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DETERMINATION OF TOTAL PETROLEUM HYDROCARBONS (TPH) CONCENTRATION LEVELS IN AUTOMOBILE WORKSHOP SOILS AS PREVENTIVE MEASURES FOR ENVIRONMENTAL RISK ASSESSMENT

[*1]Orhuebor N. Ernest, [2]Zaynad Muhammad Chellube, [3]Egbere Ogbemudia Moses, [4]Abeokuta O. Johnbull, [5]Ofogharenor Tanro Maris, [6]Apuyor K. Efe, [7]Ikechukwu S. Chikwe, [8]Onwugbuta G. Chukwuemeka, [9]Brown Amieye Bright, [10]Njor OruOgar and [11]Erienu Obruche Kennedy

[1]Department of Chemistry, Southern Delta University, Ozoro.

[2]Department of Analytical Chemistry, University of Maiduguri.

[3]Department of Chemical Sciences, Niger Delta University, Wilberforce Island.

[4]Department of Chemistry, Southern Delta University, Ozoro, Delta State.

[5]Department of Science Laboratory Technology, Federal Polytechnic, Orogun.

[6]Department of Chemistry, Dennis Osadebay University, Asaba, Delta State.

[7]Department of Science Laboratory Technology, Imo State Polytechnic, Omuma.

[8]Department of Biochemistry/Chemistry Technology, University of Port Harcourt, River State.

[9]Department of Pure and Industrial Chemistry, University of Port Harcourt, River State.

[10]Department of Science Laboratory Technology, Federal Polytechnic, Ugep.

[11]Department of Chemistry, Delta State College of Education, Mosogar, Delta State, Nigeria.

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***Corresponding Author: Orhuebor N. Ernest**

Department of Chemistry, Southern Delta University, Ozoro.

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ABSTRACT

This study determined the concentration levels of Total Petroleum Hydrocarbons (TPH) in soils collected from automobile workshops across selected locations in Warri metropolis, Delta State, Nigeria. Soil samples were obtained from eight automobile workshop sites, comprising bike, keke, truck, and car repair workshops. At each location, samples were collected from the main workshop and at a point 10 m away, giving a total of sixteen samples. Total Petroleum Hydrocarbons were extracted using an Accelerated Solvent

Extractor (ASE), purified through Florisil clean-up, and quantified by gas chromatography with flame ionization detection (GC-FID). The results revealed considerable variation in TPH concentrations across the sampled locations, indicating different levels of petroleum contamination associated with workshop activities. The highest TPH concentration (157,150.24 mg/kg) was recorded at the Agbarhokeke workshop, 10 m from the main workshop, while the lowest value (249.92 mg/kg) occurred at the Okorikperhe truck workshop, 10 m away. Elevated TPH levels were also observed at Okuokoko truck (37,763.60 mg/kg), PTI Road 2 car workshop (17,041.60 mg/kg), and Warri/Sapele Road keke workshop (15,745.00 mg/kg). In several locations, the main workshop exhibited higher contamination than adjacent areas, although some sites showed greater TPH concentrations 10 m away, suggesting contaminant migration. Overall, the findings demonstrate widespread petroleum hydrocarbon contamination of automobile workshop soils, highlighting the need for routine environmental monitoring, improved waste management practices, and effective soil remediation measures to minimize ecological and public health risks.

KEYWORDS: TPH, Automobile Workshop Soils, Environmental, Risk Assessment.

INTRODUCTION

Environmental pollution resulting from petroleum hydrocarbons has become one of the most serious ecological challenges confronting both developed and developing countries (Obruche et al., 2025). Petroleum hydrocarbons are complex mixtures of organic compounds derived from crude oil and its refined products. They are widely used as fuels, lubricants, and industrial raw materials because of their high energy value and diverse applications. Despite their economic importance, improper handling, storage, and disposal of petroleum products have resulted in widespread environmental contamination, particularly of soils (Akacha et al., 2025). Soil contamination by petroleum hydrocarbons alters the physical, chemical, and biological properties of soil, reduces soil fertility, disrupts microbial communities, inhibits plant growth, and poses significant risks to human health through the contamination of groundwater and the food chain.Among the various indicators of petroleum pollution, Total Petroleum Hydrocarbons (TPH) are widely recognized as one of the most important environmental parameters for assessing the degree of hydrocarbon contamination in soils (Ekpoet al.,2023). TPH represents the cumulative concentration of a broad range of hydrocarbon compounds originating from crude oil, gasoline, diesel, lubricating oils, and other petroleum products. The determination of TPH provides valuable information regarding the extent of pollution, environmental quality, and the effectiveness of remediation efforts (Itodo et al., 2021). Consequently, TPH analysis has become an essential component of environmental monitoring and pollution assessment programmes worldwide.In many developing countries, rapid urbanization and increasing dependence on motorized transportation have contributed significantly to the growth of automobile repair and maintenance workshops (Abeokuta et al., 2025). These workshops perform activities such as engine servicing, oil changes, mechanical repairs, fuel system maintenance, vehicle washing, welding, battery servicing, and replacement of lubricants. While these operations are essential for maintaining transportation systems, they generate considerable quantities of petroleum wastes, including spent engine oil, diesel, petrol, transmission fluids, grease, hydraulic oil, brake fluid, and oily sludge (Umudi et al., 2025). In many cases, these wastes are discharged directly onto surrounding soils without adequate environmental protection measures, resulting in persistent hydrocarbon contamination.Automobile workshops have therefore become important non-industrial sources of petroleum hydrocarbon pollution. Continuous discharge of waste lubricants and accidental spillages allow hydrocarbons to accumulate in surface soils over many years (Etus and Obruche, 2026). Unlike many organic contaminants that degrade rapidly, petroleum hydrocarbons often persist in soils because of their complex chemical composition and resistance to microbial degradation under unfavorable environmental conditions. Their persistence leads to deterioration of soil quality, reduction in nutrient availability, decreased microbial activity, poor soil aeration, and impairment of agricultural productivity (Kehinde et al., 2025). Furthermore, hydrocarbons can migrate through soil profiles into groundwater or be transported by surface runoff into nearby streams and wetlands, thereby extending environmental pollution beyond the immediate source (Festus-Amadi et al., 2021).Nigeria is one of the world's major petroleum-producing countries and has experienced increasing environmental challenges associated with petroleum exploration, transportation, refining, and utilization (Obruche et al., 2018). While considerable attention has been directed toward oil spill incidents in the Niger Delta, relatively less emphasis has been placed on pollution arising from automobile repair activities in urban centres (Ekpo et al., 2025). Across many Nigerian cities, automobile workshops operate without designated waste management systems or impermeable workshop floors. Used engine oil and petroleum residues are frequently discharged directly onto bare ground, allowing contaminants to infiltrate surrounding soils (Erienu et al., 2022). The cumulative effect of these practices has become a growing environmental concern requiring continuous monitoring and scientific assessment (Micheal et al., 2026).Warri metropolis, located in Delta

State, represents one of the most important commercial and industrial centres in the Niger Delta region (Moses et al., 2025). The city hosts numerous automobile repair workshops serving private vehicles, commercial buses, trucks, motorcycles, and tricycles (Jacintha et al., 2025). The high concentration of vehicular activities and repair operations has increased the likelihood of petroleum hydrocarbon accumulation within workshop environments. Continuous disposal of spent lubricants and petroleum products may gradually degrade soil quality, reduce ecosystem productivity, and threaten environmental sustainability (Umudi et al., 2026). Despite these concerns, environmental monitoring of hydrocarbon contamination within many automobile workshop locations in Warri remains inadequate.The determination of TPH concentrations in automobile workshop soils is therefore essential for evaluating the extent of petroleum contamination and identifying areas requiring environmental intervention. Accurate quantification of TPH provides baseline information for environmental risk assessment, regulatory enforcement, pollution control programmes, and the development of effective remediation strategies (Odimgbe et al., 2026). It also assists policymakers and environmental managers in formulating sustainable waste management practices aimed at minimizing future contamination.Several previous studies conducted in Nigeria have reported elevated concentrations of petroleum hydrocarbons in soils surrounding mechanic villages and automobile workshops (Obruche et al., 2019). However, many of these investigations have focused on a limited number of sampling locations, concentrated primarily on major mechanic villages, or assessed only general hydrocarbon pollution without providing comparative evaluations across different categories of automobile workshops such as car, truck, motorcycle, and tricycle repair facilities. Furthermore, available studies on Warri metropolis remain relatively scarce, fragmented, and outdated despite the rapid expansion of automobile servicing activities within the city (Micheal et al., 2026). Consequently, there is insufficient current information regarding the spatial distribution and concentration levels of Total Petroleum Hydrocarbons in soils associated with different automobile workshop types across the metropolis (Etus and Obruche, 2026).This research addresses this important knowledge gap by determining the concentration levels of Total Petroleum Hydrocarbons (TPH) in soils collected from selected automobile workshops located across Warri metropolis, Delta State. By evaluating TPH concentrations at both the main workshop locations and adjacent areas situated 10 km away, the study provides updated baseline data on the extent of petroleum hydrocarbon contamination and the potential migration of pollutants from workshop environments (Nathan et al., 2025). The findings will contribute to environmental monitoring programmes, support evidence-based pollution management policies, and provide scientific information necessary for protecting soil quality, safeguarding public health, and promoting sustainable environmental management in Warri metropolis.

MATERIALS AND METHOD

STUDY AREA

The study area includes a host of locations situated in Warri metropolis (Warri/Sapele road,Petroleum Training Institute (PTI)road, Otokutu, Okuokoko, Okorikperhe and Agbarho). The study area comprises of a pair of 4 locations making up a total of 8 locations of which two samples are to be collected from each. These locations include; 2 locations from PTI road, 2 locations from Agbarho, and Okuokoko, Okorikperhe, Warri/Sapele and Otokutu roads each comprising of a pair of locations (Ogwuche and Obruche, 2020).

Table 1: Showing location, workshop type, points of collection and GPS readings.

S/N	LOCATIONS	WORKSHOP TYPE	POINTS	NORTHINGS	EASTINGS
1	Warri/Sapele road	Keke	Main workshop 10m away	N05^{0}33’49.5’’ N05^{0}33’49.8’	E005^{0}47’05.3’’SW E005^{0}47’04.3’’W
2	Okuokoko	Truck	Main workshop 10m away	N05^{0}34’32.9” N05^{0}34’34.3’’	E005^{0}49’09.8’’S E005^{0}49’09.7’’NE
3	Okorikperhe	Truck	Main workshop 10m away	N05^{0}34’51.3’’ N05^{0}34’51.4’’	E005^{0}50’21.2’’SW E005^{0}50’21.1’’E
4	Otokutu	Bike	Main workshop 10m away	N05^{0}32’58.3’’ N05^{0}32’58.5’’	E005^{0}49’34.7’’SE E005^{0}49’34.6’’SE
5	Agbarho	Bike	Main workshop 10m away	N05^{0}35’05.3’’ N05^{0}35’06.0’’	E005^{0}51’29.4’’W E005^{0}51’29.8’’S
6	Agbarho	Keke	Main workshop 10m away	N05^{0}34’58.6’’ N05^{0}34’59.8’’	E005^{0}51’08.0’’S E005^{0}51’07.9’’NE
7	PTIroad	Car 1	Main workshop 10m away	N05^{0}34’00.6’’ N05^{0}34’00.7’’	E005^{0}47’47.9’’W E005^{0}47’48.7’’SW
8	PTI road	Car 2	Main workshop 10m away	N05^{0}33’50.4’’ N05^{0}33’50.6’’	E005^{0}47’36.6’’N E005^{0}47’36.5’’S

SAMPLE COLLECTION

Sample collection was in tandem with the work of Obruche et al., (2019) with little modification. Two samples each were collected from eight locations which involved collection from the main workshop and 10m away from the workshop. A hand soil auger (Nickel-plated carbon steel, 3´´ diameter) was used to collect soil samples from the site at depths of 0 to 15 cm at the top soil only. About 500g of soil samples were collected into polythene bags. The auger was cleaned with de-ionized water and rinsed with methanol

(99.9%) after each sampling point. The samples were then transferred to a laboratory for futher analysis to be done.

SAMPLE PREPARATION AND EXTRACTION

Sample collection was in tandem with the work of Okpanachi et al., (2025) with little amendment. All samples were inspected prior to extraction by ASE (Accelerated Solvent Extractor). Large rocks and sticks were removed.Samples that appeared dry and loaded directly into the extraction cells containing glass-fiber filters at the outlet end. The extraction cells with a screw-on filter were tarred on the analytical balance and the dry samples were weighed(10g) directly into the cells. Wet samples were weighed into a 100-mL beaker and mixed thoroughly with ASE drying agent (sodium sulphate) using a spatula until a free-flowing mixture resulted. These samples were then placed into the extraction cell through the screw-on funnel and were then extracted using the conditions cited above.

EXTRACTION OF TOTAL PETROLEUM HYDROCARBON CONTAMINANTS IN SOIL USING AN AS3000 AUTO SAMPLER

The analyses were performed using an AS3000 auto sampler designed to achieve maximum precision in automatic liquid injection in capillary GC. This automatic sampler allows the user to inject using two different techniques; cold needle and hot empty needle, both providing excellent performance in terms of data repeatability. The selection of injection technique can be accomplished in a fully automatic fashion, so that any possible lack of reproducibility due to mixed vaporization modes is eliminated.

METHOD

According to the official methods, prescribed by Ugochukwu et al., (2025)with little amendment. These parameters can be measured by capillary gas chromatography, cumulating the total peak area of compounds eluted between n-Decane ($C_{10}H_{22}$) and n-Tetracontane ($C_{40}H_{82}$) used as internal standards. The hydrocarbons contained in the sample are initially extracted with cyclohexane. Eventually extracted polar substances are then separated from the hydrocarbons by a clean-up step with Florisil (manganese silicate). At this point the extract is concentrated, evaporating most of the solvent. An aliquot of the clean concentrated extract is finally analysed by capillary chromatography using a non-polar column and FID detection.

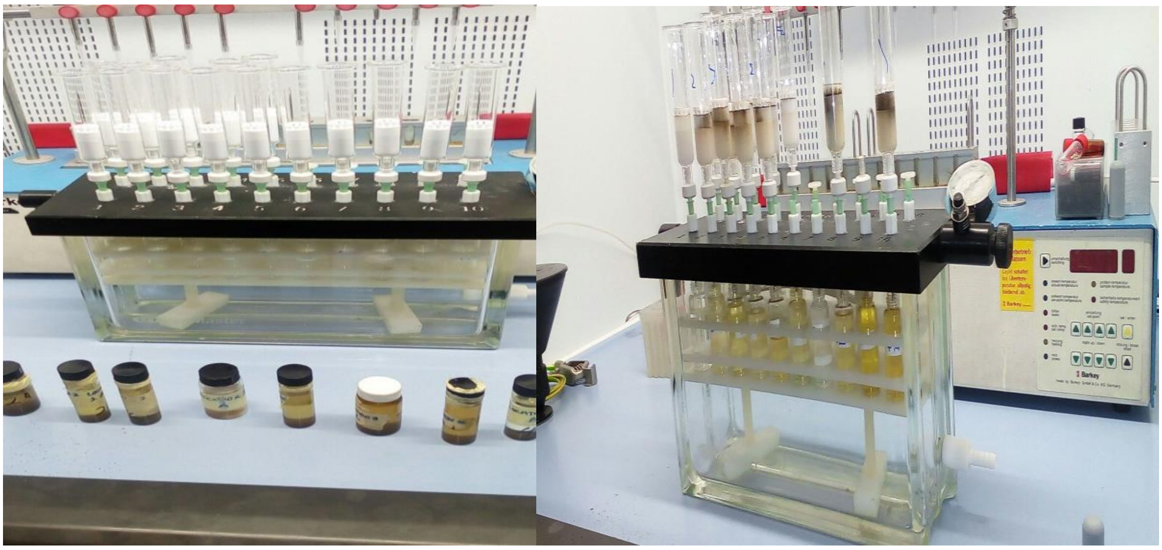

Figure 1: samples undergoing Florisilcleanup.

ANALYSIS

This injection is performed using liquid band formation technique. According to this technique proposed by Saral et al., (2026), the needle penetrates only partially into the inlet with no pre or post-dwell time, and the plunger is compressed at maximum speed, allowing it to carry out cold needle type injections. This can easily be exploited by setting needle penetration depth to ‘’minimum” as on theAS3000automaticsampling system in figure below.

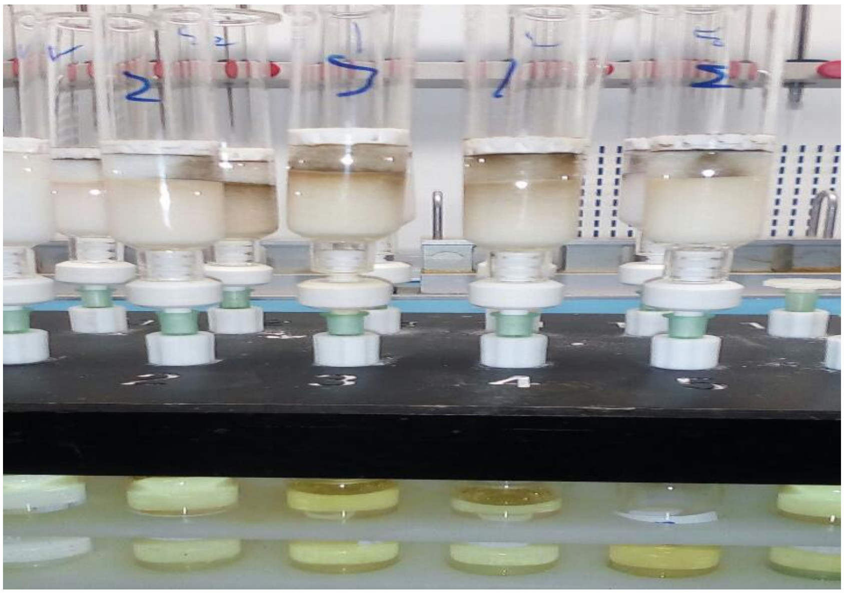

Figure 2: Cold needle injection.

When using this approach, the solvent expelled from the needle tips forms a liquid band and is deposited into the bottom of the liner onto an inert glass wool packing, necessary to prevent the liquid from entering as such in the analytical column.The analytical column used for this application is a RTX-1 column, 5m long, 0.32m i.d, with 0.25µm film thickness. The column temperature is programmed from 400C (18 sec) to 3500C (30sec) at a linear heating rate of 3.30C/sec. an initial isotherm is required to achieve the correct elution of the hydrocarbons with lower boiling points. The injection is performed in split less mode using constant flow operating mode at 5ml/in. the injector temperature is set at 3000C, while the heated block temperature at 3500C. The injected volume is 1µL. quantification is performed using two external standards consisting of different types of soil diluted in cyclohexane.

RESULTS AND DISCUSSION

Table 2: Results of Total Petroleum Hydrocarbons. (TPH) (mg/kg)

LOCATIONS	POINTS	TPH RESULTS (mg/kg)
Agbarho (Bike)	1 (main workshop) 2 (10m away)	1097.15 2317.68
Agbarho (Keke)	1 (main workshop) 2 (10m away)	48619.76 157150.24
Okuokoko (Truck)	1 (main workshop) 2 (10m away)	37763.6 13114.48
Otokutu (Bike)	1 (main workshop) 2 (10m away)	1366.48 1127.99
Warri/Sapele Road (Keke)	1 (main workshop) 2 (10m away)	15745.0 1766.67
Okorikperhe (Truck)	1 (main workshop) 2 (10m away)	14380.8 249.92
PTI Road 1 (Car)	1 (main workshop) 2 (10m away)	1198.90 1077.36
PTI Road 2 (Car)	1 (main workshop) 2 (10m away)	17041.6 3239.38

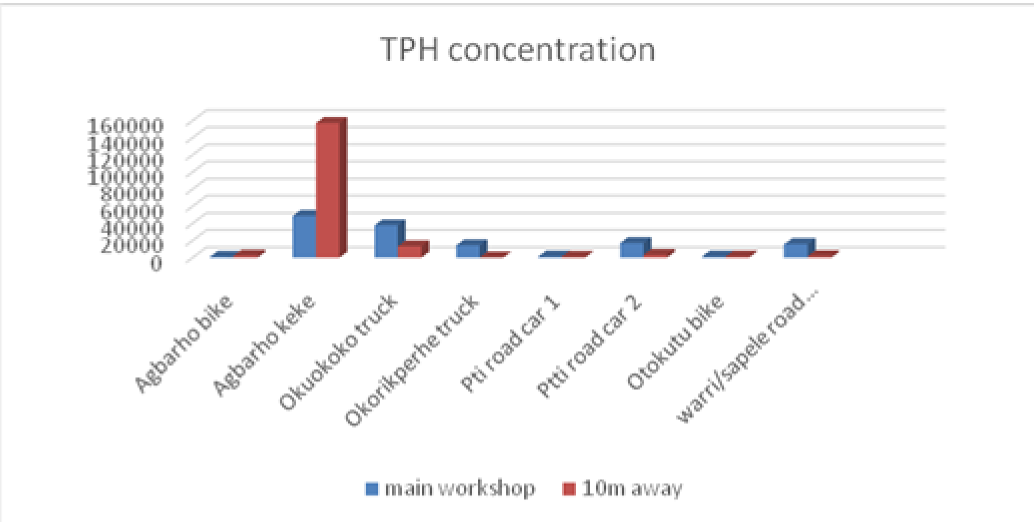

Figure 1: Graphical Representation Showing the Concentration Of TPH.

DISCUSSION

The results of this study revealed substantial variations in the concentrations of Total Petroleum Hydrocarbons (TPH) in soils collected from automobile workshops across selected locations in Warri metropolis. The wide range of TPH values obtained indicates that automobile repair activities are major contributors to petroleum hydrocarbon contamination of surrounding soils. The contamination observed can be attributed to the indiscriminate disposal of spent engine oil, fuel leaks, lubricants, grease, hydraulic fluids, and other petroleum-based products commonly generated during vehicle servicing and maintenance. These findings confirm that automobile workshops serve as important point sources of hydrocarbon pollution. This results are align with the work of Umudi et al., (2026)

Among all the sampling locations, the Agbarhokeke workshop recorded the highest TPH concentration of 157,150.24 mg/kg at the point located 10 m away from the workshop, while the main workshop recorded 48,619.76 mg/kg. This unusually high concentration suggests prolonged petroleum discharge and possible migration of contaminants through surface runoff or infiltration into adjacent soils. The accumulation of hydrocarbons beyond the workshop boundary may also indicate poor drainage conditions, repeated waste disposal practices, and inadequate environmental management. Similar observations have been reported in studies of mechanic workshops where hydrocarbons spread beyond the immediate source due to rainfall, erosion, and soil permeability.

High TPH concentrations were also observed at the Okuokoko truck workshop (37,763.60 mg/kg), PTI Road 2 car workshop (17,041.60 mg/kg), Warri/Sapele Road keke workshop (15,745.00 mg/kg), and Okorikperhe truck workshop (14,380.80 mg/kg). These elevated values reflect intensive mechanical operations involving trucks, cars, and commercial tricycles, which typically consume larger quantities of lubricating oils and petroleum products. Frequent servicing, oil changes, engine repairs, and accidental spillages contribute significantly to the build-up of hydrocarbons in surrounding soils. The results further suggest that workshops handling heavier vehicles tend to generate greater hydrocarbon contamination because of the larger volumes of petroleum products involved in maintenance activities.

Conversely, relatively low TPH concentrations were recorded at Otokutu bike workshop (1,366.48 and 1,127.99 mg/kg), PTI Road 1 car workshop (1,198.90 and 1,077.36 mg/kg), Agbarho bike workshop (1,097.15 and 2,317.68 mg/kg), and the Okorikperhe truck workshop at 10 m away (249.92 mg/kg). These lower concentrations may reflect lower workshop activity, improved waste handling practices, recent site establishment, natural attenuation processes, or reduced frequency of petroleum spills. The exceptionally low value recorded at the Okorikperhe site 10 m away suggests limited contaminant migration or effective dilution with uncontaminated soil.

Comparison between samples collected within the workshops and those collected 10 m away showed no consistent contamination pattern. In several locations, including Warri/Sapele Road, Okorikperhe, Okuokoko, and PTI Road 2, the main workshop exhibited higher TPH concentrations than the surrounding area, indicating that contamination was concentrated around the source of petroleum handling. However, in Agbarhokeke and Agbarho bike workshops, the samples collected 10 m away contained higher TPH concentrations than those obtained within the workshops. This finding suggests that petroleum hydrocarbons are capable of migrating from their points of origin through runoff, seepage, or soil transport mechanisms, thereby extending contamination beyond operational boundaries.

Overall, the study demonstrates widespread petroleum hydrocarbon contamination of soils associated with automobile workshops in Warri metropolis. The magnitude of contamination observed in several locations indicates potential ecological and environmental risks, including deterioration of soil quality, reduced microbial activity, impaired vegetation growth, and possible groundwater contamination. The findings emphasize the need for strict environmental regulations governing automobile workshop operations, proper collection and disposal of used petroleum products, routine environmental monitoring, and the implementation of appropriate soil remediation strategies to restore contaminated sites and protect public health.

CONCLUSION

This study successfully determined the concentration levels of Total Petroleum Hydrocarbons (TPH) in soils collected from selected automobile workshops across Warri metropolis. The results revealed that petroleum hydrocarbon contamination is widespread in automobile workshop environments, with considerable variation in TPH concentrations among the sampled locations. The highest contamination was recorded at the Agbarhokeke workshop, while the lowest concentration was observed at the Okorikperhe truck workshop located 10 m away from the main workshop. These differences reflect variations in workshop activities, the volume of petroleum products handled, waste disposal practices, and environmental conditions influencing contaminant distribution.

The findings further showed that although the highest TPH concentrations were generally recorded within workshop premises, some locations exhibited higher contamination at points 10 m away, indicating the movement of petroleum hydrocarbons through runoff, infiltration, or other environmental processes. This demonstrates that pollution from automobile workshops extends beyond the immediate work area and may pose risks to surrounding soils and nearby ecosystems.

Overall, the study confirms that automobile workshops are significant sources of petroleum hydrocarbon pollution in Warri metropolis. The high TPH concentrations observed emphasize the need for improved environmental management, proper collection and disposal of used petroleum products, regular monitoring of contaminated sites, and the implementation of effective soil remediation strategies to protect soil quality, groundwater resources, ecosystem health, and public safety.

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