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Assessment of Heavy Metal Contamination in Soils Around Auto-Mechanic Workshops in Ozoro, Delta 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

Auto-mechanic activities have been identified as a significant contributor to heavy metal contamination in Nigerian urban ecosystems. This study assessed the impact of such activities on soil heavy metal accumulation by analyzing 28 soil samples (labeled A, B, and C) collected from three auto-mechanic workshops, along with a control sample (D) from an uncontaminated site. Concentrations of lead (Pb), cadmium (Cd), chromium (Cr), copper (Cu), zinc (Zn), and iron (Fe) were determined through laboratory analysis and compared with established environmental quality standards. Elevated levels of copper (6.721 mg/kg), cadmium (0.228 mg/kg), and zinc (58.232 mg/kg) were observed in the sampled soils, suggesting substantial anthropogenic input, particularly from used oil spills. The persistent presence of heavy metals across all sites reflect the environmental risks associated with improper waste handling in automobile repair stations. It is recommended that appropriate containment systems, such as oil collection drums and sealed containers, be implemented to mitigate further contamination and protect soil quality.

Keywords: Automobile; mechanic; workshop; soil; heavy metal.

1. INTRODUCTION

The general definition of environmental pollution is the release of pollutants that are detrimental to living organisms into the land, water, or atmosphere. Concerns regarding the negative environmental effects of petroleum product contamination have been brought up by activities associated to petroleum around the world, and in Nigeria specifically (Obianime et al., 2017). An exceptional rise in population, urbanization and human activities associated with modernization has increased pollutants to critical levels (Ehis-Eriakha et al., 2024). According to Egwurugwu and Nwafor (2013) and Egwurugwu et al. (2013), human exposure has so far been linked to an increasing occurrence of a variety of acute and long-term negative health impacts and diseases.

Eighty percent of the deadliest illnesses, such as cancer, respiratory conditions, and cardiovascular disorders, are influenced by environmental factors (WHO, 2006). Nigerian professional auto mechanics are particularly vulnerable to poisonous or contaminated crude oil and its refined products, which could have a negative impact on the environment or human health. Regretfully, there is little to no information available in Nigeria on automotive workshop environmental policy, automotive environmental standards, and inspection checklists. According to certain research, car workshops can have a negative impact on people's health, particularly those who live nearby. However, there is a dearth of research on the impact of environmental concentrations of stationary emissions of pollutants in the air, water, and soil—particularly petroleum products—on human physiological processes (Obianime et al., 2017).

The long-term presence of the resulting pollutants in the soil increases concerns about soil microorganisms poisoning, which can lower soil fertility, which is dependent on both the type and quantity of microorganisms living there as well as the soil's chemical makeup (Okobia et al., 2024). Heavy metals and metalloids can build up in soils through emissions from rapidly growing industrial areas, mine tailings, leaded gasoline and paints, high metal waste disposal, fertilizer and animal manure land application, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, petrochemical spills, and atmospheric deposition (Wuana and Okieimen, 2011).

One of the biggest health concerns in the world is the pollution caused by heavy metals, even at low levels, and the long-term cumulative health impacts that occur (Huton and Symon, 1986). Their propensity to bio accumulate, go up the food chain, and harm soil microorganisms, as well as their permanence in the soil, increase the level of worry (Udousoro et al., 2010). Auto mechanic work is one of the main causes of the rise in heavy metal concentrations in Nigerian ecosystems (Adewole and Uchegbu, 2011). According to Nwachukwu et al. (2011), these auto maintenance shops are located in groups of open land plots close to cities and urban centers. Individuals in the clusters specialize on electrical aspects of auto repairs, while others work on brake and steering repairs, standard or automatic transmission engine repairs, spray painting, auto battery recharge, welding, and soldering.

All of these activities produce different kinds of trash, such as paint, gasoline, diesel, and used engine oil, which are easily dumped in the adjacent regions or bushes. Pollution and soil contamination result from this unhealthy method of getting rid of such dangerous garbage. Their propensity to bio accumulate, go up the food chain, and harm soil microorganisms, as well as their permanence in the soil, increase the level of worry (Udousoro et al., 2010). The frequency of spills exacerbates Nigeria's environmental pollution situation.

2. MATERIALS AND METHODS

2.1 Study Area

Ozoro is the headquarters of Isoko North Local Government Area of Delta State. It is one of the administrative units of the Isoko regions in Delta State Nigeria situated at Latitude: 5.5383 and Longitude: 6.2161 with approximate population of 13,411(at 2015) inhabitants and land mass of 1.136km^2. It is host to spills from petroleum products and subject to frequent flooding which helps in dispersing pollutants over a large area. Ozoro falls within the southern tropical evergreen forest zone and characterized by two climatic seasons. It comprises also of commercial activities and other municipal practices which causes environment pollution.

2.2 Collection of Sample/Preparation

Contaminated soil samples were collected using a soil auger in a randomized method along transect at 100cm interval from three different automobile mechanic workshop within the study area. These sampling points have been subject to spent engine oil and were labeled as samples A (7 samples), B (7 samples) and C (7 samples). An additional soil sample from a point free from spent oil discharge was obtained as sample D (7 samples). At each sampling location, auger-boring instrument was used to bore holes of depths 10cm, 15cm and 30cm. The samples were homogenized in a clean plastic bucket, poured into a polythene bag, labeled adequately and transported to the laboratory immediately for analysis.

2.3 Materials

Analysis of soil pollution from mechanic workshops was conducted through adequate sampling and analysis of some heavy metals concentration in soil from mechanic workshops in Ozoro Community. This analysis was done in phases.

2.4 Soil Analysis

Each polythene bag was used to create a composite sample. Before analysis, all of the composite samples were allowed to air dry and go through a 2 mm sieve. One milliliter of concentrated $HClO_4$, three milliliters of HNO_3, and one milliliter of concentrated HF were added to 2.0 grams of 2 mm sieved air-dried soil that had been weighed into a 300 cm³ conical flask under a fume hood. After heating the flask containing the sample until a thick white fume appeared, the heating process was continued for 30 seconds. After letting the flask cool, 40–50 milliliters of distilled water were added. After letting the mixture cool fully, it was filtered

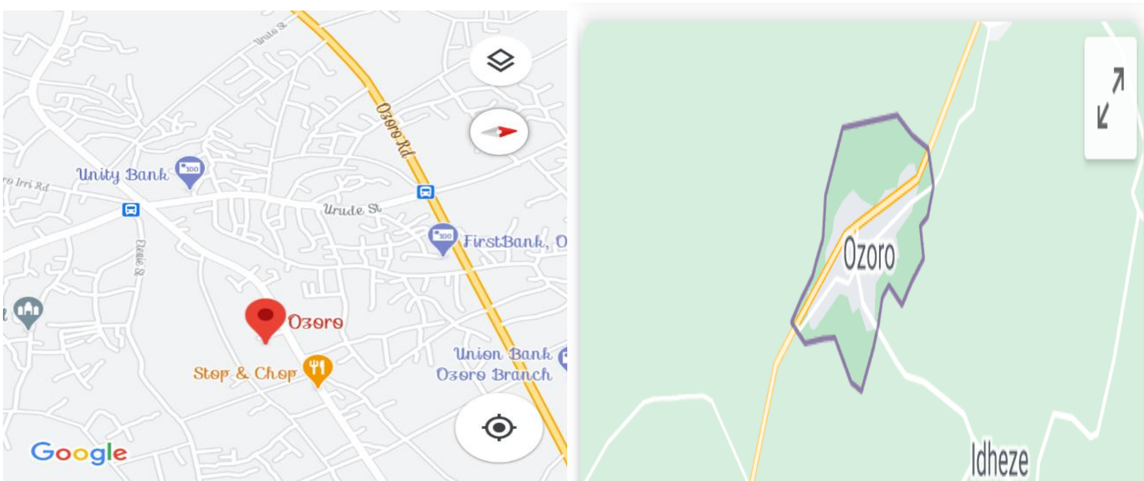

Fig. 1. Map showing study location

through a wash bottle and transferred into a Pyrex volumetric flask. After filling the flask to the mark with distilled water, a Whatman No. 42 filter paper was used to filter it once more. After that, the soil extract and standard solution were inhaled into the Varian 220 Atomic Absorption Spectrometer's air-acetylene flame.

3. RESULTS

Results obtained from laboratory analysis of soil samples from three different sampling sites subject to spent oil spill are tabulated and degree of pollution assessed using the geo-accumulation index formula. Results represented Table 1.

Geo-accumulation Index

$$I - geo = Log_2\left(\frac{Cn}{1.5Bn}\right)$$

Where Bn represents the concentration of the metal in the uncontaminated (control) samples and Cn represents the concentration of the heavy metal in the enriched sample. To reduce the impact of any changes in the background or control values that could be caused by lithogenic differences in the soil, a factor of 1.5 has been included (Fagbote and Olanipekun, 2010).

Table 1. Heavy Metals Concentration at Three Sampling Sites

Parameter	Units: mg/kg				
	A	B	C	D	Standard NESREA (2011)
Lead	0.014	0.653	<0.001	0.002	164
Cadmium	0.228	0.142	<0.001	<0.001	3
Chromium	1.173	<0.001	0.843	0.013	100
Copper	6.721	<0.01	0.821	<0.01	70-80
Zinc	58.232	36.712	<0.001	<0.001	421
Iron	16.642	1.834	2.791	0.82	400

Table 2. Seven Classes of Geo-accumulation Index

Class	Value of Soil Quality
<0	Unpolluted
0-1	Unpolluted to moderately polluted
1-2	Moderately polluted
2-3	Moderately polluted to highly polluted
3-4	Highly polluted
4-5	Highly polluted to very highly polluted
>5	very Highly polluted

Sources: Pam et al.*, (2013)*

Table 3. Geo-accumulation Index Results

A		B		C	
Parameters	**I-geo index**	**Parameters**	**I-geo index**	**Parameters**	**I-geo index**
Lead	2.22	Lead	7.77	Lead	-1.58
Cadmium	7.25	Cadmium	6.56	Cadmium	-0.58
Chromium	3.14	Chromium	-4.29	Chromium	5.43
Copper	8.81	Copper	-0.58	Copper	5.77
Zinc	15.24	Zinc	14.58	Zinc	-0.58
Iron	3.76	Iron	0.58	Iron	1.18

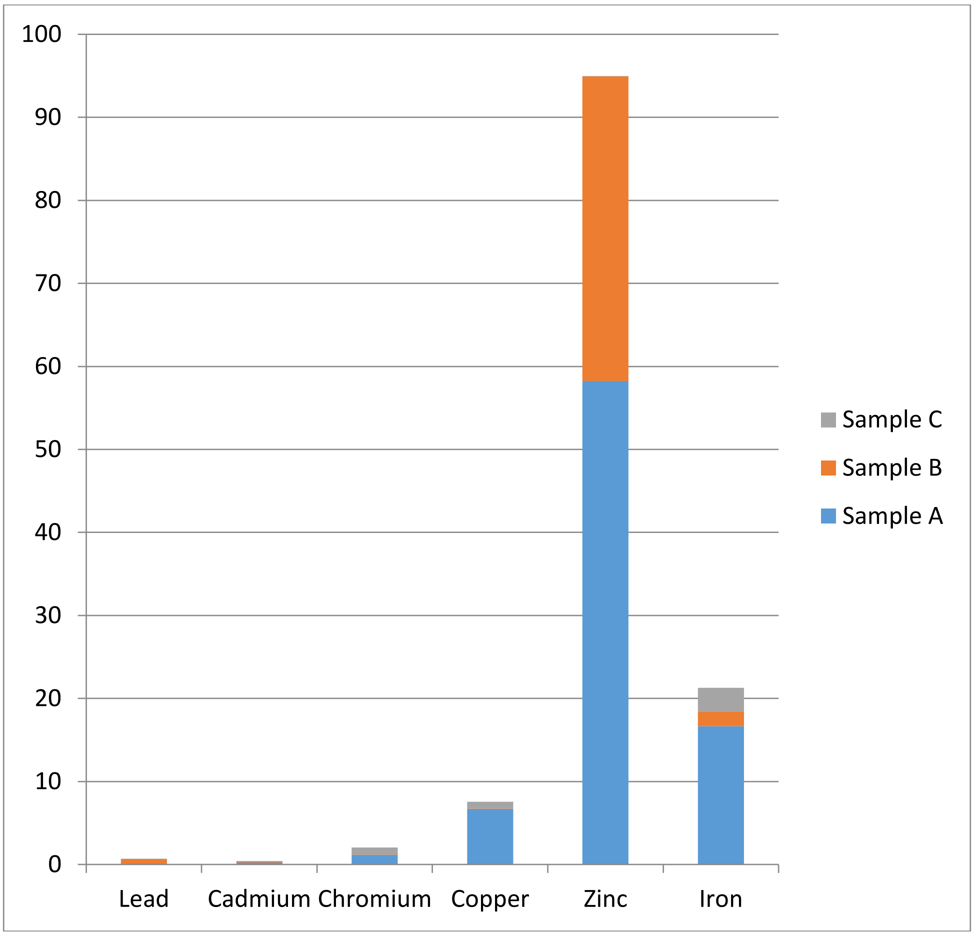

Fig. 2. Heavy Metals Concentration in Three Auto-Mechanic Workshop

4. DISCUSSION

Numerous studies have demonstrated that because urban settlements have higher rates of anthropogenic activity, their soils typically absorb loads of pollutants that are larger than those of adjacent contiguous sub-urban or rural areas (Adelekan and Alawode, 2011). This contamination has led to increase in heavy metals concentrations above the recommended limits as well as growth stress on plants. One of such anthropogenic activities that increase the levels of contaminant includes automobile repair operations.

According to reports, lead has the heaviest metals in waste oils (Oguntimehin et al., 2008). The quantity of waste oil, the presence of vehicle fumes, and the careless disposal of old motor batteries by nearby battery chargers and automechanics may all contribute to the elevated lead content of the soil. Results acquired for lead contents in soil indicates that lead is present in sample A and B alone and also in small fractions within the control location which shows that lead contents in soil has been influenced or increase by unsafe practices from automobile repair operations and hence leading to soil pollution. Result obtained for sample C indicate that the soil remains unpolluted and this could be due to work practices and shorter years of operation as compared to soil samples obtained at point A and B. Comparison with calculated values for geo-accumulation index shows that the study area is moderately polluted and very highly polluted (for sample A and B) although below/within limits set by the NESREA. This is supported by Nwachukwu et al., (2011) although below the average result obtained in their study due to years of existence of the service station.

The lubricating fluids, car wheels, and metal alloys used to strengthen engine parts are probably the main sources of cadmium accumulation in the regions examined in this study. Compared to many other heavy metals, cadmium appears to be more mobile in soil systems, which may account for the lower levels of concentrations seen in soil.

Results obtained reveals that cadmium contents met allowable standards and were even not detected in sample C and this is as a results of leaching of cadmium into lower parts of the soil because of its high mobility which is in line with studies by Adelekan and Abegunde (2011), on heavy metals contamination of soil and groundwater at automobile mechanic village. Similar study by Pam et al*.,* (2013), revealed low concentration of Cadmium in soil samples from other automobile repair station in Nigeria with concentration ranging from 0.32-1.0mg/kg. Comparison with calculated values for geo-accumulation index shows that samples A and B are very highly polluted with Cadmium. Results also detected Cadmium in control sample which means that domestic homes also contributors to Cadmium pollution. However, all three samples results are below/within limits set by the NESREA.

One of the heavy metals whose concentration in the environment is continuously rising as a result of industrial expansion is chromium, particularly the rise of the metal, chemical, and tanning sectors. Additional sources of environmental chromium include power plants, liquid fuels, hard and brown coal, industrial and municipal trash, and the erosion of rocks by air and water. Measured amounts reveals chromium to be present in sample A and C which is due to spills from lubricating oil and because chromium mobility in soil is lower. According to studies by Adelekan and Abegunde, (2011), chromium concentrations are higher at top soil depths than lower depth with results indicating a decrease with depth. This reveals the reason for higher concentration of chromium from soil sample analysis.

According to Ghosh and Singh (2005), chromium's environmental persistence is caused by its non-biodegradability. After being combined with soil, it changes into a variety of mobile forms before becoming an environmental sink. Despite being very uncommon, environmental chromium poisoning poses considerable concerns to human health since it can build up on the skin, lungs, muscles, fat, liver, dorsal spine, hair, nails, and placenta, where it can be linked to a number of illnesses. Comparison with calculated values for geo-accumulation index shows that sample A and C are high polluted. Although, with concentrations below limits set by the NESREA.

Leaching can happen when the applied concentration of copper exceeds the soil type's limited capacity to store copper ions. Copper concentrations in soil can cause growth stress in plants and affect their chances of survival. Measured concentration indicated copper to be with the range of 0.8-6.7mg/kg. This result is in line with reports by Pam et al*.,* (2013), showing low concentrations of copper which could be as a result of copper ions leaching to deeper soil depth as a result of excessive concentration of copper above the retaining ability of the soil. Comparison which allowable standards reveals copper concentrations to be within set limits and very highly in soil between depths of 0-30cm as against a soil within the same geographical area.

Zinc is present in lubricating oils as zinc dithiophates, among other additions. Samples A and B in this study have high zinc concentrations, which are comparable to those found in numerous other investigations by Nwachukwu et al*.* (2010), Nwachukwu et al. (2011), and Shinggu et al. (2007). Zinc concentration has also been reported to be with an average values of 14.58mg/kg in soil samples from automobile repair stations. Although recorded values are within set standards, geo-accumulation index reveals to be very highly polluted in soil samples from location A and B.

Iron contents are present in soil especially from steel parts around the sample locations which have been subject to natural weathering processes. Iron concentrations were shown to be moderately polluted in soil samples B and C, but highly polluted in Sample A. This reveals that soil these workstations contain influences the natural concentrations of Iron in soil.

5. CONCLUSION

This study analyzed possible soil contamination from automobile repair activities through laboratory analysis to determine concentration of heavy metals in soil. In conclusion, concentrations of heavy metals were observed across all samples of soil with higher concentration observed in copper (6.721mg/kg), cadmium (0.228mg/kg) and zinc (58.232mg/kg) indicating possible addition of heavy metals to soil from anthropogenic activities. Concentration of heavy metals indicates that spent oil spill still persist across all three automobile repair stations. Although certain metals where recorded in small fractions, this is as a result of leaching into deeper layers which is as a result of higher concentrations altering the ability of the soil to hold ions. Hence, it is of note that excessive spills occur within this environment and possibility of groundwater contamination as well as soil contamination in deeper layers persist.

It is recommended that; Spilling of Spent oil around soil at automobile repair stations be prevented by setting up appropriate collection drums and containers so as to avoid increasing heavy metals concentrations in soil; Analysis of heavy metals in soil along these stations should be done at greater depths to ascertain the leaching powers of heavy metals and how they may influence groundwater pollution; Education of automobile technicians on the adverse effects of unsafe/detrimental actions around the workstations should be conducted.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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