Pollution status of soil within the vicinity of Automobile mechanic workshops in Owerri Municipality, Nigeria

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Abstract *Physicochemical parameters and heavy metal ions in soils within the vicinity of some mechanic workshops in Owerri metropolitan in Imo State were investigated. Soil samples were taken from mechanic workshops around Aba road, Orji and Avu. AOAC methods were used in the analysis of soil physicochemical parameters while heavy metals ions determination was performed using Atomic Absorption Spectrophotometer. The results obtained indicated a marked variation in the levels of physicochemical properties and heavy metal ion concentrations within locations and soil depth. Soil samples from Avu mechanic workshop had the highest level of Zn, Pb and Cu with mean concentrations of 26.79, 1.12 and 2.70 mg/kg respectively while soil samples from Orji had the least, with mean concentrations of 19.63, 0.05, 1.05, 0.77 and 9.46 mg/kg for Zn, Ni, Cu, Cd and Fe respectively. Soil samples from Aba road mechanic workshops recorded the highest mean values of 1.25 and 21.80 mg/kg for Cd and Fe ions respectively. These values were higher than the concentrations obtained for the control. The results revealed that Avu mechanic workshop was the most contaminated, while Orji had the least contaminants. Physicochemical analysis indicated that Orji had the highest amount of SO_4^{2-}, NO_3^- and pH with mean values of 34.91, 12.90 and 5.99 mg/kg respectively while soil samples from Avu were characterised with highest level of PO_4^{3-}, total organic matter and total organic carbon with mean value of 3.69 mg/kg, 1.93 % and 1.12 % respectively. Calculated enrichment factor of Cd^{2+} ranged from 1.38 to 5.29, indicating soil contamination by Cd^{2+} due to anthropogenic activities.*

Key words: *Physicochemical, heavy metal, auto-mechanic workshop*

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1.0 Introduction

Soil is an essential natural resource which support basic human needs and activities. It serves as reservoirs and recycling plant for both liquid and solid wastes. Soil can be polluted by accumulation of heavy metals and metalloids from industrial and anthropogenic wastes such as sewage sludge, pesticides, wastewater irrigation, spillage of petrochemicals, atmospheric deposition, mine tailings, indiscriminate disposal of heavy metal rich wastes, leaded gasoline and paints, land application of fertilizers, animal manures, coal combustion residues, vehicular exhaust emission, industrial effluents, gas flaring (Singh, 2001; Osu and Ogoko, 2015; Kadafor and Ogoko, 2018).Waste containing trace element generated in the vicinity of auto mobile workshop due to activities of auto skilled workers such as metal scraps, used batteries, packaging materials, spent lubricants and worn-out parts, is known to be one of the route course of environmental degradation (Pam *et al*., 2013). Some heavy metal ions play very vital role in maintaining human metabolism such as zinc, iron amongst

others. Nevertheless, many other heavy metals are known to be poisonous at higher concentrations, and have the tendency to bioaccumulation in human bodies (through the food chain) over a period of time and thereby poses great health and environmental threats (Lenntech, 2005; Udousoro *et al*., 2010). Heavy metal accumulation in soils is of great concern even in agricultural production due to the adverse effects on food quality, environmental health and crop growth as a result of phytotoxicity (Fergusson, 1990; Ogoko, 2015). Metals on the surface of the soil may be carried by runoff water and transported to the groundwater.

Though soil may restrain the infiltration of introduced chemicals such as heavy metals, through some natural processes, this depends on sorption properties of the soil, soil texture, soil pH, moisture content and cation exchange capacity. Some studies have been conducted on heavy metal content of some soil exposed to various wastes. For example, Eddy *et al*., (2006) found high levels of heavy metal accumulation around typical dumpsites in Akwa Ibom State of Nigeria and attributed the source to waste from some cottage industries and domestic waste. Pam *et al*. (2013), reported relatively high concentrations of Cd, Cu, Mn, Ni, Pb and Zn ions in soil samples around some mechanic workshops in Gboko and Makurdi in Central Nigeria and stated that the measured concentrations exceeded permissible limits. Ojiako, *et al.* (2013), also reported high concentrations of Cu, Cr and Ni ions in soils around some mechanic workshop in Onitsha and stated that the observed concentrations posed a serious contamination risk when compared to permissible soil limits for heavy metal ions concentrations. These and several other reports have confirmed that auto mechanic workshops are potential sources of heavy metal contamination in soils, within its vicinity. Therefore, the present study is aimed at assessing soil physicochemical properties and heavy metals contents in some automobile mechanic workshops around Owerri. Knowledge of soil heavy metal levels can guide against short term approach to dangerous concentration.

2.0   Materials and methods
2.1   Sample collection and preparation
Composite soil samples were taken from three different depth profiles, 0 -10 cm, 10 -20 cm, 20-30 cm (from each station within the vicinity of automobile mechanic workshop) using depth calibrated soil auger. Three major cities considered for this study were Orji, Avu, and Aba road. The control samples were collected from a fallowed farm land in the remotest community of Amakohia in Owerri metropolis. Samples were collected in sterile polythene bags between the months of September and October 2019.

2.2   Study area
Owerri is the capital of Imo State and is located in the South Eastern Nigeria with coordinates: $5°29′06″N$ $7°02′06″E$/ $5.485°N$. Owerri is made up of three local government areas, namely Owerri Municipal, Owerri North and Owerri West. Owerri city has an approximate land mass of 100 square kilometer with an estimated population of about 401,873 according to the 2006 census. The sampling sites were auto-mechanic workshops at Aba road, Orji, Avu and control site at the outskirt of Amakohia.

2.3   Determination of soil pH and conductivity
5.0 g of dried and homogenized soil sample was accurately weighed into a 100 ml beaker and 50 ml of distilled water was added. The content of the beaker was vigorous stirred until a homogenous slurry was formed. The prepared mixture was allowed to stand for an hour in order to attain equilibrium. The pH was determined using a pH meter while conductivity was determined using a conductivity meter.

2.4   Extraction of sulphates, nitrates and phosphates
50 g each of the soil samples were weighed into a 250 ml stopper conical flask and 50 ml of distilled water was added, the flask was shaken for about 10 minutes with the help of mechanical shaker. Subsequently the equilibration was allowed to take place by leaving the samples for 30 minutes. The samples were filtered through Buchner funnel fitted with Whatman paper number 42. In the case of turbid filtrates, they were centrifuged by using 3000 cycle/min centrifuge for 5 min.

2.4.1   Determination of nitrates
5 ml of the sample was taken in centrifuge test tube and was make up to 10 ml with distilled water. The tube was centrifuged for 10 min at 2500 rpm. 5 ml of the clear solution was evaporated to dryness in an evaporating dish. The dried residue was allowed to

cool and 1ml of phenoldisulphonic acid was added followed by 10 ml of water after 10 min. The mixture was transferred to 100 ml volumetric flask and made alkaline by the addition of concentrated NH_4OH after which, it was made up to volume with distilled water. The absorbance was measured at 410 nm, using UV Visible Spectrophotometer (Spectronic 21D). A calibration curve was prepared from a standard solution of 40 ppm, 60 ppm, 80 ppm 100 ppm and 120 ppm of KNO_3 and the concentration of nitrate ion was estimated through extrapolation.

2.4.2   Determination of sulphates:
5 ml of sample was measured into a 100 ml volumetric flask and diluted up to the 100 ml mark with distilled water. It was transferred into a 250 ml conical flask and 5.0 ml of the conditional reagents was added. The mixture was properly stirred, during which 0.3 g of $BaCl_2$ crystals was also added and the mixture allowed to stay for 4 minutes, after which the absorbance was measured at 420 nm using UV-VIS Spectrophotometer. A calibration curve used for estimation of concentration of sulphate ions was prepared using 40 ppm, 60 ppm, 80ppm, 100 ppm and 120 ppm of sulphate.

2.4.3   Determination of phosphate
10 ml of the sample was placed in a 50 ml measuring flask and 10 ml of the mixed reagent was added, followed by the addition of 10 ml of colour developing reagent such as ammonium molybdate. The mixture was stirred and allowed to stand for 15 minutes and the absorbance was measured at 880 nm using UV/ Visible Spectrophotometer and glass cells. A standard calibration curve was prepared by reading the absorbance of 40 ppm, 60 ppm, 80 ppm, 100 ppm and 120 ppm of phosphate from KH_2PO_4

2.4.4   Determination of total organic carbon (TOC) and total organic matter (TOM) contents
0.5 g each of air-dried soil sample was put into a conical flask and 2.5 ml of 1 N potassium dichromate solution $K_2Cr_2O_7$ was added and swirled gently to disperse the sample in the solution. 5 ml of concentrated tetraoxosulphate (VI) acid was added rapidly, into the flask and swirled gently until sample and reagents were mixed and finally swirled vigorously for about a minute. The flask was allowed to stand in a fume cupboard for 30 minutes. Five to ten (5 to 10) drops of the indicator were added and the solution titrated with 0.5N $FeSO_4$ to maroon end colour. A blank determination was carried out to standardize the dichromate. TOC and TOM contents were calculated.

2.4.5   Determination of heavy metal ions
The digestion method recommended by the Ministry of Agriculture, Fisheries and Food (MAFF, 1981) was adopted after slight modifications. 1.0 g of previously dried and homogenized soil sample was weighed into a 100 ml beaker and 10 ml of nitric acid was added. The content of the beaker was heated to dryness. A mixture of 10 ml HNO_3 and 3 ml $HClO_4$ was added and the solution was re-heated until fuming occurred. The residue was treated with hot solution of 6 M HCl and was filtered. The filtrate was diluted with distilled water to 50 ml mark. Concentrations of the various heavy metal ions were determined by using their respective hallow cathode lamp to read their respective absorbance and estimation through extrapolation of the already prepared calibration curve. The model of Atomic Absorption Spectrophotometer used was (UNICAM SOLAR 32).

2.5   Theoretical framework
There are several pollution indices that can be used theoretically to evaluate or assessed the status or level of contamination of the environment. Some of these indices considered in this work are as follows:

2.5.1   Geo-accumulation index
Geo-accumulation Index (Igeo) can be used to access the degree of metal contamination in earthly environment (Muller, 1969; Ogoko and Emeziem, 2019).

$$I_{geo} = \frac{\ln (Metal\ concentration\ (C_m)}{1.5 \times Background\ value\ of\ the\ metal\ (B_m)} \quad (1)$$

The correction factor due to variation in the background concentration as a result of lithologic differences has a value of 1.5.

2.5.2   Pollution load index (PLI)
Pollution load index describes the expected metal contamination status and the crucial action that is required to be taken in alleviating objectionable condition. PLI is calculated using the formula below:

$$PL1 = (CF_1 \times CF_2 \times CF_3 \dots.. \times CF_N)^{1/N} \quad (2)$$

where CF is the contamination factor, N is the number of metals assessed. Generally, PLI value > 1 is customary for polluted soil while PLI value < 1 indicates no pollution (Chakravarty and Patgiri 2009; Ogoko and Emeziem, 2019). The extent of contamination compared to measured background

values of a geologically similar and unpolluted area is described as Contamination Factor (Chakravarty and Patgiri 2009; Ogoko and Emeziem, 2019). CF is the average crustal composition of the metal and can be expressed as

$$CF = \frac{C_m}{B_m} \tag{3}$$

where, CF is the contamination factor, Cm refers to the metal concentration and Bm is the background value of the metal.

2.5.3   *Enrichment factor (EF)*

EF is a very important index which is used to evaluate the plausible consequence of anthropogenic activity on the levels of heavy metals in the soil. The concentration of heavy metals characterized by low variability of occurrence (LV) is used as a reference, both in the analysed samples and in background samples in order to access the probable influence of anthropogenesis on the heavy metal ion concentrations in the terrestrial environment. Any of these metal (Fe, Al, Ca, Ti, Sc or Mn) constitutes the reference element. EF is evaluated according to Sutherland (2000) by the equation:

$$EF = \frac{\left[\frac{Cn}{LV}\right] \; sample}{\left[\frac{GB}{LV}\right] \; background} \tag{4}$$

where, Cn is the concentration of analysed heavy metal and (LV) is any of heavy metals considered to have low variability of occurrence. G_B is the reference content of the analysed metal while (LV) represents the reference content of one of the heavy metals categorised by low variability of occurrence.

EF values within the range, 0.5 to 1.5, indicates that the content of a particular heavy metal in the soil is caused by natural processes. On the other hand, EF values greater than 1.5, reveals that the heavy metal pollution is consistent with anthropogenic activities (Zhang and Liu 2002; Elias and Gbadegesin 2011; Ogoko and Emeziem, 2019).

3.0   Results and Discussion

3.1   *Physicochemical parameters*

Physicochemical parameters obtained from analysis of soil in mechanic workshops within Owerri are recorded in Table 1. The results obtained indicated differences in the concentration of physicochemical parameters of soil.

Table 1: Physicochemical parameters of the soil samples at the mechanic workshop in Owerri

Station	Depth Profile (cm)	Moisture content	Ec ms/cm	pH	TOC %	TOM %	PO_4^{3-} mg/kg	NO_3^- mg/kg
Avu	0-10	0.83±0.01	4.81± 0.10	5.88±0.05	1.49±0.01	2.57±0.11	5.43±0.02	15.40±0.0
	10 -20	1.55± 0.10	4.17±0.05	5.67±0.11	1.06±0.02	1.83±0.05	3.06±0.01	12.08±0.2
	20 -30	1.18±0.05	3.73± 001	5.33±0.04	0.80±0.01	1.38±0.03	2.59±0.04	9.30±0.10
Aba road	0-10	0.75±0.10	5.54±0.16	6.54±0.12	1.42±0.03	2.45±0.01	5.04±0.05	16.20±0.2
	10 -20	0.95±0.02	4.68±0.11	5.68±0.01	0.93±0.01	1.60±0.02	2.89±0.02	11.50±0.0
	20 -30	1.36±0.06	4.13±0.20	5.33±0.03	0.85±0.01	1.47±0.04	2.02±0.02	7.10±0.04
Orji	0-10	0.72±0.03	5.32±0.01	6.93±0.07	1.63±0.02	2.81±0.02	4.36±0.01	17.80±0.3
	10 -20	1.88± 0.02	4.65±0.04	5.65±0.21	0.87±0.03	1.50±0.01	3.88±0.05	12.20±0.1
	20 -30	1.98± 0.11	3.40±0.06	5.40±0.10	0.82±0.02	1.47±0.03	2.46±0.01	8.70±0.03
Control	0-10	0.67±0.04	3.04±0.12	5.54±0.03	0.74±0.04	1.28±0.01	4.54±0.03	14.80±0.0
	10 -20	0.82±0.05	1.12±0.01	5.17±0.30	0.68±0.01	1.13±0.01	3.64±0.01	12.60±0.1
	20 -30	0.96±0.01	0.82±0.01	5.09±0.20	0.61±0.01	1.05±0.03	2.98±0.01	11.20±0.0

** Mean of three ± Standard Deviation

Maximum values of total organic matter (TOM) recorded at depth range of 0-10 cm were 2.81±0.02, 2.57±0.11 and 2.45±0.01 % for Orji, Avu and Aba Road sampling stations respectively. The TOM content at the control site was lower which indicate that the measured concentrations of the heavy metals are most probably caused by activities within the mechanic workshops

At depth range of 0-10 cm, TOC content recorded were 1.63±0.02%, 1.49±0.01% and 1.42±0.03% for Orji, Avu and Aba Road sampling stations respectively. These values tend to be higher than the TOC content obtained at other depths. The TOC

content at the control station was lower compared to those of the other sampling stations.

Soil pH, electrical conductivity and moisture content obtained were 5.88±0.05, 6.54±0.12, 6.93±0.07 and 5.54±0.03; 4.81±0.10, 5.54±0.16, 5.32±0.01 and 3.04 ± 0.12 µs/cm; 0.83±0.01 0.75±0.10 0.72±0.03 and 0.67±0.04% for Avu, Aba road, Orji, and control stations respectively. These values recorded at depth level of 0-10 cm tend to be higher than those obtained at other depth profiles studied. The pH, Electrical conductivity and moisture content at the control sites were lower than those from the other sampling stations.

Phosphate ion concentrations in the soil samples ranged from 2.59±0.04 to 5.43±0.02 mg/kg in samples from Avu, 2.02±0.02 to 5.04±0.05 mg/kg in samples from Aba Road, 2.46±0.01 to 4.36±0.01 mg/kg and 2.98±0.01 mg/kg to 4.54±0.03 mg/kg from the control station for samples from Orji and control sites respectively. Phosphate ion content at the control station was relatively lower than those of the other sampling stations. However, highest concentration of phosphate ion was observed at soil depth of 0 – 10 cm while lowest concentration was measured at a depth range of 20 to 30 cm. The release of phosphate to the soil gradually decreases with soil depth because of the changing strength of dynamic soil alteration processes (such as pH, solubility, type of soil, nutrient content and type of soil metal among others) with depth.

In Avu, concentrations of nitrate ions in the soil samples ranged from 9.30±0.10 to 15.40±0.01 mg/kg and from 7.10±0.04 to 16.20±0.20 mg/kg in Avu. However, in Aba Road and control sites, the ranges were 8.70±0.03 to 17.80±0.30 mg/kg and 11.20±0.03 to 14.80±0.02 mg/kg respectively. Just as in the distribution of phosphate ions, nitrate ions obtained from soil samples within the mechanic workshops were relatively higher than the one from the control site, which is also attributed to similar reason. Also nitrate ion concentration decreases with soil depth due to decrease in soil absorption process with depth.

Analysis of sulphate ion revealed that soil samples obtained at depth profile (0-10 cm) had 32.29 ± 0.21, 38.40±0.04, and 37.04±0.22 mg/kg of sulphate for Avu, Aba road and Orji auto mechanic workshop

respectively. These values were significantly higher than 27.28±0.02 mg/kg recorded for the reference (control) sample. At depth ranges of 10 to 20 cm, sulphate concentrations were 29.55±0.10, 34.54±0.30, and 34.87±0.10 and 21.83±0.01 mg/kg. But at depth range of 20 to 30 cm, the measured concentrations were 25.98±0.08, 31.63±0.13, 32.08 ±0.06 and 17.34±0.02 mg/kg for Avu, Aba road, Orji and the control soil samples respectively. It is highly believed that sulphur is presence in most gasoline and other petroleum products and is capable of undergoing oxidation to sulphate ions, which can add to the background soil sulphate.

3.2   *Heavy metal ions concentrations*

In Table 2, concentrations of heavy metal ions measures at the studied locations are presented. Variation in concentration was observed for different heavy metal ions, different soil depth and for different sampling locations as indicated in Table 2. Zinc concentration in the soil samples ranged from 19.42±0.09 to 40.54±0.30 mg/kg, 19.08±0.11 to 34.03± 0.01 mg/kg, 16.00±0.07 to 22.50±0.21 mg/kg, and from 14.55±0.05 to 18.76±0.10 mg/kg at Avu, Aba Road, Orji and the control sampling stations respectively. Highest concentration was observed at depth range of 0-10 cm and lowest at 20 -30 cm depth. Concentration of zinc ions above soil background level may be associated with zinc additives in some petroleum products such as lubricant. There was a stepwise steady decrease in concentration of Zn ions with soil depth and Zn content was much lower at the control stations than at the other sampling sites. However, recorded concentrations of zinc were lower than those reported by Nwachukwu *et al*., (2010) and Shinggu *et al*., (2007) at mechanic villages within the vicinity of Imo River basin. Lead ion concentrations in the soil samples ranged from 0.67±0.03 to 1.95±0.02mg/kg, 1.17±0.03 to 0.86±0.10 mg/kg, and 0.94±0.11 to 1.17±0.03 mg/kg for samples from Avu, Aba Road, and Orji respectively. Concentration of lead ions also decrease with soil depth and was much lower at the control stations than the other sampling sites. However, the observed concentration is lower than those reported by Nwachukwu *et al*. (2010) for soil samples from mechanic workshops in Owerri.

Table 2: Heavy metal concentration of soil samples at the vicinity of mechanic workshop in Owerri

Sampling Station	Depth Profile (cm)	Zn (mg/kg)	Pb (mg/kg)	Ni (mg/kg)	Cu (mg/kg)	Cd (mg/kg)	Fe (mg/kg)
Avu	0-10	40.54±0.30	1.95±0.02	0.06± 0.01	4.31±0.11	1.11±0.10	23.40±0.20
	10 -20	20.40±0.02	0.73± 0.01	0.08±0.03	2.11±0.02	1.83± 0.06	18.71±0.10
	20 -30	19.42±0.09	0.67±0.03	0.08±0.02	1.69± 0.05	0.48±0.01	18.80±0.12
Aba road	0-10	34.03± 0.01	0.78±0.01	0.08±0.01	2.12±0.12	1.31±0.03	25.60±0.50
	10 -20	21.60±0.05	0.86±0.10	0.09± 0.01	1.76± 0.01	1.62±0.10	20.01±0.08
	20 -30	19.08±0.11	0.63±0.08	0.08± 0.01	1.30± 0.04	0.82±0.04	19.80±0.01
	0-10	22.50±0.21	1.17±0.03	0.04±0.01	1.34± 0.02	0.81±0.02	18.40±0.04
Orji	10 -20	20.40±0.01	1.04±0.01	0.05±0.02	1.20± 0.06	0.72± 0.01	16.39±0.10
	20 -30	16.00±0.07	0.94±0.11	0.05±0.01	0.61±0.01	0.79± 0.01	13.40±0.03
	0-10	18.76±0.10	0.08±0.06	0.00±0.00	0.64±0.02	0.00±0.00	10.34±0.07
Control	10 -20	16.40±0.21	0.07±0.01	0.00± 0.00	0.60±0.03	0.00±0.00	9.92±0.11
	20 -30	14.55±0.05	0.06±0.05	0.00±0.00	0.58±0.02	0.00±0.00	8.12±0.01

** Mean of three ± Standard Deviation

Measured mean concentrations of nickel ions ranged from 0.06 ± 0.01 to 0.08 ± 0.03 mg/kg, 0.08±0.01 to 0.09± 0.01mg/kg, and 0.04±0.01mg/kg to 0.05±0.02 mg/kg, at Avu, Aba Road and Orji sampling stations respectively. At the control station, nickel concentration was lower than those obtained in soil samples from Ayu, Aba Road and Orji sampling sites. However, in all sampling locations, the concentration decreases with soil depth. Similar trend was observed for copper ion concentration in the same sites. However, mean concentrations were in the ranges, 1.69 ± 0.05 to 4.31±0.11 mg/kg, 1.30± 0.04 to 1.76± 0.01 mg/kg, 0.61±0.01 to 1.34± 0.02 mg/kg, and from 0.58±0.02 to 0.64±0.02 mg/kg in soil samples from Avu, Aba Road, Orji and the control station, .

These values did not exceed the maximum allowable limit (100 mg/kg, 125 mg/kg and 50 mg/kg) in Australia, Japan and Germany respectively (Lacatusu, 2000).

Mean concentration of cadmium ions ranged from 0.48±0.01 to 1.83± 0.06 mg/kg, 0.81±0.02 to 1.62 ± 0.10 mg/kg, 0.72 ± 0.01 to 0.81±0.02 mg/kg, at Avu, Aba Road, and Orji sampling stations respectively.

Concentrations of cadmium ion at the control station were below detectable limit of the instrument used for the analysis, indicating that there was no cadmium found in the control soil samples. However, the measured concentrations are within the relatively relaxed criteria acceptable in Germany (Lacatusu 2000) and also consistent with the range (0.6 - 3.5 mg/kg) reported by Luter *et al*. (2011) for heavy metals in soils in automobile workshops and some dumpsites in Makurdi, Central Nigeria.

Concentration of iron in the soil samples ranged from 18.80±0.12 to 23.40±0.20 mg/kg, 19.80±0.01 to 25.60±0.50 mg/kg, 13.40±0.03 to 18.40±0.04 mg/kg, and 8.12±0.01 to 10.34±0.07 mg/kg for soil samples from Avu, Aba Road, Orji and the control stations respectively. Iron content had a higher values at depth range of 0-10 cm but least at 20 -30 cm. As recorded for other metal ions and for the same reasons, measured concentrations of iron ions were higher at Avu, Orji and Aba Road sampling stations than those from the control sites. Concentration of iron ions was also found to decrease with depth.

3.3   Pollution indices

The computed geochemical parameter of soil samples assessed are presented in Table 3

The enrichment factor for most of the metal ions at various depth were within the range of 0.0003 to 1.000, indicating that soil contamination by the studied heavy metal ions is majorly linked to natural sources. However, it was observed that cadmium ion recorded higher enrichment factor (EF) when

compared to other heavy metal ions. Calculated EF values of Cd^{2+} ranged from 1.38 to 5.29, indicating that the observed contamination is associated with anthropogenic activities. The reference (control) soil samples had very low levels of enrichment factor, which suggest that other contribution to background heavy metal ion enrichment cannot be dismissed.

Ranges of Pollution Load Index (PLI) obtained for Avu, Aba Road and Orji automobile mechanic workshop were higher than those calculated for the control site (1.019 to 1.061) and ranged from 1.414 to 1.540, 1.399 to 1.608 and from 1.311 to 2.408 respectively.

Table 3; Computed geochemical parameter of soil

Station	Depth Profile (cm)	Parameter	Zn	Pb	Ni	Cu	Cd	Fe
Avu	0-10	CF	0.2580	0.0490	0.0010	0.030	8.7333	2.8818
		Igeo	-6.6442	-3.4271	-3.1710	-3.903	3.6588	0.2836
		EF	0.1071	0.0423	0.0003	0.021	2.564	1.000
	10 -20	CF	0.1641	0.054	0.00115	0.0251	10.8	2.3042
		Igeo	-7.0981	-3.328	-3.11539	-4.0887	3.8712	0.1864
		EF	0.0670	0.0198	0.0004	0.013	5.287	1.0000
	20 -30	CF	0.1480	0.040	0.001	0.0186	5.4667	2.3152
		Igeo	-7.1960	-3.640	-3.17609	-4.3916	3.1903	0.1885
		EF	0.0640	0.0181	0.0004	0.010	1.380	1.0000
Aba road	0-10	CF	0.1710	0.073	0.0005	0.0191	5.4112	3.1527
		Igeo	-7.0581	-3.021	-3.4771	-4.3613	3.1781	0.3226
		EF	0.0820	0.0155	0.0003	0.010	2.767	1.0000
	10 -20	CF	0.1550	0.065	0.0006	0.0171	4.8210	2.4643
		Igeo	-7.1560	-3.139	-3.3802	-4.4716	3.0603	0.2156
		EF	0.0661	0.0218	0.0005	0.0100	4.376	1.0000
	20 -30	CF	0.1210	0.059	0.0006	0.0087	5.2667	2.4384
		Igeo	-7.3991	-3.240	-3.3802	-5.1483	3.1531	0.2110
		EF	0.0590	0.0162	0.0004	0.008	2.239	1.0000
Orji	0-10	CF	0.3070	0.122	0.00075	0.0616	7.4102	2.2660
		Igeo	-6.469	-2.510	-3.3010	-3.1930	3.4931	0.1792
		EF	0.0751	0.0322	0.0002	0.0091	2.3801	1.0000
	10 -20	CF	0.1550	0.046	0.0010	0.0301	12.2021	2.0185
		Igeo	-7.156	-3.492	-3.1761	-3.9072	3.9931	0.1289
		EF	0.0771	0.0322	0.0003	0.0091	2.3751	1.0000
	20 -30	CF	0.1471	0.042	0.001	0.0241	3.2120	1.6502
		Igeo	-7.205	-3.579	-3.17609	-4.1292	2.6548	0.0414
		EF	0.0731	0.0356	0.0004	0.0050	3.187	1.0000
Control	0-10	CF	0.142	0.005	0.000	0.0091	0.0000	1.2734
		Igeo	-7.239	-5.704	0.000	-5.1003	0.0000	-0.0711
		EF	0.1120	0.0039	0.000	0.0071	0.0000	1.0000
	10 -20	CF	0.124	0.004	0.000	0.0086	0.0000	1.2217
		Igeo	-7.374	-5.837	0.000	-5.1648	0.0000	-0.0891
		EF	0.1021	0.0036	0.000	0.0071	0.0000	1.0000
	20 -30	CF	0.110	0.004	0.000	0.0083	0.0000	1.0000
		Igeo	-7.494	-5.991	0.000	-5.1987	0.0000	-0.1761
		EF	0.1100	0.0038	0.000	0.0081	0.0000	1.0000

In all the soil samples studied, values of PLI were greater than 1, which indicate that the studied locations are contaminated by heavy metal ions. It is interesting to note that the geo-accumulation index (I_{geo}) of individual metal ions were less than zero in most case, except iron and cadmium ions, which ranged from -0.176 to 0.283 and from 2.66 to 3.99 respectively. The observed relatively higher range of values calculated for I_{geo} translate to strong cadmium contamination of the soil.

4.0   Conclusion

Soil contamination by Zn, Pb, Ni, Cu and Fe ions is predominantly associated with natural sources since the values of the EF were less than unity. However, from the calculated enrichment factor of Cd^{2+}, anthropogenic activities is a major contributor to soil pollution in the studied area. Strong contamination of soils in the studied automobile mechanic workshops by cadmium ions is also evidence from the calculated high value of geo-accumulation index (2.66 to 3.99)

Based on the findings of this work, it is therefore recommended that further research works be carried out to determine the effects of these pollutants on plants and the health risk of these contaminants, especially cadmium on the people living and working within the automobile mechanic workshops and possible mitigation measures to be adopted. As a matter of urgency, the relevant agencies of government should therefore rise up to their responsibility in enacting appropriate legislatures that will ensure that automobile mechanic workshops are not located near residential areas in order to circumvent the adverse effect of these contaminants on humans.

5.0   References

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