DETERMINATION OF SOME HEAVY METALS CONCENTRATIONS FROM TOP SOIL OF METALS SCRAP YARDS AND THEIR CORRESPONDING CONTROL AREAS WITHIN GOMBE METROPOLIS, GOMBE STATE, NIGERIA, USING ATOMIC ABSORPTION SPECTROMETRY

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ABSTRACT

The analysis of heavy metals in soil samples collected was done using Atomic Absorption Spectrometer (AAS) model: Buck-205. The soil samples were air-dried to remove the moisture content. One gram (1 g) each of the soil samples was weighed, and then digested with aqua regia a mixture of concentrated hydrochloric acid and concentrated nitric acid in ratio 3:1 with continuous addition until the solution became pale yellow. The mixture was heated slowly and steadily on a hot plate by using a fume chamber and evaporated to about 50ml, then colored solution appeared colorless, then samples were cooled and analysed. The concentrations of heavy metals determined are in ppm Mn (41.022±9.712), Mg (15.00±2.806), Cu (4.416±1.511), Pb (2.685±0.442), Cr (0.460±0.084), Cd (0.125±0.019) and Co (0.04), whereas, the concentrations of Ni was not detected in all samples. However the comparison of the concentrations of the trace elements (Mn> Mg > Cu >Pd> Cr > Cd > Co) in the study area have shown that the metal scrap yard has impact in the presence of trace elements in soil. Hence concentrations of the metals in the sampling locations were greater than those determined in their control areas.

Keyword: Heavy metals, Atomic Absorption Spectroscopy, Metals Scrap Yard.

INTRODUCTION

Industrialization in many parts of developing countries has led to increased generation of scrap materials. These are often dumped in parts of many cities along with heavy metals and other machineries, which may eventually damage the environment (Atiemo *et al.,* 2010; Adelekan and Abegunde, 2011) Heavy metals are serious pollutants because of their toxicity and non-degradability in the environment (Grzebisz *et al.,*2002). Consequently, they can be used as an index to determine environmental quality including soil and water (Alkhasham and Shawabkeh, 2006; Abolude *et al.,* 2009). Aaccording to (Xu and Tao, 2004), soils are usually regarded as the eventual sink for heavy metals discharged into the environment. Antropogenic actvities involving heavy metals, e.g. scrap recycling, may lead to an increase in their toxic levels due to bioaccumulation in environment, leading to metal poisoning in man, animals and plants (Audu and Lawal, 2005). The presence of Cadmium, Chromium and Copper in high proportion, indicate heavy metal concentrations. These metals are toxic and may cause severe problem with prolonged exposure. Ni is considered as a contaminant because some Ni compounds are carcinogenic and Ni can cause allergic skin reactions in some individuals (Defra, 2013).

However at certain level of contamination, heavy metal becomes dangerous to the health of the soil and plants in the environment. This may be due to pollution of topsoil by toxic metals such as lead and cadmium,from human activities within metal scrapyards leading to possible ingestion by the workers (Atiemo *et. al.,* 2010). Scrapyards are comprehensively sited in urban centers in Nigeria where all sort of scraps from disused automobiles, machineries, and electrical appliances are dismantled and reprocessed for further uses. Many of these scrap materials are full of contaminants that are toxic and have harmful environmental affects when not properly managed (Liu *et al.,* 2006).

Not much is identified about the scale of scrapyard soil contamination in Nigeria due to insufficient investigation, hence an assessment of the soils and water around scrapyards would help to determine the concentration of these heavy metals and how the risks they posed can be minimized in the interest of assurance public health and safety. Monitoring the accumulation of these metals in soil samples is very important and the practice of cultivating the land for planting vegetables and legumes by farmers around the dumpsites must be discouraged to prevent the transportation of these toxic metals

MATERIALS AND METHODS

Study Area

This study was carried out within Gombe metropolis, the capital of Gombe State, located on latitude $10^0$12'N and longitude $11^0$10'E, it is situated at elevation 460 meters above sea level (see Fig. 1). Gombe state shares common borders with Borno,Yobe, Taraba, Adamawa and Bauchi states, and has two distinct seasons, the dry season (November-March) and the rainy season (April-October) with an average rainfall of 850mm. It has an area of 52 km² and according to 2006 population census, and the current population is projected to be 453,739 using a growth rate of 3.2 % .

Sample Collection

Sixteen (16) soil samples (each with control area) were collected from top soil of eight different metals scrap yards and their respective control areas within Gombe metropolis. The locations of samples collected and their respective code are: TashanDukku (GM 1), Behind Tashan Bauchi (GM 2), Inside Tashan Bauchi (GM 3), TashanDadinKowa (GM 4), Tashan Bus - main market A (GM 5) Tashan Bus main market B (GM 6), Kasuwanmakera main market (GM 7) and Tsohowarkasuwa Bola jari (GM 8). Global position system (GPS) was used to determine the location of each sampling point. Their control points taken as GM 1C, GM 2C, GM 3C, GM 4C, GM 5C, GM 6C, GM 7C, and GM 8C, respectively. The samples was transferred into polyethylene bags and labeled for easy identification. The sample locations with later code shown in Table 1, of some metal scrap yard in Gombe metropolis.

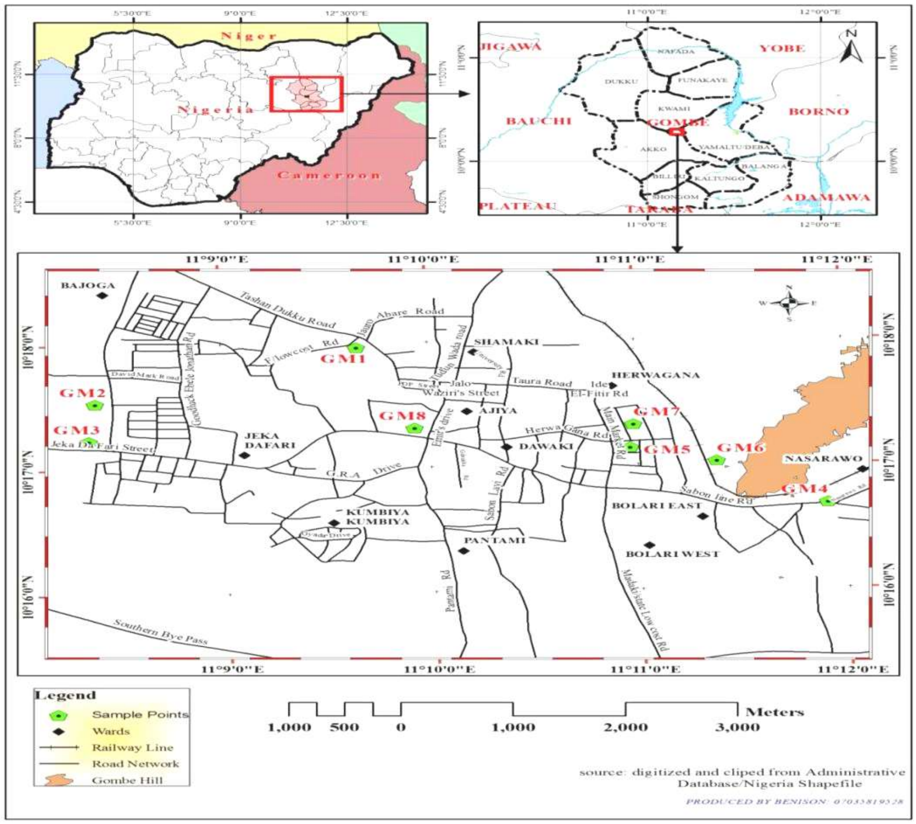


Figure 2: Map of Nigeria showing Gombe state and Gombe metropolis.

Table 1: Samples Locations and Codes

Station code	Name	Latitude	Longitude
GM1	TashanDukku	10.299	11.161
GM2	TashanBauchi (Behind)	10.297	11.155
GM3	TashanBauchi (Inside)	10.295	11.150
GM4	TashanDadinKowa	10.278	11.198
GM5	Main Market A	10.268	11.198
GM6	Main market B	10.279	11.194
GM7	KasuwanMakera	10.285	11.184
GM8	TsohowarKasuwa	10.286	11.180

Analysis of Heavy Metals

Analysis of heavy metals in soil from the samples collected was done using AAS machine (model Buck-205), at the department of biochemistry Gombe State University (G.S.U.) Gombe. Elements of interest are Cu, Cd, Cr, Co, Ni, Pb, Mg, and Mn, as measured and detected from the soil samples collected from the metal scrap yards within Gombe metropolis.

Sample Preparation, Digestion and Analysis

First, the soil samples were air-dried to remove the moisture content. One gram (1 g) each of the soil samples was weighed, and then digested with aquaregia, a mixture of concentrated hydrochloric acid and concentrated nitric acid in ratio 3:1 with continuous addition until the solution became pale yellow.

Digestion of reagent blank was also performed in parallel with the soil samples keeping all the digestion parameters the same without the samples. The mixture was heated slowly and steadily on a hot plate using a fume chamber and evaporated to about 50ml ensuring that the colored solution appears colorless. The samples were allowed to cool ready for analysis (Ogundele *et al.,* 2015). The digests were allowed to cool after which were filtered using Whatman filter paper and the volumes were made up 100 mL with distilled water, and finally the samples were then submitted for analysis of the Elemental Concentration (EC) of the heavy metals in all the samples (Cool and De-Vos, 2010).

Elemental Analysis

The concentration of Copper (Cu), Cadmium (Cd), Chromium (Cr), Cobalt (Co), Nickel (Ni), Lead (Pb), Magnesium (Mg) and Manganese (Mn) were determined using Buck Scientific Atomic Absorption spectrophotometer (AAS) Model 205 at Biochemistry Laboratory of Gombe State University (Ogundele *et al.,* 2015).

The EC gives the concentration in mg/kg of each trace element in the study area for the sixteen composite samples collected.

The EC can be calculated using the following relations (Abolude, *et al*., 2009)

$$EC = \frac{Instrumentreading(mg/kg) – Blank(mg/kg) x finalvolumeprepared(ml)}{Weightofthesample(g)} \quad (5.0)$$

RESULTS

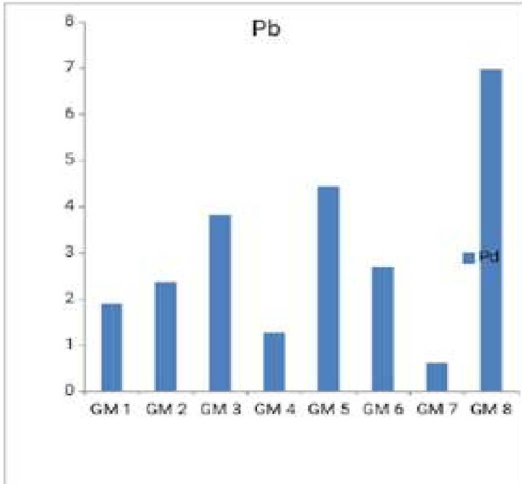
Analysis involving AAS has been effectively used in determining the heavy metal presence in the surface soil in all the eight samples and their corresponding control points from the study area.

The results obtained from the soil samples showed presence of Copper (Cu), Cadmium (Cd), Cobalt (Co), Chromium (Cr), Nickel (Ni) Manganese (Mn), Lead (Pb) and Magnesium (Mg) for all the samples at surface soil. Their elemental concentrations are given in table 2, whereas, Pb and Mn concentrations comparison was presented in figure 3 and 4 respectively.

Table 2: Elemental concentration (EC) of trace element in soil samples

Sample Codes	**Concentrations (ppm)**							
	Cu	**Cd**	**Cr**	**Co**	**Ni**	**Pb**	**Mg**	**Mn**
GM 1	0.28	N.D	N.D	N.D	N.D	1.90	15.33	19.83
GM 2	3.13	N.D	0.04	N.D	N.D	2.38	17.78	29.26
GM 3	0.37	N.D	N.D	N.D	N.D	3.81	9.20	21.34
GM 4	1.80	N.D	0.58	N.D	N.D	1.27	32.47	113.23
GM 5	19.32	0.20	1.01	0.02	N.D	4.44	27.37	**138.15**
GM 6	1.95	0.05	0.47	N.D	N.D	2.70	28.39	69.45
GM 7	2.05	N.D	0.20	N.D	N.D	0.63	25.33	72.09
GM 8	6.43	N.D	N.D	N.D	N.D	6.98	28.18	87.00
GM 1 C	N.D	N.D	N.D	N.D	N.D	1.42	N.D	9.07
GM 2 C	N.D	N.D	N.D	N.D	N.D	N.D	N.D	**2.66**
GM 3 C	N.D	N.D	N.D	N.D	N.D	N.D	N.D	8.51
GM 4 C	N.D	N.D	N.D	N.D	N.D	1.75	13.90	43.23
GM 5 C	N.D	N.D	N.D	N.D	N.D	N.D	1.67	15.68
GM 6 C	N.D	N.D	N.D	N.D	N.D	N.D	0.84	3.98
GM 7 C	N.D	N.D	N.D	0.02	N.D	N.D	2.67	11.34
GM 8 C	N.D	N.D	N.D	N.D	N.D	N.D	2.47	11.53

C = control points/ location and ND – Not Detected.



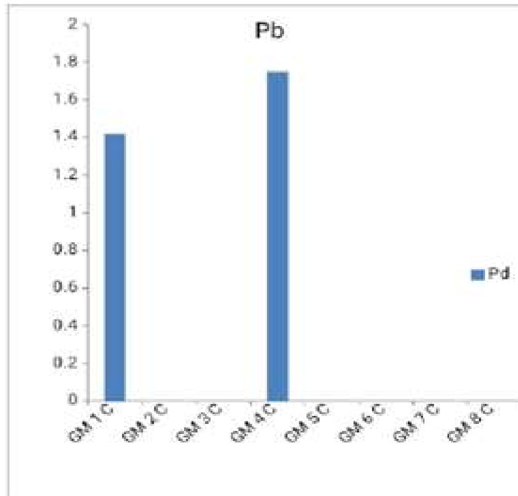
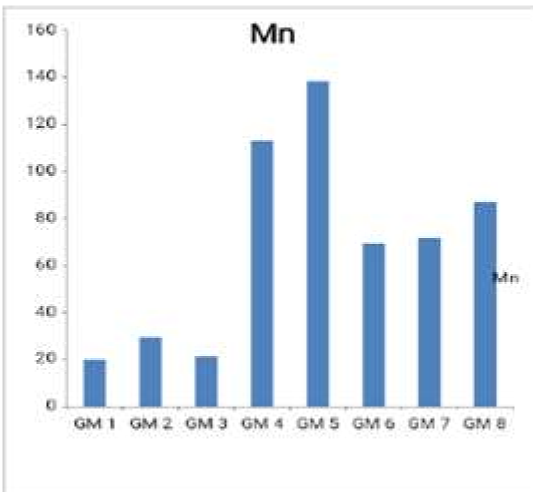


Figure 3a and b: Comparison of concentrations of Pb in the metal scrap yard and its control point.



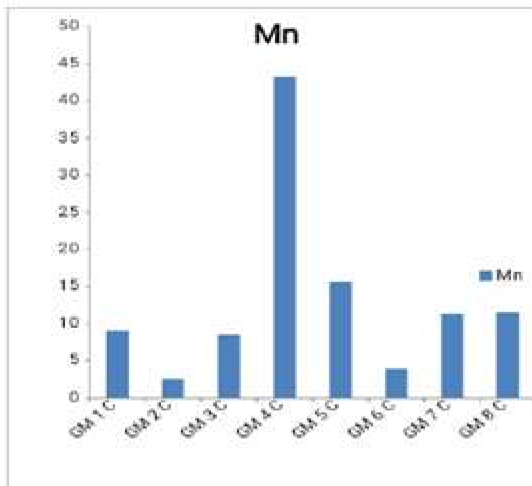


Figure 4a and b: Comparison of Concentrations of Mn in the metal scrap yard and it's control point.

Table 3: Statistical summary showing Mean, Range and Mean ± SD of concentrations of trace element in soil samples

Elements	n	Mean	Range	Mean ± SD
Cu	8	4.416	0.28 - 19.32	4.416±1.511
Cd	2	0.125	0.20 - 0.05	0.125±0.019
Co	2	0.040	0.000	0.04
Cr	5	0.460	0.04 - 1.01	0.460±0.084
Ni	BDL	BDL	BDL	BDL
Mn	16	41.022	2.66 - 138.15	41.022±9.712
Pb	10	2.685	0.63 - 6.98	2.685±0.442
Mg	13	15.815	0.84 - 32.47	15.815±2.806

BDL = Below Detection Level

DISCUSSION

Manganese toxicity is more common on very acidic soil. It can be toxic in its own right but excess manganese can also cause iron deficiency (Wade, 2019). The above findings indicate that manganese (Mn) is present in all the samples from the main and control location, as shown from the following from Fig. 4 a and 4 b. The highest and lowest values for this element were observed at locations GM 5 and GM 2C, at 138.15 ppm and 2.66 ppm, respectively. The high concentration at GM 5 (Main market A), may not be unconnected with high volume of metal scrap activities in the area. The yard is the largest in Gombe metropolis and such activities has been going on for many years. Manganese can enter the environment in atmospheric deposition from the exhaust emissions of vehicles running on lead replacement petrol (Ross *et al.,* 2007). It can also be released from industrial processes such as the manufacture of engineering steels and electrical storage batteries. For this reason, the concentrations at the control areas are less than those from the main sample locations. Consequently, Mn is generally present in soils in higher concentrations than other trace elements apart from iron (Defra, 2013).

Nickel was not detected at all the sixteen (16) locations because it is strongly absorbed by organic matter and is likely to be concentrated only in coal and oil (Defra, 2013) and consequently, absent in all the samples. In contrast, Cu is detected in all the eight main locations, but absents at all the control areas, indicating the presence of scrap activities at the main locations.

All the elements (Cu, Cd, Cr, Co, Ni, Pb, Mg, Mn) were detected at GM 5 (main market A). Results of metals concentrations from GM 5 are elevated compared with other locations. This is because the scrap yard location (GM 5) is a high activity area, involving supply, storage, processing, and distribution of all sorts of scrap materials from within and outside Gombe metropolis, and therefore contains a lot of metal deposit on the soil surface. In fact, the highest values for all the elements were detected at the main market A (GM 5) and apart from Mn, only two elements were detected at both the scrap yards and control areas. These are Pb at GM 1 at 1.90 ppm and 1.42 ppm for the yard and control areas, respectively. The other element is Mg at GM 4 (32.47, 13.90), GM 5 (27.37, 1.67), GM 6 (28.39, 0.84), GM 7 (25.33, 2.67), and GM 8 (28.18, 2.47), for the yard and control, respectively (table 2 above). Figure (3a and b) and Figure (4a and b) shows the concentrations of the elements Pb and Mn, both at the yards and control points, respectively.

Table 3 above showed the statistical summary of elemental concentration in the study area. The mean elemental concentration is in the order of Mn> Mg > Cu >Pd> Cr> Cd > Co > Ni with lowest and high mean values of 0.000 (ppm) and 41.022 (ppm) from Ni and Mn, respectively. The lowest and highest concentration from all the elements at all the sixteen locations is from Co and Mn at 0.040 ppm and 41.022 ppm, respectively. Ni was not detected at all the areas studied.

CONCLUSION

A study was conducted to determine the concentrations of heavy metals from top soil in a metal scrap yards within Gombe metropolis using AAS. Results obtained indicates the presence of the following metals, i.e.Mn Mg Cu Pb Cr Cd and Co whereas, the concentrations of Ni was not detected in all samples. The mean elemental concentrations of the elements in the study area is in the following order Mn> Mg > Cu >Pd> Cr > Cd > Co. The study also showed that a metal activity within the scrap yards, to a large extent, has impact on the presence of heavy elements in soil. This is evident by the higher concentrations of these metals in the sampling locations relative to those determined in the control areas. The higher concentration observed at GM 5 (Main market A - Bola Jari) is due to high volume of scrap metal activity for over three decades. The people involved in the scrap metal business are in daily contact with the soil. These metals accumulate in the soil and after some time, may pose a serious health hazard to the people engaged in the scrap activities. Consequently, this study believes there is a crucial need to ensure adequate information on the heavy element concentration of top soil at a depth of 10 cm at these scrap yard.

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