of 10 km apart from each other. Samples were identified with local names and coded as A1= Akkoyel primary school kumo soil, A2=University of science and Technology Kumo soil, A3=General Hospital kumo soil. These different samples were collected from kumo farmland. Then two corresponding samples from each location were mixed together to form representative fraction suitable for the analysis as adopted with little modifications from Usman *et al*., (2018).

Sample Preparation

Soil samples collected from the three sample locations were dried by open air circulation on clean spread polythene bag on top of laboratory tiles for three days until completely dried.

Mortar and pestle were used that grinded the dried soil samples and sieved with 2 mm sieve that obtained powder form of the required amount for analysis. Gross samples were reduced to test sample sizes through the process of cone and quartering that obtained a representative fractions. Required portions of about 50g were taking from the two opposite sides of the quarter for sampling process was obtain with little modifications as reported by Ndaji *et al*., (2016)

Analysis of pH Values of Soil
Exactly 2g of the preserved soil samples from the three sample locations ware separately weighed and placed into a three 250 cm^3 beakers and 20 cm^3 of distilled water was added to each sample. Constant stirring with a glass rod was carried out and shaken moderately that made sample components became homogenous mixtures. A pre –calibrated pH meter was inserted into the mixtures separately and kept for 10 seconds to calibrate the pH meter reading, values was recorded as adopted with small modifications as reported by Muhammed and Maitera, (2023).

Determination of Ash Content
The collected samples from the samples locations are analyzed by process as described by REFERENCE with modifications. Exactly 2g of the portion of representative fraction of the samples from sample locations was measured (W1) as initial weight were place into an empty crucible (Wo) and placed into muffle furnace until the sample was completely heated into ashes at temperature 600 ^oC. The content of the crucible comprising the ash was removed from the furnace and cooled in a desiccator and weighed (W2). The cooled sample ash was measured by calculating the difference between the ash sample and initial empty weight of the crucible. Percentage ash was calculated using the formula below (Fai *et al*., 2013).

$$\%\ \text{Ash} = \frac{W2-Wo}{W1-wo} \text{ X } 100$$

Conductivity Test
A 50cm^3 distilled water was poured into 5g each of the samples from three locations and was shaken in an extraction bottle with mechanical shaker for 1 hr. Suspension turbidity was removed at lowest level by filtering the content from the bottle, then two drops of 0.1% Na_2PO_3 was added to the filtrate from each prepared samples. Conductivity meter indicator end was dipped into each sample solutions and the correct values was captured in $NScm^{-1}$ as adopted with little modifications from Usman *et al*., (2018).

Soil Texture Analysis
A mesh sieve was used to filter the soil collected from the sample location to remove unwanted dirt and other consolidated particles, the separated soil was then poured into a 400cm^3 beaker. The content of the soil was then emptied into a jar which was to be tested. Clean water was poured into the jar with soil, with a little air space at the top. The jar was then closed with a cap and shaken vigorously until the soil particles turned into uniform slurry. Time of one minute was then set on a level surface which allowed the particle to separate into layers. Meanwhile, a level mark was indicated outside of the jar, representing different soil layer settled ranging from bottom to the final level indicated on the jar. The content under investigation inside the jar was left for two hours to form several layers of different parts. Level indicated with marker at the top of the jar form the silt layer followed by the clay layer which accumulated at the top of the silt layer, finally the sand form the bottom layer. A ruler was used that measured and recorded the height of each layer form after

48 hours of settlements of the investigated soil samples and the total heights of all three layers was estimated and plotted on bar chats as adopted by Andrew, (2023).

Analysis of PAHs from POPs

Using the portion of the prepared soil sample, 25 g was weighted into a flask, and 1 ml of a solution of the standards of about 10 mg each in deuterated PAH together with 50 cm^3 of acetone was added. The flask was shaken vigorously for 1 hour. Later 50 cm^3 of petroleum ether was added into the solution, shaken while unreacted parts of the mixture was removed, then second portion of 50 cm^3 of petroleum ether was then added. The solution extracts were placed into a separatory funnel to remove impurities. Acetone and other polar compounds were then eliminated by shaking for the second time with 400 cm^3 of water. Organic layer was dried after evaporating water content over anhydrous sodium sulphate and the extract was poured into evaporation panel to remove water content, and 100 cm^3 of isooctane was added to stabilize the mixture. The extract was concentrated under reduced pressure to 10 cm^3. Further concentration was done using a gentle stream of nitrogen at room temperature. The extracted PAHs were determined by GC-MS process using internal standard addition after extraction as adopted with slight modifications from Mimoza *et al*., (2016).

RESULTS AND DISCUSSIONS

Ash Content of Soil Sample

Analysis of ash content of three samples of soil showed that sample S1 has the highest ash content of 11.5% followed by sample S2 with 6.0% Ash content. Among the three samples of soil S2 showed the lowest ash content of 2.5%. The result obtain is

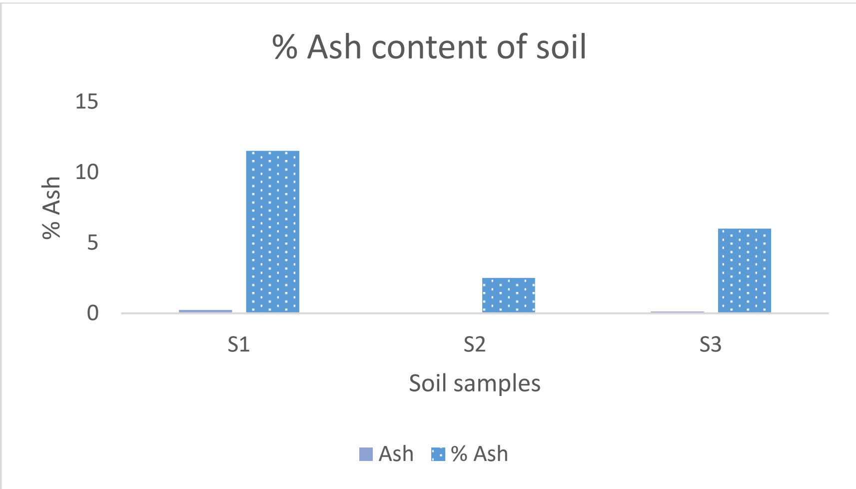

Figure 2. Ash Content of Soil Samples

pH Values of Soil Samples

The mean pH values of sample soil investigated showed that Hospital area soil (S3) has 6.01 followed by Akkoyel soil (S1) with pH value of 5.95, while University area soil (S2) showed the lowest pH value of 5.20. This showed that the trend in acidity value of analyzed soils decrease in the order as S2=5.20 > S1 = 5.95 > S3 = 6.01 respectively. The result obtain indicated that Hospital area soil of kumo has higher acidity content than all the other soil samples investigated. This indicated that Akkoyel was more alkaline than the other samples, which was subsisted to higher POPs content due its higher spread of pesticides and insecticides at that location of Kumo town. The result obtained was contrary to pH values of 3-6 as investigated by Muhammed and Maitera, (2023).

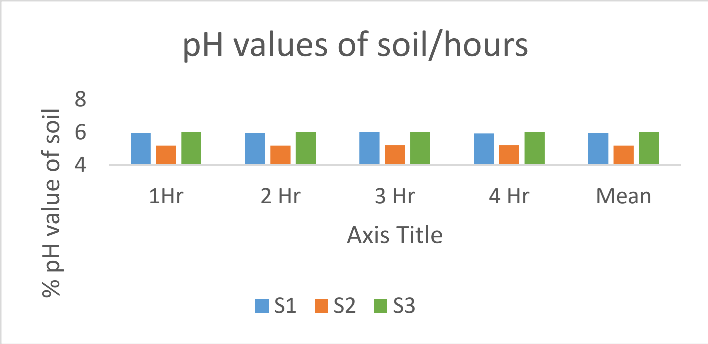

Figure 3. pH Values of Soil Samples

Conductivity Test of Soil

The result on figure 4 showed that S2 has the highest conductivity of 0.26 μScm^{-1} followed by S3 with conductivity of 0.24 μScm^{-1} while S1 showed the least conductivity of 0.23 μScm^{-1} respectively. This indicated that the value decrease in the order as S2=0.26 μScm^{-1} > S3=0.24 μScm^{-1} > S1=0.23 μScm^{-1} accordingly. The result obtain was contrary to pH values rage of 3.7 to 2.2 μScm^{-} as investigated by Usman *et al.*, (2018).

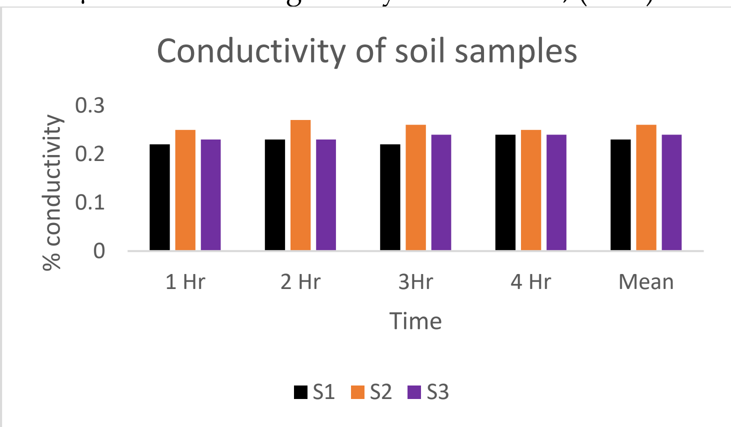

Figure 4. Conductivity of soil samples in μScm^{-1}.

Soil Texture Analysis

Three soil samples from Kumo farmland were analyzed and the results was shown as measurements conducted on samples after shaken with water in jar and left for 48 hours that formed layers; S1 soil showed a height of sand layer = 1.0 cm with silt height layer = 0.9 cm, clay height layer = 0.1 cm. Total height of layers = 2.8 cm, the percentage layers displayed after investigation was calculated using the formula mentioned in the methodology and results shown as; % Sand = 35.71% > % Silt = 32.14% > % Clay = 3.57%. Thus S1 soil from Akkoyel primary area of kumo contain high percentage sandy soil than all the three samples of soil investigated.

Sample S2 sample were analyzed and the result was shows as follows; Measurements stratified layers conducted after shaken in jar with water, Sample S2 showed sand height layer = 0.9 cm with silt height layer = 0.8 cm and clay height layer = 0.1 cm. Total height of layers = 2.9 cm, the percentage layers displayed after investigation was calculated using the formula mentioned in the methodology and result show as % Sand = 31.03 > % Silt = 27.58 > % Clay = 3.44, S2 Soil from University area have moderate amount of sandy sol hence the soil type was perfect for agricultural process than Akkoyel primary area soil and Hospital area soil. Moreover, the percentage of silt and clay was also moderate.

Also Sample S3 soil analyzed showed as measurements conducted stratified layers of soil form after shaken in jar with water, where Sample S3 showed a sand height layer = 1.0 cm while slit height layer = 0.8 cm, clay height layer = 0.2 cm. Total height of layers = 2.8 cm, the percentage layers displayed after investigation was calculated using the formula mentioned in the methodology and result show as % Sand = 35.71 > % Silt = 28.57 > % Clay = 7.14
The investigation on soil texture showed that Kumo soil was perfect for agricultural process but applications of pesticides may have reduced natural quality of the soil as excess concentrations of POPs were determined. Also the percentage composition of three major layers of soil ranges 31.0 % to 35.7% was contrary the result of 45% sand as investigated by Andrew, (2023).

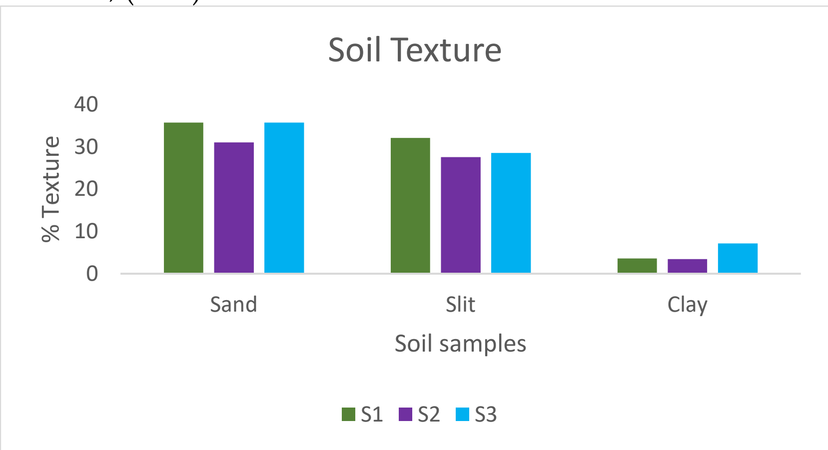

Figure 5. Soil Texture

POP Composition of Sample S1

Figure 6 Indicated the composition of Akkoyel area soil which shows the presence of eight persistent organic pollutant in decreasing order as naphthalene with a retention time of 5.02 minute revealed a highest composition of 0.004141 ppm followed by acenaphthene with a retention time 8.82 minute showed 0.00395ppm followed by fluorene with a retention time 10.15 minutes showed 0.001525ppm followed by acenaphthylene with a retention time 8.45 minutes showed 0.001384ppm followed by 2-methylnaphthalene with a retention time 6.90 minute showed 0.001013ppm followed by fluoranthene with a retention time 15.5 minute showed 0.000239ppm followed by pyrene with a retention time 15.5 minute showed 0.000227ppm followed by phenanthrene with a retention time 12.5 minutes showed 0.000139ppm. This indicated as naphthalene > acenaphthene > fluorene > acenaphthylene > 2-methylnaphthalene > fluoranthene > pyrene > phenanthrene respectively. The result obtain of the eight POPs components in S2 soil sample ranges between 0.000139 to 0.004141 ppm which was contrary to the POPs values of organochlorine pesticides(OPC) and its metabolites (0.51–0.53 µg L^{-1}) as investigated by Al-Alimi *et al*., (2022).0.000139ppm to 0.004141 ppm. Also 16 PAHs residues investigated by Mimoza *et al*., (2016) ranged between 8.93 - 13.19 and 39.10 - 50.21 µgkg

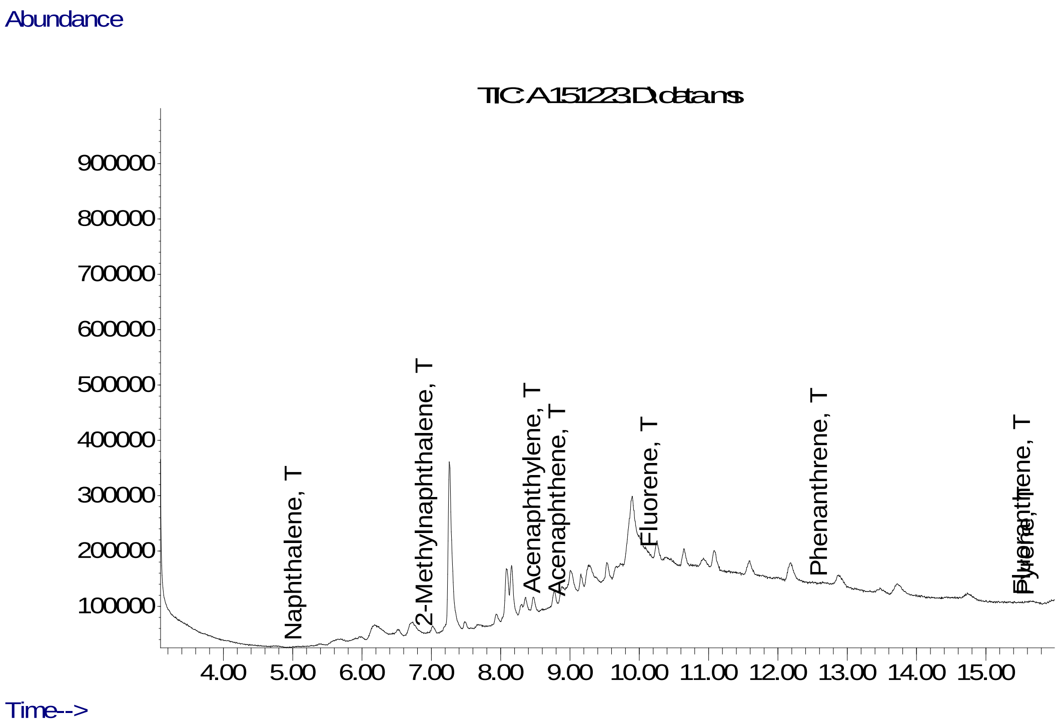

Figure 6. Total ion chromatogram (TIC) showing POP Component of Sample A

POP Component of Sample S2

Figure 7 indicate the composition of University area soil sample which shows the presence of eight persistent organic pollutant in decreasing order as naphthalene with a retention time of 4.97 minute revealed a highest composition of 0.006924 ppm followed by acenaphthene with a retention time of 8.83 minute showed 0.003713ppm followed by acenaphthylene with a retention time of 8.47 minute shows 0.002534 ppm followed by 2-methylnaphthalene with a retention time of 6.6 minute shows 0.001107ppm followed by phenanthrene with a retention time of 12.62 minute shows 0.000594 ppm followed by fluorene with a retention time of 10.14 minute shows 0.000508 ppm followed by pyrene with a retention time of 15.81 minute shows 0.000231ppm followed by fluoranthene with a retention time of 15.65 minute shows 0.000226ppm. This indicated as naphthalene > acenaphthene > acenaphthylene > 2-methylnaphthalene > phenanthrene > fluorene > pyrene > fluoranthene. The result obtain of the eight POPs components in S2 soil sample range between 0.00023 to 0.00253 ppm which was contrary to the POPs values of Organochlorine pesticides(OPC) and its metabolites(0.51–0.53 µg L^{-1}) as investigated by Al-Alimi *et al*., (2022).

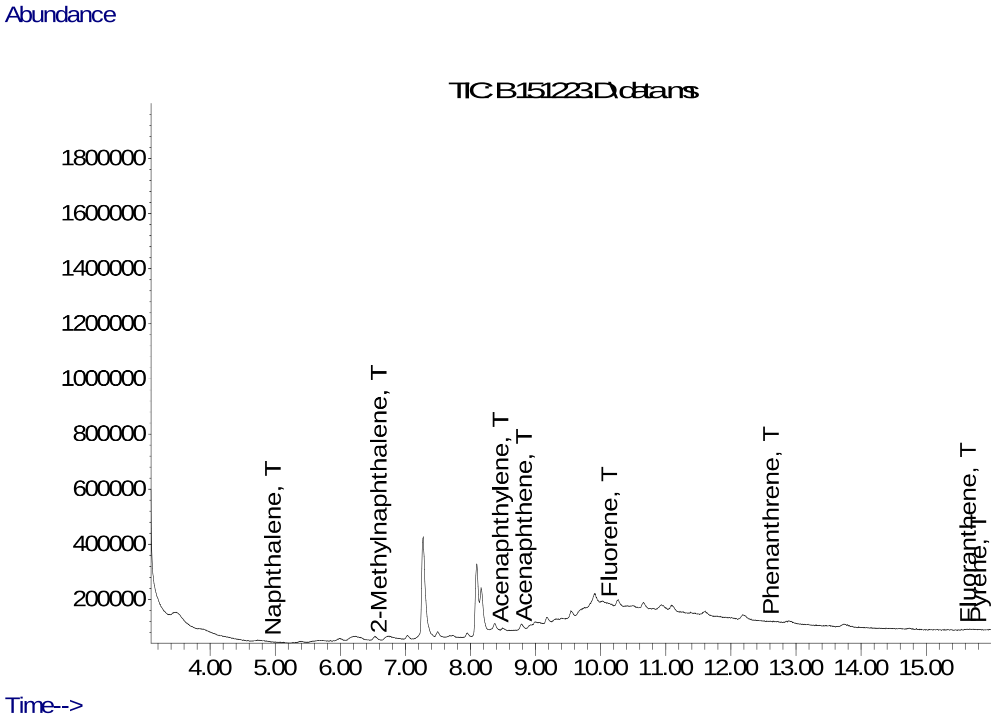

Figure 7. Total ion chromatogram (TIC) showing POP Component of Sample S2

POP Component of Sample S3

Figure 8 Indicate Composition of Hospital area soil Sample (S3) which shows the presence of eight persistent organic pollutant in decreasing order as naphthalene with a retention time of 4.99 minute shows 0.00706ppm followed by 2-methylnaphthalene with a retention time of 6.58 minute shows 0.00197ppm followed by acenaphthylene with a retention time of 8.45 minute shows 0.0017ppm, followed by fluorine with a retention time of 10.15minute shows 0.001533 ppm, followed by pyrene with a retention time of 15.87minute shows 0.000537ppm, followed by fluoranthene with a retention time of 15.34minute shows 0.000322ppm, followed by phenanthrene with a retention time of 12.59minute shows 0.000293ppm, followed by acenaphthene with a retention time of 8.83minute shows 0.000254ppm. This indicate as naphthalene > 2-methylnaphthalene > acenaphthylene > fluorene > pyrene > fluoranthene > phenanthrene > pcenaphthene. The result obtain of POPs in S3 ranges between 0.000254 ppm to 0.0017ppm which was also contrary to range of POPs (0.51–0.53 µg L^{-1}) as investigated by Al-Alimi *et al*., (2022).The result of POPs obtain was contradicted the findings of 16 PAHs residues of POPs investigated by Mimoza *et al*., (2016) whose ranged between 8.93 - 13.19 and 39.10 - 50.21 µgkg

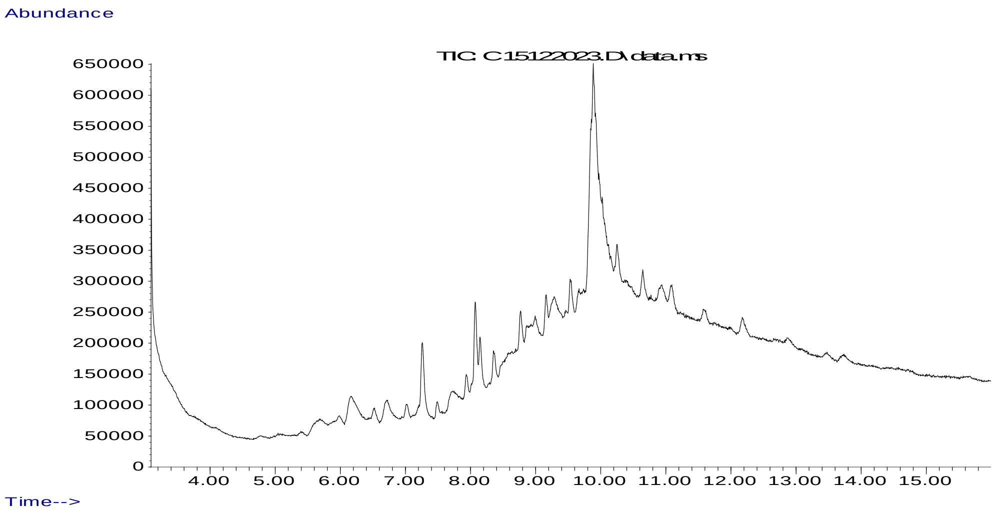

Figure 8. Total ion chromatogram (TIC) showing POP Component of Sample C

CONCLUSION

The physicochemical properties of soil sample analyzed such as the ash showed that S1 has the highest ash content of 11.5% followed by sample S3 with 6.0% Ash content, while soil samples S2 showed the lowest ash content of only 2.5%. The pH obtain showed that the trend of acidity value decrease while alkalinity value increase in the order as S2=5.20 > S1=5.95 > S3=6.01 respectively. Conductivity of three analyzed soil sample indicate that the value decrease in the order as S2 = 0.26 μScm^{-1} > S3= 0.24 μScm^{-1} > S1 = 0.23 μScm^{-1} accordingly. The mean pH values of sample soil investigated showed that S3 has the highest value of 6.01 followed by S1 with pH value of 5.95, while S2 showed the lowest pH value of 5.20. This showed that the acidity value increase in the order as S2 = 5.20 > S1= 5.95 > S3 = 6.01 respectively.

The soil texture analysis of S1 soil showed that the % sand = 35.71% and S2 = 28.57 % has the highest % sand of 35.71%, also sample S2 showed the lowest % sand of 31.03%. The sample S1 has the highest % silt of 32.14% followed by sample S3 28.57%. Among the three samples, sample S3 showed the lowest % slit of 27.58%. The sample S3 has the highest the % clay of 7.14% followed by sample A has 3.57%, while sample S2 showed lowest % clay of 3.44%.
The result showed no significant difference between the sample and falls under permissible limit of FAO/WHO guidelines with the exception of the electrical conductivity that is little less than permissible limit.

The POPs composition of sample S1 soils, investigated on this research revealed that eight components of POP such as Naphthalene has a retention time of 5.02 minute revealed a highest composition of 0.004141 ppm followed by acenaphthene with a retention time 8.82 minute showed 0.00395ppm ppm while phenanthrene showed the least with a retention time 12.5minutes showed 0.000139ppm.

Sample S3 soil showed the eight persistent organic pollutants detected where naphthalene of has the highest retention time of 4.99 minute showed values of 0.00705988 ppm followed by sample S2 with a retention time of 4.97 minute revealed a composition of 0.00692412 ppm. At the same time S1 showed the lowest with a retention time of 5.02minute with of 0.004140ppm indicated by naphthalene.

Meanwhile, sample S2 soil showed 2-Methylnaphthalene has the highest with a retention time of 6.58 minute shows 0.00197ppm followed by S3 sample with a retention time of 6.6 minute shows 0.001107ppm. Among the three samples and sample S1 shows the lowest with a retention time 6.90 minute showed 0.001013ppm.

The sample S2 soil investigated showed acenaphthylene has the highest with a retention time of 8.47 minute shows 0.002534ppm followed by S3 soil sample with a retention time of 8.45minute shows 0.0017ppm, while sample S1 shows the lowest value with a retention time 8.45 minutes showed 0.001384ppm. acenaphthene of sample S1 has the highest with a retention time 8.82 minute showed 0.00395ppm ppm followed by S2 sample with a retention time of 8.83 minute showed 0.003713ppm, among the three samples, sample S3 shows the lowest retention time of 8.83minute shows 0.000254ppm.

Fluorine of sample S3 soil has the highest with a retention time of 10.15minute shows 0.001533ppm followed by sample S1 soil with a retention time 10.15 minutes showed 0.001525ppm but sample S2 soil shows the lowest with a retention time of 10.14 minute shows 0.000508ppm.

The sample S2 soil showed phenanthrene has the highest with a retention time of 12.62 minute shows 0.000594ppm followed by sample S3 soil with a retention time of 12.59minute shows 0.000293ppm but, sample S1 shows the lowest with a retention time 12.5 minutes showed 0.000139ppm among the three samples.

Fluoranthene of S3 soil has a retention time of 15.34minute shows 0.000322 ppm followed by S1 soil sample with a retention time 15.5 minute showed 0.000239ppm, while sample S2 soil shows the lowest with a retention time of 15.65 minute shows 0.000226ppm among the three sample.

Finally pyrene of S3 soil sample has the highest With a retention time of 15.87minute shows values 0.000537ppm followed by sample S2 soil with a retention time of 15.81 minute shows 0.000231ppm but, sampleS1 shows the lowest with a retention time 15.5 minute showed 0.000227ppm Among the three sample.

Acknowledgement
Authors of this research work concurrently acknowledges the efforts of Dr. Falalu Yahaya of Department of Chemistry American University of Nigeria (AUN) Yola for his tremendous analysis of GC-MS of soil samples investigated.

REFERENCES

Al-Alimi, A. A, Al-Sarheed, H. T, Elarabiyat, O. I, and Rimawi, O. (2022). *Assessment of the Levels of Persistent Organic Pollutants in the Ghabawi Landfill in Jordan*. *Egytian Journal of Occupational Medcine*. 46(3): 77-92 Https://Doi.Org/10.21608/Ejom.2022.119063.1265

Andrew Drew Jeffers (2023). Spartanburg Cooperative Extension, Horticulture and Natural Resource Agent, Soil Texture Analysis, Clemson Universe Factsheet |HGIC 1656 Revised: Dec 1, 2023

Begum, M., Sarmah, B., Kandali, G. G., Kalita, S., Ojha, I., Bhagawati, R., andTalukdar, L. (2021). Persistant Organic Pollutants in Soil and Its Phytoremediation.

Fai Predrick Y. Danbature Wilson L., Bala Abubakar Sadiq and Usman Yakubu M**.** (2013). Proximate and some Mineral Analysis of *Colocacia esculenta* (Taro) Leaf. Journal of Medical and Biological Sciences volume 3 November 2 2013. Insuderc Academic Publishers. Abuja Nigeria.

Mansour, S. A. (2009). *Persistent organic pollutants (POPs) in Africa: Egyptian scenario*. https://doi.org/DOI: 10.1177/0960327109347048

Mimoza Mukaj, Sofiana Mai, Magdalena Cara, Vojislava Bursić, Gorica Vuković, and Tijana Zeremski (2016). Determination of Persistent Organic Pollutants in Soils of some Greenhouses in Albania. The International Scientific Multi-Conference Attentis 2016. SciVerse Science Direct. Available online at www.sciencedirect.com

Muhammed A. B, and Maitera O.N (2023).Determination of Chemical Explosive Remnants in Soils of Boko Haram's Affected Areas of Gombe State Nigeria. *Asian Journal of Chemical Sciences* 13(6):106-117: 10.9734/ajocs/2023/v13i6266

Mukaj, M., Mai, S., Cara, M., Bursić, V., Vuković, G., &Zeremski, T. (2016). Determination of Persistent Organic Pollutants in Soils of some Greenhouses in Albania. International scientific multi-conference Attentis 2016SciVerse Science Direct Procedia Agricultural Sciences p 1-7 www.sciencedirect.com

Ndahi1 J. A, Maitera1 O.N, Kubmarawa D, and Shagal M.H (2016). Assessment of Minerals and Trace Elements in Termiteria and Ten Meter (10 M) Adjacent Soils in Maiha Local Government Area of Adamawa State, Nigeria. American Chemical Science Journal 12(3): 1-7, ACSJ.23195 ISSN:2249. SCIENCEDOMAIN international. www.sciencedomain.org

Poslet Shumbula, Collet Maswanganyi and Ndivhuwo Shumbula(2021). Type, Sources, Methods and Treatment of Organic Pollutants in Wastewater. Open access peer reviewed chapter. DOI: 10.5772/intechopen.101347

Usman Y. M**.**, Maitera O. N., Modibbo U.U., Ndahi J. A. (2018). Physico-Chemical Parameters of Water from Galena mining area at Nahuta Alkaleri Local Government Area, Bauchi State, Nigeria. International Journal of Recent Research in Physics and Chemical Sciences (IJRRPCS) Vol. 5, Issue 1, pp: (1-9), Month: April 2018 – September 2018, (ISSN 2350-1030) Available at: www.paperpublications.org

Wenjing Guo, Bohu Pan, Sugunadevi Sakkiah, Gokhan Yavas, Weigong Ge, Wen Zou,Weida Tong and Huixiao Hong (2019). International Journal of Environmental Research and Public Health. Persistent Organic Pollutants in Food:Contamination Sources, Health Effects and Detection Methods. 16, 4361; doi:10.3390/ijerph16224361