Journal of Materials and Environmental Science
ISSN : 2028-2508
e-ISSN : 2737-890X
CODEN : JMESCN


J. Mater. Environ. Sci., 2025, Volume 16, Issue 1, Page 102-111

http://www.jmaterenvironsci.com

# Evaluation of Heavy Metals Contamination from Automobile Workshops in Uyo Local Government Area, Akwa Ibom State

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***Received*** *04 Jan 2025,*
***Revised*** *17 Jan 2025,*
***Accepted*** *18 Jan 2025*

***Citation***: *Daniel D.O., Udofia I. M., Agwo M. U., Asiwe T. N. (2025) Evaluation of heavy metals contamination from automobile workshops in Uyo Local Government Area, Akwa Ibom State. J. Mater. Environ. Sci., 16(1), 102-111*

**Abstract:** Soil represents the most crucial components of the earth's crust, and their quality is of utmost importance, demanding serious consideration. This study aimed to evaluate the contamination of heavy metal concentrations in selected automobile workshop within Uyo Local Government Area. Soil samples collected from the two mechanic workshops and non-mechanic shop as control undergone pretreatment, digestion, and the concentration was determined using an Atomic Absorption Spectrophotometer (AAS). The concentrations of the samples were Pb(2.658mg/kg), Hg(0.001mg/kg), Co(0.003mg/kg), Ba(28.104mg/kg), As(3.412mg/kg), Fe(11.262mg/kg), Cu(0.827mg/kg), Cd(2.203mg/kg), Cr(0.144mg/kg), Mn(2.015mg/kg), Ni(1.418mg/kg), and Zn(3.524mg/kg) for Mechanic Village, Abak Road, and Pb(4.065mg/kg), Hg(0.001mg/kg), Co(0.002mg/kg), Ba(31.735mg/kg), As(4.018mg/kg), Fe(12.613mg/kg), Cu(0.694mg/kg), Cd(1.873mg/kg), Cr(0.221mg/kg), Mn(1.894mg/kg), Ni(1.705mg/kg), and Zn(44.116mg/kg) for mechanic workshop at Atiku Abubakar Road. Geo-accumulation index, contamination factor and pollution load index were used to determine the pollution status of the soil. The findings revealed that the concentrations of all metals at both sites, except for Zn at the Abak Road exceeded those at the control site. It was recommended that mechanic workshops be sited afar from residential and farmland areas to avoid the transfer of these heavy metals into the food chain, ground and surface water systems.

***Keywords:*** *Soil, Heavy metals, Automobile Workshop, Contamination, Pollution*

## 1. Introduction

The environment is continuously being contaminated by heavy metals through various human activities, primarily, by wastewater from mines being used to irrigate paddy fields (Adelekan and Abegunde, 2011), by emissions from nonferrous metal refineries (Xing *et al.*, 2020), waste from abattoirs (Anweting *et al.*, 2024a), land application of fertilizers (El Bouraie *et al.*, 2010), transportation (Udofia *et al.*, 2024), animal manures (El Bouraie *et al.*, 2010), sewage sludge (Adelekan and Abegunde, 2011), pesticides (El Bouraie *et al.*, 2010) and coal combustion residues (El Bouraie *et al.*, 2010), as well as automobile workshops (Onah *et al.*, 2019). Waste generated in the auto mobile workshop environment as a result of artisan activities includes metal scraps, used batteries, packaging materials, spent lubricants and worn-out parts, which contain contaminants such as heavy metals (Pam *et al.*, 2013a & b). Where such activities are not properly monitored and regulated, they may give rise to elevated levels of metals and hydrocarbons in the environment. Over a long period of time, a large fraction of these contaminants may become buried in soil and even small residual amounts of these contaminants are a concern (Sakan and Đorđević, 2010; Jodeh *et al.*, 2015).

Heavy metal refers to any chemical element with potential toxicity, has high atomic mass, relatively high density, thus at least five (5) times the specific gravity of water (Oguntimehin and Ipinmoroti, 2008; Nwokem *et al.*, 2023 Okon et al., 2022, 2023a & b, 2024; Anweting *et al.*, 2024a & b; Udofia *et al.*, 2024), They include; lead (Pb), zinc (Zn), iron (Fe), copper (Cu), chromium (Cr), and cadmium (Cd), and can have serious health and environmental impacts (Okon *et al.*, 2022; Ebong *et al.*, 2022; Etuk *et al.*, 2023 a & b; El Hammari *et al.*, 2023; Ebong 2022, 2023, 2024). Heavy metals occur naturally in the earth's crust (Aderinola *et al.*, 2009). They are non-biodegradable and tend to be contaminants to living things in the environment (Obodai *et al.*, 2011; Karim *et al.*, 2016). Heavy metals persist for a long time in the environment being non-degradable and are translocated to different components affecting the biota (Kumar *et al.*, 2010; Obodai *et al.*, 2011; Rajaganapathy *et al.*, 2011). The persistence of heavy metals can result in bioaccumulation and biomagnifications causing heavier exposure for some organisms than is present in the environment alone (Adelekan and Abegunde, 2011). Some metals such as manganese, iron, zinc, selenium, cobalt, copper etc. are nutritionally important for healthy life and major biochemical processes, while arsenic, lead, cadmium, mercury, nickel etc. are deleterious, even at trace amounts. Complete avoidance of exposure to the toxic metals is completely impossible (Singh and Kalamdhad, 2011). In Nigeria and most developing nations, increased automobile repairs/workshop activities are due to ever-in-creasing demand for personal vehicles, most of which are used Tokunbo vehicles. These have contributed markedly to the problem of soil contamination in most cities. Automobiles used (waste) oil contains oxidation products, sediments, water and metallic particles resulting from machinery wears, used batteries, organic and inorganic chemicals used in oil additives and metals (European Environment Agency, EEA 2007). Unfortunately, information on the impact of automobile mechanics' activities on the ecosystem is still very rare. Pollution of the natural environment by heavy metals has received the attention of researchers globally. This is mainly due to their harmful effects on both plants and animals (Förstner and Wittmann, 2012; Etuk, 2023a Udofia *et al.*, 2024). Through human activities, the metals are distributed, concentrated and chemically modified, which may increase their toxicity. Auto-mechanic workshops have been shown to generate heavy metals and contaminants, which may disperse throughout the environment, leading to serious contamination problems (Okoye *et al.*, 2017).

There are several automobile workshops in Uyo to meet the vehicular needs of the populace. Most of these workshops are indiscriminately sited around homes and business premises. Though there is a general mechanic village at Abak road in Uyo, Uyo mechanic workshop owners have the liberty to site their workshops wherever they so wish on like the one at Atiku Abubakar road in Uyo and the host of others. They can one day decide to convert the workshop to residence or farm. Several studies have been done on heavy metal contamination of soils of automobile workshops and its impacts on various properties of the soil in different cities of the country, but previous works that compare the levels of heavy metal contamination of automobile workshops from the two locations (mechanic village, Abak road and Atiku Abubakar road) in Uyo are scarce or non-existent in the literature. This research, therefore, is aimed to establish the status of heavy metals contamination as well as highlights health effects caused by heavy metals on prolong exposure.

## 2. Methodology

### 2.1. *Study area*

Uyo municipality lies in South-South geopolitical zone in Nigeria, popularly known as Niger Delta region and it is the territory of Akwa Ibom State. This region hosts the most extensive reservoir of natural resources in the country's crude oil. Many oils exploration and servicing industries are situated in this area, besides being a booming businesses center and the state capital, Uyo also links with Abia and Imo in the South-Eastern Nigeria. The area lies in the tropical hinter-land climate of Nigeria characterized by the rainy and dry seasons (Ihedioha *et al*., 2017). The rainy season begins in April and end in September with a peak in June and July, while the dry season commence from October and end in March and is usually accompanied by a dry cold harmattan wind which prevail during December and January (Ihedioha *et al*., 2017). The average rainfall in Uyo is 2509mm with annual temperature averages of 26.4°C. The relative humidity varies between 71 and 90%. Uyo city geology reveals that it is generally flat and lies within thin beach dunes and large valleys. Uyo is characterized by mangrove swamps, tidal creeks and brackish lagoon. The study area is located within the region of Niger-Delta sedimentary basin.

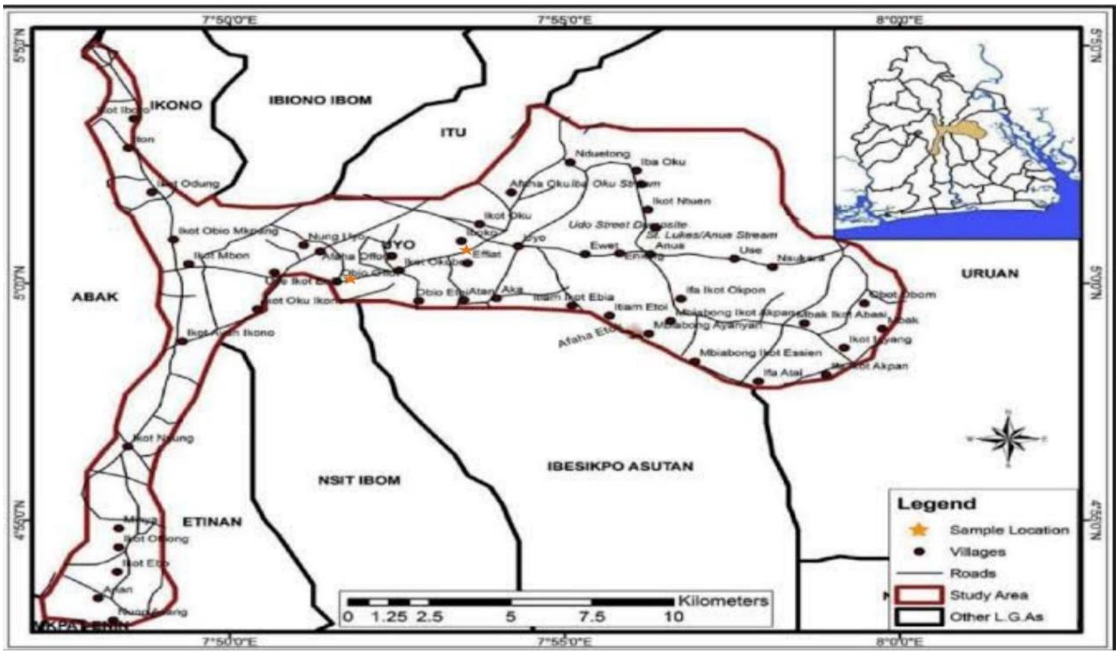


**Fig. 1:** Study locations on the map of Uyo local government area

### *2.2. Sample collection, preparation and digestion*

Samples of soil were collected from two automobile workshops within Uyo metropolis, and from University of Uyo main campus which serve as the control. The samples were stored in sample bottles in a polyethylene bag and transported to Ministry of Science and Technology laboratory, Uyo for analysis. The samples were prepared as per the standard methods of the American Society for Testing and Materials (ASTM, 2010). The soil samples were air-dried to constant weight and disaggregated with mortar and pestle and were sieved using 2mm plastic sieve.

The sample (0.5g) was placed in 250ml beaker and 0.5ml of concentrated nitric acid was added directly to each sample in a fume cupboard and stirred. One hundred milliliter of distilled water was added to each sample and were heated using heating mantle in a fume cupboard until the volume reduced to 20ml. The heating was done below boiling point within the range of 80-90°C. The digests were filtered using Whatman No. 42 filter paper into 100ml standard volumetric flask and made up to mark with distilled water (Ebong *et al*., 2008). The blanks were prepared and analyzed in a similar way as described above except for the omission of sample. This was done in order to remove occurrence of metal ions present in the reagent mixture (Ihedioha *et al*., 2017). The instrument settings and operational conditions were in accordance with the manufacturer's specifications. The instrument was calibrated with analytical grade standard metal solutions (1mgcm$^{-3}$) in replicates (Pam *et al*., 2013b).

The concentration of metals in sample solution were determined by the use of calibrated GBC 902, XploraAA double beam Atomic Absorption Spectrophotometer (AAS) at the Ministry of Science and Technology, Uyo, Akwa Ibom state.

### *2.3 Pollution assessment of studied soils*

### *2.5.1 The geo-accumulation index ($I_{geo}$)*

The geo-accumulation index ($I_{geo}$) was applied to quantify the metal pollution in the soils. The geo-accumulation index ($I_{geo}$) for soil samples were calculated using the equation below:

$$I_{geo} = \log_2 \frac{Cn}{1.5Bn} \qquad \textbf{Eqn. 1}$$

Where Cn = concentration of metal measured in soil samples in the study area, Bn = background value of the corresponding metal, 1.5 = background matrix correction due to lithological effects. Muller (1969) proposed the geo-accumulation index following seven grades or classes: (i) $I_{geo} > 5$ = extremely polluted, (ii) $I_{geo}$ = 4–5 = strongly to extremely polluted, (iii) $I_{geo}$ = 3–4 = strongly polluted, (iv) $I_{geo}$ = 2–3 = moderately to strongly polluted, (v) $I_{geo}$ = 1–2 = moderately polluted, (vi) $I_{geo}$ = 0–1 = unpolluted to moderately polluted, (vii) $I_{geo} < 0$ = practically unpolluted.

### *2.5.2 Contamination factor*

The contamination factor is obtained from a ratio between the measured concentration of the heavy metals in soil and the control value for the same metal. The computing equation for contamination factor ($C_f^i$ ) is;

$$C_f^i = Ci/C_n^i \qquad \textbf{Eqn. 2}$$

Where $C_f^i$ = the measured concentration of the heavy metals in soil and $C_n^i$ = the standard pre-industrial reference level. The classification of contamination factor is as follows; (i) CF < 1 - Low contamination (ii) 1 < CF < 3 - Moderate contamination (iii) 3 < CF < 6 - High contamination (iv) 6 > CF - Very high contamination (Hakanson, 1980).

### *2.5.3 Pollution load index (PLI)*

The pollution load index (PLI) is obtained from the contamination factors ($C_f^i$ ). The PLI of the soils were calculated by obtaining the n-root from the n-CFs that were obtained for all the metals. The pollution load index (PLI) as developed by Tomlinson *et al.* (2012) and adopted by Anweting *et al.* (2024b) is shown below;

$$PLI = \sqrt[n]{CF1 \times CF2 \times CF3 \ldots \times CFn} \qquad \textbf{Eqn. 3}$$

Where Cf = contamination factor and n is the number of metals in the study. The PLI gives unassuming yet sensible intends to evaluating a site quality, where an estimation: (i) PLI < 1 mean perfection, (ii) PLI = 1 present that only baseline levels of contaminant are available, (iii) PLI > 1 would show decline of site quality.

## 3. Results and discussion

### 3.1 Distribution of Heavy Metals in Soils

The heavy metals distributions at the two study areas and control are shown in Table 1. The concentrations of lead in the soil samples were 2.658mg/kg, 4.065mg/kg and 0.927mg/kg for mechanic village, Abak road automobile workshop (MVA), Atiku Abubakar road automobile workshop (AAA) and control respectively. The concentrations were above the WHO and SON standard (0.01mg/kg), but below the FMENV standard which is 8.5mg/kg. The value of lead obtained from AAA workshop, 4.065mg/kg was the highest in the areas. This high level of lead may be attributed to waste oil, automobile emissions and expired batteries indiscriminately dumped within the workshops. Chromium was present in all the soil samples investigated. Concentrations of 0.144mg/kg, 0.221mg/kg and shops, since this element is found as part of many additives of lubricating oils. The concentration may be due to factors such as age of the mechanic workshops, volume of work done on each site, types of automobile service or repairs, type of lubricant commonly used, mode of wastes disposal and type of soil. Onder *et al.* (2003) also reported high concentrations of zinc. The concentration of iron evaluated showed a range of 11.262-12.613mg/kg, while the control site shows the concentration of 8.684mg/kg (Table 1). The concentration of iron observed at the studied soils were found to be higher than that of the control site revealing the effect of automobile mechanics' activities. However, the concentration of iron recorded at all sites was within the permissible limit of 30mg/kg which is the standard set by WHO. At this level in the soil, iron has no relative effect on human health and agricultural activities. The increase in iron content of the soil might be as a result of waste in automobile workshops in the study area which includes solvent, hydraulic fluid, spent lubricants, metal construction works, welding of metals and panel beatings. This result corroborates the findings of Adewole and Ucheagbu (2010), where they noted that iron concentration in auto mechanic workshops fell within the permissible limits of WHO.

**Table 1:** Heavy metal distributions at study areas and control soil

| Heavy Metals | STANDARD LIMITS (mg/kg) | | | | Mechanic Village (mg/kg) | Atiku Abubakar (mg/kg) | Control Site (mg/kg) |
|---|---|---|---|---|---|---|---|
| | WHO | SON | DUTCH | FMENV | | | |
| **Pb** | 0.01 | 0.01 | - | 8.5 | 2.658 | 4.065 | 0.927 |
| **Hg** | - | - | - | 0.03 | 0.001 | 0.001 | <0.001 |
| **Co** | - | - | 9 | - | 0.003 | 0.002 | <0.001 |
| **Ba** | - | - | - | 200 | 28.104 | 31.735 | 18.147 |
| **As** | 0.009 | - | - | - | 3.412 | 4.018 | <0.001 |
| **Fe** | - | 0.3 | - | - | 11.262 | 12.612 | 8.684 |
| **Cu** | - | - | 36 | - | 0.827 | 0.694 | 0.323 |
| **Cd** | 0.003 | 0.003 | - | 100 | 2.203 | 1.873 | 0.056 |
| **Cr** | 0.05 | 0.05 | - | - | 0.144 | 0.221 | 0.038 |
| **Mn** | 0.5 | 0.2 | - | - | 2.015 | 1.894 | 1.203 |
| **Ni** | - | - | - | 35 | 1.418 | 1.705 | 0.879 |
| **Zn** | 3 | 3 | - | 140 | 27.116 | 25.617 | 21.104 |

They further concluded that Iron is an important plant micronutrient, which is needed for physiological plant growth in small amount but may be increased due to improper disposal of spent engine oil. The concentration of manganese examined at both auto mechanic workshops showed a range of 1.894-2.015mg/kg, while the control site showed the concentration of 1.203mg/kg. The concentration of manganese observed at the auto mechanic workshops were higher than that of the control site, and also above the permissible limit of 0.04mg/kg which is the standard set by WHO. At this level in the soil, manganese is prominent, making the soil contaminated at all sites. Manganese is one of the elements found in abundance in the earth's crusts and is widely distributed in soils, sediments, rocks and water.

This result is of public health importance as heavy metals in soil are toxic and some of the soluble metals may find their way into soil, rivers, lakes and streams resulting in pollution and may lead to geo-accumulation, bioaccumulation and biomagnifications in the ecosystems. Thus, it's possible for soil pollution to change the whole ecosystem (Seifi *et al.*, 2010). Considering the year of establishment of the auto mechanic workshop clusters and mean concentration observed in the study area as compared with the control sites revealed that the level of Manganese in the soils investigated is building up and need to be monitored to prevent any further increase. The concentration of arsenic analyzed at both auto mechanic workshops showed a range of 3.412-4.018mg/kg while the control site shows the concentration of <0.001mg/kg. The concentration of arsenic observed at the auto mechanic workshops were higher than that of the control site. However, the concentration of arsenic recorded at all sites except the control were above the permissible limit of 0.009mg/kg which is the standard set by WHO. The implication of this is that prolong accumulation of arsenic in human causes central nervous system damage and may be detrimental to human health. The levels of arsenic concentration obtained were higher than those reported by Iwegbue (2007) and Idugboe *et al.* (2014). The concentration of copper analyzed at various automobile workshops showed a range of 0.694-0.827mg/kg, while the control site showed concentration of 0.323mg/kg.  Copper observed at the auto mobile workshops were found to be higher than that of the control site. This result corroborates with the statement by Adelekan and Alawode (2011) that areas with heavy vehicular traffic and higher tempo of anthropogenic activities of urban settlements have high soil contaminants than those with low vehicular traffic. However, the concentration of copper recorded falls below the permissible limit of 36mg/kg which is the standard set by DUTCH. At this level in the soil, copper has a low concentration in the soil, which means the soil is not contaminated by copper. Mercury recorded the lowest value of 0.001mg/kg for both auto mechanic workshops. This value falls below the standard of 0.03mg/kg recommended by FMENV. Mercury, despite being very useful can cause harm to human, it is attributed with acute and chronic poisoning. The concentration of Cobalt from MVA and AAA workshops were 0.003 and 0.002mg/kg respectively (Table 1). The control soil had the lowest concentration of < 0.001mg/kg. The concentration of cobalt revealed from all the sites falls below 9mg/kg of DUTCH permissible limit. The concentration of barium at MVA and AAA workshops were 28.104 and 31.735mg/kg respectively (table 4.1). The control recorded the lowest concentration of 18.147mg/kg. The concentrations from all the sites falls below 200mg/kg standard limit set by FMENV. It is therefore noted that the soils were not contaminated by barium. Overexposure of barium is attributed to gastrointestinal effects, cardiac dysrhythmias, abnormal blood pressure, muscle weakness and paralysis.

### *3.2 Pollution Assessment of Studied Soils*

#### *3.2.1 Geoaccumulation index ($I_{geo}$)*

The geoaccumulation index was obtained using Eqn.1, and the results were presented with Fig. 1. Using the classification of Muller (1969), Hg (-0.43), Fe (-0.21 to -0.05) and Zn (-0.22 to -0.31) depicts no contamination at both automobile workshops. Ba (0.05-0.22), Cu (0.52-0.77), Mn (0.07-0.16) and Ni (0.10-0.37) at both automobile workshops, Pb (0.93) at MVA workshop, Co (0.57) at AAA workshop indicated a low to moderate contamination. Cr (1.33-1.96) at both automobile workshops and Co (1.15) at MVA workshop indicated moderate contamination. Cd (4.48-4.71) at both automobile workshops showed a strong to extreme contamination, and with values between 11.30-11.54, both automobile workshops was extremely contaminated by As.

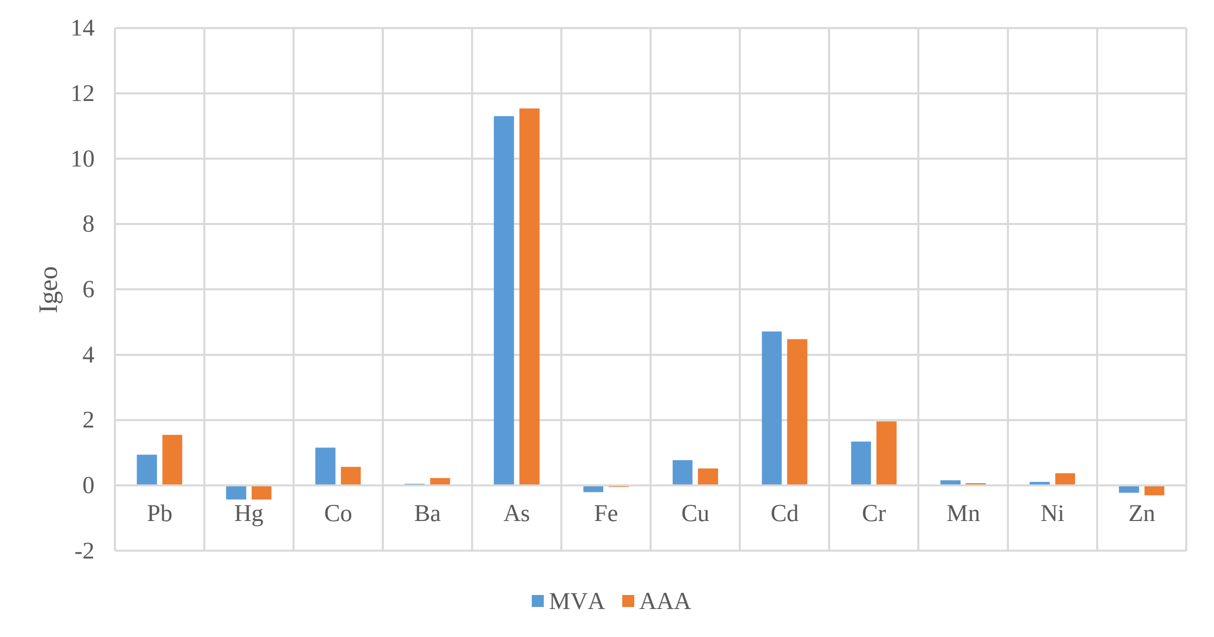


**Fig 1:** Geoaccumulation index of the study areas.
Key: MVA= mechanic village automobile workshop, AAA= Atiku Abubakar automobile workshop

### *3.2.2 Contamination factor (CF)*

This model was used to assess the level of contamination by individual metals at the study areas. The results were obtained using Eqn. 2 and presented in Table 2 below.

**Table 2:** Results for the contamination factor of the study areas

| Parameters | Pb | Hg | Co | Ba | As | Fe | Cu | Cd | Cr | Mn | Ni | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MVA** | 2.87 | 1.11 | 3.33 | 1.55 | 3,791.11 | 1.30 | 2.56 | 39.34 | 3.79 | 1.67 | 1.61 | 1.28 |
| **AAA** | 4.39 | 1.11 | 2.22 | 1.75 | 4,464.44 | 1.45 | 2.15 | 33.45 | 5.82 | 1.57 | 1.94 | 1.21 |

Key: MVA= Mechanic village automobile workshop, AAA= Atiku Abubakar automobile workshop

Following the classification criteria of Hakanson (1980), Values for Hg, Ba, Fe, Cu, Mn, Ni and Zn at both automobile workshops, Pb at MVA workshop and Co at AAA workshop showed a moderate contamination. Cr at both automobile workshops, Pb at AAA workshop and Co at MVA workshop indicated a high contamination. The values also indicated that As and Cd showed a very high contamination at both automobile workshops.

### *3.2.3 Pollution load index (PLI)*

This index was calculated using Eqn. 3. At the Mechanic village and Atiku Abubakar automobile workshops, 4.668 and 4.897 were obtained respectively. Following the classification of Tomlinson *et al.* (2012) as highlighted by Anweting *et al.* (2024b), soils of both automobile workshops had declined in quality.

## 4. Conclusion

The presence of heavy metal contaminants in soil has raised significant environmental concerns. This research evaluated the extent of heavy metal contamination in automobile workshops, aiming to evaluate their contamination levels. The findings indicated that the levels of most of the studied metals in the workshop exceeded the permissible limits of WHO, SON, DUTCH and FMENV, hence potentially posing risks to the local population. Geoaccumulation index showed some degree of contamination except Hg, Fe and Zn. Contamination factor and pollution load index showed that the soils at the automobile workshops have been polluted and that the soil quality has declined. Consequently, there is a pressing need for ongoing monitoring of these human metals-inducing activities to prevent potential health hazards linked to heavy metal exposure. This research underscores the pollution and vulnerability of soil within these automobile workshops. This raises concerns regarding health, environmental quality, and agricultural productivity in the study area.

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