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Evaluation of Heavy Metals in Soil from Automobile Mechanic Village Dutse, Jigawa State, Nigeria

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Abstract

Soil contamination by heavy metals is a worldwide environmental problem. Some heavy metals pollutants are released from the activities in the auto-mechanic workshops and have various effects on human health as well as the environment. It is important to determine the presence and concentration level of the heavy metals in the soil. This research was aimed to determine the level of some selected heavy metals and physicochemical parameters of the soil sample. The soil samples were digested with nitric and hydrochloric acid and heavy metals were analyzed from digested samples using atomic absorption spectrometer (AAS). Results of the atomic absorption spectrophotometric (AAS) analysis of soil samples revealed that sample is contaminated with Ni, Zn, Mn, Fe and Cu with concentrations level (mg/kg) range between (0.75 - 5.55), (0.30 - 0.40), (1.00 -1.42) (0.80 - 1.30) and (0.05 - 0.60), respectively. Other metals such as As, Cd, Cr also contaminated the soil with concentrations (mg/kg) ranged between (0.12-0.76), (0.13-01.13) and (0.11-1.30), respectively. The results were compared with the standard set by National Environmental Standards and Regulations Enforcement Agency (NESREA). The research concluded that the anthropogenic activities at auto-mobile workshops contaminate soil with heavy metals which may have a direct or indirect effect on human. Further studies should be conducted to ascertain the effects of those metals on human, plants, groundwater, and environment.

Keywords: Heavy metals, auto-mechanic, geo-accumulation, contamination factor, quantification

INTRODUCTION

Automotive service and repair workshops are the largest small quantity generators of hazardous waste. Auto repair shops create many different types of waste during their daily operations. These include used oil and fluids, dirty shop rags, used parts, asbestors from brake pads and waste from solvents used for cleaning parts. All of which are expensive to dispose of and sometimes hazardous. The most dangerous waste commonly created in auto repair shops is from the solvents used to clean parts. Many of the chemicals that make up the solvents are extremely dangerous to human and the environment (Imevbore and Adeyemi, 1981).

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Advancement in technology had led to high level of industrialization leading to discharge of heavy metals into our environment. Toxic heavy metals entering the ecosystem may lead to geo- accumulation, bio-accumulation and bio-magnifications. They get accumulated with time in soils and plants and would have a negative influence on physiological activities of plants (e.g. photosynthesis, gaseous exchange and nutrient absorption), determining the reductions in plant growth, dry matter accumulation and yield (Suciu *et al*., 2008).

Idugboe *et al*. (2014) studied soil pollution in auto-mechanic villages in Benin City, Nigeria. The study showed pollution in the soils of the auto-mechanic villages which were due to the waste generated in the auto-mechanic market. Chokor and Ekanem (2016) studied the heavy metals contamination profile in soil from automobile workshops in Sapela, Nigeria. Joseph *et al*. (2017), Identify the presence of Fe, Cu, Mn, Cr, Zn, Mg, Pb, Cd, Ni and As in soil samples from ten different auto mechanic workshops in Okitipupa, Ondo State, Nigeria. The results shows that the heavy metals are lower than the maximum allowable limits in soils used for many countries.

Another study by Rabe *et al*. (2018), they assessed the heavy metals contamination at soil depth of (0 - 15 cm) in auto mechanic workshop in Anyigba, Kogi State, Nigeria. The concentrations of the studied heavy metals in the soils from experimental sites were higher than the corresponding values from the control soil site. According to Ogunkolu *et al*. (2019), anthropogenic activities of humans lead to the transfer of heavy metals into the soils. Auto mechanic workshops are one of the major sources of increase in heavy metal concentration in soils in Katsina North-western Nigeria. Heavy metals in the soil samples at 0-15 cm and 15-30 cm depths were subjected to sequential extraction to ascertain the bioavailability of the metals in the soils. Since heavy metals pollutant are released from the activities in these auto mechanic workshops (EEA, 2007) and have various effects on human health as well as the environment (Mohiuddin *et al*., 2010), it is very important to assess the concentration of heavy metals in the environment. Several studies on heavy metals contamination of soils from auto-mobile workshops in Nigeria have been carried out but very few compared their research finding with the standard set by National environmental regulation, 2009 (NESREA). This research work is intended to generate a data on heavy metals in soil from auto mobile mechanic village Dutse and compare it with NESREA standard guidelines. The novelty of this research is the determination of heavy metals concentration level from auto-mobile soil, compared the results with NESREA guidelines and the effect of the workshop activities on the soil quality. This baseline data will give an idea on remediation techniques and future investigation of activities leading to changes in the soil.

MATERIALS AND METHODS

Description of Study Area

Jigawa state is located in the north western geo-political zone of Nigeria covering an area extending between latitude 12.228^0 N and longitudes 9.5616^0 E. Jigawa State was created out of the old Kano state in 1999 with the state capital in Dutse. Within the state, mechanic village is located along Aliyu Ibrahim by-pass with a geographical coordinate 11^0 4134'.2184''N and $9^0$21'4.7347''E in Dutse local Government of Jigawa State. Mechanic village is automotive service and repair shops in Dutse where many cars and buses are repaired.

Sample collection and preparation

The soil samples for the study were collected from the mechanic village in Dutse, Jigawa State, Nigeria. The samples were collected at ten (10) different coordinates in the automobile workshop at three different strata; the top soil to 10 cm, 20 cm and 30 cm bottom at each point. The samples were properly labelled and stored in polythene bags and transported to the laboratory for analysis. A total of 30 soil samples were collected. The soil samples were allowed to dry in a room for three days and sieved with 2 mm sieves before the analysis.

Soil physical characteristics

The pH of the soil was tested following the procedure described by Black (1973), while electrical conductivity (EC) was conducted as explained by Rayment and Higginson (1992). Total organic carbon (TOC) was carried out using the procedure described by Nelson and Sommers (1982). Particle size analysis to separate sand, silt and clay was achieved following the procedure described by Boujouiuos (1962). Organic matter and matter contents were determined according to the procedure explained in standard methods ASTM (2000). Cation exchange capacity (CEC) was determined using the 1.0 M Ammonium ethanoate (NH_4OAc) (at pH=7) method (Page, 1983). Organic carbon was determined by preparing a solution of 1M potassium dichromate solution ($K_2Cr_2O_7$) with the soil, 5 mL of concentrated H_2SO_4 was added rapidly. After 30 minutes, 7 drops of an indicator were added and titrated with 0.5 N $FeSO_4$ to maroon color, and also soil acidity was determined following the procedure explained by Enete *et al.* (2022).

Soil digestion and analysis

The procedure outlined by Joseph *et al*. (2017) was followed with a lot of modifications. Approximately 2.0 g of each soil samples was accurately weighed in to a crucible and then heated to ash at 550 ^{0}C for 4 hours in muffle furnace. The crucibles were removed from furnace and allowed to cool. 1.0 mL of deionized water was added followed by 1.0 mL of concentrated nitric acid and evaporated to dryness on a hot plate. It was transferred to muffle furnace and heated to 400 ^{0}C for 15 min. The samples were immediately added with 1.0 mL of deionized water and 2.0 mL of concentrated hydrochloric acid and then evaporated to dryness on a hot plate. The samples were then added with 25.0 mL deionized water, filtered with Whatman 125 mm filter in 50 mL volumetric flask. The filtrate was diluted to 50 mL volumetric flask mark with de-ionized water (Durumin-Iya *et al*., 2018). Blank was also prepared by following the same procedure. The triplicate of the samples and the blank were analyzed using atomic absorption spectrophotometer (AAS) at Central Laboratory, Bayero University Kano (BUK).

Impact assessment

Three indices were used to assess the impact of soil samples compared with the unpolluted (control soil) soil samples. The indices are quantification of anthropogenic concentration of metals, geo-accumulation index (I-geo) and contamination factor. The quantification of anthropogenic concentration of metals (QACM) was obtained by using equation (1):

$$\text{QACM} = \frac{C - Cx}{Cx} \times 100 \qquad (1)$$

Where C is the average concentration of heavy metal in the auto-mechanic soil sample, and Cx is the average concentration of heavy metals in the control samples (Pam *et al*., 2013). The concentration of heavy metals from control soil and auto-mechanic soil samples were used as an initial and final concentrations, respectively.

The Index of Geo-accumulation (I-geo)

The I-geo was used to evaluate extent soil sample contamination by comparing current and previous concentrations of the contaminants; this index is computed using Equation (2) (Dasaram *et al*., 2010).

I-geo = $\mathrm{Log}_2\, Cn/1.5Bn$ (2)

Contamination Factor (CF)

Is the use of contamination factor (Cf) and the degree of contamination. The equation (3) used in calculating Cf was suggested by Dasaram *et al.* (2010)

$C_f = C_{0-1}^{1}/C_{n}^{1}$ (3)

Where C_{0-1}^{1} is the mean concentration of metals from at least 5 soil sample sites, while, C_{n}^{1} is taken to be the concentration of metals from control sample (Victor *et al*., 2006). The difference between the metals from natural sources and human activities can be calculated using CF, and also the degree of human activities influence can be evaluated (Pam *et al*., 2013).

RESULTS AND DISCUSSION

Characteristics of the soil sample

Physicochemical parameters of soil such as pH, conductivity, clay, silt, organic matter (OM), cation exchange capacity (CEC), sand, moisture content and acidity distribution are known to influence the interactions and dynamics of heavy metals within the soil matrix. The results of the physicochemical properties of the soil samples investigated are presented in Table 1 and Table 2.

Soil pH is the most widely accepted parameter which exerts a controlling influence on the availability of micronutrients and heavy metals in the soil to plants (Igwe *et al.,* 2005). Table 1 shows averaged pH values of the soil samples from ten (10) locations of automobile workshops and was found to be acidic (6.00 - 6.73). The pH values obtained were in line with those reported by Adelaken and Alawode (2011). The pH value from location A has high pH with value of 6.73, while location F which has lowest value of 6.00.

Table 1: Physicochemical Parameters of Automobile mechanic soils and control soil (n=3)

Parameters	Control	A	B	C	D	E
pH	7.1±0.24	6.73±0.02	6.24±0.04	6.30±0.11	6.32±0.03	6.14±0.01
Conductivity (µS/cm)	653.26±21.53	1110±12.6	1112±6.13	1713±10.11	1275±23.09	1734±28.10
CEC (mg/kg soil)	3.07±0.99	4.22±1.35	3.94±1.94	5.73±1.22	4.86±2.01	3.91±1.63
OMC%	2.6±0.12	2.76±0.64	5.20±1.99	4.38±0.83	3.79±0.99	5.77±1.00
Organic Carbon %	1.3±0.05	1.66±0.03	1.81±0.01	1.57±0.07	1.92±0.26	1.65±0.06
Moisture%	5.11±2.78	6.43±1.98	5.09±0.87	8.11±0.68	4.19±1.03	4.27±1.27
Clay %	10.09±2.89	2.22±0.81	2.13±0.19	2.91±0.23	2.21±0.91	2.09±0.82
Silt %	20.57±3.45	2.27±0.04	2.67±0.31	2.35±0.15	2.13±0.13	2.61±0.24
Sand (%)	68.32±6.79	92.32±15.28	93.61±16.14	92.52±19.11	92.14±18.16	92.53±16.11
Acidity(cmole/kg)	7.1±1.09	25.39±3.44	23.44±4.13	31.05±6.ii	27.46±5.09	26.27±6.14

Electrical conductivity measures soil salinity of the soil samples. Table 1 shows average values EC of the soil samples from ten (10) locations at automobile workshops. The results obtained were higher compared to what was obtained by (Anegbe *et al*. 2018). This indicates that movement of charge particles would be more at the mechanic village workshops compared to the location where Anegbe (2018) conducted their research.

Table 2: Physicochemical Parameters of Automobile mechanic soils and control soil (n=3)

Parameters	Control	F	G	H	I	J
pH	7.1±0.24	6.00±0.00	6.53±0.21	6.49±0.03	6.81±0.05	6.62±0.01
Conductivity (µS/cm)	653.26±21.53	1518±16.72	1205±9.74	1127±11.05	1306±15.4	1443±17.6
CEC (mg/kg soil)	3.07±0.99	4.32±0.71	4.24±1.09	4.71±2.11	5.01±1.57	4.37±0.95
OMC%	2.6±0.12	6.01±1.33	3.58±1.17	4.66±1.34	3.93±0.09	4.17±1.07
Organic Carbon %	1.3±0.05	1.82±0.11	1.91±0.10	1.77±0.02	1.83±0.08	1.61±0.04
Moisture%	5.11±2.78	6.41±0.12	4.78±0.09	5.13±0.19	6.05±0.13	6.83±0.07
Clay %	10.09±2.89	2.33±0.11	1.98±0.17	2.07±0.16	2.26±0.10	2.87±0.03
Silt %	20.57±3.45	2.20±0.09	2.09±0.21	2.77±0.21	2.91±0.12	3.01±0.08
Sand (%)	68.32±6.79	93.4±6.33	93.99±2.81	92.64±2.98	93.66±1.62	92.81±3.77
Acidity(cmole/kg)	7.1±1.09	25.1±2.59	25.82±3.11	26.03±1..84	24.85±1.08	25.17±1.69

This high electrical conductivity could be due to the high ionic concentration of the heavy metals in the contaminated soil. From Table 1 it indicated that location E has high electrical conductivity with value of 1734±28.10 µ**s/cm**, while location A has lowest values of 1110.0 µ**s/cm**.

The cation exchange capacity (CEC) ranged between 3.91±1.63 to 5.73±1.22 cmol (+)/kg. CEC can maintain the rate of heavy metals mobility in soil and it can increase with the increase in pH. It is reported that sandy soils have lower CEC than loamy soils (Brummer and Herms, 1982). The auto–mobile soil studied are sandy with an average pH range of 6.42 ± 0.24.

Organic matter (OM) plays an important role in metal binding (Akans *et al.*, 2010). From the results obtained, site F was observed to have the highest organic matter (6.01%), while site A had the least (2.76%). It was reported that, organic matter contents of soils immobilize metals at strongly acidic conditions by forming insoluble organic metal complexes and mobilizes metals at weakly acidic to alkaline reactions by producing soluble organic metal complexes (Brummer and Herms, 1982).

The particle size of the soil was distributed according to loamy or sandy and textural classification. This soil was found to have low sorption capacity for metal ions due to its sandy texture. Therefore, it is expected that the concentrations of metals of interest may increase with depth of the soil due to leaching from the soil surface (Enete *et al.,* 2022). The particle size distribution recorded here agrees with other studies in Owerri (Enete *et al*., 2022).

The moisture content (MC) of the soil sample was ranged from 4.19% to 8.11%. It was reported that the moisture content of a soil is one of the most important factors that determines the survival of soil microflora (Molin and Molin, 1997).

The result of soil organic carbon content obtained ranged between 1.57% and 1.92%. It was reported that the soil organic matter is greatly contributing to the acidity of the soil through organic acids and biological activity through the color of the metals (Enete *et al*., 2022). And also, a high soil organic carbon results in larger adsorption surfaces and increased metal adsorption on organic materials (Nelson and Sommers, 1982).

Soil acidity is one of the major issues in terms of land degradation. The pH of the soil samples was a little bit acidic or below neutral. “Soil pH has an effect on both the availability of soil nutrients to plants and the way those nutrients react with one another” (Enete *et al.,* 2022).

Heavy Metals in soil Samples

The results of the analysis of nine (9) heavy metals of soil samples in mg/kg obtained in this research work were presented in Table 3. The mean concentration and standard deviation of all the heavy metals detected in soil sample at ten (10) locations were presented. The results of the control soil were also presented in Table 3.

Table 3: Average concentration (mg/kg) of heavy metals from each location (n=3)

Locations	Pb	Cr	Cu	Fe	Cd	Mn	Ni	As	Zn
A	0.72±0.01	1.01±0.02	0.32±0.00	0.95±0.02	0.83±0.03	1.20±0.02	1.85±0.26	0.75±0.87	0.15±0.03
B	0.69±0.04	0.91±0.01	0.35±0.04	0.85±0.01	0.79±0.00	1.31±0.02	5.55±0.15	0.46±0.13	0.21±0.05
C	0.74±0.03	0.96±0.01	0.41±0.02	1.31±0.27	0.77±0.01	1.42±0.03	2.05±0.20	0.24±0.19	0.60±0.05
D	0.70±0.02	1.22±0.12	0.37±0.11	0.96±0.38	0.89±0.02	1.35±0.01	2.01±0.26	0.55±0.31	0.13±0.15
E	0.83±0.01	1.09±0.03	0.36±0.02	1.05±0.01	1.13±0.01	1.01±0.01	0.75±0.31	0.12±0.63	0.19±0.11
F	0.79±0.01	0.87±0.04	0.38±0.01	0.82±0.23	1.00±0.04	1.25±0.03	2.95±0.41	0.76±0.15	0.05±0.02
G	0.63±0.11	1.26±0.01	0.29±0.10	1.07±0.31	0.93±0.01	0.99±0.01	1.36±0.06	0.33±0.01	0.11±0.01
H	0.77±0.03	0.99±0.11	0.43±0.21	1.11±0.10	0.72±0.0	1.54±0.05	1.98±0.01	0.51±0.00	0.26±0.01
I	0.81±0.04	1.30±0.12	0.51±0.11	0.99±0.05	0.91±0.03	1.07±0.08	2.17±0.12	0.16±0.00	0.13±0.02
J	0.65±0.02	1.11±0.21	0.48±0.03	1.21±0.11	1.00±0.1	0.92±0.01	0.87±0.03	0.47±0.03	0.92±0.11
Control	0.01±0.00	0.11±0.00	0.21±0.00	0.32±0.01	0.13±0.00	0.16±0.00	0.01±0.00	0.00	0.14±0.00
NESREA Standard	164.00	100.00	100.00	NS	3.00	NS	70.00	NS	421.00

National environmental (chemical, pharmaceutical, soap, and detergent manufacturing industries) regulation, 2009. (NESREA) (Amaechi and Onwuka, 2021). NS= not specified

Heavy metals concentrations in the soil samples are higher in the auto repair shops compared to control soil sample. This could be explained based on the work of Nwachuku, *et al.* (2011), who reported that engine oil and transmission fluids when discharged may increase the concentration of heavy metals in soils.

Table 3.0 showed mean concentration of Arsenic determined at ten locations of auto mechanic workshop at the study area. The concentration of Arsenic observed at the location F was found to be higher than other locations, while location E was found the lowest compared to others. This reveals the impact of Arsenic concentration in the soil. However, the concentration of Arsenic recorded at all the locations ranged between 0.12 to 0.76 mg/kg was not specified by the NESREA (2009) regulations. The results shows that Arsenic has high concentrations in the soil from all location which means the soil is contaminated. The implication of this is that prolong accumulation of arsenic in human causes central nervous system damage and maybe detrimental to human health. The levels of arsenic concentration value obtained are higher than those reported by Iwegbue *et al*., (2013).

The mean concentration of Nickel was presented in Table 3.0. High concentration of Ni was observed at location B, while at location E, the concentration level was observed to be low.

However, the concentration of Ni recorded from the soil was far below the permissible limit of 70.0 mg/kg which is the standard set by NESREA (2009). Francis, (2005) reported that the degree of heavy metal pollution in urban areas varied according to location. Airborne particles emitted by brakes and wears from vehicle tyres can contain considerable amounts of Ni.

The concentrations level of Cd obtained from the ten locations ranged between 0.72 – 1.13 mg/kg. The concentration of Cd obtained from B, C and H locations were found below 3.0 mg/kg set by NESREA (2009). The presence of Cd in the soil could be due to the dumping of Poly vinyl chloride (PVC) plastics, vehicle wheel, nickel-Cd batteries, motor engine-oil and disposal of sludge in the auto-mechanic soil (Eluyera and Tukura, 2020). The concentration level of Cd in the soil areas confirms that the auto-mobile workshop environment is enriched with Cd.

The concentrations level obtained were all below 164.0 mg/kg as set by NESREA (2009). Lead concentration may have resulted from Pb containing compounds being used in the auto-mobile workshops. The concentration values of Pb obtained in this study were far below the 1162 mg/kg reported by Nwachukwu *et al*. (2011) for auto mechanic workshop soil in Owerri, South-East Nigeria. Allowable limits of Pb concentrations vary widely with countries (Lacatusu, 2000).

Chromium concentrations obtained were low with a level ranged between 0.87±0.04 (location F) and 1.30±0.12 (location I). One of the major sources of Cr is from industrial effluents and wastes containing Cr. "Chromium is commonly found at contaminated sites in form of chromium (VI) and it is the dominant form of chromium in shallow aquifers where aerobic conditions exist" (Eluyera and Tukura, 2020).

The mean concentration and standard deviation of Cu from ten locations was presented on Table 2.0. The results reveals that the high concentration level of Cu was observed at location I, while at location G the concentration level was low. The results signify the impact of the auto repairs activities at the location. However, the concentration of Cu recorded at all the locations were found below the limit of 100.0 mg/kg which is the standard set by NESREA (2009), which means the soil is not Cu contaminated. This result is corroborating with the report of Adeleke and Alawode (2011). Therefore, the concentration level of Cu could be attributed to automobile wastes containing electrical and electronic parts, such as Cu wires, electrodes copper pipes and alloys from corroding vehicle scraps which have littered the vicinity for a long time. These levels of Cu recorded in this study were in accordance with those reported in soils of auto-mechanic sites in Makurdi by Aloysius *et al.* (2013).

The concentration level of Fe from the soil samples were presented in Table 3.0. The results of Fe obtained shows that the concentration level was high at C location and it was low at location F. These reveals the effect of automobile activities in the study area. However, the concentration of Fe recorded was not specified by the standard set by NESREA (2009). With these concentration levels in the soil, Fe has no relative effect on human health and agricultural activities. Although, excessive level of Fe can seriously affect flora and fauna in water bodies. The value of Fe obtained agrees with what was obtained by Shinggu *et al*., (2007). The increase in Fe content of the soil might be as a result of waste generated in automobile workshops in the study area which includes solvent, hydraulic fluid, spent lubricants, metal construction works, welding of metals and Fe bending. This result corroborates the findings of Adewole and Ucheagbu (2010), reported that Fe 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 Mn was observed to be high at H location (1.54±0.05 mg/kg) while, it was low at J location (0.92±0.01mg/kg). However, standard permissible limit of Mn in the soil is not set by NESREA regulation (2009). The results reveal that, Mn concentration in the soil is prominent making the soil to be contaminated. Mn is one of the elements found in abundant in the earth's crusts and is widely distributed in soils, sediments, rocks and water (Shrivastava and Mishra, 2011). 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 whole ecosystem (Seifi *et al*., 2010).

Table 3.0 showed the concentration of Zn determined at ten locations of auto mechanic workshop. The concentration of Zn observed at location J was found to be higher compared to other locations revealing the impact of Zn concentration in the soil, while location F shows low Zn concentration level. However, the concentration of Zn recorded at all location are below the permissible limit of 421.00 mg/kg which is the standard set by NESREA (2009). The increase of Zn levels in the study area may be due to factors such as age of the mechanic workshops, volume of work done on each location, types of automobile service or repairs, type of lubricant commonly used, mode of wastes disposal and type of soil. Onder *et al*. (2003) reported that high concentration of Zn in heavy traffic zones indicate that fragmentation of car tyres are the source of the metal. Other possible sources of Zn in relation to automobile traffic in addition to wearing of brake lining are losses of oil and cooling liquid of vehicles and wearing of road paved surface (Osakwe, 2009).

Impact evaluation of auto-mechanic workshop on the surrounding soil

To assess the auto-mechanic impact, data obtained from the soil samples were compared with those obtained from unpolluted (control) soil or background values. "The background value of an element is the maximum level of the metal in an environment beyond which the environment is said to be polluted with the element "(Pam *et al*., 2013). The contamination level of heavy metals from the auto-mechanic village soil samples shows that it is not from a natural source (e.g., soil geology of the area), because of the low concentration level of heavy metals from control soil as an evidence. The distribution pattern of the heavy metals concentrations follows: Ni>Mn>Cr>Fe>Cd>Pb>As>Cu>Zn>Co as presented in Table 3.0. To assess the impact of human activities on the concentration level of metals in the soil, quantification of anthropogenic concentration of metals (QOC), Index of geo-accumulation (I-geo) and contamination factor (CF) have been used. Assessment of the impact of the auto-mechanic workshop on the soil within the environment. Table 4.0 presents the four (4) contamination categories of the contamination factor where high CF considered as strong human activities influence. Table 5.0 presents the seven (7) classes of geo-accumulation index

Table 4: Categories of contamination

Contamination Factor (CF)	Category
CF <1	Low contamination factor indicating low
1<CF<3	Moderate contamination factor
3<CF<6	Considerable contamination factor
6<CF	Very high contamination factor

Categories of contamination factor (Dasaram *et al*., 2011)

Table 5. Classes of geo-accumulation Index.

I_{geo} Class	I_{geo}	**Pollution intensity**
0	<0	Unpolluted
1	0-1	unpolluted to moderately polluted
2	1-2	Moderately polluted
3	2-3	Moderately to strongly polluted
4	3-4	Strongly polluted
5	4-5	Strongly to very strongly polluted
6	>5	Very strongly polluted

Contamination Index

Contamination Index values between 0.5 and 1.5 show that the metal is absolutely from natural processes; whereas contamination Index values greater than 1.5 suggest that it is from anthropogenic sources. The highest contamination factor from the soil occurred on Ni, Mn, Cr, Fe, Cd and Pb with a range from 7.33 – 21.54, which indicate that there is a very high contamination of these metals in the soil. While, As and Zn had minimal to considerable contamination. On the other hand, Zn demonstrated a moderate contamination and Co had a low contamination factor. "High (>1.5) Cf values of a metal indicate significant contribution from anthropogenic origins" (Pam *et al*., 2013).

Table 6: The contamination factor, geo-accumulation factor, quantification of soil contamination and background concentration of heavy metals.

Sample	Pb	Cr	Cu	Fe	Cd	Mn	Ni	As	Zn
CF	7.33	10.72	3.91	9.32	8.97	12.06	21.54	4.35	2.75
I-geo	2.20	3.2	1.18	2.80	2.70	3.60	6.50	1.31	0.83
QoC %	99.86	98.97	94.63	96.57	98.55	98.67	99.95	100	95.16
BC	0.01	0.11	0.21	0.32	0.13	0.16	0.01	0.00	0.14

CF=contamination factor, I-geo=geo-accumulation index, QoC= quantification of contamination and BC= background contamination of metals (Pam *et al.,* 2013).

Therefore, the high contamination values of Cf in Table 4, especially for Ni and Mn, is an indication that the contamination in the soils within the auto mechanic village originates from anthropogenic activities. The order of anthropogenic activities inputs in auto-mechanic village soil is Ni > Mn > Cr > Fe> Cd>Pb >As >Cu > Zn >Co.

Geo-accumulation index (I-geo)

Table 6.0 showed the geo-accumulation Index values of the ten (10) heavy metals analyzed from mechanic village. The soil sample was unpolluted with geo-accumulation index values of Co and Zn were within 0 – 1. It was observed that the soil I-geo index value for arsenic and copper made the soil sample to be moderately polluted as described on Table 6.0. Cd, Fe and Pb from the samples could be classified as moderately to strongly polluted because their geo-accumulation index values fell within the range of 2 - 3. The samples were strongly polluted with Cr and Mn with their geo-accumulation index value that falls within the range of 3 - 4 according to the I-geo classification. Sample was very strongly polluted with Ni with its geo-accumulation index value greater than 5 from the I-geo Index. It was observed that the soil samples were neither unpolluted nor strongly to very strongly polluted classes because there was no metal observed to have I-geo Index value of < 0 and 4 – 5.

Quantification of soil contamination (QoC)
The quantification of anthropogenic input of the metals into the auto-mechanic soil presented in Table 6. I-geo index and contamination factor CF are not comparable due to the calculation nature of I-geo which contains some parameters that involves logarithms. But the results obtained from different assessing indices used in this research are consistent with each other. And this could be a clear indication that there is an anthropogenic source of heavy metals in the soils within the auto mechanic workshop. Nickel and lead were recorded high with QoC values 99.95% and 99.86%, respectively, as shown in Table 6.

CONCLUSION
The values of electrical conductivity obtained during analysis at study area indicated that, movement of charge particles would be more at study area. Moreover, the pH values obtained from the locations showed that, the soils are slightly acidic. The investigation in this study revealed that the auto-mechanic workshop environment is getting polluted, particularly with arsenic, magnesium and zinc based on their concentration. This is a reflection of anthropogenic contribution which might partly result from the use of metal containing additives as lubricants. The high organic matter content and other waste from the car engine and body of the car which favors heavy metal binding, could be source of high level of the metals that contributed to the present level that contaminated the soil. However, it can be concluded that the results obtained from this study showed that, there are variation in the metal contents in the soil from one location to the other.

Conflict of interest
They declare that there is no conflict of interest

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