



## DETERMINATION OF THE PHYSICOCHEMICAL PROPERTIES AND SOME HEAVY METALS IN SOILS AROUND SELECTED AUTOMOBILE WORKSHOPS IN MINNA, NIGERIA

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**ABSTRACT:** *Automobile workshops generate wastes containing hazardous chemicals. Heavy metals present in these workshops are the major pollutants capable of seeping into the soil and further spreading to other nearby environments during floods. Three different sampling points (A, B and C) were mapped out at a distance of 20 meters apart around each automobile workshop: Railway station (RW), Sabon Gari (SBG) and Mypa School (MY). The soil samples were pretreated and digested with HNO<sub>3</sub> and HClO<sub>4</sub> (3:1). The heavy metals (Zn, Mn, Pb, Cd and Cu) concentrations were determined using the multiple plasma atomic emission spectrophotometer (MP AES). The physicochemical properties (pH, electrical conductivity, organic carbon (OC), organic matter (OM), exchangeable cations, soil texture, cation exchange capacity (CEC), total exchangeable bases (TEB) and percentage clay, silt and sand) were determined using standard methods of analysis. The concentrations of Pb at points A, B and C of MY (2.10±0.01, 9.50±0.05 and 2.90±0.03 mg/kg) were lower than 35.10±0.20, 37.20±0.21 and 46.50±0.54 mg/kg at RW and 25.80±0.29, 64.80±0.75 and 75.60±0.87 mg/kg at SBG. Zinc concentration was in the order MY < RW < SBG. Cadmium concentrations were 3.20±0.20, 3.70±0.02 and 3.40±0.02 mg/kg at points A, B and C in RW, 3.90±0.02, 2.80±0.05 and 3.50±0.02 mg/kg in MY soil. The high concentrations of cadmium in soils at RW and MY are indication of considerable contamination and the soils at MY and RW are not suitable for planting crops but require remediation action.*

**KEYWORDS:** Heavy metals, soil, non-biodegradable, automobile workshop, pollution



## INTRODUCTION

Man's activities in the environment have led to the pollution of soil by chemical contaminants such as heavy metals. Some of these activities include the burning of fossil fuels, rusting of metals, automobile waste discharge and production of batteries. Heavy metals are naturally present in the soil (Hutton and Symon, 2014; Battarbee *et al.*, 2013;). Geology and anthropogenic activities activate the increase in the concentration of these elements to the amounts that would eventually get into the human body through the food chain, which could be toxic to living organisms when ingested above tolerable levels (Antoaneta *et al.*, 2009). Chronic problems associated with long-term heavy metal exposures are mental lapse, skin poisoning, toxicological effects on the kidney, central nervous system, liver and gastrointestinal tract (Iyama *et al.*, 2022; Adelekan and Abegunde, 2011).

In Nigeria, most automobile workshops are open lands allocated to automobile repair workers in the vicinity of an urban/rural centre. The common activities carried out in the automobile workshops are auto-mechanic repairs and inexorably involve leaking and spilling of oils, greases, battery electrolytes, diesel, petrol, paint and other materials which contain heavy metals into soil. Some of these heavy metals are also components of automobile parts such as tyres and engines, from which they are released during abrasion and wear; junked car parts, spent petrol, grease and oils; suspended solids, organic solvents and gasoline additives, which are usually dumped as waste in automobile repair shops.

The level of heavy metals in soil is increasingly becoming an issue of global concern, at private and governmental levels, especially as soil constitutes a crucial component of the rural and urban environment. The automobile workshops contain heavy metals that may be toxic to plants and harmful to animals (Ayodele and Modupe, 2007). Heavy metal contamination is one of the major environmental problems threatening human health, food chains, plants and animals (Pikula and Stepien, 2021).

Heavy metals present in automobile workshops remain unknown to many people and are the major pollutants capable of seeping into the soil and further spreading to other nearby environment during runoffs or floods. As a result of pollution, farmlands and water bodies could be contaminated with these heavy metals which might lead to disruption of the ecosystem, a lower yield of farm produce, infections of various degrees and a reduction in the nation's economy. This study determined the physicochemical properties and concentrations of selected heavy metals in soils around automobile workshops in Minna, Nigeria.

## MATERIALS AND METHODS

### Sample Collection

A total of nine (9) topsoil samples were collected at three different sampling points A, B and C from each of the three (3) selected automobile workshops located at Railway (RW), Sabon Gari (SBG) and Mypa (MY) areas in Minna, Nigeria. In each automobile workshops and sampling points, soil sample were collected at four cardinal points which were 20 metres away from one another.



## Sample Preparation

Soil samples were air-dried and pulverized with a mortar and pestle. The samples were homogenized by coning and quartering to get composite samples. These were then stored in polyethene bags and labelled accordingly before being subjected to different analytical techniques (Agbenin, 1996).

## Physicochemical Parameters of Soil

### Mechanical Analysis of Soil

Solution of the soil was made by weighing 51.00 g of air-dried and pulverized soil sample, and placed in a baffled cup. The cup was  $\frac{1}{2}$  filled with distilled water followed by the addition of 5.00 cm<sup>3</sup> of sodium hexametaphosphate (SHMP) solution. The cup was then placed on a stirrer and stirred until soil aggregates were obtained at 6 minutes for sands, 10 minutes for light-heavy sandy loams and 15 minutes for other soil. The suspension was transferred to a buoyance cylinder and filled to the mark with distilled water while the hydrometer was in suspension. The percentage of sand in the sample was determined by removing the hydrometer so that the corrected reading gave the grams of soil material in suspension which was shaken vigorously. The glass cylinder was placed on the desk and the time was recorded. At the end of 20 and 40 seconds, the hydrometer was carefully inserted which was read and recorded on the datasheet and these gave the actual amount of silt and clay. The hydrometer was removed from the suspension and the temperature of the suspension was recorded. The weight of the sand was obtained by subtracting the corrected hydrometer reading from the total weight of the sample (Agbenin, 1996). The percentage of sand was calculated by dividing the weight of sand by the weight of the sample and multiplied by 100.

### Determination of Organic Carbon and Organic Matter

The Walkley-Black wet oxidation method was used (Combs and Nathan, 2015). The soil sample was ground to pass through a 0.5mm sieve; 10.00 g of the soil sample was weighed and replicated then transferred into 250 cm<sup>3</sup> Erlenmeyer flasks. 10.00 cm<sup>3</sup> of 1M K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> solution was pipetted accurately into each flask which was swirled gently to disperse the soil. 20.00 cm<sup>3</sup> of conc. H<sub>2</sub>SO<sub>4</sub> was then added using an automatic pipette into the suspensions. The flasks were immediately swirled gently until soil and reagent were mixed and further swirled vigorously for one minute. The flasks were rotated again and later allowed to stand on a sheet of asbestos for 30 minutes. 100.00 cm<sup>3</sup> of distilled water was then added into the solution. Three drops of phenanthroline indicator were also added and this was titrated against 0.25 M of ferrous sulphate solution. As the endpoint was approached, the solution took a greenish colour and then changed to dark green; ferrous sulphate was then added drop by drop until the colour changed sharply from blue to red. The blank titration was made without soil to standardize the dichromate.



$$\% \text{ Organic Carbon in soil} = \frac{(\text{meq } K_2Cr_2O_7 \times \text{meqFeSO}_4) \times 0.003}{f} \times 100$$

Where correction factor,  $f = 1.33$

meq = normality of  $x \text{ cm}^3$  of solution used

Organic Matter in soil = % Organic Carbon  $\times 1.729$

### Determination of Soil pH

With the aid of an analytical balance, 20.00 g of air-dried soil sample was weighed into a 50  $\text{cm}^3$  beaker, 20.00  $\text{cm}^3$  of distilled water was added and allowed to stand for 30 minutes. This was occasionally stirred with a glass rod. The pH meter was inserted into the partly settled suspension and the pH was measured. The suspension was not stirred during measurement and the result of the soil pH was measured in water. The electrode and probe of the pH meter were rinsed before and after measurement.

### Determination of Soil Electrical Conductivity

The soil sample weighing 20.00 g was transferred into a beaker. 20.00  $\text{cm}^3$  of distilled water was added and this was allowed to stand for 30 minutes. It was then stirred with a glass rod at intervals. The conductivity meter probe was inserted into the suspension and the electrical conductivity was measured. The probe of the conductivity meter was rinsed before and after immersion.

### Determination of Total Exchangeable Bases (TEB)

#### Leaching Method

Leaching method was used to determine the total exchangeable bases. In this method, the leaching tube was prepared by pouring filter paper pulp onto a perforated base plate and gentle suction was applied and tapped down to form a filter pad. 15.00 g of air-dried soil was weighed and mixed with a similar volume of coarse silica which was transferred onto a filter pad in the leaching tube. 250.00  $\text{cm}^3$  of neutral ammonium acetate in a volumetric flask was inverted into the tube and a controlled rate of leaching was slowed drop wise with a pinchcock on the outlet. Gentle pressure from a blow ball to the top of the leaching tube was applied when the supply flask was empty in order to free the soil of liquid. The residue was then kept for direct determination of cation exchangeable capacity (CEC). The leachate was transferred to a 250  $\text{cm}^3$  volumetric flask and distilled water was used to make up the mark. Potassium and sodium were determined by flame photometer while calcium and manganese were determined by versenate titration (Agbenin, 1996).

#### Calcium Determination

Versenate titration method was employed to determine the calcium content in the soil sample (Warncke and Brown, 2015; Agbenin, 1996). 20 % KOH and 20.00  $\text{cm}^3$  of the extract with 50.00  $\text{cm}^3$  of distilled water were placed into a 250  $\text{cm}^3$  conical flask. 0.05 g of calcium indicator powder was added. The green fluorescent colour disappeared after titrating against 0.01 M versenate. A yellowish-pink colour was observed at the endpoint.



$$Ca^{2+} \text{ (in meq./ 100g soil )} = \frac{N \times V_1}{20 \times S} \times 100$$

Where N = Normality of versenate

$V_1$  = volume of versenate used

S = weight of soil used

### Calcium plus Magnesium Determination

50.00 cm<sup>3</sup> of distilled water was poured into a 250 cm<sup>3</sup> conical flask, 25.00 cm<sup>3</sup> of conc. ammonia solution and 20.00 cm<sup>3</sup> of the soil extract were added. Five drops of Erichrome black T indicator solution and 1.00 cm<sup>3</sup> of 2 % NaCN were then added. A bright blue colouration was observed after titrating the solution with 0.01M versenate. The titration used was a measure of the total Ca plus Mg in the sample aliquot used (Warncke and Brown, 2015; Agbenin, 1996).

**Calculation:** If  $V_2$  is the volume of versenate used in the above titration then

$$Ca^{2+} + Mg^{2+} \text{ (in meq./ 100g soil )} = \frac{N \times V_2 \times 5}{\text{Sample}} \times 100$$

The amount of  $Mg^{2+}$  (in meq. /100g soil) was obtained by subtracting the value of calcium from the value obtain for ( $Ca^{2+} + Mg^{2+}$ ).

### Nitrogen Determination

#### Total Nitrogen in Soil by Regular Macro-Kjeldahl Method

10.00 g of soil sample was placed into a dried 500 cm<sup>3</sup> Macro-Kjeldahl flask, 20.00 cm<sup>3</sup> of distilled water was added and the flask was swirled for few minutes. This was allowed to stand for 30 minutes. 1.00 g of K<sub>2</sub>SO<sub>4</sub> mixture catalyst and 10.00 g of K<sub>2</sub>SO<sub>4</sub> were added then followed by 30.00 cm<sup>3</sup> of conc. H<sub>2</sub>SO<sub>4</sub> through an automatic pipette. The flask was heated cautiously at low heat on the digestion stand. When the water was removed and frothing was ceased, the heat was increased until the digest cleared. The mixture was boiled for 5 hours while the heating was regulated so that the H<sub>2</sub>SO<sub>4</sub> condensed to about the middle of the way up the neck of the flask. The flask was allowed to cool and 100.00 cm<sup>3</sup> of water was slowly added to the flask. The digest was carefully transferred into another Macro-Kjeldahl flask. The sand particles in the original digestion flask were retained to avoid severe bumping during Kjeldahl distillation. The sand residue was washed four times, with 50.00 cm<sup>3</sup> of distilled water and the aliquot was then transferred into the same flask. 50.00 cm<sup>3</sup> of H<sub>3</sub>BO<sub>3</sub> indicator solution was put into a 500 cm<sup>3</sup> Erlenmeyer flask which was then placed under the condenser of the distillation apparatus. 750 cm<sup>3</sup> of Kjeldahl flask was attached to the distillation apparatus and 150.00 cm<sup>3</sup> of 10 M NaOH was poured through the distillation flask by opening the funnel stopcock. The condenser was kept cool to prevent suck-back by allowing sufficient cold water to flow through and the heat was regulated to minimize frothing. 150.00 cm<sup>3</sup> of the distillate was collected and the distillation was stopped. NH<sub>4</sub>-N in the distillate was then determined by titrating 0.50 M standard HCl using a 25 cm<sup>3</sup> burette graduated at 0.10cm<sup>3</sup> interval. The colour change at the end was from green to pink. The percentage of the Nitrogen content in soil was calculated (Bremner, 2009).



## **Colourimetric Determination of Phosphorus in Soil Extracts Using Ascorbic Acid**

### **Molybdate Blue Method (Murphey and Riley Method).**

5.00 cm<sup>3</sup> of the soil extract was added into a 50 cm<sup>3</sup> volumetric flask, 1.00 cm<sup>3</sup> of 5.50 M sulfuric acid and 0.40 g ammonium persulfate were mixed and boiled gently for 30 minutes in a 121°C autoclave. This was allowed to cool, diluted to 40 cm<sup>3</sup> and then filtered (Wolf and Baker, 2008). The resultant solution was read using a colorimeter.

### **Determination of Exchange Acidity in Soil**

#### **KCl Extraction Method**

Using a weighing balance, 5.00 g of the soil sample was weighed into a 50 cm<sup>3</sup> centrifuge tube and 30.00 cm<sup>3</sup> of KCl was added. The centrifuge was covered tightly with a rubber stopper and shook for 1 hour on a shaker. The content was centrifuged at 2,000 rpm for 15 minutes and the clear supernatant was decanted into a 100 cm<sup>3</sup> volumetric flask.

#### **Soil Sample Digestion using Acid Digestion Method**

All nine (9) air-dried samples were firmly ground separately and were passed through a 0.45 µm sieve. A solution was made by weighing 0.50 g of the sieved ground soil sample into a beaker, 10.00 cm<sup>3</sup> of distilled water was added, followed by 10.00 cm<sup>3</sup> of 3:1 Perchloric acid and trioxonitrate(v) acid (Hsen, 2004). The beakers were placed on a hot plate and were covered with a platinum lid. The beakers containing the sample were heated to 200-225 °C and the contents were allowed to boil. The beakers were removed from the hot plate and allowed to cool which was then filtered into a 50 cm<sup>3</sup> volumetric flask. Distilled water was added to each of the content in the volumetric flask to make it up to 50 cm<sup>3</sup>. The contents were transferred into the reagent bottles then Cd, Pb, Cu, Mn and Zn were determined using Multiple Plasma Atomic Emission Spectrometric (MPAES).

### **Data Analysis**

The analyses were carried out in triplicate to obtain a representative result and the data was reported in mg/kg (on a dry weight basis). Data were arranged and subjected to a one-way analysis of variance (ANOVA) at a 95 % confidence level using the statistical software SPSS.

## **RESULTS AND DISCUSSION**

### **Results**

The results of the physicochemical properties of soil such as pH, conductivity, organic carbon/ matter in soil, cation exchange capacity (CEC) and particle size distribution, and concentration of selected heavy metals around automobile workshops (Railway station, Sabon Gari and Mypa areas in Minna, Nigeria) are presented in Tables 1-6.

**Table 1: Physicochemical Properties of Soil around Automobile Workshop at Railway Station**

Parameter	Points/Distance Apart (20 meters)		
	A	B	C
pH	6.66± 0.04 <sup>a</sup>	6.53± 0.04 <sup>a</sup>	6.69± 0.04 <sup>a</sup>
Conductivity (µS/cm)	605.00±6.99 <sup>b</sup>	949.00±10.96 <sup>a</sup>	416.00± 7.21 <sup>c</sup>
Organic carbon (%)	6.94±0.04 <sup>a</sup>	3.88±0.02 <sup>b</sup>	2.28±0.01 <sup>c</sup>
Organic matter (%)	11.99 ±0.07 <sup>a</sup>	6.71±0.04 <sup>b</sup>	3.94±0.05 <sup>c</sup>
Ca <sup>2+</sup> (cmol/kg)	17.00±0.10 <sup>a</sup>	14.20±0.08 <sup>b</sup>	12.50±0.07 <sup>c</sup>
Mg <sup>2+</sup> (cmol/kg)	0.30±0.00 <sup>c</sup>	3.13±0.02 <sup>a</sup>	0.70±0.00 <sup>b</sup>
Na <sup>+</sup> (cmol/kg)	2.50±0.01 <sup>c</sup>	3.09±0.02 <sup>b</sup>	3.63±0.04 <sup>a</sup>
K <sup>+</sup> (cmol/kg)	0.68±0.03 <sup>c</sup>	42.40±0.24 <sup>a</sup>	1.44±0.01 <sup>b</sup>
Nitrogen (mg/kg)	2.50±0.01 <sup>a</sup>	2.03±0.01 <sup>b</sup>	1.98±0.02 <sup>b</sup>
P(mg/kg)	5.40±0.03 <sup>b</sup>	2.66±0.02 <sup>c</sup>	7.09±0.04 <sup>a</sup>
Clay (%)	1.50±0.03 <sup>a</sup>	0.50±0.00 <sup>b</sup>	0.50±0.01 <sup>b</sup>
Silt (%)	2.00±0.01 <sup>c</sup>	8.50±0.05 <sup>b</sup>	9.50±0.16 <sup>a</sup>
Sand (%)	96.50±0.56 <sup>a</sup>	91.00±0.53 <sup>b</sup>	90.00±0.52 <sup>b</sup>
Textural Class	Sand	Sand	Sand
EA(cmol/kg)	38.00±0.22 <sup>a</sup>	30.20±0.17 <sup>b</sup>	38.00±0.22 <sup>a</sup>
TEB(cmol/kg)	20.48±0.24 <sup>b</sup>	62.83± 0.73 <sup>a</sup>	18.27±0.32 <sup>c</sup>
CEC(cmol/kg)	58.48±0.34 <sup>a</sup>	93.03±0.54 <sup>a</sup>	56.27±0.32 <sup>c</sup>

Means on the same row with different superscripts are significantly different at  $p \leq 0.05$

(n±SE), n =mean; SE= Standard Error.

**Table 2: Heavy Metal Concentrations (mg/kg) in Soil around Automobile Workshop at Railway Station**

Heavy Metal	Points/Distance Apart (20 meters)			WHO Permissible Limit
	A	B	C	
Pb	35.10± 0.20 <sup>c</sup>	37.20± 0.21 <sup>b</sup>	46.50± 0.54 <sup>a</sup>	100
Zn	156.70±0.90 <sup>b</sup>	117.50±0.68 <sup>c</sup>	234.10± 1.35 <sup>a</sup>	300
Cd	3.20±0.02 <sup>c</sup>	3.70± 0.02 <sup>a</sup>	3.40±0.02 <sup>b</sup>	3
Mn	228.10 ±1.32 <sup>b</sup>	289.70±1.67 <sup>a</sup>	218.60±2.52 <sup>c</sup>	2000
Cu	54.50±0.31 <sup>a</sup>	25.00±0.14 <sup>c</sup>	29.40±0.17 <sup>b</sup>	100

Means on the same row with different superscripts are significantly different at  $p \leq 0.05$

(n±SE), n =mean; SE= Standard Error.

**Table 3: Physicochemical Properties of Soil around Automobile Workshop at Sabon Gari Area**

Parameter	Points/Distance Apart (20 meters)		
	A	B	C
pH	7.32± 0.04 <sup>b</sup>	7.32± 0.04 <sup>b</sup>	7.54± 0.08 <sup>a</sup>
Conductivity (µS/cm)	1327.00±7.66 <sup>c</sup>	3260.00±37.64 <sup>a</sup>	2114.00± 42.28 <sup>b</sup>
Organic carbon (%)	6.26±0.04 <sup>b</sup>	8.30± 0.05 <sup>a</sup>	4.90± 0.03 <sup>c</sup>
Organic matter (%)	10.82 ±0.12 <sup>b</sup>	14.35± 0.17 <sup>a</sup>	8.47± 0.10 <sup>c</sup>
Ca <sup>2+</sup> (cmol/kg)	6.40±0.37 <sup>b</sup>	5.50± 0.02 <sup>c</sup>	9.00± 0.05 <sup>a</sup>
Mg <sup>2+</sup> (cmol/kg)	1.00±0.01 <sup>c</sup>	2.50± 0.01 <sup>a</sup>	2.30± 0.01 <sup>b</sup>
Na <sup>+</sup> (cmol/kg)	3.20±0.04 <sup>a</sup>	2.24± 0.03 <sup>b</sup>	1.93± 0.02 <sup>c</sup>
K <sup>+</sup> (cmol/kg)	0.49±0.02 <sup>b</sup>	0.84± 0.05 <sup>a</sup>	0.38± 0.04 <sup>a</sup>
Nitrogen (mg/kg)	3.52±0.04 <sup>a</sup>	2.75± 0.03 <sup>b</sup>	3.50± 0.04 <sup>a</sup>
P(mg/kg)	6.25±0.04 <sup>a</sup>	2.17± 0.01 <sup>c</sup>	4.33± 0.03 <sup>b</sup>
Clay (%)	1.00±0.01 <sup>a</sup>	0.50± 0.01 <sup>b</sup>	0.50± 0.06 <sup>b</sup>
Silt (%)	15.00±0.09 <sup>a</sup>	11.00± 0.13 <sup>b</sup>	9.50± 0.11 <sup>c</sup>
Sand (%)	84.90±0.49 <sup>b</sup>	88.50± 0.51 <sup>a</sup>	90.00± 0.52 <sup>a</sup>
Textural Class	Loamy sand	Loamy sand	Sand
EA(cmol/kg)	41.00±0.24 <sup>a</sup>	31.00± 0.18 <sup>c</sup>	33.50± 0.19 <sup>b</sup>
TEB(cmol/kg)	11.09±0.06 <sup>b</sup>	11.08± 0.13 <sup>b</sup>	13.61± 0.16 <sup>a</sup>
CEC(cmol/kg)	52.09±0.30 <sup>a</sup>	42.08± 0.24 <sup>c</sup>	47.11± 0.27 <sup>b</sup>

Means on the same row with different superscripts are significantly different at  $p \leq 0.05$

(n±SE), n =mean; SE= Standard Error.

**Table 4: Heavy Metal Concentrations (mg/kg) in Soil around Automobile Workshop at Sabon Gari Area**

Heavy Metal	Points/Distance Apart (20 meters)			WHO Permissible Limit
	A	B	C	
Pb	25.80± 0.29 <sup>c</sup>	64.80± 0.75 <sup>b</sup>	75.60±0.87 <sup>a</sup>	100
Zn	204.50±1.18 <sup>c</sup>	531.00± 3.07 <sup>a</sup>	399.50±2.31 <sup>b</sup>	300
Cd	2.00±0.01 <sup>b</sup>	1.70± 0.01 <sup>c</sup>	2.60±0.02 <sup>a</sup>	3
Mn	428.70±4.95 <sup>a</sup>	410.80± 4.74 <sup>b</sup>	380.40±4.39 <sup>c</sup>	2000
Cu	36.70±0.21 <sup>c</sup>	134.80± 0.78 <sup>a</sup>	130.10±0.75 <sup>b</sup>	100

Means on the same row with different superscripts are significantly different at  $p \leq 0.05$

(n±SE), n =mean; SE= Standard Error.

**Table 5: Physicochemical Properties in Soil around Automobile Workshop at Mypa School Area**

Parameter	Points/Distance Apart (20 meters)		
	A	B	C
pH	6.83±0.04 <sup>c</sup>	8.78±0.05 <sup>a</sup>	7.60±0.04 <sup>b</sup>
Conductivity (µS/cm)	437.00±2.52 <sup>c</sup>	709.00±4.09 <sup>b</sup>	1018.00±5.88 <sup>a</sup>
Organic Carbon (%)	4.86±0.03 <sup>c</sup>	5.26±0.03 <sup>b</sup>	5.98±0.03 <sup>a</sup>
Organic Matter (%)	8.40±0.05 <sup>c</sup>	9.09±0.05 <sup>b</sup>	10.34±0.06 <sup>a</sup>
Ca <sup>2+</sup> (cmol/kg)	2.00±0.02 <sup>c</sup>	5.70±0.07 <sup>a</sup>	3.50±0.04 <sup>b</sup>
Mg <sup>2+</sup> (cmol/kg)	1.00±0.01 <sup>c</sup>	1.80±0.03 <sup>a</sup>	1.30±0.08 <sup>b</sup>
Na <sup>+</sup> (cmol/kg)	3.74±0.02 <sup>a</sup>	2.85±0.02 <sup>b</sup>	2.79±0.02 <sup>b</sup>
K <sup>+</sup> (cmol/kg)	0.84±0.04 <sup>b</sup>	0.75±0.00 <sup>c</sup>	0.94±0.00 <sup>a</sup>
Nitrogen (mg/kg)	2.52±0.14 <sup>a</sup>	2.13±0.01 <sup>b</sup>	2.13±0.01 <sup>b</sup>
P(mg/kg)	4.27±0.02 <sup>b</sup>	4.90±0.03 <sup>a</sup>	1.96±0.01 <sup>c</sup>
Clay (%)	0.50±0.00 <sup>b</sup>	5.50±0.09 <sup>a</sup>	5.50±0.03 <sup>a</sup>
Silt (%)	49.50±0.57 <sup>a</sup>	9.00±0.10 <sup>b</sup>	6.50±0.08 <sup>c</sup>
Sand (%)	50.00±0.58 <sup>c</sup>	85.50±0.99 <sup>b</sup>	88.00±1.76 <sup>a</sup>
Textural Class	Loamy sand	Loamy sand	Sand
EA(cmol/kg)	30.60±0.17 <sup>b</sup>	30.00±0.17 <sup>b</sup>	41.00±0.24 <sup>a</sup>
TEB(cmol/kg)	7.58±0.04 <sup>c</sup>	11.10±0.06 <sup>a</sup>	8.53±0.05 <sup>b</sup>
CEC(cmol/kg)	38.18±0.22 <sup>c</sup>	41.10±0.24 <sup>b</sup>	49.53±0.29 <sup>a</sup>

Means on the same row with different superscripts are significantly different at  $p \leq 0.05$

(n±SE), n =mean; SE= Standard Error.

**Table 6: Heavy Metal Concentrations (mg/kg) in Soil around Automobile Workshop at Mypa School Area**

Heavy Metal	Points/Distance Apart (20 meters)			WHO Permissible Limit
	A	B	C	
Pb	2.10±0.01 <sup>c</sup>	9.50±0.05 <sup>a</sup>	2.90±0.03 <sup>b</sup>	100
Zn	109.10±0.63 <sup>c</sup>	185.10±2.14 <sup>a</sup>	149.10±1.72 <sup>b</sup>	300
Cd	3.90±0.02 <sup>a</sup>	2.80±0.05 <sup>c</sup>	3.50±0.02 <sup>b</sup>	3
Mn	142.70±0.82 <sup>c</sup>	203.80±1.18 <sup>b</sup>	447.80±2.59 <sup>a</sup>	2000
Cu	11.20±0.06 <sup>c</sup>	26.60±0.15 <sup>a</sup>	19.50±0.11 <sup>b</sup>	100

Means on the same row with different superscripts are significantly different at  $p \leq 0.05$

(n±SE), n =mean; SE= Standard Error.



## DISCUSSION

Physicochemical properties of soil such as pH, conductivity, organic carbon/ matter in the soil, cation exchange capacity (CEC) and particle size distribution influence the interactions and dynamics of metals within the soil around automobile workshops.

The pH values of the soil samples from the three different sampling points (A, B and C) around the automobile workshops in the study areas (RW, SBG and MY) ranges from 6.53 to 6.69, 7.32 to 7.54 and 6.83 to 8.78 respectively. For the railway area, the sampling points (A, B and C) were not significantly different and the low value in pH indicates slight acidity. The sampling points (A and B) of the SBG area were not significantly different but differ from that of SBG C and the values indicate slightly alkaline. The sampling point of MY B was highly significantly different from A and C. The pH value of point A indicates slightly acidic soil while points B and C are slightly alkaline. Similar results were reported by other researchers (Pam *et al.*, 2013; Ajai *et al.*, 2016). The pH Level influences the quantity and type of microorganism that lives in the soil, and these microorganisms have a great influence on the health of plants and animals. More so, the pH of the soil influences the presence and mobility of heavy metals in the soil. Thus the measured pH values may have implication on the availability and uptake of metals by plant and microorganisms. Furthermore, the solubility of metal cation generally increases with a decrease pH.

Electrical conductivity affects the productivity of the soil. The electrical conductivity of the soil in the sampling points A, B and C for all the sampled sites (RW, SBG and MY) range from 416 to 949, 1327 to 3260 and 437 to 1018  $\mu\text{S}/\text{cm}$  respectively. The values obtained in all the sites were higher than the values reported by Egbenda *et al.* (2015), Ajai *et al.* (2016) but lower than the values reported by Obasi (2013). The values for RW B and SBG B were significantly different from A and C respectively; an indication of more soluble ions in point B while that of MY C was significantly different from points A and B; implying that point C has more soluble ions when compared to points A and B.

The results for particle size distribution of the soil in the Railway sampling site range from 90.00 to 96.50, 2.00 to 9.50 and 0.50 to 1.50 for sand, silt and clay respectively. For the SBG sampling site, the particle size distribution range from 84.90 to 90.00, 9.50 to 15.00 and 0.50 to 1.00 for sand, silt and clay respectively while that of MY sampling site range from 50.00 to 88.00, 6.50 to 49.50 and 0.50 to 5.50 respectively for sand, silt and clay respectively. This shows that the sand fraction was prominent than the silt and clay in all the sampling points and sites. These values for the soil fractions in the sampling points (A, B and C) for RW and SBG sampling sites differed significantly except for sampling points B and C for sand and clay fractions. For MY sampling site, the values of the soil fractions in the sampling points differed significantly with the exception of sampling point B and C for clay fraction.

The mean values for the organic carbon/matter in soil in the three different sampling points A, B and C of these sites RW, SBG and MY range from 2.28 to 6.94/ 3.94 to 11.99, 4.90 to 8.30/ 8.47 to 14.35 and 4.86 to 5.98/ 8.40 to 10.34 respectively. This implies that the SBG and MY study areas have higher microorganism survival. For the RW site, point A was significantly different from points B and C which equally differ from each other. In SBG, point B was significantly different from points A and C, which also differ significantly. For MY, point C was significantly different from points A and B, however, they differ significantly too. These values were similar to that reported by Banjoko and Sobulo (1994).



The mean values of lead in the three different sampling points A, B and C of the soil in the automobile workshops for these areas (RW, SBG and MY) range from 35.10 to 46.50, 25.80 to 75.60 and 2.10 to 9.50 mg/kg respectively. For sampling locations RW and SBG, the concentrations of lead in the soil increased with increase in the distance apart. More so, point C was significantly different from A and B while sampling location MY, point B was significantly different from A and C. The values of lead in the various sites for points A, B and C were below the permissible limit of WHO and shows that the concentrations of Pb in the study areas were low.

Zinc contents in the three different sampling points- A, B and C in all the sites (RW, SBG and MY) range from 117.50 to 234.10, 204.50 to 531.00 and 109.10 to 185.10 respectively. Sampling point C in RW was significantly different from A and B while sampling point B in SBG and MY were significantly different from A and C. The levels of zinc in the RW area increased with increase in the distance apart and were below the permissible limit. The values for SBG sampling points B and C were above the permissible limit; an indication of contamination of the surrounding environ of the automobile workshop. This could be as a result of the additives to lubricating oils (Abenchi *et al.*, 2010). Also, this implies that if there is further bioaccumulation of zinc in the soil, it may seep thereby contaminating underground water.

The mean concentration of cadmium in sites RW, SBG and MY in three different sampling point A, B and C ranges from 3.20 to 3.70, 1.70 to 2.60 and 2.80 to 3.90 respectively. Sampling points RW (B), SBG (C) and MY (A) had the highest cadmium concentration. The contents of cadmium for SBG in all the sampling points were below the permissible limit while those of RW were above the permissible limit. For MY area, sampling points A and C were above the permissible limit while that of point B was below the permissible limit. The high content of cadmium in all the sampling points for RW and part of the MY is an indication of the contamination load which might pose serious hazard to man, plants and animals.

The manganese contents in these sites; RW, SBG and MY in the three different sampling points A, B and C range from 218.60 to 289.70, 380.40 to 428.70 and 142.70 to 447.80 respectively. Sampling locations and points RW (B), SBG (A) and MY (C) had the highest manganese contents. For MY area, the concentration of manganese increased with increase in the distance apart. The values of manganese for the various sites for all the sampling points were below the permissible limit.

The copper contents in these sites RW, SBG and MY in the three different sampling points A, B and C range from 25.00 to 54.50, 36.70 to 134.80 and 11.20 to 26.60 respectively. Sampling site SBG had the highest copper concentrations while that of MY had the lowest. The values of copper in this study are higher than that reported by Ajai *et al.* (2016). The level of copper present in sampling point B for SBG and MY respectively were significantly different from those of sampling points A and C which were equally significantly different from each other. For RW area, sampling point A value was significantly different from B and C. The values of all the sampling points for RW and MY were below the 100 mg/kg permissible limit while sampling points B and C for SBG were above the permissible limit. The high concentration of copper in SBG sampling points B and C could be as a result of wastes containing electrical and electronic parts such as copper wire and electrodes which are leached during runoffs and floods into the soil (Nwachukwu *et al.*, 2011).



## CONCLUSION

Results obtained indicate that automobile workshops in the study areas emit large amounts of heavy metals into the soil resource which could be absorbed by plants and eventually passed onto human being through the food chain leading to severe health-related issues when exposed or ingested above tolerable limits. Fruits from plants around the study could contain these metals and easily passed to consumers. Heavy metal contamination in soils around automobile workshops can be reduced by enforcing regulations on the management of hazardous wastes from automobiles that are discharged into the environment.

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