International Journal of Innovative Environmental Studies Research 14(3):228-235, July-Sept, 2026

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DOI:10.5281/zenodo.22308025

Heavy Metals Levels in Auto Mechanic Workshop's Soil in ONELGA in the Oil-rich Niger Delta Region of Nigeria

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ABSTRACT

Soil analysis was carried out on soil samples around auto mechanic workshop in three different communities (Omoku, Obite and Egbema) all in Ogba-Egbema-Ndoni Local Government Area of the oil-rich Niger region of Nigeria. The purpose of this study was geared towards ascertaining the levels of five heavy metals (Cd, Cr, Cu, Pb and Zn) in soil samples collected from the surroundings of auto mechanic workshops in these communities. The study employed a stratified random sampling technique where 9 auto mechanic workshops spread throughout ONELGA 's various zones were identified by the study and soil samples collected at three different depths, along with three control sites that were at least one kilometer from each of the auto mechanic workshop under study. The concentration of these heavy metals was compared with the that of the control sites as well as the WHO permissible limits where it was observed that the concentrations of heavy metals in soils around auto mechanic workshops were higher than that in the control site in the three communities with Cr (246.43±15.89) in Egbema approximately 16 times higher than the control of (15.37±0.47). Cd and Cr concentration in the three communities were also at least 1.6-2.5 and 1.4-1.9 times the WHO permissible limit respectively thereby indicating that auto mechanic workshops around ONELGA are contributing to soil contamination. The results therefore call for an immediate attention on environmental monitoring and mitigation to curb the forecasted danger ahead.

Keywords: Heavy Metal, Mechanic Workshop, Contamination Factor

INTRODUCTION

In many developed or developing countries, auto mechanic workshops usually situated in densely populated urban and semi urban areas where their target is to meet the repair needs of the populace. Human activities of urban dwellers have continued to pose a huge treat on the environment where the live and of which the soil around them is not been left out (Lawal et al., 2015, Ololade, 2014, Duru et al., 2024). These environmental treats caused by human activities may be direct or indirect as they may arise from oil spillage, improper industrial waste, population growth, poor environmental policies as well as technological development. The continuous growth in population of a locality will always give rise for more auto mobile machines such as motor bike, tricycles, car and heavy-duty vehicles like trailers, trucks and bulldozer to aid transportation as well as easing the process of performing both personal and industrial tasks (Gota, 2014). These auto mobile machines have to be maintained or service for maximum

efficiency and as such the need for auto mechanic workshops. These auto mechanic workshops are locations within the locality isolated for the purpose of servicing or repairing auto mobile parts, where the workshops may consist of mechanics, spray painter, panel beaters, car electricians and a lot more. Environmental policies on how to dispose waste material from these workshops are not really available and in cases where they available, the adherence to these policies are very poor, thereby exposing our arable soil to the danger of heavy metals that are harmful to humans at a relatively high concentration as they are taken up by both animals and plants. Heavy metals are basically composed of the earth's crust which cannot be degraded and are specific metals whose specific densities are more than $5g/cm^3$ and adversely affect the environment and the living organisms present (Tchounwou et al., 2012). Auto mechanic workshop is one of the main contributors of heavy metal such as Cadmiun (Cd), Chromium (Cr), Copper (Cu), Nickel (Ni), Lead (Pb) and Zinc (Zn) contamination which results from improper disposal of spent engine oil, filling from meta, other auto mobile solvents, brake dust (Iwegbue et al., 2006). Their presence in soil results in heavy metal uptake by plant and accumulates through food crops (Inam, et al., 2015, Islam et al., 2024, Abdulrasool & Zainab, 2024).

Heavy metals are natural constituents of the Earth's crust and since they cannot be degraded or destroyed, they are considered persistent environmental pollutants. Generally, heavy metal pollution originates from anthropogenic sources, such as untreated domestic and industrial wastewater discharges, accidental chemical spills, direct soil waste dumping, and residues from some agricultural inputs.

Heavy metal enrichment in the soils surrounding auto mechanic workshops has been reported in a number of Nigerian studies, but none have yet taken time to specifically address that of Ogba-Egbema-Ndoni Local Government Area. The mean soil levels of Pb (≈14.5 mg/kg), Cu (≈0.50 mg/kg), Ni (≈0.17 mg/kg), and Cd (≈0.67 mg/kg) were found in Uyo city (Akwa Ibom State), with higher risk quotients for operators in direct contact zones (Inam, Edet, & Offiong, 2015). Similarly, topsoil samples (0–100 cm depth) from various workshop sites in Okitipupa, Ondo State, revealed heavy metals in the order Fe > Mg > Zn > Mn > Cu > Pb > Ni > Cr > Cd > Co, although values stayed within Nigeria DPR permissible soil limits (Adebayo et al., 2017). Emolade et al. (2025) found that used oil spills from vehicle maintenance activities were the main cause of the elevated Cu (≈6.72 mg/kg), Cd (≈0.228 mg/kg), and Zn (≈58.23 mg/kg) in Ozoro, Delta State. Other studies conducted in Imo State (Nekede and Orji) also found that soil Zn (up to ~89 mg/kg), Pb (~51 mg/kg), Cu (~29 mg/kg), and Ni (~4 mg/kg) had contamination indices that ranged from mild to moderate across sites (Bridget et al., 2023). Significant Zn, Mn, Fe, and Cu contamination has also been found in soils close to mechanic workshops in Jigawa State and Oyo, outside of southern Nigeria (Durumin Iya et al., 2023; Isibor, 2016).

Ogba-Egbema-Ndoni Local Government Area in Rivers State is part of the oil-rich region of Niger Delta, which is renowned for its oil-bearing terrain, frequent environmental damage from gas flaring and oil spills, and dense urban populations. Although the majority of research to date has focused on the effects of oil production, there is a noticeable lack of information regarding contamination brought on by small-scale urban industries like auto mechanic repair workshops. Ogba-Egbema-Ndoni Local Government Area are communities with a large number of unofficial auto mechanic repair workshops, so there is a high but little-studied risk of soil heavy metal buildup.

Particularly concerning is the persistence of heavy metals in tropical soils, like those found in the Niger Delta. Metals migrate through the soil profile and may contaminate groundwater or enter food chains through plant uptake (Ramos-Romero et al., 2026, Emmanuel et al., 2025). They are non-biodegradable and can remain bioavailable for decades (Edo et al., 2024, Parida et al., 2024). According to Iwegbue et al., 2006, the distribution of metals in Nigerian mechanic waste dumps was Pb > Zn > Cu > Cd > Ni > Cr, with elevated concentrations of metals significantly above background or residential limits. Likewise, mechanistic exposure models in the Niger Delta and elsewhere suggest that prolonged oral or dermal ingestion of contaminated soils can increase health risks, particularly for workshop workers and children.

Permissible heavy metal limits for soil are established by Nigeria's environmental regulatory framework, but grassroots enforcement is lax. Numerous small workshops are located in residential areas, operate without a license, and lack secondary containment for waste fluids and oil. This raises the risk of direct

exposure, particularly for families and children who live close to work sites (Ogunbunmi, 2014). The issue is made worse by improper waste management techniques, buildup of oil residues, and a lack of soil testing procedures.

For a number of reasons, it is essential to comprehend the levels of heavy metals in Ogba-Egbema-Ndoni Local Government Area soils. First, it closes a data gap in the Niger Delta, a strategically significant area where environmental vulnerabilities and human-driven industries coexist. Second, it informs local environmental policy and urban land use planning and offers evidence for risk assessments related to public health. Thirdly, it makes it possible to identify priority contaminants for potential phytoremediation trials or remediation efforts in the future.

Prior research conducted in nearby Nigerian states such as Ozoro in Delta State offers helpful methodological templates, including depth profiling at surface and subsurface layers where atomic absorption spectroscopy (AAS) was used for heavy metal analysis, comparison with approved soil standards, and systematic sampling across workshop and control sites (Emolade et al., 2025; Adebayo et al., 2017; Bridget et al., 2023). The high rainfall and close proximity to swampy mangrove soils factors that affect metal mobility and geochemical behavior makes the Ogba-Egbema-Ndoni Local Government Area context unique.

Lastly, this study's background is based on regional and global concerns. Agricultural productivity, ecosystem function, and human health have all been negatively impacted by heavy metal soil contamination worldwide. Chronic exposure to metals like Pb and Cd, even at low levels, can harm kidney function, reproductive health, and neurological development. As informal industries flourish in Nigeria without environmental protections, urban soil contamination is becoming a bigger problem. In addition to making a local contribution, filling this gap in Ogba-Egbema-Ndoni Local Government Area will support larger initiatives to map hotspots for heavy metal pollution in African cities.

Therefore, the purpose of this study is to ascertain the levels of a few chosen heavy metals (Cd, Cr, Cu, Pb, and Zn) in soils that were gathered from the vicinity of auto mechanic repair workshops in three communities (Omoku, Obite and Egbema) Ogba-Egbema-Ndoni Local Government Area, Niger Delta Region. In addition, it will calculate contamination indices, evaluate spatial distribution by depth and proximity, compare these levels with control soils from adjacent uncontaminated sites, and assess potential health risks in relation to national and international soil quality thresholds. The results are intended to inform stakeholders about mitigation strategies and to supply baseline data for assessments of urban contamination in the Niger Delta.

METHODOLOGY

Soil sampling, laboratory analysis, and statistical data interpretation were all combined in this study's field-based experimental design. To determine baseline heavy metal contamination levels, samples were taken from both workshop locations and control sites (non-impacted soils) in Omoku Town, Rivers State. According to the United States Environmental Protection Agency (USEPA, 2007), the Nigerian Department of Petroleum Resources (DPR), and earlier Nigerian studies on mechanic workshop pollution (Inam, Edet, & Offiong, 2015; Adebayo et al., 2017; Bridget et al., 2023), the methodology adhered to standard environmental monitoring protocols.

Three communities namely Omoku, Obite and Egbema of Ogba-Egbema-Ndoni Local Government Area in Rivers State, Nigeria, served as the study's area. This study area is located in the humid tropical rainforest region of the Niger Delta, which receives more than 2,000 mm of rain on average each year. With areas of clay-rich subsoil that affect heavy metal mobility, the soils are primarily sandy loam. Omoku, Obite and Egbema's auto mechanic repair workshops are perfect for assessing the risk of contamination because they are usually unregulated and centered around residential areas.

The method of stratified random sampling was applied where nine auto mechanic workshops spread throughout ONELGA various zones were identified by the study, along with three control sites that were at least one kilometer from any workshop activity area. Soil samples were taken at a depth of 0-15cm and 15-30cm and then mixed together for each location. This was done to record the vertical distribution and

possible leaching of heavy metals (Emolade et al., 2025; Durumin Iya et al., 2023). 15 composite soil samples in all were collected, homogenized in sterile polythene bags, and labeled appropriately for each composite sample.

The soil samples were air dried for 10 days at room temperature inside the chemistry laboratory and were then gently crushed using a porcelain mortar and sieved through a 2 mm mesh screen to get rid of any debris. For chemical digestion and analysis, portions of the samples were further ground to a particle size of less than 0.5 mm. To avoid contamination, all tools were rinsed with deionized water after being acid-washed with 10% HNO_3.

In line with the USEPA 3050B protocol, heavy metals were extracted using the aqua regia digestion method ($HCl:HNO_3$, 3:1 v/v) and then diluted with deionized water to a final volume of 50 mL, about 1.0 g of soil was weighed into a Teflon beaker and digested at 95°C on a hot plate until a clear solution was obtained. To guarantee quality control, blanks and certified reference materials (CRMs) were digested concomitantly.

Atomic Absorption Spectrophotometry (AAS) was used to measure the concentrations of Cd, Cr, Cu, Pb, and Zn. where standard solutions (1–10 mg/L) made from 1000 mg/L stock standards were used to develop calibration curves. For Cd, Cr, Cu, Pb, and Zn, the analytical detection limits were 0.01 mg/L, 0.02 mg/L, and 0.05 mg/L, respectively. Mean values were recorded immediately after each sample was examined in triplicate.

RESULTS AND DISCUSSION

Table 1: Mean Values of Heavy Metal Concentrations (mg/kg) in Soils Samples from Auto Mechanic Workshops and Control Sites in Omoku

Metals	Sites		Permissible Limit (WHO/FAO)
	Auto Mechanic Workshop (Mean±SD) (mg/kg)	Control (Mean±SD) (mg/kg)	
Cr	177.03±58.93	11.33±0.51	100.00
Cd	4.21±1.00	1.52±0.44	3.00
Cu	78.27±5.49	52.68±0.78	100.00
Pb	42.41±2.14	39.71±1.00	100.00
Zn	256.24±6.32	199.79±6.53	300.00

The results presented in Table 1 above showed the concentration of the five heavy content in soil samples collected from auto mechanic workshop sites around Omoku vicinity compared with that of the controlled site. The results showed significantly high concentration of all the heavy metals compared to that of the control site. The mean concentration of Chromium (Cr) and Cadmium (Cd) were observed to have been far higher that the permissible limit of the World Health Organization (WHO). The increased concentration of Cr and Cd may be as a result of the improper disposal of spent engine oil, metal fabrication materials, corrosion of metallic automobile parts. The mean concentration of Copper (Cu) and Zinc (Zn) in soil samples in auto mechanic workshops around Omoku vicinity were (78.27±5.49 and 256.24±6.32 mg/kg respectively) which were relatively high compared with that of the control site, but were still below the permissible limit of WHO. The increase in the mean concentration of Copper and Zinc may be as a result of improper disposal of condemned electrical wires, brake linings, galvanized automobile parts and grease. These may not have exceeded the permissible limit of WHO, but their elevation above the control site becomes a concern because if not checked, may continue to increase and later surpass the permissible limit, as excessive accumulation in soil may negatively affect

microorganism's activities in soil as well as plant growth. The mean concentration of Lead (Pb) (42.41±2.14 mg/kg) in auto mechanic workshop site around Omoku vicinity which was approximately 7% higher than that of the control site and far less than the WHO permissible limit may not be a concern, the persistence and bioaccumulative nature of lead make its presence in soil sample environmentally significant.

Table 2: Mean Values of Heavy Metal Concentrations (mg/kg) in Soils Samples from Auto Mechanic Workshops and Control Sites in Obite

Metals	Sites		Permissible Limit (WHO/FAO)
	Auto Mechanic Workshop (Mean±SD) (mg/kg)	Control (Mean±SD) (mg/kg)	
Cr	166.46±15.89	12.87±0.65	100.00
Cd	4.93±0.70	1.68±0.20	3.00
Cu	69.53±5.78	46.87±0.19	100.00
Pb	41.66±6.06	31.73±4.93	100.00
Zn	252.90±7.30	181.11±2.88	300.00

The results presented in Table 2 above showed the concentration of the five heavy content in soil samples collected from auto mechanic workshop sites around Obite vicinity compared with that of the controlled site. The mean concentration of Chromium (Cr) and Cadmium (Cd) 236.40±15.89 and 4.93±0.70 mg/kg respectively were observed to be the highest compared to the permissible limit of WHO. The mean concentration of Copper (Cu) and Zinc (Zn) in soil samples in auto mechanic workshops around Obite vicinity were (69.53±5.78 and 252.90±7.30 mg/kg respectively) which were relatively high compared with that of the control site, but were still below the permissible limit of WHO. The increase in the mean concentration of Copper and Zinc may be as a result of improper disposal of condemned electrical wires, brake linings, galvanized automobile parts and grease. The mean concentration of Lead (Pb) (41.66±6.06 mg/kg) in auto mechanic workshop site around Obite vicinity which was approximately 31% higher than that of the control site and far less than the WHO permissible limit may not be a concern however, the persistence and bioaccumulative nature of lead make its presence in soil sample environmentally significant.

Table 3: Mean Values of Heavy Metal Concentrations (mg/kg) in Soils Samples from Auto Mechanic Workshops and Control Sites in Egbema

Metals	Sites		Permissible Limit (WHO/FAO)
	Auto Mechanic Workshop (Mean±SD) (mg/kg)	Control (Mean±SD) (mg/kg)	
Cr	246.43±15.89	15.37±0.47	100.00
Cd	5.99±0.64	1.87±0.36	3.00
Cu	97.17±5.15	53.01±0.45	100.00
Pb	59.77±2.95	49.29±3.21	100.00
Zn	298.57±16.58	199.18±4.62	300.00

The results presented in Table 3 above showed the concentration of the five heavy content in soil samples collected from auto mechanic workshop sites around Egbema vicinity compared with that of the controlled site. The mean concentration of Chromium (Cr) and Cadmium (Cd) 236.40±15.89 and

5.92±0.64 mg/kg respectively were observed to be the highest compared to the permissible limit of WHO. The mean concentration of Copper (Cu) and Zinc (Zn) in soil samples in auto mechanic workshops around Egbema vicinity were (97.17±5.15 and 298.57±16.58 mg/kg respectively) which were relatively high compared with that of the control site, but were still below the permissible limit of WHO. The increase in the mean concentration of Copper and Zinc may be as a result of improper disposal of condemned electrical wires, brake linings, galvanized automobile parts and grease. These may not have exceeded the permissible limit of WHO, but their elevation above the control site becomes a concern because if not checked, may continue to increase and later surpass the permissible limit, as excessive accumulation in soil may negatively affect microorganism's activities in soil as well as plant growth. The mean concentration of Lead (Pb) (59.77±2.95 mg/kg) in auto mechanic workshop site around Egbema vicinity which was approximately 21% higher than that of the control site and far less than the WHO permissible limit, but one may raise concerns over the persistence and bioaccumulative nature of lead makes its presence in soil sample environmentally significant.

Considering the mean concentration of Cd, Cr and Pb from Table 1-3, one will have to set measures to monitor the continuous uncontrolled disposal of auto Mechanic waste in order to avert the danger of their mobility to human bodies which could be carcinogenic and nephrotoxic.

Table 4: Contamination Indices of Heavy Metals in Soil Samples from Auto Mechanic Workshop Sites in Omoku, Obite and Egbema

	Contamination Factor (CF)			Geo Accumulation Index (I_{geo})			Pollution Load Index (PLI)*		
Metals	**Omoku**	**Obite**	**Egbema**	**Omoku**	**Obite**	**Egbema**	**Omoku**	**Obite**	**Egbema**
Cr	16.50	19.92	19.17	3.46	3.73	3.68	3.24	3.62	3.76
Cd	2.69	2.77	3.70	0.84	0.88	1.30			
Cu	6.86	7.61	7.31	2.19	2.34	2.28			
Pb	1.05	1.26	1.23	-0.52	-0.25	-0.29			
Zn	1.12	1.17	1.18	-0.43	-0.36	-0.35			

The contamination indices showed from Table 4 a considerable high heavy metal pollution in soil samples across the auto mechanic workshops around Omoku, Obite and Egbema where Chromium recorded the highest contamination factor of 16.50, 19.92 and 19.17 respectively with that of Obite taking the lead. This no doubt may result in severe environmental challenge, anthropogenic influence, rapid plant uptake, soil quality degradation and lots more which again pose the risk of nephrotoxic and carcinogenic. From this result one may also opine from the geo accumulation indices that soil samples from auto mechanic workshop from Omoku, Obite and Egbema were not polluted with heavy metals of Pb and Zn, but were moderately to strongly polluted with Cu, strongly polluted with Cr. The soil samples from Omoku and Obite stood between unpolluted to moderately polluted with Cd and moderately polluted at Egbema. The geo accumulation indices for soil samples from Omoku, Obite and Egbema indicated that the samples were strongly polluted.

The pollution load indices showed that the soil samples were heavily polluted across the three vicinities of ONELGA and the PLI recorded may be due to human activities.

The findings from this study were in agreement with recent Nigerian studies as Duru et al., (2024) attributed the increased heavy metal concentration in soil samples around auto mechanic workshop in Nsukka to improper disposal of spent oil as well as automobile wastes which includes, brake pads, remains of condemned batteries, metallic scraps, spent oils and other engine components that releases toxic metal such as Cd, Cr, Cu, Pb and Zn into the soil. In a similar study, Okechukwu et al., 2024 opined that deposits of spent oil in automobile market area significantly raised the concentration of heavy metal in soils, this was supported by Agaka et al., 2024 who also identified that spent lubricating oil and the activities of automobile repair workers were responsible for heavy metal accumulation recorded in soil

samples around mechanic workshops. These anthropogenic activities no doubt influences the contamination of soil as well as increase the ecological and human health risk associated with the exposure to heavy metals. In a similar study, Ann and Makyur (2025) reported high contamination factor and pollution load indices in soil samples around auto mechanic workshops within Abuja metropolis. Similarly, Etuk-Udo and Igbinosa (2025) reported moderate to very high contamination indices for Cd, Cu, Pb and Zn in auto mechanic workshops as the finding further agreed with an earlier study by Ololade (2014), stated that the heavy metal enrichment and geo-accumulation in soil samples around auto mechanic workshops were significantly on the increase. These studies conclusively confirm that auto mechanic workshop's activities are the main contributor to heavy metal pollution as well as environmental degradation. The reports from this study therefore calls for adequate monitoring of mechanic workshop activities as well as creating awareness of the dangers of continuous injection of heavy metals into our environment.

CONCLUSION

This study assessed the concentrations of selected heavy metals (Cd, Cr, Cu, Pb, and Zn) in soils surrounding auto mechanic workshops in Omoku, Obite, and Egbema communities of Ogba-Egbema-Ndoni Local Government Area (ONELGA), Rivers State, Nigeria. The findings revealed that soils from auto mechanic workshop sites contained significantly higher concentrations of all investigated heavy metals compared to the corresponding control sites, indicating substantial anthropogenic contributions from workshop activities.

Among the metals analyzed, chromium (Cr) and cadmium (Cd) consistently exceeded the WHO/FAO permissible limits across all study locations, with Egbema recording the highest concentrations. Although copper (Cu), lead (Pb), and zinc (Zn) remained below the established permissible limits, their concentrations were markedly elevated relative to the control sites, suggesting progressive accumulation within the soil environment. The contamination factor (CF), geo-accumulation index (Igeo), and pollution load index (PLI) further confirmed varying degrees of contamination, with chromium exhibiting very high contamination levels and the overall pollution status indicating significant environmental degradation attributable to auto mechanic activities.

The elevated concentrations of these metals are most likely associated with the indiscriminate disposal of spent engine oil, worn-out automobile parts, brake linings, batteries, metal scraps, lubricants, and other workshop wastes. Given the persistence, non-biodegradable nature, and bioaccumulative tendencies of heavy metals, continued accumulation in the soil may result in adverse ecological effects, reduced soil fertility, contamination of groundwater resources, uptake by food crops, and increased health risks to humans through the food chain. The elevated levels of cadmium and chromium are particularly concerning due to their known carcinogenic and nephrotoxic properties.

Overall, the study establishes that auto mechanic workshops constitute an important source of heavy metal contamination in ONELGA and contribute significantly to environmental pollution within the Niger Delta region. The findings underscore the urgent need for effective environmental monitoring, strict enforcement of waste management regulations, and the adoption of sustainable waste disposal practices in mechanic workshops. Such interventions are essential to prevent further deterioration of soil quality and to safeguard public health and environmental sustainability in the study area.

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