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Analyzing the Presence and Dispersion of Hydrocarbons at Mechanic Workshop Dumpsites, Port Harcourt, Rivers State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study aimed to analyze the presence and dispersion of hydrocarbons in dumpsites at mechanic workshops in Port Harcourt, Rivers State, Nigeria. Soil samples were collected from within 15-25 cm soil depth from three mechanic workshops in Port Harcourt, situated at Elekahia, Rumeme and Eleme Local Governments. The total petroleum (TPH) and Polycyclic aromatic hydrocarbons (PAHs) concentrations in the soil samples were determined using standard methods. Total TPH concentration in mechanic workshop dumpsites ranged from 9508.18 ppm to 10342.41 ppm, while in the control the concentration was 424.41 ppm. Total PAH concentration in mechanic workshop dumpsites ranged from 312.45 ppm to 1654.08 ppm, while in the control the concentration was 157.89 ppm. All the dumpsites had high levels of PAHs, which was several folds more than in the

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control. Results revealed that soil at mechanic workshop dumpsites was highly contaminated with hydrocarbons, exceeding the allowable limit 50 mg/kg by the Department oof Petroleum Resources (DPR). Remediation of the soil is recommended, as well as proper management of waste, where relocation of the dumpsite is not possible.

Keywords: Dumpsite; hydrocarbons; mechanic workshop; soil.

1. INTRODUCTION

One of the most significant sources of soil pollution at automobile mechanic workshops is spent lubricating oil [1-2]. In recent times, the presence of different types and numbers of automobiles has increased the use of hydrocarbon lubricating oils. Hydrocarbon is a very vital aspect of lubricant not just for vehicles but every machine in the world and with the recent massive worldwide technological advancement, hydrocarbon lubricant is becoming very essential.

An essential aspect of car servicing involves change of lubricant. If the used fluids and solvents from auto mechanic workshops are not properly handled and managed in the dumpsites, they can find their way into the air, water, soil, lakes and streams Consequently, it has led to severe environmental contamination alongside other petroleum and petrochemical products, including polycyclic aromatic hydrocarbons.

Soil polluted with hydrocarbon becomes waterlogged; inducing several stresses on the plant and microbial community; ranging from changes in structure and configuration of enzymes. Polluted soil could also become unsuitable due to an increase in the toxic levels of elements [3]. Groundwater and soil pollution arising from auto-mechanic activities from auto-mechanic workshops are well documented [4-7].

In mechanic workshops, there are accidental or deliberate releases or discharges of petrol, diesel, solvents, grease, and lubricants on the land and the atmosphere. Many of these petroleum products are organic chemicals that can be highly toxic and hazardous to soil fauna and man. Automobile hydrocarbon (waste oil) contains oxidation products, sediments, water and metallic particles resulting from machinery wear, used batteries, organic and inorganic chemicals used in oil additives and metals [2,8,9].

In Nigeria, most automotive workshops are situated in available open spaces, and they are more in urban centres than in rural areas for obvious reason. The nature of work and lack of training or awareness about environment safety by auto mechanic, implies that spilling of hydrocarbon compounds in soil within the vicinity of their operations is inevitable. Alabi [6] qualitative and quantitative assessment of hydrocarbons in auto-mechanic workshop in Akure, Ondo State, Nigeria, highlighted the high pollution rate by hydrocarbon and the implication on environmental health. Ikpe [10] in their investigation of petroleum hydrocarbons in soil from auto-mobile mechanic workshops within Ikot Akpaden and Mkpat Enin, Akwa Ibom State Nigeria, reported that concentration of hydro obtained in the three points were greater than the acceptable limit. Several other studies [11-13] also revealed that soil pollution in auto-mechanic workshops were polluted as a result of indiscriminate disposal of used oil and lubricant directly into the soil, as well as dumping of waste at the auto-mobile mechanic workshops.

This study aims to assess the degree of hydrocarbon contamination at dumpsites within automobile mechanic workshops in Port Harcourt.

2. METHODS

2.1 Sample Collection

Soil samples were randomly collected from each of the dumpsites of mechanic workshops situated at Elekahia, Rumeme and Eleme. The soil samples were collected at a depth of 15cm - 25cm using a soil auger. The control was garden soil collected from the University of Port Harcourt.

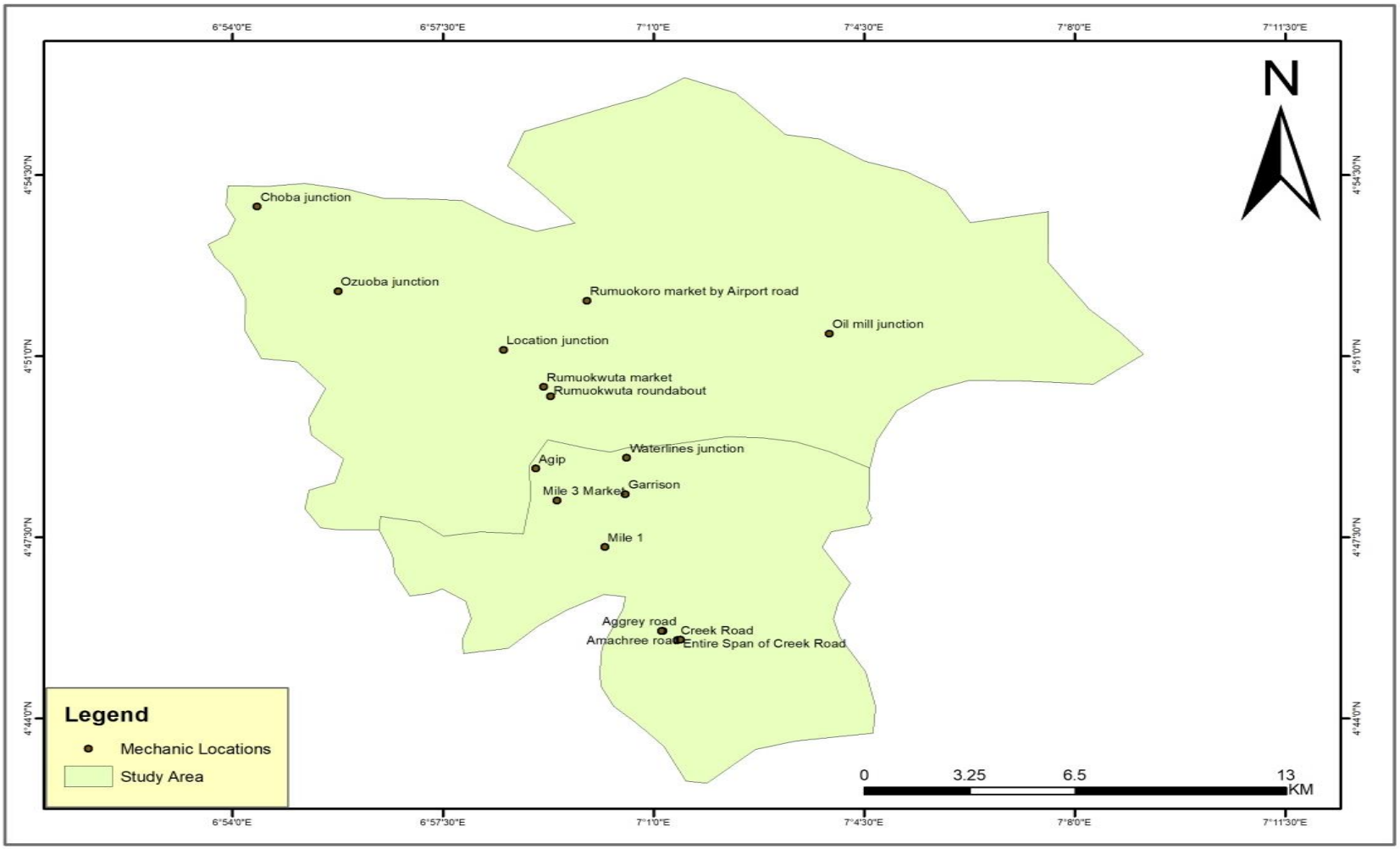

Fig. 1. Mechanic workshop dumpsites in Port Harcourt metropolis

2.2 Analysis of Total Petroleum Hydrocarbons (TPH) and Polycyclic Aromatic Hydrocarbons (PAHs)

The total petroleum hydrocarbon (TPH) and Polycyclic aromatic hydrocarbons (PAHs) concentrations in the soil samples were determined using a modified EPA 8015 [14] technique. Analysis of TPH was done using GC-FID instrument (HP 5890 Gas Chromatography with Chem Station software, capillary column, and Flame Ionization Detector (FID). The machine is fitted with autosampler vials, 150 µL vial inserts, and crimp seals; vial crimper and decrypter; 2.5mL airtight syringe or 3mL disposable hypodermic syringe; 10 micro-litre autosampler syringe; 30-m x 0.25-mm or 0.32-mm ID fused-silica capillary column, chemically bonded with SE-54 (DB-5); 1-µm film thickness; platinum filament of dimensions 20 mm × 5 mm.

The extract obtained from the ultrasonic extraction was quantified for PAH analytes using 30m x 0.25um x 0.25mm ID long chromatographic column calibrated with a standard solution of 16 component priority PAH Certified Reference Material (CRM) purchased from Chemservices, West Chester, USA. The calibration standard included USEPA 8270 LCS mix (semivolatile compound mix Supelco, Inc, St. Louis, MO; lot number LB21442), which included the target analytes.

2.3 Statistical Analysis

Data on TPH and PAHs levels were subjected to single-factor analysis of variance (ANOVA) using SPSS v20, to ascertain level of significance.

3. RESULTS

3.1 Total Petroleum Hydrocarbon Concentrations in Mechanic Workshop Soil

Total petroleum hydrocarbon (TPH) concentration in soil samples varied across locations as shown in Table 1. Table 1 shows TPH in control soil, with only C9, C12, C14, C18 and C19 detected to give a total concentration of 424.41 ppm.

Table 1. Total petroleum hydrocarbons in mechanic dumpsite soil samples

	Hydrocarbon constituent	Elekahia	Rumeme	Eleme	Control
1	C8	-	-	672.89	-
2	C9	-	-	-	70.55
3	C10	633.23	-	-	-
4	C11	-	-	-	-
5	C12	-	-	-	87.12
6	C13	-	-	-	-
7	C14	799.45	807.34	800,23	129.29
8	C15	854.16	908.23	1009.34	-
9	C16	-	699.76	-	-
10	C17	1355.48	11435.57	789.78	-
11	C18	808.47	698.57	-	50.32
12	C19	1024.11	1200.17	800.76	87.13
13	C20	323.97	509.23	201.5	-
14	C21	478.29	523.34	500.2	-
15	C22	400.11	436.11	402.2	-
16	C23	-	1001.99	1018.67	-
17	C24	156.12	642.29	798.76	-
18	C25	-	-	1000.78	-
19	C26	287.44	574.19	500.45	-
20	C27	1444.29	-	1113.25	-
21	C28	409.88	653.19	700.23	-
22	C29	533.18	152.43	309.23	-
	Total	**9508.18**	**10342.41**	**9818.05**	**424.41**

Table 2. PAH concentrations in mechanic dumpsite soil samples

S/N	Name	Elekahia	Rumeme	Eleme	Control
1	Naphthalene	-	-	1234.66	-
2	Acenaphthylene	1567.14	1400.89	-	17.11
3	Acenaphtene	1673	1204.33	1200.67	43.23
4	Fluorene	453.12	639.75	234.12	-
5	Phenanthrene	721.23	456.78	500.89	7.29
6	Anthracene	-	453.23	-	-
7	Fluoranthene	1000.34	879.23	901.2	-
8	Pyrene	801.78	890.34	453.82	51.18
9	Benz(a)anthracene	1700.15	1590.45	1542.23	-
10	Chrysene	432.98	672.34	404.19	15.85
11	Benzo(b)fluoranthene	402.76	-	-	-
12	Benzo(k)fluoranthene	540.23	672.45	312.45	-
13	Benzo(a)pyrene	901.54	1005.78	1001.56	23.23
14	Indeno(1,2,3-cd) pyrene	765.45	678.92	402.77	-
15	Dibenz (a,h) anthracene	1601.45	1654.08	1365.18	-
16	Benzo (g,h, i) perylene	567.23	489.23	678.19	-
	Total	**13128.4**	**12687.8**	**9731.04**	**157.89**

In soil from Elekahia mechanic workshop dumpsite, the least hydrocarbon fraction was C24 (156.12 ppm) while the most abundant was C27 (1444.29 ppm). Total TPH was 9508.18 ppm. In soil from Rumeme mechanic workshop dumpsite, the least hydrocarbon fraction was C29 (152.43 ppm) while the most abundant was C19 (1200.17 ppm). Total TPH was 10342.41 ppm. In soil from Eleme mechanic workshop dumpsite, the least hydrocarbon fraction was C20 (201.5 ppm) while the most abundant was C27 (1113.25ppm). Total TPH was 9818.05 ppm.

3.2 Polycyclic Aromatic Hydrocarbon Concentrations in Soil

Table 2 shows the PAHs present in soil samples. The PAHs detected in the control were benzo(a)pyrene, chrysene, pyrene, phenanthrene, acenaphthylene and acenaphthene, with total concentration of 157.89 ppm. In soil from the Elekahia mechanic dumpsite, the PAH concentrations varied from 402.76 ppm to 1601.45 ppm, with a total concentration of 13128.4 ppm. In soil from Rumeme mechanic dumpsite, the PAH concentrations varied from 456.78 ppm to 1654.08 ppm, with a total concentration of 12687.8 ppm. In soil from the Eleme mechanic dumpsite, the PAH concentrations varied from 312.45 ppm to 1542.23 ppm, with a total concentration of 9731.04 ppm.

4. DISCUSSION

Total petroleum hydrocarbon (TPH) concentrations in soil samples varied across the three mechanic workshop dumpsites. Mean TPH concentration in Elekahi, Rumeme and Eleme, 9508.18 ppm, 10342.41 ppm, in that other are several folds higher than 424.41 ppm in the control. This is indicative of the effect of continual dumping of hydrocarbon containing waste in the environment. Having high concentrations of hydrocarbons at subsurface soil is clearly an indication of transport of discharged spent engine oil and other hydrocarbon-based chemical in the soil. The sites are heavily polluted and could result in direct contamination of groundwater and even surface water through run-off activities. TPH values in the present study are higher than those reported by Alabi et al. [6] in their qualitative and quantitative assessment of hydrocarbons in soil at auto-mechanic workshops in Akure, Ondo State, Nigeria. The study reported TPH concentration in range of 12.59 to 123.76 mg/kg. Ikpe [10] in their investigation of petroleum hydrocarbons in soil from auto-mobile mechanic workshops within Ikot Akpaden and Mkpat Enin, Akwa Ibom State Nigeria, reported that concentration of hydrocarbon obtained in the three points were greater than values reported in the present study. The difference in results may be attributed to factors such as the nature of the soil, the type of oil used for serving vehicles brought to the workshops, the age of auto-mechanic workshop and the climatic conditions of the locations.

Total petroleum hydrocarbon (TPH) concentration results dumpsite soil samples show significant low amount light hydrocarbon relative to higher molecular weight hydrocarbons.

The absence of pristane and phytane suggest that the source of hydrocarbons in the soil is not from crude oil spill [15], as the study location is the Niger Delta, a region blighted with environmental pollution from oil and gas activities [16,17]. The carbon preference index, which is defined as the ratio of the sum of the odd carbon-numbered alkanes to the ratio of the even carbon-numbered alkanes, suggest that the hydrocarbons in the soil were from anthropogenic sources rather than biogenic [15].

All 16 priority PAHs were detected in the three mechanic workshop dumpsites with concentrations in the range of 9731.04 ppm to 13128.4 ppm, whereas the PAHs detected in the control were benzo(a)pyrene, chrysene, pyrene, phenanthrene, acenaphthylene and acenaphthene, with total concentration of 157.89 ppm. PAH values in the present study are higher than those reported by Alabi et al. [6] <0.01 to 0.21 mg/ kg. Petroleum products from different sources differ in their PAH constitution even though they are more resistant to weathering than hydrocarbon constituents. This distinction in PAHs can serve as a basis or fingerprint for classification. The PAH distribution of the sample for this study showed low values for two-ringed PAHs such as naphthalene and Fluorene, and very high values for EPA priority PAHs of which Phenanthrene and Benz(a)anthracene, which are of higher molecular weight. These high molecular weight PAHs (three to six-ringed PAHs) are known as pyrolytic PAHs while the low molecular weight PAHs (two-ringed PAHs) are known as fossil PAHs [18]. The abundance of the high-molecular-weight PAHs suggests that though these hydrocarbon fractions were petrogenic in origin, there might have been incidences of elevated temperature such as combustion since high molecular weight PAHs are products of the combustion of petroleum or its products [19]. The ratio of benzo (a) anthracene to chrysene, suggest the PAHs were originally of petrogenic origin as supported by Benlahcen et al. [20].

As one of the toxic components in crude oil, PAHs may cause toxicity to soil biota, because toxic contaminants can be selected for specific susceptible taxa either by inhibiting susceptible species or facilitating the selection of tolerant organisms [19].

5. CONCLUSION

The waste dumpsite at the automobile mechanic represents a potential source of hydrocarbon contamination of soils, sediment, surface and groundwater in areas far from oil production sites. Overall, the soils at the mechanic dumpsites were highly contaminated and might be detrimental to any life form within the vicinity of the study location. A solution would be to relocate the mechanic workshops and remediate the land. But a more lasting solution would be on enforcing stricter laws for the siting and operation of mechanic.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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