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Distribution of Physicochemical Parameters and Heavy Metals at Automobile Mechanic Dumpsites in 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 assess physicochemical parameters and heavy metal levels at automobile mechanic workshop dumpsites in Port Harcourt, Rivers State, Nigeria. Three dumpsites situated at, Port Harcourt, were sampled in the present study. Physicochemical parameters and heavy metals were monitored in soil samples from the dumpsites situated at Elekahia, Rumeme and Eleme, following standard protocols. The mean values of pH, total nitrogen, phosphorus, potassium, alkalinity, TPH, Cr, Cd, Fe, Pb and Mg in the soil ranged from 6.1-7.3, 163.8 mg/kg-238.33 mg/kg, 15.76 mg/kg-16.233 mg/kg, 106.67 mg/kg-144.67 mg/kg, 88.33 mg/kg-399.23 mg/kg, 8502.41-9391.58 mg/kg, 0.169 mg/kg-0.282 mg/kg, 0.256 mg/kg-0.386 mg/kg, 3.327 mg/kg-3.519 mg/kg, and 0.137 mg/kg-0.19 mg/kg and 0.18 mg/kg-0.24 mg/kg, respectively. Soil pH, alkalinity, potassium, nitrogen and TPH were above WHO maximum safe limits. The study recommended among others that the government and other environmental agencies should organise programmes to educate automobile technicians on global best practices of waste management in the automobile industry.

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1. INTRODUCTION

Automobile workshops as a place where fossil fuel-using vehicles are repaired, have become a common sight in many cities in third world countries, as their siting and operation are largely unregulated. Significant amounts of waste are produced in automobile workshops. Wastes in automobile workshops arise from activities such as maintenance and fabrication, and from materials such as solvents used for maintenance and cleaning, paint thinning, spent heat transfer fluids, spent lubricants, spent hydraulic fluids, stripped oily sludge, spent sandblasting media and wastewater.

The use of automobiles has also led to an increase in soil contamination, which has grave consequences for soil-dwelling organisms. Biotic abundance in soil can be negatively affected by waste from mechanic dumpsites [1]. Wastes ranging from petrol, grease, oils, suspended solids, organic solvents and junked car parts contain chemicals with a range that may be phytotoxic to plants and injurious to animals [2].

Aside from chemicals, temperatures inside mechanic workshop dumpsites can be so high and can disrupt existing biotic interactions, making ecosystems more susceptible to biological invasions [3]. Even moderate warming can significantly reduce the density and biomass of soil organisms [3,4]. Also, higher soil temperatures are often accompanied by lower soil water content, which can alter soil physical properties [5].

Automobile workshops can substantially contribute to heavy metal contamination of soil. Grease, peeling paint and metal in auto-catalysts are sources of heavy metal pollution. Extensive trace metal pollution in soil within and around automobile dumpsites implies that water bodies (surface and groundwater) within and away from their vicinity may equally be polluted with trace metals due to continuous interactions between soil and water and high dispersion rate in the tropical rain forest belt. Heavy metal pollution is a major source of concern in the environment, as its damage is widely known due to its bio-accumulative nature [6-8]. The threat to human health posed by large concentrations of heavy metals in soil and water has made these metals environmental pollutants of global concern, given the numerous applications requiring their use in modern times [9-11]. Heavy metals easily accumulate in the topsoil to toxic levels due to their persistence and eventually make their way to humans through the food chain, where they perturb biological processes. Therefore, there is a need to assess the physicochemical and heavy metal levels in mechanic workshop dumpsites in the Port Harcourt metropolis. According to Gupta and Gupta [3], the toxicity of heavy metals can be felt across the food chain, they can cause genetic abnormalities as a result of physiological impairments.

The massive increase in the population of Nigerians, especially in Rivers State as a result of the presence of oil and gas industries that offers ample employment opportunities has led to a corresponding increase in demand for vehicles and eventually increased demand for engine oil, grease, gear oil, coolants etc. Nigeria is a big consumer of second-hand cars. Following their incessant breakdown due to wear and tear vehicles end up in mechanic workshops. At this point, a car owner with little or no prior knowledge of the maintenance takes it to the automobile mechanic's workshop for repair and these mechanics randomly dispose of waste in their surroundings with no care to the environment.

This study aimed to assess the physicochemical parameters and heavy metal levels at mechanic dumpsites situated in Port Harcourt, Rivers State, Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

The study sampled dumpsites at mechanic workshops suited in the Port Harcourt metropolis. Port Harcourt is the capital city of Rivers State, Nigeria. Three mechanic workshops located at Rumueme, Eleme and Alakahia were sampled in this study. The three sample locations are situated in the tropical rainforest belt, having two distinct seasons the rainy season and the dry season. The mechanic workshops were chosen because of their strategic location, and are renowned for having heavy heaps of waste.

2.2 Sample Collection

Sample collection was by the completely randomized sampling method. Six samples were collected in the month of May 2022 from the mechanic dumpsites. Soil samples from the sites using a soil auger at depths of 0-15 cm, 15-20 cm and 20-30 cm.

2.3 Analysis of Soil Physicochemical Properties

The determination of soil chemical properties followed standardized methods. Heavy metal analysis was done using an Atomic Absorption Spectrophotometer (AAS Bulk Scientific 210 VGP) following EPA 8015 [12]. Total petroleum hydrocarbon (TPH) was also determined according to EPA 8015 [12].

2.4 Statistical Analysis

Data on soil physicochemical parameters and heavy metals were subjected to single-factor analysis of variance (ANOVA) using Microsoft Excel software, to ascertain the level of significance.

3. RESULTS

Table 1 shows the physiochemical parameters at the Elekahia mechanic workshop dumpsite. The mean values of pH, total nitrogen, potassium, alkalinity, TPH, Cr, Cd, Fe, Pb and Mg in the soil were 6.833, 206.467 mg/kg, 16.233 mg/kg, 106.67 mg/kg, 132.89 mg/kg, 8502.41 mg/kg, 0.201 mg/kg, 0.362 mg/kg, 3.519 mg/kg, 0.190 mg/kg and 0.180 mg/kg, respectively.

Table 2 shows the physiochemical parameters at the Eleme mechanic workshop dumpsite. The mean values of pH, total nitrogen, potassium, alkalinity, TPH, Cr, Cd, Fe, Pb and Mg in the soil were 6.1, 238.33 mg/kg, 15.867 mg/kg, 144.67 mg/kg, 88.33 mg/kg, 9391.58 mg/kg, 0.169 mg/kg, 0.386 mg/kg, 3.417 mg/kg, 0.137 mg/kg and 0.203 mg/kg, respectively.

Table 3 shows the physiochemical parameters at the Rumueme Mechanic Workshop dumpsite. The mean values of pH, total nitrogen, potassium, alkalinity, TPH, Cr, Cd, Fe, Pb and Mg in the soil were 7.3, 163.8 mg/kg, 15.76 mg/kg, 128.67 mg/kg, 399.23 mg/kg, 9216.28 mg/kg, 0.282 mg/kg, 0.256 mg/kg, 3.327 mg/kg, 0.156 mg/kg and 0.240 mg/kg, respectively.

Table 1. Physiochemical parameters at Elekahia Mechanic Workshop dumpsite

Parameters	A (0-15 cm)	B (15-20 cm)	C (20-25 cm)	Mean	WHO maximum allowable limit
pH	6.3	6.8	7.4	6.833	6.5
Total N (mg/kg)	180.1	185.3	254.0	206.467	50
Phosphorus (mg/kg)	15.2	16.4	17.1	16.233	80
Potassium (mg/kg)	103	107	110.0	106.67	80
Alkalinity (mg/kg)	20.5	88.0	290.1	132.89	6.5
TPH (mg/kg)	6777.56	8895.45	9834.23	8502.41	500
Cr (mg/kg)	0.185	0.200	0.219	0.201	3.8
Cd (mg/kg)	0.391	0.395	0.300	0.362	0.03
Fe (mg/kg)	3.023	3.431	4.103	3.519	50000
Pb (mg/kg)	0.182	0.193	0.203	0.190	85
Mg (mg/kg)	0.110	0.198	0.231	0.180	20

Table 2. Physiochemical parameters at Eleme mechanic workshop dumpsite

Parameters	A (0-15 cm)	B (15-20 cm)	C (20-25 cm)	Mean	WHO maximum allowable limit
pH	6.6	6.0	5.6	6.1	6.5
Total N (mg/kg)	173	185	357.0	238.33	50
Phosphorus (mg/kg)	12.0	16.4	19.2	15.867	80
Potassium (mg/kg)	132	151	151	144.67	80
Alkalinity (mg/kg)	53.0	82.0	130	88.33	6.5
TPH (mg/kg)	7800.34	9267.53	11106.88	9391.58	500
Cr (mg/kg)	0.221	0.145	0.142	0.169	3.8
Cd (mg/kg)	0.362	0.394	0.403	0.386	0.03
Fe (mg/kg)	2.805	3.536	3.912	3.417	50000
Pb (mg/kg)	0.121	0.143	0.148	0.137	85
Mg (mg/kg)	0.194	0.202	0.214	0.203	20

Table 3. Physiochemical parameters at Rumueme Mechanic Workshop Dumpsite

Parameters	A (0-15 cm)	B (15-20 cm)	C (20-25 cm)	Mean	WHO maximum allowable limit
pH	6.6	7.1	8.2	7.3	6.5
Total N (mg/kg)	180.1	185.3	126.0	163.8	50
Phosphorus (mg/kg)	12.0	16.1	19.2	15.76	80
Potassium (mg/kg)	108	127	151	128.67	80
Alkalinity (mg/kg)	220.2	82.0	895.5	399.23	6.5
TPH (mg/kg)	7094.28	9321.46	11233.09	9216.28	500
Cr (mg/kg)	0.191	0.334	0.321	0.282	3.8
Cd (mg/kg)	0.211	0.261	0.298	0.256	0.03
Fe (mg/kg)	2.98	3.002	4.001	3.327	50000
Pb (mg/kg)	0.102	0.180	0.186	0.156	85
Mg (mg/kg)	0.221	0.220	0.280	0.240	20

4. DISCUSSION

The physicochemical properties and heavy metals content of soil from automobile mechanic dumpsites were assessed in this study, to ascertain the contribution of these locations to environmental pollution.

pH at the automobile mechanic workshop dumpsites ranges from 6.1-7.3 indicating weakly acidic to slightly alkaline soil. The pH values at some locations were above the WHO safe limit of 6.5. The pH range is higher than 6.0 to 6.8 reported by Amukali and Bariwen [13] and 6.53-6.69 reported by Nwakife et al [14]. The difference might arise because in auto-mechanic dumpsite was sampled instead of soil within the vicinity of the workshops. For Elekehia and the mean values of total nitrogen ranged from 163.8-238.33 mg/kg and were above the WHO safe limit of 50 and 80 respectively. Total nitrogen and potassium values were also higher than values reported by Nwakife et al [14]. For Elekahia and Eleme samples N concentration increased with depth, but reverse was the case with Rumueme samples. Although N is an essential plant nutrient, too much of it in the soil increases the risk to the environment [15].

The mean values of phosphorus ranged from 15.76 to 16.233 mg/kg, which is within the safe limit. Phosphorus concentration for all sites increased with soil depth. Rumueme sample pH increased with soil depth, while for Eleme soil samples it decreased with soil depth.

The mean values of potassium ranged from 106.67-144.67 mg/kg and were above the WHO safe limit of 80. Potassium concentration increased with depth for Elekahia samples but was variable in the other two sites. High potassium concentrations in soil inhibit the uptake of exchangeable cations and may likely cause their deficiency [16].

Mean values of alkalinity ranged from 88.33-399.23 mg/kg and were within tolerable limits in soil. The mean total petroleum hydrocarbon ranged from 8502.41 mg/kg to 9391.58 mg/kg. The topsoil horizon contained less hydrocarbon than the subsurface. This is indicative of percolation of the pollutant. Having a higher concentration of hydrocarbons in subsurface soil is suggestive evidence that the petroleum hydrocarbon content of the soil at sampled waste dumps was possibly from prolonged discharge of spent engine oil and other hydrocarbon-based chemical. While the present observed a direct proportion between the depth of soil and TPH concentration, Alabi et al [17]. Reported an inverse trend.

The mean Cr, Cd, Fe, Pb and Mg concentrations in the soil ranged from 0.169-0.282 mg/kg, 0.256-0.386 mg/kg, 3.327-3.519 mg/kg, and 0.137-0.19 mg/kg and 0.18-0.24 mg/kg, respectively. The levels of heavy metals in soil were judged safe, as per WHO standards. However, the danger of heavy metal toxicity still exists, as concentration can build up over time. Oloruntoba and Ogunbunmi [18] reported that the mean concentrations of heavy metals in groundwater were significantly higher than the permissible limits for WHO. Although the present study did not examine groundwater, it can be reasoned that continual disposal of waste over time anywhere could impact groundwater quality. Adewoyin [19]. assessed the human health risk of potentially toxic mineral elements (As, Cd, Cu, Cr, Mn, Ni, Pb, and Zn) through the oral ingestion of soil and locally grown edible vegetables viz: waterleaf (*Talinum triangulare*), spinach (*Basella alba*), pumpkin leaf (*Telfairia occidentalis*), okro leaf (*Abelmolschus esculentus*), cockscomb (*Celosia argentea*) and green leaf (*Amaranthus viridis*) grown on some contaminated soil samples. Most of the values obtained were higher than the recommended tolerable safe limits established by FAO/ WHO for edible vegetables. The observed trend of heavy metal distribution was an increase in concentration with depth.

The mean of the physicochemical parameters and heavy metal concentrations within sample sites did not differ significantly (F>0.05). Amukali and Bariwen [13] in their study of the distribution of physicochemical parameters in the soil around auto-mechanic workshops in Yenagoa, also observed no significant difference in the parameters monitored, however, the mean hydrocarbon concentrations within sample sites differed significantly ($p<0.05$).

5. CONCLUSION

Soil pH, alkalinity, potassium, nitrogen and TPH were above WHO maximum safe limits. Only the subsurface horizon contained less than 450 mg kg^{-1} total petroleum hydrocarbon. The physicochemical parameters and heavy metal content within sample sites did not differ significantly. The hydrocarbon concentrations within sample sites differed significantly. The generally observed trend of distribution of physicochemical parameters and heavy metal in soil showed an increase in concentration with depth.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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