Environmental Risk Assessment of Some Selected Heavy Metals in Soil Among Small Scale Automobile Repair Workshops in Brownfields Urban of Damaturu Lga, Yobe State, Nigeria

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Abstract*: In this study, the environmental risk of some selected heavy metals in soil among small-scale automobile repair workshops in brownfields urban of Damaturu LGA, Yobe state, Nigeria was assessed. The specific objectives of the study were to assess the presence of selected heavy metals in the soil; compared the concentration of heavy metals with European council for European communities (EC), World Health Organization (WHO) and Food and Agricultural Organization (FAO) standards for soil quality. Soil samples were collected from selected automobile workshops site along Maiduguri, Gujba, Potiskum and Gashua roads respectively at the depths of 0-5, 5-10, 10-15, 15-20 and 20-25cm. A simple random sampling method was adopted for the study. Analysis were carried out using mean, standard deviation and ANOVA. Mean concentrations of heavy metals in soil samples (mgkg^{-1}) ranged from 24.49±4.18-58.18±2.60, 3.32±1.12-7.85±0.42, 19.29±2.42-40.09±1.74, 53.54±20.08- 173.74±8.51, 20.95±0.83 – 46.93±2.28 for Pb, As, Se, Fe and Cd respectively. All the values recorded for the selected heavy metals in the samples were within the permissible limit recommended by WHO/FAO except selenium (Se) and cadmium (Cd) which were found to be above the permissible limit. The concentration of lead (Pb) was found to be significant ($P<0.05$) at depth 5-10cm (36.26^{b}). So also, the concentration of Cd and As in Maiduguri road was found to be significant ($P<0.05$) at a depth 20-25cm (32.72^{b}) and 10-15cm (7.13^{b}) respectively while no significant difference was observed in Gashu'a road between the whole soil depth ($P>0.05$) recorded respectively. There is a significant differences ($P >0.05$) in the concentration of Se in both road at some certain soil depth. The concentration of Fe was found to be significant ($P<0.05$) at both road except in Potiskum road. The results indicated that soil qualities varied between slightly contaminated to highly polluted status. This showed that the heavy metal contamination of the soils do not call for any alarm; however, it is recommended that, proactive measures must be taken to minimize accumulation of these metals in the soil; health and environmental talks should also be given occasionally to automobile operators to be more safety conscious and embrace environmentally friendly practices that will enhance their performance and work operations.

***Key words*: Automobile, Contamination, Environmental, Heavy metals, Soil, Workshop**

I. INTRODUCTION

Soil is the uppermost layer of the earth crust. It may be contaminated by the accumulation of heavy metals and metalloids through emission of industrial gases, mine tailings, disposal of metal wastes, gasoline and paints, application of inorganic fertilizers, animal manures, sewage sludge, pesticides, wastewater irrigation, combustion residues, spillage of petrochemicals, and atmospheric deposition [1]. Heavy metal are generally used to describe a group of metals and metalloids with an atomic density greater or more than 5.0 g/cm^3 [2]. Heavy metals occur naturally in the soil from the pedogenetic processes of weathering of parent materials at levels that are regarded as trace (<100mg kg^{-1}) and rarely toxic [3]; [4].

Due to acceleration and disturbance of natural occurring geochemical cycle of metals by man, most of the soil in remote areas and urban environments may accumulate one or more of the heavy metals above the defined background values perceived to be high to cause risks to human health, plants, animals, and ecosystems [5]. The heavy metals essentially become contaminants in the soil environments because their rates of generation via manmade cycles are more rapidly related to natural phenomenon, which were transferred from mines to environmental locations at random. So also, where higher potentials of direct exposure occur, the concentrations of the metals in discarded products are relatively high compared to those in the receiving environment [5].

Moreover, one of the major sources of increase in heavy metal concentration of the ecosystems in Africa particularly Nigeria is automobile activities and operations [6]. These automobile workshops are found in clusters of open plots of land in the vicinity of urban towns. Within the clusters are people who specialize in electrical aspects of auto repairs, while others engage in repairs of brakes and steering, automatic or standard transmission engine, and spray painting, recharging of auto batteries, welding and soldering [7]. Each of these activities generate various types of waste such as gasoline, diesel, used engine oil and paint which were disposed to nearby bushes or surrounding areas. Therefore, there is the need to frequently monitor their nature, volume, direct harmful effects and current methods of disposal as well as potential impacts on the environment [8].

Heavy metals are present in many items used as a result of human activities, precisely the automotive service and repair workshops which are considered to be the largest small scale producers of hazardous waste in brownfield urban of Damaturu LGA. Moreover, we can argue that the level of such will be higher within Damaturu metropolis due to lack of proper waste disposal mechanisms and infrastructure. Heavy metals are considered to be an environmental concern due to their toxicity and accumulative behavior [9]. Advancement in technology had led to high level of industrialization leading to discharge of heavy metals into our environment. In the urban area of Damaturu Metropolis, automobile workshops are found scattered all over the city, waste are indiscriminately dumped on every available space and all categorize of waste ranging from lubricating oil, junked cars, tyres, spare parts are always found to litter all parts of the workshop. Waste from automobile workshop activities can be categorized into maintenance and materials handling wastes. Heavy metals in soil are toxic and some of the soluble metals may find their way to soil, lakes and streams resulting into pollution and other environmental challenges. These necessitate the need to examine the environmental risk of some selected heavy metals in soil among small-scale automobile repair workshops in brownfields urban of Damaturu LGA, Yobe state, Nigeria. The aim of this research work is to study environmental risk assessment of soil in small-scale automobile workshops in Damaturu metropolis. To achieve this, the specific objectives were to:

i. assess the presence of selected heavy metals in the soil environment of automobile workshops in the study area;
ii. examine the concentrations of heavy metals in the selected brownfield soil environment of the study area;
iii. compared the concentration of heavy metals with European council for European communities (EC), World Health Organization (WHO) and Food and Agricultural Organization (FAO) standards for soil quality.

II. MATERIALS AND METHODS

Description of Study Area

The study was conducted at Damaturu Metropolis. Damaturu is located between latitude 11^0 43' and 37" North of Equator and longitudes 11^0 58' and 26" East of prime meridian and elevation of 456m above sea level [10]. It is located in the semi-arid region of Nigeria with a tropical continental climate and a population of 88,014 according to the 2006 census [11]. The area is characterized by a short period of rainfall (June - October) and a long dry season (November - May). The mean daily maximum temperature ranges from 29.2^0C in (July and August) to 45^0C in (March and April). Annual rainfall ranges from 500mm to 1000mm, usually from June to September [11]. Damaturu LGA is bordered in the North by Tarmuwa LGA, Kaga LGA of Borno state by the East, Gujba LGA by the South and Fune LGA by the West respectively..

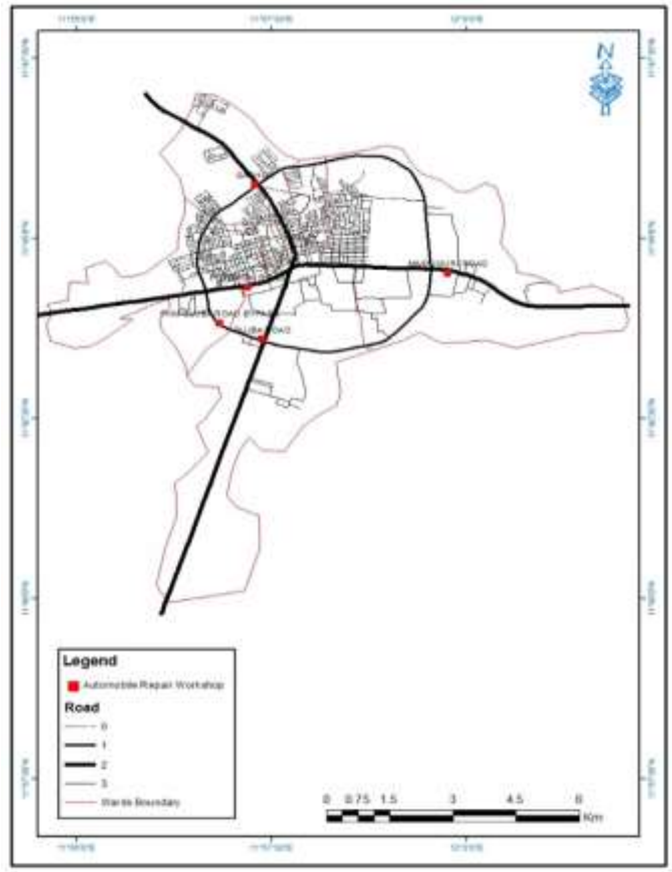

Figure 1.0: Schematic map of Damaturu town, showing sample collection points (Automobile workshops)

A) Study Design and Population

A simple random sampling method was adopted for the study. The study population is defined as mechanic operators and this includes auto mechanics, panel beaters, wielders, painters, rewires, battery chargers and vulcanizes.

B) Sample Collection

Samples was collected across the study area from four (4) automobile workshops. Simple random sampling was adopted based on the available resources to conduct the work and the spread of the workshops across the study area. Furthermore, samples of topsoil were collected in four (4) different locations from each automobile unit at different depth of 0-5cm, 5-10cm, 10-15cm, 15-20cm and 20-25cm. These samples were used as background status of heavy metals across the area. From the foregoing, a total of 20 samples for soil were collected from the study area. The samples were collected randomly from the selected area and placed in labelled polythene bags and was taken to laboratory for analysis.

C) Sample Treatment/Digestion

The samples were allowed to dry using hot oven and then ground into fine powder using a porcelain mortar and pestle. 200mg of each sample was weighed in to a clean plastic container (microwave tube) and 6.0ml of 65% HNO_3, 2.0ml of hydrochloric acid and 2.0 ml of hydrofluoric acid were added and allowed and to stand for five minutes. The plastic container (microwave tube) was then covered and placed into microwave digester and digested. The digestion was carried out at 120°C for 15min and then ramped to 160^0C for 10min, 180^0C for 20mins, and then 200^0C for 30minutes. The digestion was followed by cooling at room temperature in the microwave. The Potential presence of heavy metal in chemicals which were used in digestion were determined. Blanks were used simultaneously in each batch of the analysis to authenticate the analytical quality. The digested samples were diluted with deionized water to a total volume of 30ml.

D) Determination of heavy metal contents in soil using atomic absorption spectroscopy (AAS)

The instrument was calibrated using series of working standards. The working standard solutions of each metal were prepared from standard solutions of their respective metals and their absorbance were taken using the AAS. Concentration of the metal ions present in the sample was determined by reading their absorbance using AAS (Buck scientific model 210GP). Three replicate determinations were carried out on each sample. The metals were determined by absorption /concentration mode and the instrument readout was recorded for each solution. The same analytical procedure was employed for the determination of elements in digested blank solutions and for the spiked samples.

E) Data Analysis

Data collected were analyzed using Microsoft Office Excel. Data collection and analysis was generally instrument specific, since most of the instruments used have an inbuilt software. Further analysis were carried out using mean, standard deviation and analysis of variance (ANOVA).

III. RESULTS AND DISCUSSION

The results from the analysis of soil samples were recorded and presented in this section. Results of heavy metals analysis in soil samples from different locations are presented in Tables 1.1 and 1.2 as well as Figures 1.1 to 1.4 respectively. However, the results revealed the presence of the investigated metals in varying quantities, from negligible amounts to appreciable concentrations. These results were compared with European council for European communities (EC), and World Health Organization and Food and Agricultural Organization (WHO/FAO) standards for soil quality.

A) Lead (Pb) Concentration

The mean concentration of Pb ranged between 24.49$\pm$2.14-58.18$\pm$2.60 mg/kg^{-1} in the soil samples across the different location as shown in Table 1.1. The highest concentration 58.18$\pm$2.60 mg/kg^{-1} was recorded at Gashua road at a depth of 20-25cm. From the study it was observed that the concentration of lead along Maiduguri road was increasing as the depth increased. Soil depth from 0-5cm and 5-10cm recorded 26.92$\pm$2.14 and 36.25$\pm$2.51 mg/kg^{-1} respectively. The trend at which element percolates down to the grown level at Gujba road with low concentrations (33.47$\pm$2.12) mg/kg^{-1} at depth 10-15cm and highest value was recorded at depth 20-25cm (36.10$\pm$1.54) mg/kg^{-1}. The lead concentration in Potiskum road showed an increase of the element at the depth increases. The values recorded at depth 0-5 (24.49$\pm$4.18) mg/kg^{-1} is lower than that of 5-10 and 10-15cm 27.42$\pm$1.25 and 27.89$\pm$3.44 mg/kg^{-1} respectively. The differences obtained might be due to the nature of the soil as the top soil usually revealed lower value. But at depth 5-10 and 10-15cm the values recorded where similar which indicate similarities of substances retention between silt and clay soil.

This implies that the differences in values might be due to the nature of the soil profile from that location as the soil surface is sandy-loam which is coarse in nature and percolation can be easier for heavy metals down to the soil, while for 5-10cm depth, the soil was silt in nature which can retain substance for longer period of time. Reference [12] revealed that the Pb concentrations at 0-5 cm, 5-10 cm and 10-15cm were 76.56±39.48 mgkg^{-1}, 70.13±28.34 mgkg^{-1}, and 99.50±70.14 mgkg^{-1} respectively. High Pb concentration observed at all depths might be due to oil spills or leakage of petrol containing lead additive. It was observed that Pb concentrations obtained were lower than the report of [13]. Low concentrations of Pb obtained from some of the contaminated sites may be due to gradual decrease in metal concentration which could arise from the fact that the metals were leached away from the site [14].

Furthermore, the result of the analysis of variance (ANOVA) was presented in Table 1.2. The result revealed that in Gashu'a and Maiduguri road, the concentration of Pb was found to be significantly higher ($P<0.05$) at depth 5-10cm (36.26^b) but showed no significant difference ($P>0.05$) between the concentration at a depth of 0-5cm (26.92^c) and 15-20cm (34.46^c). This is in tandem with the findings of [15] who revealed that the concentration of lead (Pb) is higher and statistically significant but decreases as the depth increases for most of the sites. The concentration of Pb in Gujba road was found to be significantly higher ($P<0.05$) at depth 20-25cm (36.09^c) but showed no significant differences ($P>0.05$) between the concentration at depth 0-5cm (34.36^b), 5-10cm (35.38^b) and 10-15cm (33.48^b). In Potiskum road, statistically there was no significant difference ($P>0.05$) observed between depth 0-5, 5-10, 10-15, 15-20cm in which 24.47^c, 27.43^c, 27.89^c and 33.31^c were recorded respectively, but differences were observed at the depth of 20-25cm (33.54^{cd}). This implies that with an increase in depth, the Pb concentration also increases. These findings agrees with [16] who stated that Pb was present in all the samples obtained from the different spots of the mechanic workshop and range from 19.14±1.55 to 79.55±4.97 mg/kg^{-1}. The mean concentration of Pb in the control soil was 3.99±1.18 mg/kg. The concentration of Pb in the contaminated soil, 49.97±21.06 mg/kg^{-1}, was significantly higher than that of the control soil, 3.99±1.18 mg/kg, at (p <0.05).

B) Arsenic (As) Concentration

The mean concentration of Arsenic (As) ranged between 3.32±1.12-7.85±0.42 mg/kg^{-1} in soil samples across the different location. The highest concentration 7.85±0.42 mg/kg^{-1} was recorded at Gashua road at a depth of 20-25cm. From the study, the concentration of As along Maiduguri road was increasing as the depth increases but subsequently decreases as it goes down. Soil depth 0-5cm recorded 3.97±0.81 mg/kg^{-1} while in 5-10cm depth, 5.62±0.51 mg/kg^{-1} was recorded. The differences in the values might be due to the nature of the soil profile. High concentration recorded at depth 10-15cm 7.13±0.75 mg/kg^{-1} was due to the nature of the soil which is typically clay. This is apparent because the clay particles unlike the sand particles have substantial exchange surface areas and therefore absorb and stabilize organic matter and heavy metals.

Further result for As concentration in Gujba road shows the trend at which element percolates down to the grown level with low concentrations (4.34±1.14) mg/kg^{-1} at depth 10-15cm and highest value (5.43±0.23) mg/kg^{-1} was recorded at depth 5-10cm. The concentration of As at depth 5-10cm was evident due to the fact that the soil type at that depth is silt which was known to retain substances more than the top soil. On the other hand, the value recorded at depth 10-15cm (4.34±1.14) mg/kg^{-1} indicates that the soil is clayey in nature and likely to release substances down to the ground level. In Potiskum road, the values recorded at depth 0-5cm (3.32±1.12) mg/kg^{-1} is lower than that of 5-10cm (3.66±0.33). The differences obtained might be due to the nature of the soil as the top soil usually revealed lower value. Higher concentration recorded at depth 15-20cm of 5.19±0.36 mg/kg^{-1} was attributed to the presence of organic matter at the depth region. This implies that there is an increase in the concentration of the element as the depth increases. However, the concentration of As in the soil samples analysed were below the permissible limit of 20 mg/kg [17]. This result is contrary with the result of [18] who recorded high value of As in the soil which ranged from 84.53-17.11mg/kg^{-1} and attributed this to the presence of pyrites in the bedrock of the area. Many As compounds were adsorb strongly into soils and are therefore transported only over short distances in groundwater and surface water. The element is associated with skin damage, increased risk of cancer, and some other related health problems [19].

From the result of ANOVA presented in table 1.2. The concentration of As in Maiduguri road was found to be significantly higher (P<0.05) at depth 10-15cm (7.13^{b}) and also showed no significant differences (P>0.05) between the concentrations at depth 0-5cm (3.97^{b}), 5-10cm (5.62^{b}) and 15-20cm (5.46^{c}). In Gujba road, the concentration of As was found to be significant (P<0.05) at depth 5-10cm (5.43^{b}) and also showed no significant differences (P>0.05) between the concentration depth 0-5cm (4.76^{b}), 5-10cm (5.43^{b}) and 15-20cm (5.14^{b}). No significant differences was also observed for the values recorded at depth 10-15cm and 20-25cm of 4.34^{c} and 5.16^{c} respectively. Statistically, the result in Potiskum road shows that there was no significant difference (P>0.05) observed between depth 0-5cm, 10-15cm, 15-20cm and 20-25cm in which 3.32^{b}, 4.14^{c} , 5.19^{b} and 4.97^{c} were recorded respectively, but significant differences was observed at depth 5-10cm (3.66^{d}). No significant difference was observed in Gashu'a road between the whole soil depths (P>0.05) respectively.

C) Selenium (Se) Concentration

The mean concentrations of selenium (Se) ranged between 19.29±2.42-40.09±1.74 mg/kg^{-1} in soil samples across the different locations as shown in Table 1.1. Highest concentration 40.09±1.74 mg/kg^{-1} was recorded in Gujba road at a depth of 20-25cm. From the study it was observed that concentration of Se along Maiduguri road was increasing as the depth increases but subsequently decrease as it goes down. Soil depth from 0-5cm recorded 32.21±12.05 mg/kg^{-1} while 30.52±1.42 mg/kg^{-1} was recorded in depth 5-10cm. Variation in Se concentration at depth 15-20cm (36.47±5.60 mg/kg^{-1}) and depth 20-25cm (24.92±8.42 mg/kg^{-1}) indicates that the element percolates from the top soil up to the bottom line (organic matter). Moreover, in Gujba road, 0-5cm recorded 32.41± 12.05 mg/kg^{-1} while in 5-10cm soil depth 30.52±1.42 mg/kg^{-1} was recorded. This indicates that the element percolates due to the presence of organic matter. This might be the reason why the Se concentration was recorded higher. This is apparent because the clay particles unlike the sand particles have substantial exchange surface areas and therefore absorb and stabilize organic matter and heavy metals.

The Se concentration in Potiskum road showed an increase of the element as the depth increases. The values recorded at depth 0-5cm (26.46±11.1 mg/kg^{-1}) is lower than the one 20.92±1.43 mg/kg^{-1} recorded at 5-10cm. The differences obtained might be due to the nature of the soil as the top soil usually revealed lower value. But at depth 20-25cm (30.01±8.56 mg/kg^{-1}) the values recorded was on the higher side which indicate high percolation rate. Higher concentration recorded at depth 20-25cm was attributed to the presence of organic matter at the depth region. The mean concentration of Se recorded in the study area was higher than the recommended permissible limit of 10 mg/kg^{-1} reported by WHO/FAO [20]. This agrees with the findings of [21] who also recorded a higher value of Se in soil samples which ranged from 0.022-3.806 mg/kg^{-1} in the area. The implication of the study revealed that the concentration of Se is highly toxic to the inhabitant of the study area particularly where the concentration was found to be higher in the sampled soil.

Table 1.2 revealed the result of ANOVA recorded in Maiduguri road, in which Se concentration shows no significance differences (P<0.05) between the values 32.21^{a}, 30.52^{a} and 27.97^{a} recorded in depth 0-5, 5-10 and 10-15cm respectively, while significant differences (P >0.05) was observed between depth 15-20 and 20-25cm which recorded 36.47^{ab} and 24.92^{b} respectively. From the table, the concentration of Se in Gujba road was found to be significantly higher (P<0.05) at a depth of 20-25cm (40.09^{a}) but no significant difference (P>0.05) was observed between the concentrations in all the soil depths. In Potiskum road, there was no significant difference (P>0.05) observed between depth 0-5, 5-10 and 10-15cm in which 26.46^{a}, 20.92^{a}, 27.03^{a} were recorded while significant differences was observed at depth 15-20cm (30.01^{ab}). The result in Gashu'a road for Se concentration shows no variation between depth 0-5cm (26.73^{a}), 5-10cm (34.30^{a}) and 10-15cm (24.32^{a}), which entails no significant difference (P>0.05) was observed while in depth 15-20cm and 20-25cm, significant difference (P<0.05) was recorded.

Table I: Distribution of the Concentrations (mg/kg^{-1}) of Heavy Metals in Brownfield Soil of Urban Damaturu LGA

Location	Soil Depth (cm)	Pb	As	Se	Fe	Cd
Maiduguri road	0-5	26.92±2.14	3.97±0.81	32.21±12.05	73.13±4.70	21.27±0.75
	5-10	36.25±2.51	5.62±0.51	30.52±1.42	101.99±6.98	22.37±0.56
	10-15	29.57±1.43	7.13±0.75	27.97±11.81	90.60±5.33	28.77±1.92
	15-20	34.46±0.33	5.48±0.63	36.47±5.60	97.87±4.11	20.95±0.83
	20-25	30.10±1.59	4.80±0.69	24.92±8.42	81.79±9.04	32.72±2.69
Gujba road	0-5	34.36±3.15	4.76±1.05	20.44±3.98	90.68±15.34	22.95±0.39
	5-10	35.38±0.93	5.43±0.23	34.89±19.80	98.51±4.09	36.26±2.04
	10-15	33.47±2.12	4.34±1.14	37.06±10.60	84.49±14.34	44.78±2.43
	15-20	35.59±1.71	5.14±0.55	38.04±11.85	97.19±9.28	46.93±2.28
	20-25	36.10±1.54	5.16±0.53	40.09±1.74	99.14±6.32	44.60±0.27
Potiskum road	0-5	24.49±4.18	3.32±1.12	26.46±11.1	53.54±20.08	40.26±2.63
	5-10	27.42±1.25	3.66±033	20.92±1.43	66.93±6.19	21.39±0.87
	10-15	27.89±3.44	4.14±0.95	27.03±5.69	68.75±18.23	34.79±4.67
	15-20	33.31±0.92	5.19±0.36	20.48±1.65	92.30±4.75	32.40±1.88
	20-25	33.54±0.73	4.97±0.16	30.01±8.56	90.36±1.93	32.66±7.67
Gashua road	0-5	28.63±1.03	4.52±0.36	26.73±4.65	75.56±5.25	30.15±0.28
	5-10	28.51±0.72	4.40±0.46	34.30±1.77	75.17±4.52	29.38±0.84
	10-15	28.28±0.51	4.30±0.38	24.32±3.61	73.37±3.35	28.94±0.50
	15-20	43.38±1.32	5.83±0.38	27.80±0.55	122.87±3.03	31.94±0.48
	20-25	58.18±2.60	7.85±0.42	19.29±2.42	173.74±8.51	35.34±0.92

* The values of the concentrations are represented as mean ± standard deviation (SD) of five different determinations of the soil samples.

D) Iron (Fe) Concentration

The mean concentration of Iron (Fe) ranged between 53.54±20.08-173.74±8.51 mg/kg^{-1} in soil samples across the different location as shown in Table 1.1. The highest concentration was recorded in Gashua road at a depth of 20-25cm 173.74±8.51 mg/kg^{-1}. It was observed that the concentration of Fe along Maiduguri road was increasing as the depth increases. The concentration of Fe at depth 0-5cm was 73.13±4.70 while in 5-10cm depth, the concentration was101.99±6.98 mg/kg^{-1}. The result for Fe concentration in Gujba road is based on the trend at which the element percolates down to the grown level with low concentrations of (84.49±14.34) mg/kg^{-1} at depth 10-15cm and highest value was recorded at depth 20-25cm (99.14±6.32) mg/kg^{-1}. The low concentration indicates that the soil depth is clayey in nature and likely to release substances down to the ground level while the highest concentration was evident due to the fact that the soil type at that depth is silt which was known to retain substances more than the top soil. In Potiskum road, Fe concentration showed an increase of the element as the depth increases. The values recorded at depth 0-5cm (53.54±20.08 mg/kg^{-1}) is lower than that of 5-10 and 10-15cm 66.93±6.19 and 68.75±18.23 mg/kg^{-1} respectively.

The differences obtained in the concentration might be due to the nature of the soil as the top soil usually revealed lower value. Higher concentration recorded at depth 15-20 and 20-25cm was attributed to the presence of organic matter at the depth region. The results recorded in the study is below the permissible limit recommended by WHO and FAO of 50,000 mg/kg [22]. The result in the present study is similar to the report of [23] who reported that the value ranged from 151.58 to 154.58 mg/kg at the sampled mechanic workshop. This implies that the concentration of Fe is not harmful to the inhabitants of the sampled workshops even though acute exposure of iron in humans lead to vomiting, cardiac depression and metabolic acidosis [24]. This findings supported the view of [25] which revealed that the iron levels in the soil samples from all sites varied from 18.40 to 50.00 mg/kg with mean value of 40.05 mg/kg. The presence of iron could also be attributed to automobile crankshafts wear and vehicle body damage. The levels obtained in this study are contrary with those reported by [26]. The values are however lower than those reported by [27], [28] and [16].

From the result of the analysis of variance (ANOVA) in Table 1.2. The concentration of Fe in Maiduguri road was found to be significantly higher (P<0.05) at depth 5-10cm (101.98^{b}). There was no significant difference (P>0.05) between the concentrations recorded at 5-10cm (101.98^{b}) and10-15cm (90.60^{b}). Significant differences (P<0.05) was observed at depths 0-5 (73.13^{bc}), 10-15 (97.87^{c}) and 20-25 (81.79^{d}) respectively. In Gujba road, the concentration was found to be significant (P<0.05) at depth 20-25cm (99.14^{c}) and also showed no significant difference at depth 15-20cm (97.19^{c}). No significant difference (P>0.05) was also observed for values recorded at depth 0-5cm, 5-10cm and 10-15cm of 90.69^{b}, 98.51^{b} and 84.49^{b} respectively. Statistically, there was no significant differences (P>0.05) in Potiskum road between depth 0-5, 5-10 and 15-20cm in which 53.54^{c}, 66.94^{c} and 92.29^{c} were recorded respectively. However, the concentration shows a significant differences at depth 20-25cm (90.36^{cd}) and depth 10-15cm (68.75^{b}). Iron (Fe) concentration in Gashu'a road shows a significant difference (P<0.05) between depths 0-5 (75.56^{bc}), 5-10 (75.17^{c}) while 10-15cm, 15-20cm and 20-25cm shows no significant differences (P>0.05).

E). Cadmium (Cd) Concentration

The mean concentration of Cd ranged between 21.27$\pm$0.75-46.93$\pm$2.28 mg/kg^{-1} in soil samples across the different location as shown in Table 1.1. Highest concentration 46.93$\pm$2.28 mg/kg^{-1} was recorded in Gujba road at a depth of 15-20cm. It was observed that the concentration of Cd along Maiduguri road was increasing as the depth increases. The soil depth, 0-5cm recorded 21.27$\pm$0.75 mg/kg^{-1} where as in 5-10cm depth, 22.37$\pm$0.56 mg/kg^{-1} was recorded. At a depth of 10-15cm, the nature of the soil is clay which also relatively allow substances to percolate down to the soil. This might be the reason why the Cd concentration was recorded higher. The Cd concentration in Gashua road showed a trend of the element descending down to the ground level, though the concentration was similar in depth 0-5, 5-10 and 10-15cm which recorded 30.15$\pm$0.28, 29.38$\pm$0.84 and 28.94$\pm$0.50 mg/kg^{-1} respectively. The Cd concentration in Potiskum road showed a higher concentration of the element at a depth of 0-5cm. whilst, lower concentration was recorded at a depth 5-10cm (21.39$\pm$0.87) mg/kg^{-1}. The differences might be due to the nature of the soil which is loamy soil and mostly allow percolation of elements down the ground level.

The values obtained is far higher than the recommended permissible level of 3.0 mg/kg reported by EC [17]. The implication of these result is that the concentration of Cd is injurious to health because there is high risk of toxicity in the soil and probably might cause problem to the people living in the area. This also indicate that the concentration of the cadmium is reaching the ground level and there might be a tendency to reach the water level which could be harmful to the ground water. These findings are of great importance as cadmium is considered to be a very toxic heavy metal in terms of human health. The findings are in accordance with the result of [29] who reported that the concentration of cadmium was far higher than the permissible limit of WHO of 28.64 mg/kg detected at wurukum junction (heavy traffic area). So also, the study is contrary with the findings of [30] which shows high values of cadmium concentration at various areas of study 17.79 mg/kg (AP Cluster) and 12.7 mg/kg (GBK cluster) and ranged from 11.74 - 21.83 mg/kg, and 7.04 - 21.6 mg/kg.

The results also indicated that the automobile repair workshops in Gujba road was establish years back and the concentration of Cd at mechanic workshop may be due to disposal of engine oil and some other automobile waste compare to others where there is low patronage by motorist. Reference [31] stated that the Cd level in tyres were within the range of 20-90 mg/kg^{-1} as associated with cadmium contamination during vulcanization. In a related study conducted at Benue state, Makurdi, where the concentration of cadmium obtained at dumpsites may be due to the dumping of Poly vinyl chloride (PVC), nickel-cadmium batteries among others. Concentrations of Cd obtained at dumpsites and hospital incinerator sites were similar to concentrations reported from soil samples of industrialized environment [32]; [1].

Table 1.2 revealed the concentration of heavy metals based on the analysis of variance (ANOVA) carried out using SPSS 16.0. The concentration of Cd in Maiduguri road was found to be significantly higher (P<0.05) at depth 20-25cm (32.72^{b}), so also there was no significant difference (P>0.05) between the concentrations at depth 0-5cm (21.27^{c}), 5-10cm (22.37^{c}) and depth 10-15cm (28.78^{c}). In Gujba road, the result for Cd concentration shows no significant difference (P>0.05) between depth 5-10, 10-15, 15-20 and 20-25cm with value of 36.26^{a}, 44.78^{a}, 46.93^{a} and 44.60^{a} but indicated a significant difference at depth 5-10 with a value of 22.95^{c}. The result of statistical analysis in Potiskum road revealed that there was no significant difference (P>0.05) observed between depth 5-10 and 15-20cm in which 21.39^{c} and 32.40^{c} were recorded respectively. Statistically, no significant differences was observed between depth 10-15cm (34.79^{b}) and 15-20cm (32.66^{b}) respectively. The result from Table 1.2 for Cd concentration shows no significant difference (P>0.05) between depth 0-5, 5-10 and 20-25cm, and also no significant difference (P>0.05) was observed between depth 10-15 (28.93^{c}) and 15-20cm (31.94^{c}) respectively.

Table 1I: Distribution of the Concentrations (mg/kg^{-1}) of Heavy Metals in Brownfield Soil of Urban Damaturu LGA using ANOVA

Heavy Metals	Soil Depth (cm)	Location				SEM
		Maiduguri Road	Gujba Road	Potiskum Road	Gashua Road	
Pb	0-5	26.92^{c}	34.36^{b}	24.47^{c}	28.63^{bc}	4.68*
	5-10	36.26^{b}	35.38^{b}	27.43^{c}	28.51^{c}	4.22*
	10-15	29.57^{bc}	33.48^{b}	27.89^{c}	28.28^{c}	4.82*
	15-20	34.46^{c}	35.59^{c}	33.31^{c}	43.38^{b}	4.75*
	20-25	30.09^{d}	36.09^{c}	33.54^{cd}	58.18^{b}	4.11*
As	0-5	3.97^{b}	4.76^{b}	3.32^{b}	4.52^{b}	0.58*
	5-10	5.62^{b}	5.43^{b}	3.66^{d}	4.39^{c}	0.52*
	10-15	7.13^{b}	4.34^{c}	4.14^{c}	4.29^{c}	0.60*
	15-20	5.48^{b}	5.14^{b}	5.19^{b}	5.83^{b}	0.50*
	20-25	4.79^{c}	5.16^{c}	4.97^{c}	7.85^{b}	0.49*
Se	0-5	32.21^{a}	20.44^{a}	26.46^{a}	26.73^{a}	2.03^{NS}
	5-10	30.52^{a}	34.89^{a}	20.92^{a}	34.30^{a}	2.79^{NS}
	10-15	27.97^{a}	37.06^{a}	27.03^{a}	24.32^{a}	2.37^{NS}
	15-20	36.47^{ab}	38.04^{a}	20.47^{b}	27.80^{ab}	2.57*
	20-25	24.92^{b}	40.09^{a}	30.01^{ab}	19.29^{b}	2.36*
Fe	0-5	73.13^{bc}	90.69^{b}	53.54^{c}	75.56^{bc}	15.79*
	5-10	101.98^{b}	98.51^{b}	66.94^{c}	75.17^{c}	14.06*
	10-15	90.60^{b}	84.49^{b}	68.75^{b}	73.73^{b}	16.08*
	15-20	97.87^{c}	97.19^{c}	92.29^{c}	122.87^{b}	15.44*
	20-25	81.79^{d}	99.14^{c}	90.36^{cd}	173.74^{b}	13.69*
Cd	0-5	21.27^{c}	22.95^{c}	40.26^{a}	30.15^{b}	2.05*
	5-10	22.37^{c}	36.26^{a}	21.39^{c}	29.38^{b}	1.84*
	10-15	28.78^{c}	44.78^{a}	34.79^{b}	28.93^{c}	1.74*
	15-20	20.95^{d}	46.93^{a}	32.40^{c}	31.94^{c}	2.34*
	20-25	32.72^{b}	44.60^{a}	32.66^{b}	35.34^{b}	1.54*

*Means within each row with different superscripts are indication of different level of significance at 5% (P<0.05)

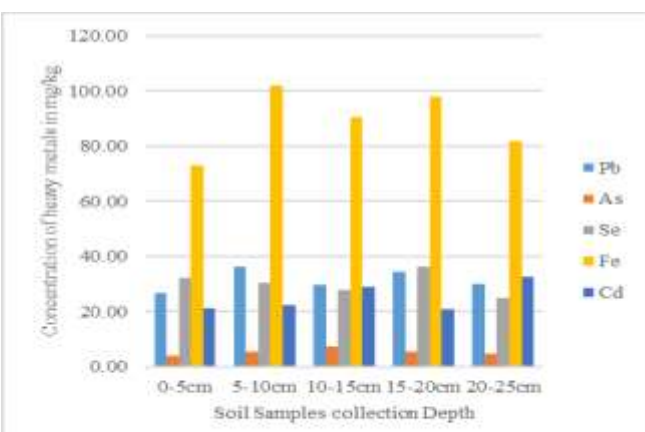

Figure 1.1: Heavy metals concentration in soil sample collected at Maiduguri road mechanic workshop.

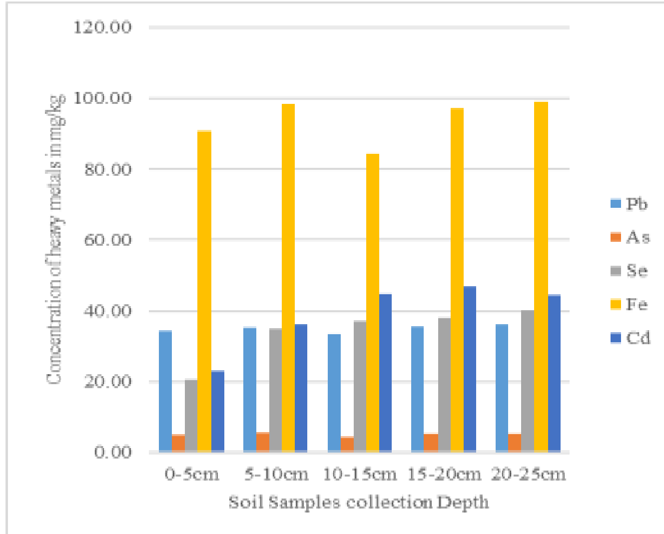

Figure 1.2: Heavy metals concentration in soil sample collected at Gujba road mechanic workshop.

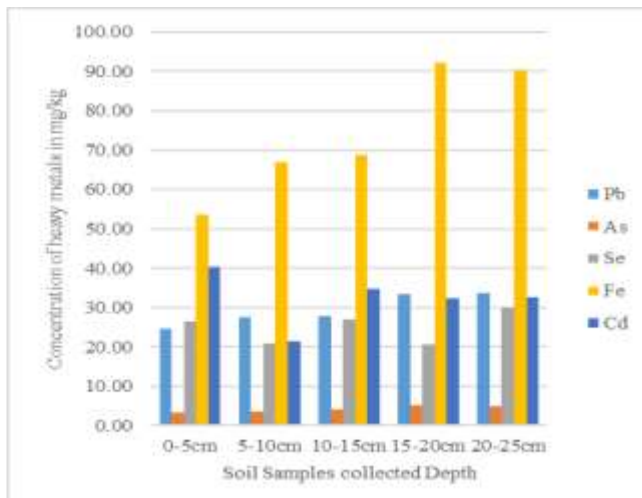

Figure 1.3: Heavy metals concentration in soil sample collected at Potiskum road mechanic workshop.

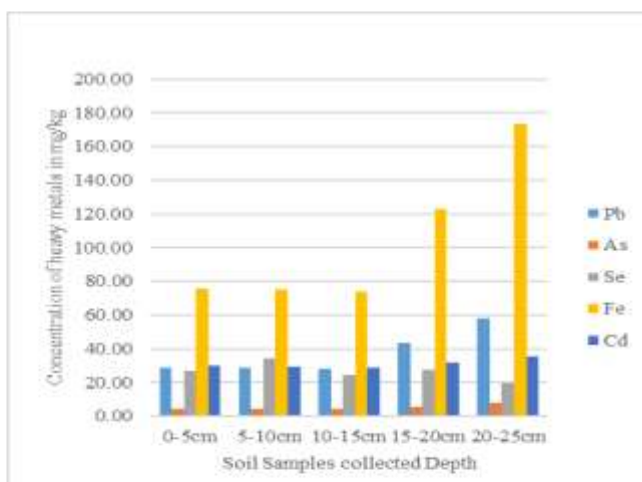

Figure 1.4: Heavy metals concentration in soil sample collected at Gashua Road mechanic workshop

IV. CONCLUSION

Soil are the most imminent segments of the earth crust whose quality cannot afford to compromise and treat with levity. This study was conducted to assess the environmental risk assessment of some selected heavy metals in soil among small-scale automobile repair workshop in brownfield urban of Damaturu LGA, Yobe state. The results reveal that concentrations of heavy metals in soil were far below WHO/FAO permissible limits and such concentrations cannot cause any harm except for selenium and cadmium which were found to be above the permissible limit because it is higher, toxic and capable of causing harm or injury to the inhabitants of the sampled environments. Therefore, there is the need for regular monitoring of these anthropogenic activities in order to forestall the impending health risk from heavy metals. There is a greater risk associated with the concentration of both soil samples at different depth which is deemed to be above the accurate measures of control and regulatory guidelines of contamination in the four (4) major roads of the study area. Despite the indications of soil contamination in some sites in the study area, a higher percentage of the auto mechanics have a positive attitude towards ensuring environmental protection and sustainability. From the outcome of this research, conclusion can be drawn that the quality of the soil in these automobile workshops has been polluted and exposed. This raises health, environmental and food productivity concerns in soils of the study area

V. RECOMMENDATIONS

i. Health and environmental awareness should be given occasionally to automobile operators to enhance their performance to be more safety conscious and embrace environmentally friendly practices.
ii. Orientation on safe waste handling and disposal methods should be given from time to time.
iii. Automobile workshops should be assessed regularly to ensure compliance to environmental regulations relevant to this workshops.
iv. Automobile workshops should be mandated to store the used oil in plastic containers rather than the present attitude of spilling on the ground.
v. Regularly evaluation of automobile activities must be carried out to ensure compliance with environmental regulations and hygiene.

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