FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 9 No. 7, July, 2025, pp 133 – 136
DOI: https://doi.org/10.33003/fjs-2025-0907-3592

DETERMINATION OF POLYCYCLIC AROMATIC HYDROCARBONS AND VOLATILE ORGANIC COMPOUNDS IN SURFACE SOILS OF MECHANIC WORKSHOPS IN AZARE BAUCHI STATE, NIGERIA

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ABSTRACT

The study aimed was to determine the organic pollutants in mechanic workshop garages in Azare, Bauchi state, Nigeria. Soil samples were collected after two weeks in a month for three months, making two replicates from three (3) popular auto mechanic workshops using a hand auger. At each location, the surface soil samples was randomly collected from the same depth of 0 – 20 cm to form composite samples. Soil samples are dried to remove moisture, followed by sieving to remove debris the size of the mesh used 2 mm. the soil sample are typically oven dried at 105 oC for a period usually 16-24 hours. The GC-MS concentration of benzene, toluene, ethyl benzene, m,p xylene and o-xylene in site 1, was found to be 12.1±0.31, 9.5±0.02, 8.2±0.02, 7.5±0.01, 6.9±0.01, respectively. Which all are above WHO permissible limits that ranging from 0.01-0.20. Where the mean values of naphthalene, phenanthrene, Anthracene, fluoranthene, and pyrene in site 2, was found to be 6.2±0.01, 5.1±0.01, 5.5±0.01, 4.1±0.1and 3.9±0.01 respectively. Which all are above USEPA limits that ranging from 0.01-0.100. Where the mean values of decane, undecane, dodecane, tridecane, pentadecane in site 3, was found to be 21.9±2.00, 18.5±1.59, 15.2±1.50, 12.9±1.20, 10.5±1.00, respectively which all are above WHO permissible limit that ranging from 0.02-0.07. The GC-MS analysis of three different soil samples from the mechanic garages contained various organic pollutants, including VOCs, PAHs, and aliphatic hydrocarbons. The results highlight the need for proper waste disposal that become crucial for protecting both human health and environment. The result showed relatively higher variations in all the study parameters. This is an indication of contamination and should be well monitored and far from living homes to avoid potential pollution that can affect the human health. Government should regulate the siting of mechanic workshops more especially far from living homes and water bodies.

Keywords: Mechanic workshops, PAHs poly cyclic aromatic hydrocarbons, PCBs poly chlorinated biphenyls, SVOCs Semi volatile organic compound, Pollutants, Garages, Workshops

INTRODUCTION

Polycyclic aromatic hydrocarbons (PAHs) in various compartments, soil in particular, have drawn a lot of interest recently due to their acute toxicity and carcinogenic properties. On Earth, atmospheric PAHs are continuously deposited by dry or wet deposition processes. Some PAHs are emitted from close sources, such as vehicle exhaust from neighbouring roads. Other PAHs come from farther away and have travelled a great distance through the air. The ability of PAHs to penetrate the soil is influenced by both the PAHs and the soil properties. As a result, PAHs sorption is one of the mechanisms that control PAHs mobility in soil (Iyama, 2021). According to research, the primary way PCBs enter humans is through dietery exposure from equatic animals particularly fish (Ediogbonya *et al.,* 2024) (PCBs have 209 congeners known as polychlorinated biphenyls (PCBs) are a combination of biphenyls containing one or more chlorine atoms. Due to their slow rate of degradation, polychlorinated biphenyls (PCBs) are a family of semi-volatile organic compounds (SVOCs) that are dangerous and persistent in the environment (Kathi, 2014). PCBs are persistent in the environment because they can travel over great distances in the background and securely adhere to soil and sediment. Numerous harmful health effects, including immune system impairment, neurological system changes, endocrine disruption, gastrointestinal bleeding, and liver damage, have been linked to PCBs exposure if found in substantial amounts above the permissible level. Since the 1970s, the production of these substances has been increasingly banned or restricted due to their persistence and toxicity to the surroundings (Edori, 2021). The service industry sector is not complete without auto shops. Unfortunately, the disposal of wasted motor oil and wash water into the earth is the present workshops' have significant environmental impact. Waste oil is a complex mixture of compounds, including petroleum hydrocarbons, 8 chlorinated biphenyls, chlorodibenzofurans, additives, by-products of decomposition, and heavy metals that are released as engine parts deteriorate. The soil loses its beneficial qualities, such as fertility, water-holding capacity, permeability, and binding capacity, when it is contaminated by oil. Nigeria, like many other nations, has substantial petroleum hydrocarbon contamination. One of Nigeria's environmental issues is pollution from the disposal of spent motor oil, which is more pervasive than pollution from crude oil. An estimated 20 million gallons of used engine oil are produced annually in mechanic shops (Osakwe, 2014)

Since the year 2000 it has been recorded that there is a decline in the production of the indigenous automobile because more of the automobile industries establish between the 70s and 80s are no longer in operation due to economic, safety and political concerns (Oguzie *et al.,* 2023).

According to new report by the United Nations Environmental Programme (UNEP) of 2020, Nigeria is the highest importer of used cars in Africa and the third highest destination for used cars globally this is supported by (Ajayi *et al.,* 2021).

According to Elizabeth (2022), the background to the existence of an automobile mechanic workshops in Nigeria, Ibadan to be precise can be traced back based on the need to render services to vehicles and cars that can suddenly

developed a fault to require an emergency repair. So this make it inevitable that some repairing workshops should be set up near the road side to render services to the vehicles when they go out of order or become inoperative, and be very helpul for the operation of vehicles within a short time, the number of vehicles increased enormousely and many workshops were set up.

Automobile mechanic services have tended to strive higher in the poor economy where people of Azare demand to repair their old vehicles rather than spending huge amount of money on purchasing a new ones which called for demand maintainance, the number of automobile technicians is grossly increases and it is still in expectance to increases higher in the future, many researchers work on the air pollution causes by automobile, and also lack of localized PAH/VOC's studies in Nigeria, for this reason this research work focuses on the organic pollutant presence in the soil of mechanic workshop in Azare town Bauchi State, Nigeria

MATERIALS AND METHODS

Study Area

Azare is a town in Bauchi State, Nigeria. It was founded by Malam Zaki who received his flag office from Shehu Usman Danfodio in the year 1814. Azare is the headquarters of Katagum division in Bauchi State, Azare town is bounded to the east by Damban LGA and PotiskumYobe State and to the south by Misau Local Government, in the west by Jama'are Local Government, and to the north by Itas/Gadau Local Government Area of Bauchi State. Azare is located at $11^{0}40'$ 27 "N'' coordinates: $10^{0}11'$ 28 ''E'' at anclevation nearly town in the region including Misau, BulkachuwaDisina, Faggo, Zadawa and Madara. However, Azare was agrarian society with majority of the populace depending on faming and animal husbandry as dictated by its climate and soil condition which favours the growing of cereal, Agriculture has great historical achievement in Azare.

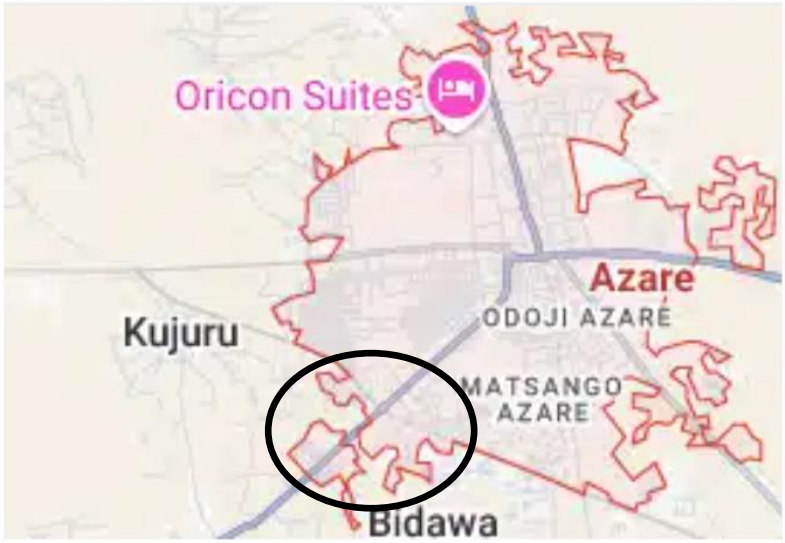

Figure 1: A map showing Matsango ward Azare town (from Google source)

Sample Collection

Soil samples were collected after two weeks in a month for three months, making two replicates from three (3) popular auto mechanic workshops using a hand auger. At each location, the surface soil samples were randomly collected from the same depth of 0 – 20 cm to form composite samples. These samples were represented of the top soil around each workshop. Additionally, control soil samples were taken at random (from a depth of 0 – 20cm) from a pristine plot of land that was centrally located, at least 20 km from each impacted site, and where no industrial, commercial, or auto mechanic activities are currently being carried out (or have ever been). Thus, a total of three (3) soil samples was obtained and analysed in three weeks for six determinations. In each week, three (3) composite soil samples from the study areas were collected, stored in sample bags and labelled as Station 1, Station 2 and Station 3, representing surface soil samples surrounding three selected auto mechanic workshops from Azare Town; also within the space of three weeks, stored in polythene bags and transported to a research laboratory for laboratory analysis.

Sample Preparation and Analysis

Sample Preparation: Sample Drying and Sieving: Soil samples was dried to remove moisture, followed by sieving to remove debris the size of the mesh used 2 mm. the soil sample are typically oven dried at 105 ^{o}C for a period usually 16-24 hours. Extraction: Organic pollutants are extracted from the soil using solvents (such as dichloromethane or hexane) in a Soxhlet extractor or by ultrasonic extraction. 28 Concentration of Extract: The extracts are concentrated using rotary evaporation and then purified.

GC-MS Analysis

Gas Chromatography: The extract is injected into a gas chromatograph, where volatile and semivolatile organic compounds are separated based on their boiling points and interaction with the GC column's stationary phase. Mass Spectrometry: After separation, the compounds are ionized in the mass spectrometer, generating unique mass spectra that can be compared to a spectral library for identification. Retention Times: Compounds are identified not only by their mass spectrum but also by their specific retention time on the GC column.

GC-MS (Gas chromatography-mass spectrometry) analysis involves a specific stationary phase column type, temperature program, and calibration procedures. Capillary columns are commonly used, with the temperature program typically starting at a lower temperature to separate lighter compounds and increasing to resolve hearvier ones. Calibration is essential for accurate quantifications and involves using known standards to create calibration curve.

Safety information for handling dichloromethane and hexane

***Dichloromethane*: -** is a liquid, so work in a well ventilated area, preferably a fume hood. Ensure adequate local exhaust ventilation. Wear appropriate PPE, including chemical resistant gloves (check compatibility with DCM, as many gloves are not suitable, such as nitrile), splash goggles, and a lab coate. Consider a respirator if ventilation is inadequate. Store DCM in a cool, dry, well-ventilated area, away from heat and ignition sources.

Hexane: - is flammable and can form explosive mixtures with ai, so work in a well-ventilated area. Wear appropriate PPE, including gloves, eye protection and a lab coat. Avoid breathing in hexane vapors, which can cause a drowsiness, dizziness, and other neurological effects. Avoid skin contacts, as it can cause irritation. Store hexane in a cool, dry, well-ventilated area, away from heat and ignition sources.

RESULTS AND DISCUSSION

The general objective of this study was to determine the organic pollutants in mechanic workshop garages in Azare, Bauchi state. This chapter therefore reports the organic pollutants observed as analyzed by GC-MS, also presented and discussed the results.

Table 1: Determination of Organic Pollutants at Tashar-Gadau Mechanic Workshop (Site 1) Compared to word Health Organisation (Site 1)

Peak	Retention Time (min)	Compound	Mean Standard Deviation	WHO Limits (In kg)
1	5.50	Benzene	12.1±0.31	0.01
2	7.20	Toluene	9.5±0.02	0.05
3	9.50	Ethylbenzene	8.2±0.02	0.05
4	11.80	M,p-Xylene	7.5±0.01	0.05
5	14.20	o-Xylene	6.9±0.01	0.20

The table presents the results of GC-MS analysis on the studied soils. The results revealed that site 1 has a GC-MS concentration value of 6-12; that are all above the WHO permissible limits ranging from 0.02-0.05, meaning that can cause a serious problems. The site 1, has the highest concentrations of organic pollutants than site 2, but lower concentrations than site 3. These values are in agreement with the results published by Pam *et al.,* (2013), Sadick *et al*., (2015), Odueze *et al*., (2017), and Olayinka *et al.,* (2017) in similar research.

Table 2: Determination of organic pollutants at Matsango Mechanic Workshop (Site 2) Compared to United state Environmental protection Agency Standard

Peak	Retention Time (min)	Compound	Mean Standard Deviation	USEPA Limits (Mg/kg)
1	15.21	Naphthalene	6.2±0.01	0.001
2	17.50	Phenanthrene	5.1±0.01	0.001
3	20.10	Anthracene	4.5±0.01	0.100
4	22.50	Fluoranthene	4.1±0.1	0.001
5	25.20	Pyrene	3.9±0.01	0.001

The concentrations of organic pollutants in site 2, ranging from 3.9-6.2 ; that are all above the USEPA permissible limits ranging from 0.001-0.1, meaning that can cause a serious problems. Station 2 has the lowest value with a mean of 3.9-6.2. Compared with the results of site 1 an site 3, these values are in agreement with the results published by Pam *et al.,* (2013), Sadick *et al*., (2015), Odueze *et al*., (2017), and Olayinka *et al.,* (2017) in similar research.

Table 3: Determination of organic pollutants at Matsango Mechanic Workshop (Site 3) Compared to world health organization Standard

Peak	Retention Time (min)	Compound	Mean Standard Deviation	WHO Limits (In Kg)
1	10.50	Decane	21.9±2.00	0.07
2	12.20	Undecane	18.5±1.59	0.03
3	14.50	Dodecane	15.2±1.50	0.06
4	16.80	Tridecane	12.9±1.20	0.02
5	19.20	Pentadecane	10.5±1.00	0.03

The concentrations of organic pollutants in site 3, ranging from 10-21. From the results obtained, Site 3 has the highest value of GC-MS concentration value with a mean of 10-21 when compared to site 2 and site 1. ; that are all above the WHO permissible limits ranging from 0.02-0.07, meaning that can cause a serious problems. These values are in agreement with the results published by Pam *et al.,* (2013), Sadick *et al*., (2015), Odueze *et al*., (2017), and Olayinka *et al.,* (2017) in similar research.

The findings demonstrate that all of the values obtained are much higher than those from the world health organization and united state environmental protection agency. This implies that the everyday activities conducted in the workshops may have contributed to the elevated level of organic matter in the soil near the study workshops. According to Akan *et al.,* (2013), carbon-based material is crucial for metal binding. According to Brummer and Herms (1982), carbon-based matter forms insoluble or soluble carbon-based metal complexes that immobilise heavy metals under strongly acidic conditions and mobilise them under weakly acidic to alkaline conditions.

The GC-MS analysis separates and identifies different organic compounds present in the soil samples. These include: Petroleum hydrocarbons: Typically found in mechanic workshops due to the use of oils, lubricants, and fuel spills. Common pollutants could include alkanes, alkenes,

cycloalkanes, and aromatic hydrocarbons (e.g., benzene, toluene, xylene). Polyaromatichydrocarbons (PAHs): These are often present due to incomplete combustion processes and may include compounds like naphthalene, anthracene, pyrene, and benzopyrene. Volatile organic compounds (VOCs): This class may include solvents or degreasers such as toluene, ethylbenzene, and chlorinated compounds (e.g., trichloroethylene). Phthalates: These compounds may be present due to plasticizers in materials used in the workshops. Comparison of Results: Sample A had higher levels of aliphatic hydrocarbons. Sample B had higher levels of VOCs. Sample C had higher levels of PAHs

CONCLUSION

The GC-MS analysis of three different soil samples from the mechanic garages contained various organic pollutants, including VOCs, PAHs, and aliphatic hydrocarbons. The results highlight the need for proper waste disposal that become crucial for protecting both human health and environment. The best methods depend on the specific type of organic pollutant , but generally involve a combination of treatment and containtment strategies these can include incineration, chemical treatment (like land-farming or bioremediation), and physical method like solidification or filtration, soil remediation, and pollution reduction strategies. Higher levels of organic pollutant in soil can pose significant health risk, including respiratory problems, neurological damage, and an increased risk of cancer. These pollutants can enter the body through ingestion, skin contact, or inhalation of contaminated dust. Long-term exposure can lead to a range of health issues, including endocrine disruption, cardiovascular diseases, and even birth defects. However, the soils in mechanic workshops and surroundings these places typically have an acidic pH, which is suspected to strongly favour: the availability and mobility of heavy metals. This is an indication that the significant increase in concentrations of the physicochemical parameters is a direct consequence of the activities of the auto mechanic workshops.

RECOMMENDATIONS

Consequent to the findings of this study, the following recommendations are made; Mechanic villages should be built in different locations far from towns. The government should set up regulatory bodies to monitor the activities of automobile workshops especially in the area of waste disposal. Owners or operators of automobile workshops as well as the populace should be sensitized on the impacts of the activities of the automobile workshops on the environment and the risks associated with human exposure to heavy metals. Further studies should be carried out in areas not covered by this studies

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