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ASSESSMENT OF HEAVY METAL CONTAMINATION FROM AUTO MECHANIC WORKSHOPS IN ABUJA, NIGERIA

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Abstract

This study investigated the effects of auto mechanic workshop activities on soil quality within three municipal area councils of Abuja, Federal Capital Territory (FCT), Nigeria — namely, Abuja Municipal Area Council (AMAC), Gwagwalada, and Kuje. The research aimed to assess the extent of heavy metal contamination and determine its impact on soil physicochemical properties and vegetation health. Soil samples were collected from fifteen selected mechanic workshops and nearby agricultural lands serving as control sites at depths of 0–10 cm and 10–30 cm. Laboratory analyses were conducted using Atomic Absorption Spectrophotometry (AAS) for heavy metals and core-cutter methods for bulk density. Parameters such as pH, nitrogen, carbon, and cation exchange capacity (CEC) were measured. Results revealed that workshop soils exhibited significantly higher concentrations of heavy metals—particularly zinc (152.22 ± 46.08 mg/kg), lead, and cadmium—compared to the control sites (0.55 ± 0.13 mg/kg). The mechanic workshop soils also showed increased bulk density, reduced porosity, and altered pH values. The Pollution Load Index (PLI) of 5.02 and Contamination Factor (Cf) of 5.0 confirmed considerable pollution levels, while vegetation cover was drastically reduced. These findings demonstrate that mechanic activities degrade soil quality and pose ecological risks. It is recommended that designated zones be established for automobile repair operations, with strict environmental monitoring and eco-friendly waste management practices.

Keywords: Heavy Metals, Soil, Atomic Absorption, Spectroscopy, Mechanic Workshop.

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1. INTRODUCTION

Urbanization and increasing automobile use have led to the proliferation of auto mechanic workshops across Nigerian cities, including Abuja. These workshops release toxic substances such as used engine oil, lubricants, and metallic wastes into the soil, leading to heavy metal contamination. Heavy metals such as zinc (Zn), lead (Pb), cadmium (Cd), nickel (Ni), and chromium (Cr) are of particular concern due to their toxicity, persistence, and bioaccumulative nature. This study aims to evaluate the concentration of heavy metals in soils from selected auto mechanic workshops in Abuja and assess their implications for soil quality, vegetation health, and environmental safety.

Heavy metals are regarded as serious contaminants due to their toxic, persistent and non-degradable state in the environment. High concentrations of heavy metals in the body can damage the liver, the kidney, reproductive system, nervous systems, urinary systems and immune systems. Due to their persistence, heavy metals easily accumulate in the top soil and finally reach humans through the food chain where they interrupt biological processes (Adesuyi *et al.,* 2021). Spent engine oil discarded by mechanics contain heavy metals such as Cadmium, Copper, Manganese, Nickel, Lead and Zinc which can adversely affect human health and results to cancer and other serious health challenges. Soil pollution can also results to water pollution due to run-off and infiltration into groundwater of aquifers (Adebayo *e*

2. STUDY AREA

The study was conducted within three municipal area councils in the Federal Capital Territory (FCT): Abuja Municipal Area Council (AMAC), Gwagwalada, and Kuje. The FCT is located between latitudes 7°25'N and 9°20'N and longitudes 5°45'E and 7°39'E, covering approximately 8,000 km². The climate is tropical with distinct wet (April–October) and dry (November–March) seasons. Average annual rainfall ranges between 900 mm and 2,200 mm. The area's soils are predominantly ferruginous tropical soils, and human activities such as auto repairs and urban agriculture contribute significantly to soil degradation.

Figure 2.1: Location of Abuja in Nigeria

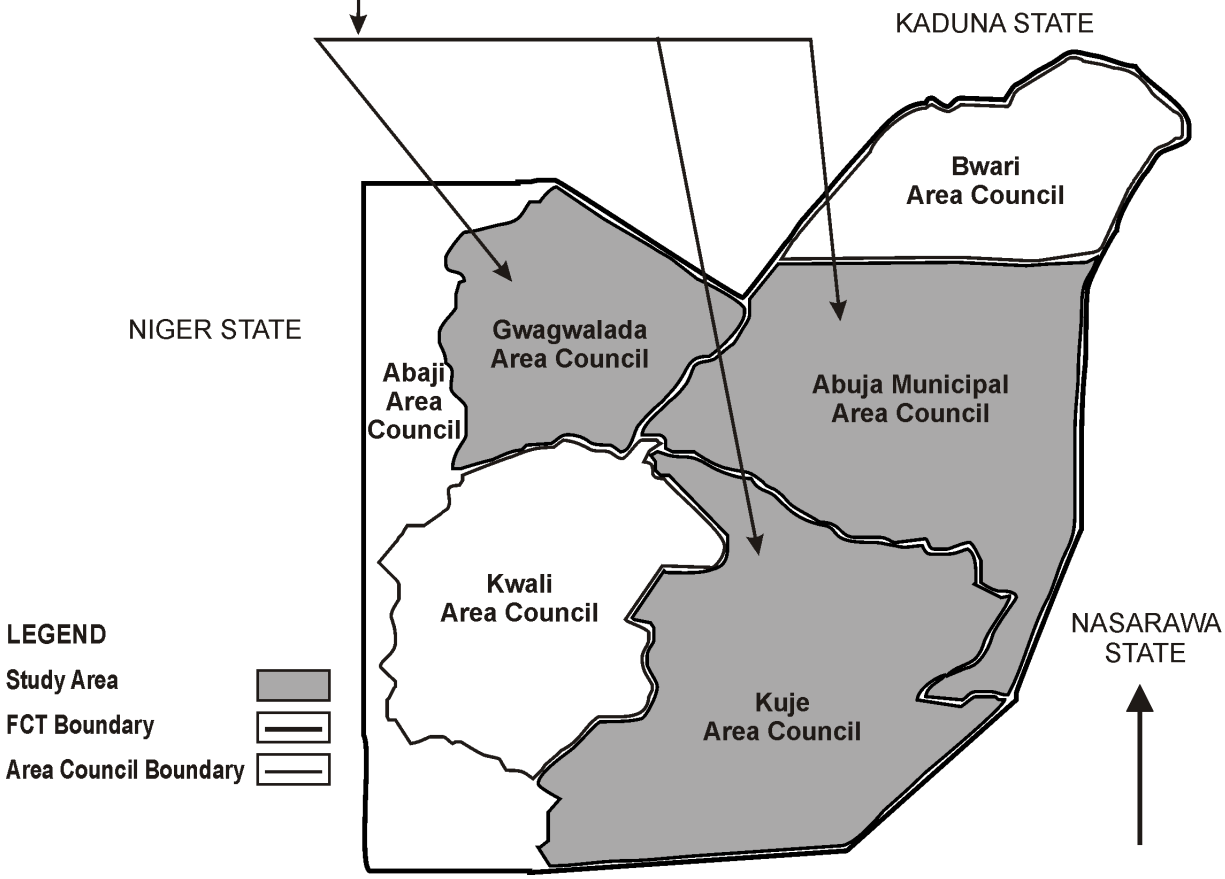

FIGURE 2.1: Map of the study area

3. RESEARCH METHODOLOGY

Soil samples were collected from fifteen auto mechanic workshops and corresponding control sites in agricultural land. Sampling depths were 0–10 cm and 10–30 cm. Heavy metal concentrations (Zn, Pb, Cd, Cr, Cu, Fe, Ni, Co, Mn) were determined using Atomic Absorption Spectrophotometry (AAS). Physicochemical parameters such as pH, organic carbon, nitrogen, and cation exchange capacity were analyzed using standard methods. Data were statistically analyzed using ANOVA and Student's t-test to determine significant differences between workshop and control sites.

4. RESULTS AND DISCUSSION

The mean concentration of heavy metals in workshop soils was significantly higher than in the control sites. Zinc (152.22 ± 46.08 mg/kg) was the most abundant metal, followed by lead and cadmium. The Pollution Load Index (PLI) of 5.02 and Contamination Factor (Cf) of 5.0 indicate a high degree of pollution. Bulk density increased while porosity and pH declined, demonstrating soil compaction and acidity. These findings are consistent with studies by Adesuyi et al. (2021) and Vincent et al. (2022), which reported similar contamination patterns in urban Nigerian soils. The degradation of soil quality also affected vegetation cover, as observed by a significant reduction in the Surface Cover Index (SCI) from 87.4 in the control to 1.4 in workshop sites.

Heavy metal Concentrations in Auto mechanic Workshop and Control Sites

Table 1: Mean Heavy Metal concentration from Auto mechanic Workshop and the Control sites during the Dry season (mg/kg).

Heavy metal	AMAC (Mean & standard deviation)	Kuje (Mean & standard) deviation)	Gwagwalada (Mean & standard) deviation)	Control (Mean & standard)	*p-value*	*WHO*
Zn	152.22±46.08	106.93±66.16	135.60±80.90	0.55±0.13	*0.02*	*50*
Ni	25.02±13.68	15.21±0.16	24.98±0.27	4.24±0.26	*0.04*	*35*
Cr	13.06±4.07	13.40±5.7	18.06±5.28	3.30±0.43	*0.02*	*100*
Co	10.06±5.02	6.02±1.96	3.11±0.61	0.03±0.02	*0.02*	

Fe	2480.76±76.52	3050.00±1098.92	2175.80.±1311.51	234±12.00	*0.04*	
Cu	112.58±29.32	90.13±56.04	93.40±24.70	10.84±0.21	*0.01*	*36*
Pb	125.37±24.04	182.66±58.19	140.00±52.68	10.27±0.21	*0.04*	*85*
Cd	0.3±0.02	0.2±0.01	0.2±0.01	0.01±0.001	*0.68*	*0.8*
Mn	517.00±2.00	418.00±157.92	279.53±275.86	50.53±0.76	*0.02*	*1000*

During Dry season, the highest level of Zn was recorded at AMAC with mean concentration of 152.22mg/kg with standard deviation of ±46.08, followed by Gwagwalada 135.60mg/kg with standard deviation of ±80.90 and Kuje with mean of 106.93mg/k with standard deviation of ±66.16kg (Table 5.12, Table 5.13 and Figure 5.7) the concentration of heavy metals obtained were higher than the control with mean value of 0.55mg/kg and with standard deviation of ±0.13. Results from one way ANOVA and student's t-test shows high significant difference ($p < 0.05$) between the Mechanic workshop and the control.

During dry season, the highest level of Nickel was recorded at AMAC with mean concentration of 25.02 with standard deviation of ±13.68, followed by Gwagwalada 24.98mg/kg with standard deviation of ±0.27 and Kuje with mean of 15.21mg/kg with standard deviation of ±0.16. The concentration of heavy metals obtained were higher than the control with mean value of 4.24mg/kg with standard deviation of ±0.26 which was highly significant at ($p < 0.05$) level of significance

During dry season, the highest level of Cr was recorded at Gwagwalada with mean concentration of 18.06mg/kg with standard deviation ±5.28 followed by Kuje mean of 13.40mg/kg with standard deviation ±5.76 and AMAC with mean of 13.06mg/kg and standard deviation ±4.07mg/kg the concentration of heavy metals obtained were higher than the control with mean value of 3.30mg/kg and standard deviation ±0.43 which was highly significant ($p < 0.05$).

During dry season, the highest level of Co was recorded at AMAC with a mean concentration of 10.06mg/kg and a standard deviation ±5.02, followed by Kuje with a mean value of 5.32mg/kg and standard deviation of ±1.96 and Gwagwalada with mean 3.49 and a standard deviation ±0.61. The concentration of heavy metals obtained were higher than the control with

mean value of 0.03 mg/kg and standard deviation ±0.02 which was highly significant ($p < 0.05$).

During dry season, the highest level of Fe was recorded at Kuje with mean concentration of 3050 mg/kg with standard deviation ±1098.92, followed by AMAC mean value of 2480.76 mg/kg with standard deviation ±76.52 and Gwagwalada with a mean of 2175.80mg/kg and standard deviation ±311.51. The concentration of heavy metals obtained were higher than the control with mean value of 234 and standard deviation ±12.00 which was highly significant

During Dry season, the highest level of Cu was recorded at AMAC with a mean of concentration of 112.58mg/kg with standard deviation ±29.32, followed by Gwagwalada 93.40mg/kg ± with standard deviation 24.70mg/kg and Kuje with a mean of 80.13mg/kg with standard deviation ±56.04. The concentration of heavy metals obtained were higher than the control with mean value of 10.84mg/kg with standard deviation ±0.2mg/kg which was highly significant ($p < 0.05$).

During dry season, the highest level of Pb was recorded at Kuje with mean concentration of 182.66mg/kg with standard deviation ±58.19, followed by Gwagwalada 140.0mg/with standard deviation ±52.68 /kg and AMAC with mean of 125.37mg/kg with standard deviation ±24.04 control recorded the least with mean value of

During dry season, the highest level of Cd was recorded at AMAC with mean concentration of 0.3mg/kg with standard deviation ±0.03mg/kg, followed by Gwagwalada 0.2mg/kg with standard deviation ±0.01 and Kuje with mean of 0.2mg/kg with standard deviation ±0.01 the concentration of heavy metals obtained were higher than the control with mean value of 0.01mg/kg with standard deviation ±0.001mg/kg which was not significant at 0.05 During Dry season, the highest level of Mn was recorded at AMAC with mean concentration of 517.00mg/kg with standard deviation ±200, followed by Kuje mean value of 418.00mg/kg with standard deviation .±157.92 and Gwagwalada with mean of 279.53mg/kg with standard deviation ±275.86mg/kg. The concentration of heavy metals obtained were higher than the control with mean value of 50.53mg/kg with standard deviation ±0.76 which was not significant at $p<0.05$ Table

Many studies have shown that soils contain large amount of heavy metals as a result of anthropogenic activities. This is seen from the results of metals investigated and that of control. (Iwegbue *et al.,* 2024; Emurotu, *et al*, 2024). There variation between the occurrences of the various heavy metals across the Automobile Workshop and the control sites.

5. CONCLUSION AND RECOMMENDATIONS

The study concludes that auto mechanic workshop activities in Abuja significantly deteriorate soil quality through heavy metal contamination. It is recommended that government authorities enforce environmental regulations by designating specific zones for automobile repair operations. Mechanics should adopt eco-friendly practices, such as proper waste oil collection and recycling. Periodic monitoring of soil and vegetation should also be conducted to track contamination trends and ensure sustainable urban land use.

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