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LEVELS OF SOME POTENTIALLY TOXIC ELEMENTS IN SOILFROM SELECTED METAL WORKSHOPS IN POTISKUM, YOBE STATE, NIGERIA

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ABSTRACT

This study is aimed at determining the levels of some potentially toxic elements in soil samples obtained from five different metal workshops namely Garejin Oga Abdul (GOA), Nakowa Welding Construction (NWC), Garejin Da'awa (GDH), Garejin Adamu Salisu (GAS) and Garejin Iliya Maina (GIM) all in Potiskum town, Yobe State, Nigeria. The soil samples were analyzed to determine the concentrations of ten elements (Pb, Zn, Cr, Cd, Co, Mn, Ni, Fe, Se and Cu) using atomic absorption spectroscopic (AAS) technique. Results obtained from this study revealed that the levels of Co (4.18 mg/kg), Mn (130.22 mg/kg) and Ni (11.8 mg/kg) were below WHO permissible limit in all the study areas. However, the concentrations of Cr in GDH (113.76 mg/kg) and GOA (103.64 mg/kg) as well as Cd (1.26 mg/kg) and Zn (56.52 mg/kg) in GIM samples were high. Lead (Pb) levels were high in all workshops except GAS and the levels of Cu, Fe and Se were above WHO permissible limits of 6, 150 and 2 mg/kg respectively in all the workshops. One-way ANOVA at 95% confidence level revealed that there is no significant difference between the elements' concentrations in the workshops, $F(4, 45) = 0.088$, $P > 0.05$. This suggests that the elements' accumulation in the soil samples were from common sources, possibly the activities taking place in the metal workshops.

Keywords: Contamination, Potiskum, soil, toxic elements, metal workshop

INTRODUCTION

Soil is the main component of the lithosphere and a very vital layer of the earth. It is populated by various organisms ranging from tiny bacteria to higher plants, animals and human. It provides the means of physical support for all terrestrial organisms [1]. Soil is a composite mixture of organic and inorganic matter, with distinct constituents that determine its physical, chemical and biological properties. Soil is a major reservoir for substances as it is capable of binding various chemicals. These chemicals can occur in different forms in soil and are bound to the soil particles by different forces [2].

The properties of the soil may change due to climate change, but mostly due to anthropogenic impact.

Many metallic elements are toxic to the living organism and even those considered as essential can be toxic if present in excess. High levels of metals therefore can impair important biochemical process posing a threat to human health, plant growth and animal life [3]. It is evident that soil containing excess of these metals poses a serious threat to the safety of the human life, by accumulation in human body via direct inhalation, ingestion and dermal contact [4]. Most potentially toxic elements are non-degradable and their accumulation not only pollutes the surface environment but also contributes to both air and water pollution. In general, the presence of these metals in high concentrations in the environment results in various health hazards with varied symptoms depending on the nature and quantity of the metal [5].

It is evident that activities of workshops constitute a source of metal pollution [6]. Activities conducted in these workshops are typically metal fabrication, soldering and brazing which are essential in the production of virtually every manufactured product involving metal works [7]. These invariably involve working with solders, metal filings, and other materials that can increase the level of metals to bare soil.

Environmental pollution from industrial activities such as workshops has become a serious issue in the recent past especially due to their locations and types of activities carried out [8]. Studies revealed that the soil at the surroundings of metal workshops contain high level of metals that could serve as potential danger if enters the food chain which poses toxic and hazardous threats to both plant and animals in the environment [6].

Many workshops in Potiskum town, Yobe State, Nigeria, are located by the roadsides within residential areas where customers could easily have access to them. A very common trend of displaying and selling of foods and food items by the roadside hawkers among others exposes consumers to health hazards. Therefore, potentially toxic elements contamination assessment of soils around these workshops cannot be overestimated.

This study focuses on the assessment of some potentially toxic elements in soil around metal workshops in Potiskun town of Yobe State.

MATERIALS AND METHODS

The equipment used in this study include drying cabinet (model: FSM 140, humidity range: 20% to 60% RH), analytical balance (Model AB54, Mettler Toledo), digestion system (Model 2006 Digestor, Foss Tecator) and Atomic Absorption Spectrophotometer (Model:

PinAAcle 900H AA Spectrometer, PerkinElmer). All the reagents used in the study were of analytical grade. These include: concentrated nitric acid (HNO_3), hydrochloric acid (HCl) purchased from Merck KGaA, Germany.

Study Area

Potiskum town is the Headquarter of Potiskum Local Government Area of Yobe State, Nigeria. It is situated on the A3 highway (Maiduguri-Kano Road) at 11°43’N and 11°04’E. The town has a total population of 244,040 people with a population density of about 436.6 people per km [9]. The Local Government covers a land area of 559 km^2 [10] and is bounded by Nangera LGA to the North, Fune LGA to the east and south and Fika LGA to the west. The town has an annual rainfall range of 600-800 mm which falls within four to five months and the onset of rain varies from May to June and terminates around September to October [11].

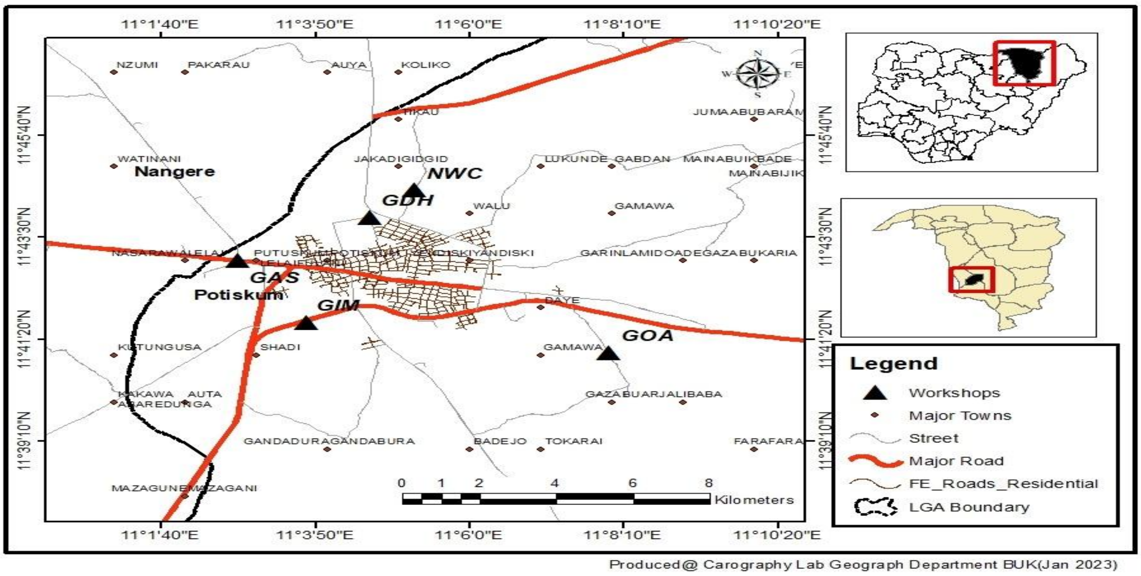

Fig. 1: Map of Potiskum town showing the Workshop sampling sites

Sample Collection

Composite soil samples were collected from five different workshops in Potiskum town (GOA, NWC, GDH, GAS and GIM) into polythene bags at a depth of 15 – 17.5 cm using plastic cups. The soil samples were ground to fine powder, sieved with 0.25 mm mesh sieve and dried in drying cabinet for 72 hours.

Sample Digestion

Analytical balance was used to weigh 5 g each of the finely powdered soil samples and transferred into digestive tube. Then 10 cm^3 of concentrated nitric acid and 5 cm^3 of concentrated hydrochloric acid were added into it. The digestive tubes were fixed on the tecator digestion system and digested for 40 minutes at 250 ^{o}C. The digested samples were allowed to cool for 30 minutes and 20 cm^3 of distilled water were added to it. The solution was filtered using Whatman no. 1 filter paper into the sample bottles and filled to 100 cm^3 marks with distilled water [12].

Sample Analysis

Concentrations of the elements in the samples were determined using atomic absorption spectrophotometer (Model: PinAAcle 900H AA Spectrometer). The instrument settings and operational conditions were in accordance with the manufacturer's specifications. The instrument was calibrated with the standard metal solutions prepared by diluting the concentrated stock metal solutions through which the metal concentrations were determined. Measurements were taken in triplicates and the mean concentrations were recorded [12].

Statistical Analysis

The data obtained were statistically analyzed to determine the significance of variations between the potentially toxic elements concentration of the soil samples from different workshops using one-way ANOVA (Analysis of variance) at 0.05 significance interval with SPSS software package (version 20).

RESULTS AND DISCUSSION

From Figure 2, the mean concentration of cadmium in the soil samples ranged between 0.30±0.0009 - 1.26±0.0011 mg/kg. The highest concentration was recorded in GIM soil sample with a mean concentration of 1.26±0.0011 mg/kg while the least was recorded in NWC soil sample (0.30±0.0009 mg/kg). Except for GIM soil sample, the concentrations of cadmium in all the other soil samples were below the maximum permissible limit of 0.8 mg/kg as reported by Iyama and Edori [13]. High level of cadmium in GIM soil sample may be due to long existing time of the workshop. The results of this study correspond with another study by Adu *et al.* [14] on assessment of soil heavy metal pollution by various allied artisans in automobile, welding workshop and petrol station in Lagos State, Nigeria, which reported 1.153±0.019 mg/kg as the highest cadmium concentration in the soil sample of workshops analyzed.

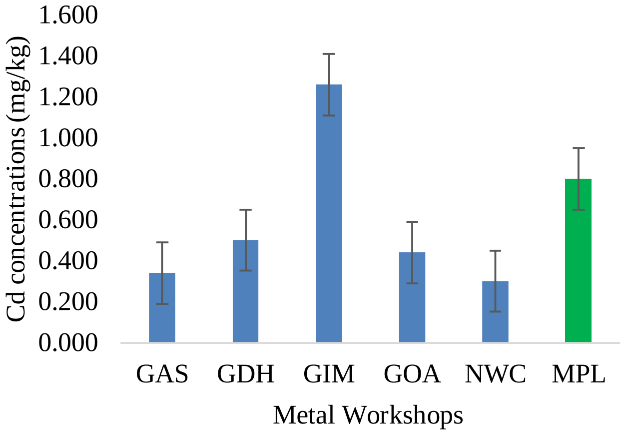

Fig. 2: Mean concentrations of Cd in the Workshops

The results in Figure 3 also revealed the concentration of cobalt in the soil samples of the workshops. From the results, GDH soil sample recorded the highest concentration of cobalt, 4.180±0.0050 mg/kg more than any other workshop. While the least, 2.460±0.0024 mg/kg, was determined in NWC soil samples. However, the cobalt concentrations of all the soil samples were below 10 mg/kg maximum permissible limit [15]. A study by Joseph *et al.* [16] titled 'Delineation of heavy metals in soils from auto-mechanic workshops within Okitipupa, Ondo State, Nigeria', also reported a similar finding. The study reported low levels of cobalt in the soil samples analyzed with highest concentration value of 0.12 mg/kg. According to the mean concentration of cobalt obtained in this study, it appears that the soils sample from the workshops pose no environmental threat for cobalt, but its substantial build-up needs to be monitored to prevent further contamination of the environment.

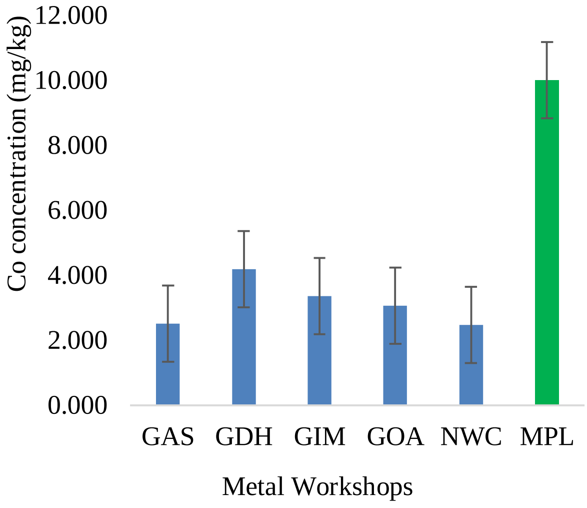

Fig. 3: Mean concentrations of Co in the Workshops

The concentration of chromium (Fig. 4) reveals that GDH soil sample has the highest chromium concentration of 113.76±0.0108 mg/kg among all the samples analyzed followed by GOA with 103.64±0.0327 mg/kg chromium concentration and lastly GIM, GAS and NWC having 86.90±0.0141, 57.64±0.0118 and 56.50±0.0197 mg/kg chromium concentration respectively. The findings revealed that GDH and GOA soil samples have an elevated level of chromium, above the maximum permissible limit of 100 mg/kg in soil as reported by Iyama and Edori [13], while soil samples from GIM, GAS and NWC workshops have chromium levels lower than the permissible limits. In contrast to the result obtained, another study on assessment of heavy metal contamination of soil around auto mechanic workshops in Anyigba, Kogi State reported a very low level of chromium in the soil samples ranging between 0.19–0.23 mg/kg with a mean value of 0.2125±0.017080 mg/kg [18]. However, the findings are in conformity with a study in Kaduna, Nigeria by Funtua *et al.* [18] which reported mean level of Cr in workshop soils ranged from 0.10 – 161.73 mg/kg at 5 – 10 cm depth. High levels of Cr in the soils could be due to the corrosion, wearing and degradation of automobile scraps, discarded plastic materials and empty paint containers [19].

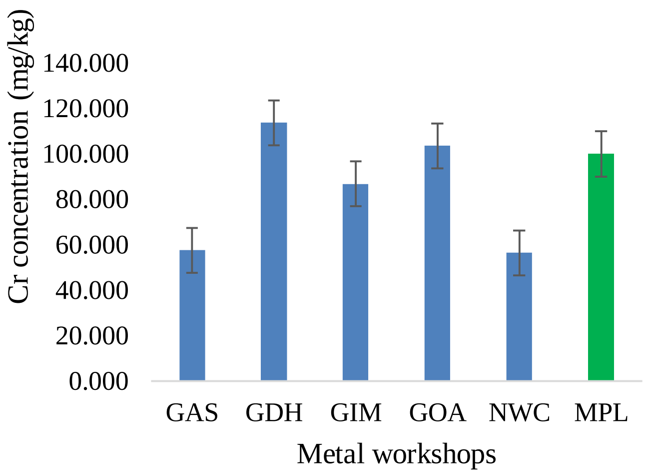

Fig. 4: Mean concentrations of Cr in the Workshops

The mean concentration of copper in the workshops as illustrated in Fig. 5 was within the range of 7.16±0.0004 – 52.50±0.0198 mg/kg. The highest concentration was obtained in GIM soil sample whereas GAS soil sample recorded the lowest. However, the copper concentrations of all the soil samples fall above the maximum permissible limit of 6 mg/kg [14]. A similar study by Pam *et al.* [20] reports an elevated level of copper with wide range of distribution (254.1 – 1,348.1 mg/kg) in soil samples surrounding auto mechanic workshop clusters in Gboko and Makurdi in Benue State, Nigeria. The elevated level of copper in the soil sample of the workshops could be ascribed to automobile wastes containing electrical and electronic parts and scraps, such as copper wires, pipes, electrodes and alloys from corroding vehicle scraps releasing metals that gradually leached into the soil [21].

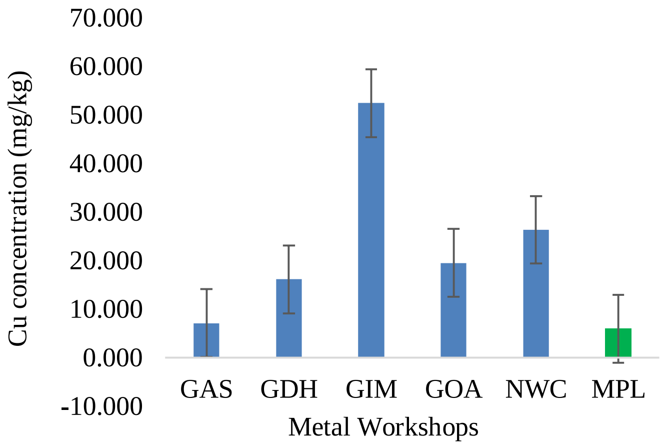

Fig. 5: Mean concentrations of Cu in the Workshops

Similarly, the results in Fig. 6 reveal the mean concentration of iron in the soil samples of the workshops. The highest mean concentration of iron, 330.40±0.0030 mg/kg was recorded by GDH soil sample. While the remaining soil samples from GOA, GIM, GAS and NWC workshops recorded 328.00±0.0150, 326.40±0.0160, 320.20±0.0050 and 317.40±0.0090 mg/kg respectively. The levels of iron in all the soil samples were above the maximum permissible limit of 150 mg/kg [22]. It could be seen that the workshops investigated nearly have the same elevated iron concentration. This may be attributed to rust of old vehicles bodies, welding and panel beating activities among others, which are all prominent activities of the sampled workshops. The elevation in the concentration of iron in the soil samples may also be from the wastes usually generated in workshops which include solvents, hydraulic fluid, spent lubricants, metal construction works, welding of metals and iron bending. The results correspond to a similar study by Joseph [16] which reported that iron has the highest mean concentration among all the metals studied in soils from auto-mechanic workshops within Okitipupa, Ondo State, Nigeria. The levels of iron obtained could also result from its natural abundance in the soil. High levels of iron in soils have been reported in various studies, confirming that natural soils contain significant levels of iron [23].

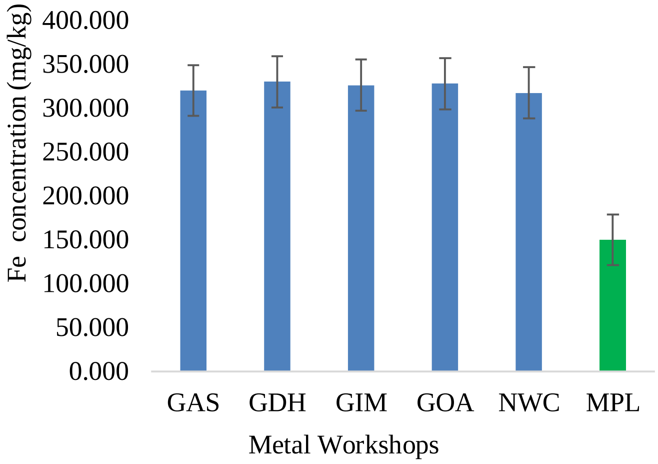

Fig. 6: Mean concentrations of Fe in the Workshops

The soil sample of GIM workshop contains the highest mean concentration of manganese (130.22±0.0184 mg/kg), while soil sample of GOA has the lowest (48.74±0.0040 mg/kg) as indicated in Fig. 7. The high level of manganese in GIM soil sample could also be due to the fact that the workshop was established before any of the other workshops under study, and therefore, have high tendency of accumulating contaminants resulting from the workshop activities in which manganese accumulation is not an exception. The levels of manganese in all the workshops analyzed fell below the maximum permissible limit (437 mg/kg) of manganese in standard soil [15]. This result is in conformity with a similar study by Pam *et al.* [20] which reported mean values of 58.76 mg/kg and 272.2 mg/kg of manganese in soil samples analyzed. Potential sources of manganese in workshop soil could be from discarded metal rails, used batteries, machinery parts and wastes from welding works and spray paintings of vehicles.

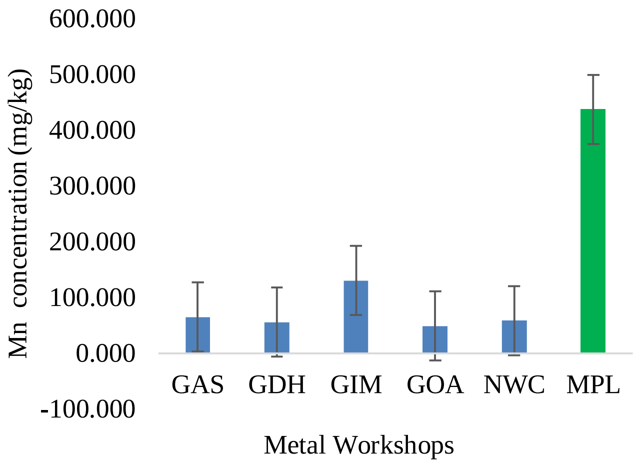

Fig. 7: Mean concentrations of Mn in the Workshops

The mean concentrations of nickel in the soil samples of the workshops shown in Fig. 8 were within the range of 4.98±0.0015 – 11.80±0.0059 mg/kg and are all below the maximum permissible limit of 35 mg/kg nickel concentration in soil [13]. The highest concentration was obtained in GDH soil sample while the least was found in NWC soil sample. The concentration of nickel obtained in the study is higher than 0.01 – 0.21 mg/kg and 2.000±0.001 mg/kg obtained by Joseph *et al.* [16] and Adu *et al.* [14] respectively. However, the results concurred with Ipeaiyeda *et al.* [24] which reported similar value of nickel concentration (11.5 mg/kg) in soil sample of auto repair workshop. Nickel concentration in soil may be increased by workshop activities such as wears from vehicle tyres, indiscriminate disposal of spent electrodes by welders and various paint wastes used by welders or from the diesel used in the automobiles and airborne particles emitted by brakes [25].

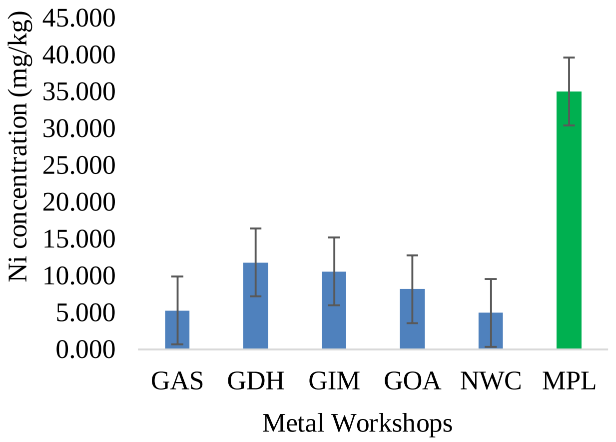

Fig. 8: Mean concentrations of Ni in the Workshops

Fig. 9 shows the result of lead concentration in the soil sample of the workshops. The results reveal that soil sample from GDH workshop recorded the highest mean concentration of lead (33.84±0.0052 mg/kg) and the lowest concentration (9.74±0.0144 mg/kg) was recorded by GAS workshop. Except soil sample from GAS workshop, lead concentrations found in all the soil samples from the workshops were above the maximum permissible limit of 10 mg/kg [15]. The elevated levels of lead in the soil samples of the workshops might be due to presence of automobile emissions, and expired motor batteries inappropriately dumped in the workshops**.** The elevated levels of the lead could also be from vehicle exhaust fumes containing some lead-rich aerosols. The use of tetraethyl lead as an anti-knocking agent in gasoline also results to its release during emissions from automobiles and fossil fuel combustion [25]. The results of the study correlate with a similar study by Abii [26] in Umuahia metropolis which reported 25.85-38.83 mg/kg as ranges of lead in abandoned mechanic workshops in Umuahia metropolis. However, the lead concentration obtained in the study is significantly lower than 1162 mg/kg obtained by Nwachukwu *et al.* [21].

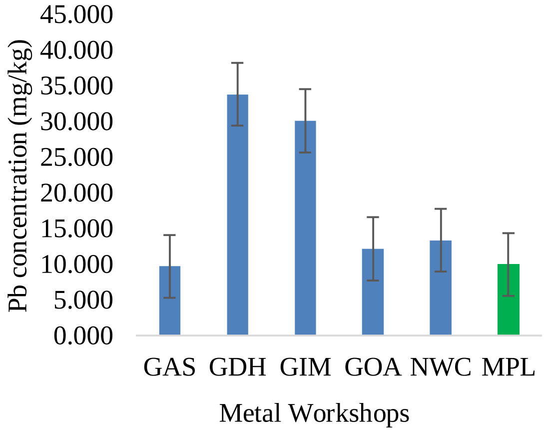

Fig. 9: Mean concentrations of Pb in the Workshops

Fig. 10 shows the level of selenium in the soil sample of the workshops. The mean selenium concentration ranged between 496.40±1.4600 – 910.00±2.9160 mg/kg. While the highest concentration was recorded by soil sample of GDH workshop, the lowest mean value was obtained in soil sample of NWC workshop. Except NWC, all the values were above the maximum permissible limit of 2 mg/kg. In contrast to this, a study by Bawwab *et al.* [15] reported 12.871 mg/kg as the highest level of selenium in soil samples of Al-Jiftlik, Palestine as well as another study by Oklo *et al.* [27] that reported selenium concentration within a range of 1.0 x 10^{-4} – 97.0 x 10^{-4} mg/kg in soils from selected sites within the lower Benue River basin development authority catchment, Nigeria. Soil contamination with selenium can be from its usage in photovoltaic photocells, light meters and solar, photoconductive industry and glass industry [15]. The high level of selenium in the soil samples of the workshops may not be limited to the activities of the workshops alone, but also to natural cause. Potiskum town is known to be naturally deposited with high amount of calcium salts (gypsum and limestone) making the soil calcareous. This may result into increased selenium level composition of the soil. Selenium in soils depends of the geological parent material, among other factors. It is known that sandy soils have lower selenium content compared to organic and calcareous soils [28, 29].

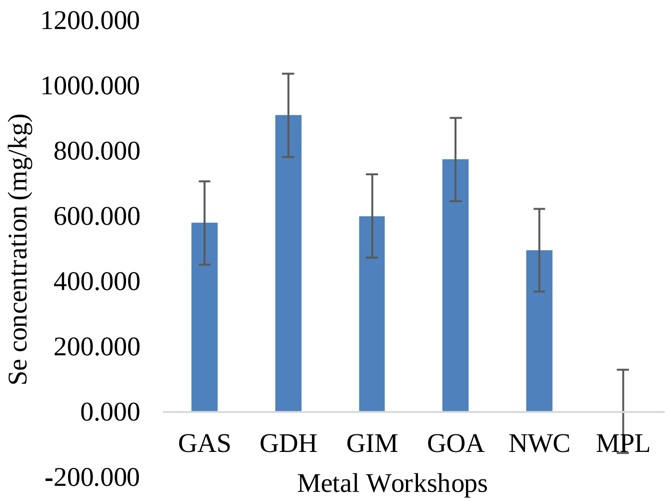

Fig. 10: Mean concentrations of Se in the Workshops

The mean concentrations of zinc in the soil samples of the workshops were shown in Fig. 11. The results revealed that soil samples from GIM and NWC workshops have the highest level (56.52±0.0235 mg/kg) and lowest level (20.52±0.0035 mg/kg) of zinc respectively. The results also revealed that while soil sample of GIM workshop has an elevated level of zinc above the maximum permissible limit of 50 mg/kg [13]**.** All other samples have zinc concentrations lower than the regulation limit. The elevated level of zinc in GIM could be ascribed to the age of the workshop. Being an old workshop, build-up of zinc in the soil to an elevated level due to the activities of the GIM workshop is most likely. Results in this study show lower concentrations than that of a similar study by Pam *et al.* [20] which reported a mean range of 295.5–553.3 mg/kg zinc concentration in all the soils analyzed. Workshop soil contamination by zinc may be due to the use of zinc in brake linings of vehicles because of its heat conducting properties and may be released during mechanical abrasion of vehicles and from combustion of engine oil and also from vehicle tyres [30].

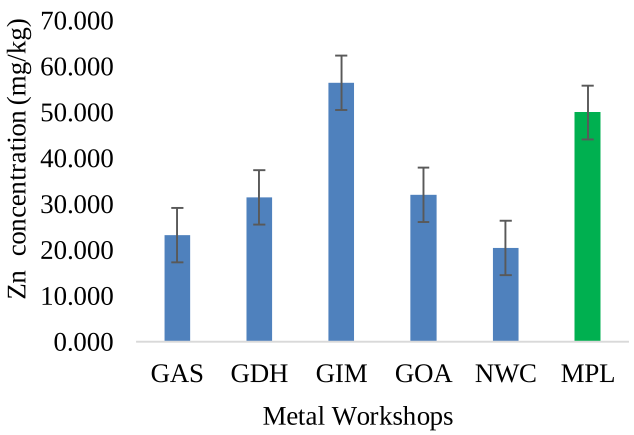

Fig. 11: Mean concentrations of Zn in the Workshops

Analysis of Variances (ANOVA)

The statistical analysis of the potentially toxic elements concentrations in the soil samples of the workshops revealed insignificant variation between the heavy metal concentrations in the workshops $F (4, 45) = 0.088$, $P>0.05$. This implies that the potentially toxic elements concentrations in the workshops are of the same origin and the contamination is emanating from the same source, possibly the activities of the workshops for being the anthropogenic sources the workshops have in common.

CONCLUSION

The levels of some potentially toxic elements in soil samples obtained from five different metal workshops in Potiskum town, Yobe State, Nigeria, were investigated with AAS. Based on the results obtained, the soil samples of all the workshops have Cu, Fe and Se levels above the maximum permissible limits. While Co, Mn and Ni levels obtained in all the workshop samples are below maximum permissible limits. Similarly, elevated levels of Cd and Zn above the standard were only recorded in GIM workshop soil samples as well as high levels of Cr in GDH and GOA workshops soil. Pb levels below the permissible limit was recorded in GAS soil samples only. One-way ANOVA at 95% confidence level revealed insignificant variations between the elements' concentrations in the workshops and thus, suggests that the elements' accumulation in the soil samples were from common sources, possibly the activities taking place in the metal workshops. It is therefore, recommended that periodic soil evaluation and treatment to help rid soils of the contamination should be considered and the various environmental agencies in Yobe State should provide soil treatment standard to help remedy the situation.

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