

Heavy Metals Pollution in Irrigated Farmland and Automobile Mechanic Village Soil: A Review

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Received on: August, 2025

Revised and Accepted on: September, 2025

Published on: October, 2025

ABSTRACT

Heavy metal contamination in soil has emerged as a significant environmental concern due to its adverse effects on agricultural productivity, ecosystem health, and human well-being. This seminar presents a comprehensive review of various studies on the assessment of heavy metals such as lead (Pb), cadmium (Cd), arsenic (As), chromium (Cr), and mercury (Hg) in soil across different geographic regions. The review explores the major anthropogenic and natural sources contributing to heavy metal accumulation, including industrial activities, mining, wastewater irrigation, and atmospheric deposition. Emphasis is placed on common assessment techniques such as Atomic Absorption Spectroscopy (AAS), Inductively Coupled Plasma Mass Spectrometry (ICP-MS), and X-ray Fluorescence (XRF). Additionally, the seminar highlights spatial distribution patterns, risk assessment indices (e.g., geo accumulation index, contamination factor), and ecological implications of heavy metal presence in soil. The findings underscore the necessity for continuous monitoring, adoption of remediation strategies, and formulation of stringent environmental policies to mitigate soil pollution and safeguard public health. This review provides a scientific foundation for future research, environmental management, and sustainable land use practices.

Keywords: farmland, automobile, heavy metals, mechanic village.

1.0 INTRODUCTION

As an essential part of terrestrial ecosystems, soil is key to preserving biodiversity, controlling biogeochemical cycles, and maintaining agricultural output. However, anthropogenic activities, including intensive agriculture, urbanization, and industrialization, have caused heavy metal poisoning in soils on a large scale in recent decades. Lead, cadmium, arsenic, mercury, and chromium are examples of heavy metals that are persistent and non-biodegradable environmental contaminants. Through bioaccumulation and biomagnification in the food chain, their buildup in soil poses serious threats to human health, food safety, and ecological stability (Alloway, 2013; Wuana and Okieimen, 2011). Heavy metals pose a serious environmental hazard because of their inability to break down chemically or biologically, unlike organic pollutants.

Numerous factors, such as inappropriate waste disposal, vehicle emissions, industrial effluents, and the overuse of agrochemicals, have been implicated in the global increase in heavy metal contamination (Tóth *et al.*, 2016). For example, cadmium and arsenic are frequently linked to phosphate fertilizers and insecticides, whereas lead pollution frequently comes from the battery recycling sector (Nagajyoti *et al.*, 2010). Serious health consequences, including neurotoxicity (Pb), renal dysfunction (Cd), carcinogenicity (As), and developmental abnormalities (Hg), have been linked to long-term exposure to these metals (Jaishankar *et al.*, 2014). Because they are more susceptible to hazardous exposure, vulnerable

groups—such as children and the elderly are especially in danger.

1.1 Definition of Heavy Metals.

According to Yadav *et al.* (2018), heavy metals are naturally occurring metallic elements with high atomic weights and densities, often greater than 5 g/cm³. Because they are not biodegradable, they can accumulate in living organisms and the environment, making them toxic in small amounts and potentially harmful to human health and the environment. Pb, Cd, Hg, As, Cr, and Ni are a few examples (Gupta *et al.*, 2019).

The study's focus, Mechanics Village, is an area of increasing environmental concern because of its diverse land-use patterns, which include small-scale industry, residential communities, and agricultural operations. Sure! Here's a refined paraphrase of your text. Heavy metals and metalloids (HMs) are recognized as environmental pollutants and significant contaminants of agricultural soils. When accumulated at high concentrations, they can adversely affect crop growth, health, and overall productivity (Rashid *et al.*, 2023). Automobile repair workshops frequently deal with hazardous substances such as fuels, lubricants, spent batteries, brake pad asbestos, oxidizing agents, and metals, which may pollute nearby soils through leakages, spillages, and inappropriate waste management practices (Duru *et al.*, 2024). According to preliminary studies, soil degradation may have been exacerbated by the village's close vicinity to unofficial auto repair businesses, metal scrap yards, and past

chemical fertilizer use. Lax waste management regulations and a general lack of knowledge about soil contamination heighten the dangers of heavy metal exposure. Despite these worries, little empirical information is available regarding the concentration levels, geographic distribution, and probable origins of heavy metals in the soil of Mechanics Village. Heavy metal contamination's effects on the environment and human health demand a thorough assessment to guide remediation plans and legislative initiatives. Soil quality evaluations are very important in rural areas like Mechanics Village, where subsistence farming remains the primary source of income. Heavy metals in soil have the ability to go into crops and then into the human body through food. Arsenic-contaminated rice paddies, for instance, have been connected to higher cancer rates in South Asia (Meharg *et al.*, 2009), underscoring the necessity of proactive monitoring in susceptible areas. The possibility of direct ingestion or cutaneous absorption for children playing in contaminated soils further intensifies the urgency of this study.

1.2 Review Objectives

Aim Reviewing the ecological and public health effects of heavy metals in the soil of irrigated farmland in the hamlet of automobile mechanics, as well as determining the concentration, possible origins, and sources of the metals, are the objectives of this study.

2.0 LITERATURE REVIEW

An earlier investigation into the assessment of heavy metals in soil from the car repair village of Dutse, Jigawa State, Nigeria, was conducted by Durumin Iya *et al.* (2023). It was demonstrated that the most prevalent heavy metal in the village is Ni, Zn, Mn, Fe, and Cu. The highest concentration of Ni is 0.75–5.55 mg/kg, followed by Mn (1.00–1.42 mg/kg), Fe (0.80 (0.05–0.60)), and N (0.30–0.40).

Similarly, in Benin City, Nigeria, Ilduo investigated soil contamination in auto-mechanic villages. According to the study, the waste produced in the auto-mechanic market was the cause of the contamination found in the soils of the auto-mechanic villages. In Sapela, Nigeria, Chokor and Ekanem (2016) investigated the profile of heavy metal pollution in soil from auto shops. Fe, Cu, Mn, Cr, Zn, Mg, Pb, Cd, Ni, and As were detected in soil samples from 10 distinct auto repair shops in Okitipupa, Ondo State, Nigeria, by Joseph *et al.* (2017). The findings indicate that the levels of heavy metals in soils utilized in many nations are below the uppermost permitted limits.

In a different study, Rabe *et al.* (2018) evaluated the level of heavy metal pollution in an auto mechanic workplace in Anyigba, Kogi State, Nigeria, at a soil depth of 0 to 15 cm. Compared to the control soil site, the experimental sites' soils had higher concentrations of the heavy metals under study. According to

Ogunkolu *et al.* (2019), heavy metals enter soils as a result of human anthropogenic activities. Researchers have extensively studied heavy metal contamination in soils from a variety of anthropogenic sources. These include agricultural practices (Culbard and Johnson, 1984), urbanization (Lavado *et al.*, 1998), automobile emissions (Largerwerff and Specht, 1970; Furgusson *et al.*, 1980), industrial waste (Haine and Pocook, 1980; Parry *et al.*, 1981; Culbard *et al.*, 1983; Gibson and Farmer, 1983), and agricultural practices.

Dawaki *et al.* (2013) examined the physicochemical characteristics and heavy metal concentration of soils in urban agricultural areas in Kano, Kano State, Nigeria, particularly along the banks of the Challawa, Jakara, and Watari rivers. Alkalinity, medium to high quantities of organic carbon (7.16 to 11.21 g/kg), and a moderate CEC (12.63 to 23.22 cmol/kg) were all indicated by the soils' mean pH range of 7.42 to 7.77. For Cu, Cr, Ni, Zn, Pb, and Cd, the corresponding total values were 4.95 to 5.99, 5.85 to 165.66, 54.03 to 57.77, 55.07 to 255.52, 42.84 to 68.12, and 0.59 to 11.81 mg/kg. Every reading was below the maximum allowed values in soil, with the exception of Cd at Jakara and Challawa. For Cu, Cr, Ni, Zn, Pb, and Cd, the corresponding soluble values were 0.27 to 0.48, 0.61 to 15.91, 5.60 to 7.15, 4.90 to 17.42, 2.78 to 9.36, and 0.00 to 0.60 mg/kg. Exchangeable and total metal forms were shown to be significantly correlated ($p \leq 0.05$) with soil characteristics as organic carbon, accessible P, total N, and basic cations. While substantial levels of metals were found in different forms, concentrations were significantly greater ($p \leq 0.05$) in Challawa and Jakara, which are irrigated with waters that receive domestic and industrial sewage, than in Watari, which is the control.

Bichi and Bello (2013) investigate heavy metals from cropland soils used for irrigation agriculture along the Tatsawarki River in Kano, Nigeria. Three farms (a, b, and c) located near the riverbanks provided soil samples and used surface water for irrigation. Furthermore, farms (d) distant from the riverside provided control samples. These samples, which were taken between 0 and 15 cm below the surface, were securely packed in polyethylene bags and taken to a lab for close inspection. Two samples were collected in each zone: one from farms that only used on water and another from farms that only used groundwater. The pH, texture, and concentrations of heavy metals (Cr, Cu, Co, Cd, Fe, Zn, Mn, and Pb) in the samples were analyzed. Irrigation with contaminated water significantly impacted the level of heavy metals in the soil. The soil's low clay content and acidic quality increased porosity and reduced retention capacity, making groundwater more susceptible to increased metal mobility. Cadmium levels surpassed predetermined thresholds. If the pollution source remains unaddressed, the accumulation of metals in

soils will eventually approach and surpass the regulatory limit. We recommend immediately controlling this increasing accumulation.

Correlational studies and pollution index evaluation of the distribution of toxic metals in soil and crops are essential for comprehending the risk of chronic diseases linked to these metals, claim Alhassan *et al.* (2019). To ascertain the distribution of Pb, Cd, Cr, and Hg in soil (S), beans (B), and maize (M), the study employed correlational analysis in the sampling zones of Bunkure (BKR), Dambatta (DBT), Gwarzo (GRZ), Ungogo (UGG), and Wudil (WDL) in Kano State, Nigeria. Metal content was measured using atomic absorption spectroscopy (AAS) on samples taken from agricultural harvests in each survey zone. Each local government's range for Hg, Pb, Cd, and Cr was 0.33 to 3.13, 0.14 to 0.84, 0.02 to 0.05, and 0.01 to 0.49 in soil; 0.04 to 4.23, 0.06 to 0.23, 0.02 to 0.04, and 0.00 to 0.10 in maize; and 0.20 to 4.23, 0.16 to 0.19, 0.03 to 0.04, and 0.00 to 0.03 in beans, according to the results. With the exception of mercury, all of the dangerous metals are below the range that is deemed acceptable by both international and European regulatory standards. The fact that the observed amounts fall within the higher permitted ranges increases the likelihood of a potential hazard. Nearly all of the samples had higher mercury levels, suggesting potential human activity-related hazards. Whereas a negative correlation can be the consequence of differences in the agrochemicals used, a significant positive correlation in soil samples with respect to hazardous constituents might suggest a shared property of the soil. Wudil exhibited the highest soil pollution load index for Hg (3.13 ± 0.16), Cd ($1.6 \times 10^{-2} \pm 0.01$), and Cr ($4.9 \times 10^{-3} \pm 0.01$), whereas Ungogo had the highest pollution load for Pb. All grains in the research locations also displayed a favorable transfer factor, except for Bunkure, Dambatta, and Gwarzo's Cr. It's possible that some of these dangerous metals might bioaccumulate in crops that are grown in these kinds of places, making their way into the food chain and endangering human health.

In Kano Metropolis, the impact of irrigation with industrial effluent on soil and crop heavy metal levels was investigated (Hussaini *et al.*, in 2021). An atomic absorption spectrophotometer (AAS) was used to measure the levels of Cd, Cr, Ni, and Pb in soil and crop samples (cucumber, maize, onion, and spinach) that were randomly selected from three locations. The researchers compared the results to World Health Organization (WHO) guidelines to evaluate the possible health risks associated with ingesting these heavy metals through eating crops. For Cr, Ni, and Pb, the measured concentrations in the soil (4.76–52.38 mg/kg, 2.45–3.43 mg/kg, and 7.65–14.21 mg/kg, respectively) did not surpass the allowable limits of 100, 50, and 100 (mg/kg). All soil samples, however, had Cd amounts between 3.67 and 4.28 mg/kg, which

was more than the allowable limit of 3.00 mg/kg. The mean concentrations of the heavy metals surpassed the highest permissible criteria advised by WHO/FAO, even though all electrical conductivity (EC) measurements were above the normal range and pH values were below it in plant samples, with the exception of Ni. All plant samples had estimated daily intake (EDI) levels that were higher than the European Food and Safety Agency's (EFSA) tolerable daily intake (PTDI) standard for Cd and Cr. Hazard quotient (HQ) values for Cd and Pb and hazard index (HI) values for all samples suggested that eating the tainted crops could pose a serious health risk. According to the study, the main source of heavy metal contamination in the plants and soils under investigation is probably irrigation with untreated wastewater. As a result, it is advised against using wastewater for agricultural irrigation.

Imam *et al.* (2019), looked into the concentrations and physicochemical characteristics of heavy metals in River Getsi irrigation water as well as the buildup of heavy metals in various irrigated vegetable sections. Examining the physicochemical properties of irrigation water revealed an average temperature of 30.1°C and a mean biochemical oxygen demand of 80.3 mg/l. At 0.0 mg/l, mercury was the least accessible heavy metal, whereas chromium was the most prevalent at 7.8 mg/l. This finding resulted from the application of ecologically friendly irrigation methods. An examination of heavy metal concentrations in irrigation soil revealed that chromium was the most abundant metal ($t = 5.5$ mg/kg, $r = 0.4$ mg/kg, $SD = 0.1$ mg/kg), while mercury was the least prevalent ($t = 0.0$ mg/kg, $r = 0.0$ mg/kg, $SD = 0.0$ mg/kg). It was discovered that both components fell within the range of recommended dietary intake. According to the study, there was a considerable level of heavy metal contamination in the water, soil, and vegetables in the River Getsi irrigation basin. It was recommended that farmers in the River Getsi irrigation area be instructed in environmentally friendly irrigation practices and that proper washing and processing practices for irrigated commodities be prioritized during Kano's health awareness campaigns.

The quantities of heavy metals in the soil from irrigated fields using tube-well water and industrial effluent at Gidan Maza and Yarimawa of Kano Municipal and Tofa Local Government over a 12-month period were compared in a study conducted between March 2011 and February 2012. Twenty randomly chosen samples were analyzed for heavy metals, pH, Ni, Cu, Pb, Cr, Fe, and Cd in accordance with standard protocols. The following heavy metals were found in Yarimawa: Cd (0.96 ± 0.78 mg/kg), Pb (1.24 ± 0.93 mg/kg), Cu (1.35 ± 0.43 mg/kg), Ni (1.27 ± 0.32 mg/kg), Cr (1.61 ± 0.35 mg/kg), and Fe (6.12 ± 0.25 mg/kg). The values for Pb, Cu, I, Cr, and Fe were 4.34 ± 0.54 mg/kg, 4.12 ± 0.87 mg/kg, 2.90 ± 0.45 mg/kg, 7.37 ± 0.65 mg/kg,

8.88±0.66 mg/kg, and 1.79±0.17 mg/kg, respectively. The amounts of heavy metals in the soil samples from Gidan Maza and Yarimawa differed significantly ($p=0.05$). Although the results from the two locations are below the FAO and WHO's maximum allowable limits for agricultural uses, the issue with heavy metals in the environment is that they build up in the food chain and have long-term effects. Therefore, to slow down the gradual deterioration of agricultural produce, it is advised that uncontrolled release of untreated effluents near the sample sites be reduced, particularly through irrigation and other human activities (Lambu *et al.*, 2017).

The levels of the following heavy metals (Fe, Pb, Cd, Cu, Cr, Ni, and Zn) and their contamination in the soil of a village of car mechanics in Abuja, Nigeria, are examined by Chinenye *et al.* (2017). The levels are in the following order: Fe > Zn > Cu > Pb > Cr > Ni > Cd and Fe > Cr > Zn > Pb > Cu > Ni > Cd, respectively. The heavy metal concentrations in the contaminated soil ranged from 158.55 for iron, 0.01 for cadmium, 17.14 for copper, 3.17 for cadmium, 1.96 for nickel, 16.40 for zinc, and 60.41 for lead (mg/kg). This suggests that the source of Ni in the contaminated soil was the same as that of Fe and Zn, as evidenced by the correlations between total organic matter and carbonate content ($r = 0.96$, $p = 0.043$, $p = 0.008$; and $r = 0.85$, respectively). All of the mechanic workshop's heavy metal contamination levels, potential ecological risk factors, and prospective risk indices were of low quality. All of the metals in the various sites had negative mean geo-accumulation index (I-geo) values. Therefore, the heavy metals have not yet caused harm to the mechanic workshop under investigation.

The atomic absorption spectrophotometric (AAS) analysis of soil samples around two major clusters of auto mechanic workshops in Benue State, Central Nigeria, was conducted (Pam *et al.*, 2013). The results showed that the concentrations of most heavy metals in the soil are above background levels and permissible limits recommended for soils in some countries, as indicated by the following ranges (mg/kg): Cu, 254-1-665; 5; 295-553; 58.8-272; 0-41; d-41, with a variation pattern in the order of Pd>Zn>Mn>Ni>Cd. Additionally, the metal collection in the auto mechanic workshops is arranged as follows: Gboko > Apir. The soils' pH, cation exchange capacity (CEC), organic matter (OM) content, and texture were other variables that seemed to have a major impact on the mobility of metals in the soils. While Zn, Mn, and Cd showed minimal to moderate enrichment and Ni showed moderate to considerable enrichment, Pb and Cu contamination factors in the study locations ranged from considerable to very high contamination. The environment around the workshops is heavily contaminated with Pb and Cu, and to a lesser extent with Ni, according to the geo-accumulation index

values for the metals in the soils. While the soils are still free of zinc pollution, both Cd and Mn displayed moderate levels of contamination (Pam *et al.*, 2013).

Meanwhile, Adelekan *et al.* (2011) investigated these heavy metals (Cd, Cu, Pb, Cr, and Ni). The study's objective was to measure the levels of heavy metals in the groundwater and soil in Ibadan, Nigeria, in car repair communities. The findings were then compared to international standards. For the workshop soil samples, the total levels of Cd, Cu, Pb, Ni, and Cr varied from 0.41 to 117117.23, 8 to 47476.0, 18.25 to 15100, 2.0 to 25.0, and 2.0 to 29.75 $\mu\text{g}/\text{kg}$, respectively. When these results were contrasted with the control, it was clear that these soils were contaminated. In all control samples, Ni was below the detection limit, whereas Pb and Cd were less than 0.05 and 0.002 $\mu\text{g}/\text{kg}$, respectively. Whereas Cr varied from 6.25 to 19.75 $\mu\text{g}/\text{kg}$, Cu varied from 4.30 to 10.05 $\mu\text{g}/\text{kg}$. The values measured in this study were higher in several cases than the established limitations imposed for soils in various nations. With the exception of Cu, where all values were greater than the limits, values recorded in the groundwater samples were lower than the WHO drinking water guidelines for the heavy metals.

Sadick *et al.* (2015) contribute by examining the level of heavy metal contamination in the soils surrounding clusters of auto mechanic workshops in Kumasi, Ghana's central agricultural station. The majority of the heavy metals under investigation had concentrations higher than the background level (control), according to their findings. The heavy metal concentration showed an elevated pattern of Pb>Fe>Cu>Mn>Cd>Zn. Additionally, the cation exchange capacity, pH, organic matter, and nitrogen ranged from 6.15, 0.88%, 0.10%, and 4.01 $\text{cmol (+)}/\text{kg}$ to 7.30, 9.09%, 0.57%, and 25.01 $\text{cmol (+)}/\text{kg}$. In comparison to the background level (control), the data demonstrated a relative decrease in the nutrient levels in the experimental soils. The Kwadaso Central Agricultural Station in Kumasi has heavy metal contamination in its soil, which is a result of the auto repair shops.

Another study by Akpoedafe *et al.* (2023) examined the effects of operations at car repair workshops on the degree of heavy metal contamination in the soil in Isoko Community, Niger Delta, Nigeria. Twenty soil samples in all (10 topsoil and 10 subsoil) were gathered for his study from nine active clusters of auto repair shops as well as a reference location. According to ASTM International standards, the concentrations of eight heavy metals—cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), nickel (Ni), and zinc (Zn)—were determined in the soil samples. According to the findings, the topsoil samples had mean concentrations of Cd, Cr, Cu, Fe, Pb, Mn, Ni, and Zn of 0.172 mg/kg, 0.36 mg/kg, 0.64 mg/kg, 159.40

mg/kg, 0.415 mg/kg, 1.39 mg/kg, 0.745 mg/kg, and 2.184 mg/kg, respectively. In contrast, the subsoil included 0.139 mg/kg of Cd, Cr, Cu, Fe, Pb, Mn, Ni, and Zn; 0.274 mg/kg; 0.462 mg/kg; 138.90 mg/kg; 0.349 mg/kg; 1.144 mg/kg; 0.586 mg/kg; and 1.793 mg/kg, respectively. Furthermore, the findings of the pollution indices showed that the soil was safe for both plants and animals due to its low level of heavy metal contamination.

The spatial variability of heavy metal concentrations in the soil of clusters of auto mechanic workshops in Nsukka, Nigeria, was examined (Duru *et al.*, 2024). Duru *et al.* randomly selected ten sampling points from both inside and outside the cluster. The coordinates of the chosen locations were determined using a portable GPS device, and a digital map was produced. Using a spectrophotometer, soil samples from depths of 0–30 cm and 30–60 cm were examined for Cu, Fe, Zn, Pb, As, and Cd. The soil ranged from sandy loam to sandy clay loam, according to the results. In the area under study, zinc and cadmium had the highest and lowest concentrations, respectively. Significant variations were found between the amounts of heavy metals in soils outside and inside the auto mechanic cluster at different depths (0–30 cm and 30–60 cm). The concentration levels (mg/kg) for the soil samples in the cluster ranged from 0.716–0.751 (Cu), 2.981–3.327 (Fe), 23.464–30.113 (Zn), 1.115–1.21 (Pb), 2.6–2.912 (As), and 0.133–0.365 (Cd), according to the analytical results. This result indicates a pattern of variation in the order Zn > Fe > As > Pb > Cu > Cd. On the other hand, concentration values (mg/kg) for soil samples that were not part of the cluster varied from 6.011–0.618 (Cu), 2.233–2.516 (Fe), 12.841–15.736 (Zn), 0.887–0.903 (Pb), 1.669–1.911 (As), and 0.091–0.091 (Cd). Indicators such as the Geo-accumulation Index (Igeo), Contamination Factor (Cf), and Anthropogenic Metal Concentration (QoC) were used to evaluate soil pollution. The highest contamination factors for zinc, cadmium, and arsenic suggested severe soil pollution, likely due to human activity. The metal concentrations not only decreased with increasing depth but also remained within WHO permitted levels.

Vincent *et al.* (2022) conducted a study in Adamawa State to determine the amount of heavy metals in soil and groundwater near automobile mechanic workshops in Yola and Jimeta towns. They used the AAS model 210 VGP to measure the heavy metals and an electronic JENWAY glass electrode pH meter (model 3510) to measure the pH of the sample, which ranged from 7.52 to 5.19. According to the study, the amount of heavy metals in the soil is in the following order: Zn > Ni > Fe > Pb > Cd. On the other hand, the sequence of heavy metals in the groundwater at repair shops is Ni > Fe > Zn > Cd > Pb.

The mean ages of the car mechanics and controls were

47.27±9.99 and 48.94 ±10.34 years, respectively, according to Adejumo *et al.*'s (2023) study of cardiovascular risk factors and kidney function among auto mechanics and their association with serum heavy metals in Southwest Nigeria. The prevalence of raised blood glucose (16.0% vs 4.9%; p = 0.013), elevated serum cadmium (25.9% vs 7.9%; p < 0.001), and alcohol usage (55.1% vs 30.0%; p = 0.001) was substantially greater among auto mechanics. Serum cadmium, atherogenic index of plasma (AIP) (p = 0.024; r = 0.382), and triglycerides (p = 0.020; r = 0.391) all showed significant positive relationships among the auto mechanics. The level of heavy metal concentration in the auto mechanic villages of Okigwe, Nekede, and Orji in Anambra state was examined in a 2010 study by Nwachukwu *et al.*

Assessment of Heavy Metal Pollution in Soil and Their Implications Within and Around Mechanic Villages. The results of metal concentrations (mg/kg) above the background levels in the top 100 cm soil profile range as follows: iron (748 -70,606 ±114.3), lead (99-1090 ± 251.3), manganese (186-600 ± 180), copper (102-1001 ± 201.9), cadmium (8-23 ± 12.9), chromium (4-27 ± 6.0), and nickel (3-10 ± 2.2). The order of abundance for the metals is as follows: iron > lead > manganese > copper > cadmium > chromium > nickel, with Okigwe having the highest concentration, followed by Nekede and then Orji. The metals exhibit comparable contamination patterns across the three layers (L1-L3), according to pollution indices, [urce-d930be33e0acdee6e01031d10493f744cd5094a007e44d83a70ab28b77465ef5](https://doi.org/10.57233/ijsgs.v11i3.937)">with L1 (0-10 cm) > L2 (10-20 cm) > L3 (90-100 cm) in Okigwe, L3 > L1 > L2 L2L2 in Nekede, and L3 L > > L1 in Orji. In actuality, the sandy Nekede and Orji soils are more polluted in the lower levels, whereas the top layer of the shaly Okigwe soil is more polluted.

In the same vein, a study was conducted to evaluate the concentration of heavy metals in the automobile mechanic workshops located in Ilaro, Ogun State. The amount of heavy metals present in the soil samples was ascertained using Atomic Absorption Spectrophotometry (AAS). Zn, Cr, Cu, Pb, Co, and Ni concentrations ranging from 62.416 to 81.163 mg/kg, 8.314 to 12.678 mg/kg, 15.078 to 18.402 mg/kg, 81.697 to 84.128 mg/kg, 12.070 to 14.112 mg/kg, and 28.162 to 30.456 mg/kg were measured from soil samples taken from the automobile mechanic workshops. The mean values were 70.115 mg/kg, 10.315 mg/kg, 16.470 mg/kg, 82.731 mg/kg, 12.739 mg/kg, and 29.361 mg/kg, respectively. With the exception of zinc, which had a content over the WHO/FAO standard threshold of 60 mg/kg, the data indicate that the mean concentrations of the heavy metals were below the standard values.

Additionally, Ololade (2014) conducted excellent

research to use enrichment and contamination factors with geo-accumulation indices to assess the level of heavy-metal contamination in soils within auto-mechanic workshops. All of the metals were found at exceptionally high concentrations in the soils above background values, with the majority (Ni, Cu, Fe, Cr, and Cd) declining with soil depth. $Fe > Cu > Zn > Pb > Cr > Ni > Cd$. Fe and Cd had the highest ($476.4 \mu\text{g}\cdot\text{g}^{-1}$) and lowest ($37.5 \mu\text{g}\cdot\text{g}^{-1}$) mean values, respectively, across all sample locations and profiles. The enrichment factors (EFs) for Pb, Ni, and Cd are severe, although the pollution load index (PLI) and the index of geo-accumulation (I-geo) showed generally high and moderate contamination, respectively.

2.1 Heavy Metal Classification

Below, we cover the two main categories of heavy metals: essential and non-essential. Heavy metal is essential.

2.1.1 Essential Heavy Metals

These metals are essential for metabolic activities and are required in trace amounts for normal physiological functions (Chen *et al.*, 2015). Hemoglobin and myoglobin depend on iron (Fe) to carry oxygen (Kumar *et al.*, 2020). Zinc is essential for enzymatic activity, immunological response, and DNA synthesis (Sarwar *et al.*, 2016). According to Sun *et al.* (2013), copper aids in electron transport (cytochrome c oxidase) and antioxidant defense (superoxide dismutase). Mn: A cofactor for metabolic enzymes and bone production (Khan *et al.*, 2008). Mo: Required for the nitrogen metabolism-related enzyme xanthine oxidase (Kumar *et al.*, 2020b). Co: Vitamin B12's primary component (Zhang *et al.*, 2010).

2.1.2 Heavy Metals That Are Not Essential

These metals have no recognized biological function and are hazardous even at low quantities. Pb is neurotoxic, for instance, and can cause organ damage as well as cognitive impairment (Mustapha *et al.*, 2019). According to IARC Group 1, cadmium is nephrotoxic and carcinogenic. Methyl mercury is neurotoxic and bioaccumulates in aquatic food chains. For example, cadmium is carcinogenic and can lead to bladder, lung, and skin cancer. According to IARC Group 1, breathing in chromium (Cr-VI) can cause cancer. Nickel (Ni) can induce cancer and allergies in certain forms (Kumar *et al.*, 2020a).

3.0 NATURE AND ANTHROPOGENIC

According to Kabata Pendias and Pendias (2010) and Kumar *et al.* (2017), the pedogenetic weathering of

parental chemicals happens naturally in the soil environment at quantities regarded as trace ($< 1,000 \text{ mg/kg}$) and rarely harmful. In both rural and urban areas, most soils may accumulate heavy metals over the specified background levels, which are high enough to pose a danger to human health through plants, animals, ecosystems, or other media (Maurya *et al.*, 2019; Kumar *et al.*, 2020a). (i) Heavy metals are also a soil pollutant because (i) human cycle rates are faster than natural ones; (ii) they are transported from mines to random ecological locations where direct exposure is more likely; (iii) concentrations of metals are higher in unnecessary goods than in the reception setting; and (iv) Kaasalainen and Yli Halla suggest that heavy metals are more mobile in soil than in pedogenic or powder metallurgy soils, making them bioavailable (Kaasalainen and Yli Halla 2001). Both natural processes and human activity release heavy metals into the atmosphere. The primary source of heavy metals is the parent material from which they originate. According to Sarwar *et al.* (2016), approximately 5% of sedimentary stone and 95% of the earth's crust are made of imaginative steel. According to Muradoglu *et al.* (2015), the basalt pillar has a richness of heavy metals, including Cu, Cd, Ni, and Co, as well as significant amounts of Pb, Cu, Zn, Mn, and Cd. The release of heavy metals in soil systems requires natural processes, including weather, biogenic, earth, and volcanic processes, such as erosion and surface wind (Muradoglu *et al.* 2015). According to Dixit *et al.* (2015), man-made sources of heavy metals are more significant than natural ones. The main industrial processes that contribute to excessive metal accumulation in the environment are mining and smelting of metalliferous ores, metal processing, burning fossil fuels, sewage sludge, and other agricultural practices (Yadav *et al.* 2018; Gupta *et al.* 2019). According to a number of studies, anthropogenic activities such as mining and smelting, burning fossil fuels for energy, disposing of garbage in cities, using pesticides, water irrigation, and fertilization are among the things that contribute to rising soil levels of heavy metals. (Khan *et al.* 2013; Ogunlade and Sun *et al.* 2013; Chen *et al.* 2015; Muradoglu *et al.*, 2015). Additionally, some studies suggested that the sample should contain solids from various metal mining residues, fuel, plumbing, land use, animal manure, biosolids, compost, petrochemical and ambient waste, and the treatment and processing of high-tech waste at toxic sites (Khan *et al.*, 2008; Zhang *et al.*, 2010; Kumar *et al.*, 2020b).

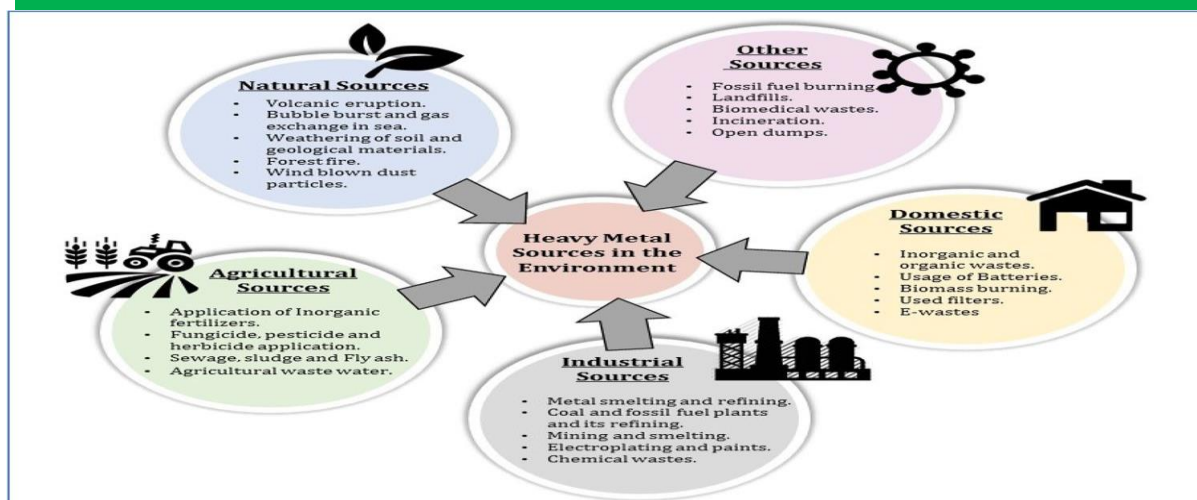


Fig. 1 Sources of heavy metals in the soil (Jayakumar et al., 2021)

Effects of heavy metals on the environment and human health the effects of heavy metals on human health and the environment are significant due to their toxicity, ability to persist in ecosystems, and tendency to accumulate in living organisms (Dawaki *et al.*, 2019).

4.0 EFFECT ON HUMAN POPULATION

They may have immediate effects or take time to show up impact on people Adesina *et al.* (2012) state that exposure to lead (Pb) primarily affects the neurological system, which can lead to behavioral problems, learning difficulties, and a lower IQ, particularly in children. In adults, it results in issues with reproduction, hypertension, and kidney damage. According to Abdullahi *et al.* (2023), lead can accumulate in bones and remain there for a long time. Cd is extremely dangerous, even in tiny quantities. Long-term exposure damages kidneys, leading to renal failure, and weakens bones, resulting in osteoporosis and fractures (Miko and Ibrahim, 2024).

Cadmium (Cd) is extremely toxic, even at low concentrations. Long-term exposure degrades bones, resulting in osteoporosis and fractures, and damages kidneys, causing renal failure. Lung cancer can result from breathing in cadmium dust or smoke. The Itai-Itai illness in Japan, where contaminated rice caused severe bone pain and abnormalities, is a prominent example of cadmium poisoning (Chao *et al.*, 2014).

Mercury (Hg) is a potent neurotoxin that affects sensory ability, coordination, and brain activity. The organic form of methylmercury accumulates in fish and seafood and poses a risk to people who consume them. Mercury-contaminated wastewater caused the Minamata illness outbreak in Japan, which led to severe neurological problems and birth abnormalities (Abdullahi *et al.*, 2024).

Exposure to drinking water or food containing arsenic

(As) results in skin lesions, hyperpigmentation, calcified hard patches on the palms and soles. Long-term exposure causes lung, bladder, and skin cancers. Diabetes and cardiovascular disorders are also exacerbated by arsenic (Samali *et al.*, 2017). Inhaling the poisonous form of chromium, known as Cr-VI, can lead to lung cancer, especially among industrial workers. Ingestion harms the kidneys and liver, whereas skin contact causes ulcers and allergic dermatitis (Maharazu, 2010).

Exposure to nickel (Ni) mostly happens by inhalation, which can cause lung fibrosis and other respiratory issues. Dermatitis and allergic responses can result from skin contact. According to Chiroma *et al.* (2014), prolonged exposure raises the risk of lung and nasal malignancies.

Impacts on the Environment By destroying helpful bacteria, decreasing nutrient availability, and impeding plant growth, heavy metals damage soil health. These metals are absorbed by some plants and subsequently make their way into the food chain, where they impact both humans and animals. For instance, crops like rice may absorb cadmium from the soil, endangering the health of consumers. Fish and other organisms are poisoned by heavy metals in aquatic environments. Fish that collect mercury are unsafe to consume. In water bodies, lead and cadmium sink into sediments and remain there for years, continuously releasing toxins into the water. These metals have the ability to destroy aquatic life, upsetting entire ecosystems (Nura *et al.*, 2021).

Exposure to heavy metals also harms wildlife. When birds consume lead from tainted food or ammunition, they become poisoned and eventually die. Cadmium builds up in the kidneys of mammals like deer and rats, eventually leading to organ failure. Because of biomagnification, which occurs when toxin

concentrations rise at every stage of the food chain, predatory creatures at the top of the food chain, including eagles and huge fish, are particularly at risk (Dawaki *et al.*, 2013).

4.1 Long-Term Repercussions

Because heavy metals don't decompose naturally, their effects last for many years. Polluted water supplies continue to be dangerous, and contaminated soil is no longer suited for agriculture. As vulnerable species disappear, biodiversity decreases, upsetting the natural equilibrium. People who live close to polluted places are at constant risk for health issues, such as increased cancer rates and childhood developmental issues (Khan *et al.*, 2008). Preventative measures and solutions It's critical to stop additional contamination. Some strategies are:

- (i). Using plants, such as sunflowers, to absorb and extract metals from soil is known as phytoremediation.
- (ii). Lime or organic matter can be added to soil to lessen the toxicity of metals.
- (iii). Tight Rules: imposing restrictions on industrial waste and keeping an eye on the quality of the land and water.
- (iv). Public Awareness: Teaching local populations about the risks posed by heavy metals and how to limit exposure.

5.0 REGULATIONS FRAMEWORKS

Globally, heavy metal regulations have been put in place to protect human health and ecosystems from contamination. The World Health Organization (WHO) sets drinking water guidelines that limit levels of lead (Pb) to 10 µg/L due to its neurotoxic effects, cadmium (Cd) to 3 µg/L to prevent kidney damage, and arsenic (As) to 10 µg/L to reduce the risk of cancer. The WHO recommends temporary limits for soil in residential areas of 20 mg/kg arsenic and 100 mg/kg lead. The Food and Agriculture Organization (FAO) enforces stricter standards for food goods, such as 0–2 mg/kg of lead in cereals and 0–5 mg/kg of methylmercury in fish. For residential soil in the US, the Environmental Protection Agency (EPA) establishes screening values of 400 mg/kg for lead and 0–39 mg/kg for arsenic. According to drinking water guidelines, the action level for lead is 15 µg/L, and the maximum contamination level (MCL) for arsenic is 10 µg/L. The European Union (EU) establishes varying soil limitations under its food safety laws, such as 0–1 mg/kg for cadmium in rice and 50–300 mg/kg for lead in agricultural areas. Nigeria's National Environmental Standards and Regulations Enforcement Agency (NESREA) permits up to 85 mg/kg of lead in agricultural soils and 0.01 mg/L of arsenic in water. Industrial zones usually allow greater thresholds than agricultural areas, such as cadmium restrictions of up to 15 mg/kg. NESREA (2013), permit's a minimum concentration of As, Cd, Co, Cu, Pb, Hg, Ni, and Cr heavy metals as 20, 3.0,

50.0, 100, 164, 4.0 70.0, and 100 mg/kg, respectively, from soil samples.

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Soil contaminated with heavy metals presents a serious risk to food security. The reviewed studies reveal that concentrations of chromium (Cr), cadmium (Cd), and lead (Pb) occasionally surpass the permissible limits established by WHO/FAO. However, the levels of Cr, Cu, Co, Cd, Fe, Hg, Mn, Ni, Pb, and Zn in soils, plants, and irrigation water typically stay within acceptable thresholds. Ongoing assessment of heavy metal levels in agricultural soils, food crops, and human tissues is essential to reduce related health risks. Soil leaching, a process that entails washing contaminated soils with appropriate chemical agents to dissolve and eliminate heavy metal complexes, should be employed when required. Additionally, encouraging farmers to adopt phytoremediation practices can act as a sustainable strategy. This approach employs particular plants that can hyperaccumulate heavy metals from polluted soils, effectively lowering pollutant concentrations and enhancing soil quality gradually.

6.2 Recommendations

- i. Implementation of Regular Soil Monitoring Programs
- ii. Adoption of Eco-friendly Remediation Strategies
- iii. Strict Regulation and Public Awareness Campaigns

Acknowledgement

The authors would like to express appreciation to the Department of Chemistry, Faculty of Physical Science, Federal University Dutse (FUD), Jigawa State Nigeria.

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