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Impact of Metals Scrap Yard on the Presence of some Heavy Metals Concentration within Gombe Metropolis, Gombe State, Nigeria, using Atomic Absorption Spectrometry

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ABSTRACT

The Metal scrap yards play a crucial role in the recycling and reuse of metals, contributing significantly to the economy and conservation of natural resources. However, the processing and storage of metal scraps can lead to the release of heavy metals such as lead, chromium and cadmium, into the environment. The presence of heavy metals in metal scrap yards poses a significant risk to nearby communities, workers and the environment, also causing air and water pollution, soil contamination, and health problem. Study of impact of metals scrap yard on the presence some of some heavy metals in soil samples was done using Atomic Absorption Spectrometer (AAS). Top soil sample were collected from eight metals scrap yards and their corresponding control areas. One gram (1 g) each of the soil samples was digested and then heated slowly and steadily, the solution appears colorless. The samples were allowed to cool and ready for analysis. The result obtained was, the mean elemental concentration element was of the order ofMn (41.022±41.202)> Cu (4.416±4.274) >Pb (2.685±1.399) > Mg (0.500±10.122) > Cr (0.460±0.187) > Cd (0.125±0.027) > Co (0.04±0.000)> Ni (0.000±0.000). The comparison of the elemental concentration of the heavy metals of (Mn, Mg, Cu, Pd, Cr, Cd, Co and Ni) in the study area ware shows the metal scrap yard has impact in the presence of heavy metals in soil. In addition, the Contamination factor (CF), and Pollution load index (PLI) of each trace element in soil of the study area and their respective control area were all < 1 which implies that they all have low contamination factors, less polluted and low contaminated.

Keywords:
Heavy metals,
Atomic Absorption,
Spectroscopy,
Metals Scrap Yard,
Soil Sample.

INTRODUCTION

Companies in varied parts of growing nations of the world have led to enlarged production of scrap materials which areoften dumped in parts of town centers where heavy metals and other machineries are leaked into the environment resulting tospoil the environment. Heavy metals are serious pollutants because of their toxicity, determination and non-degradability in the environment. (Grzebisz and Potarzyck, 2002), They can be used as an index to resolveecologicalvalue including soil and water (Alkhasham and Shawabkeh, 2006) and soils are regularly regarded as the eventual sink for heavy metals discharged into the surroundings (Xu and Tao, 2004).

Heavy metal becomes harmful to the health of the soil and plants in the site. They are derives from anthropogenic sources and can contaminate the topsoil and water, and particularly within the metals scrap yards and workshops, releasing toxic, metals such as lead and cadmium (Atiem, 2010). Although heavy metals concentration and movement in environmental media such as the soil and water bodies are healthy acknowledged for a number of places of developed countries, there is a shortage of information for the majority developing countries (Huu, 2010). For example, in Nigeria, little care had being paid to measures in metal scrap yards, which are accountable to contamination arising from release of heavy metals and other poisonous substances. Scrap yards are usually sited in city centers in Nigeria where all kind of scraps from disused automobiles, machineries, and electrical appliances are dismantled and recycled for further uses (Chang, 1983). Several of these scrap materials are full of contaminants that are toxic and have harmful environmental affects while not correctly managed (Geoderma, 2006). Scrapyards are also related with emission of flammable, asphyxiant or negative gases and likely existence of radioactive materials. Surface overflow from scrap yards may present a risk of pollution of water particularly the surface watercourses and groundwater sources.

Measures within the scrap yards such as the dismantling of motor vehicles, machinery, metal cleaning, arrangement and retrieval generally for non-ferrous metal, poses potential health risk due to occurrence of toxic substances, which may affect human health, plant growth and animal existence (Atiemo, 2010). Soil, being a hard absorbent material recollects and transports harmful contaminants such as Cd, Co, Cu, Ni, Pb, and Zn into equally nearby surface and groundwater making residents in such region straight susceptible health risks (Bridgen, 2008). Studies have revealed that groundwater in the neighborhoods of scrap yards controlled one or more of these heavy metals (Momudu and Anyakora, 2010). Concern for heavy metals in soils is directly associated to their relations surrounded by all the systems throughout the food chain as soil heavy metals conformation may influence intake by plants, which may eventually the level of concentration in animals and humans (Ekosse, 2005). Not much is recognized regarding the scale of scrap yard soil contamination in Nigeria due to insufficient research, therefore a measurement of the soils and water around scrap yards would help to determine the concentration of these heavy metals and how the risks they posed can be minimized in the interest of assurance community health and protection.

Cadmium, Chromium and Copper can be toxic and their occurrence in high amount in a substance specifies heavy metal concentrations due to their accumulation in soil. Consequently the cultivation of land for planting of vegetables and legumes by farmers around scrap metal dumpsites is discouraged to avoid the relocate of these toxic metals in to individual system.

Contamination due to solid west has been of concern to authorities in Nigeria. When such wastes are not correctly managed, they can cause a serious threat to the well-being of town and its people due to potential poisoning of the water, food sources, land, air and plants (Njoroge, 2007) and(Porteous, 1985). It is as a result, vital to study the accumulation of these metals from chosen sites of metal scrap yards in Gombe metro polis, Gombe state Nigeria, with view to determine the impact of the metals scrap yards in the present of these trace elements, their concentration level and risk hazard to the people working in the environments.

Study Area

The study area is Gombe metropolis, the capital of Gombe State, located on latitude $10^0$12'N and longitude $11^0$10'E, it is located at elevation 460 meters above sea level, make it largest city in Gombe state, with area of 52 km². The state has two different seasons, the dry season (November-March) and the rainy season (April-October) with an usual rainfall of 850mm and according to 2006 population census, and the current population is expected to be 453,739 using a growth rate of 3.2 % (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 % (National Population Commission, 2006)

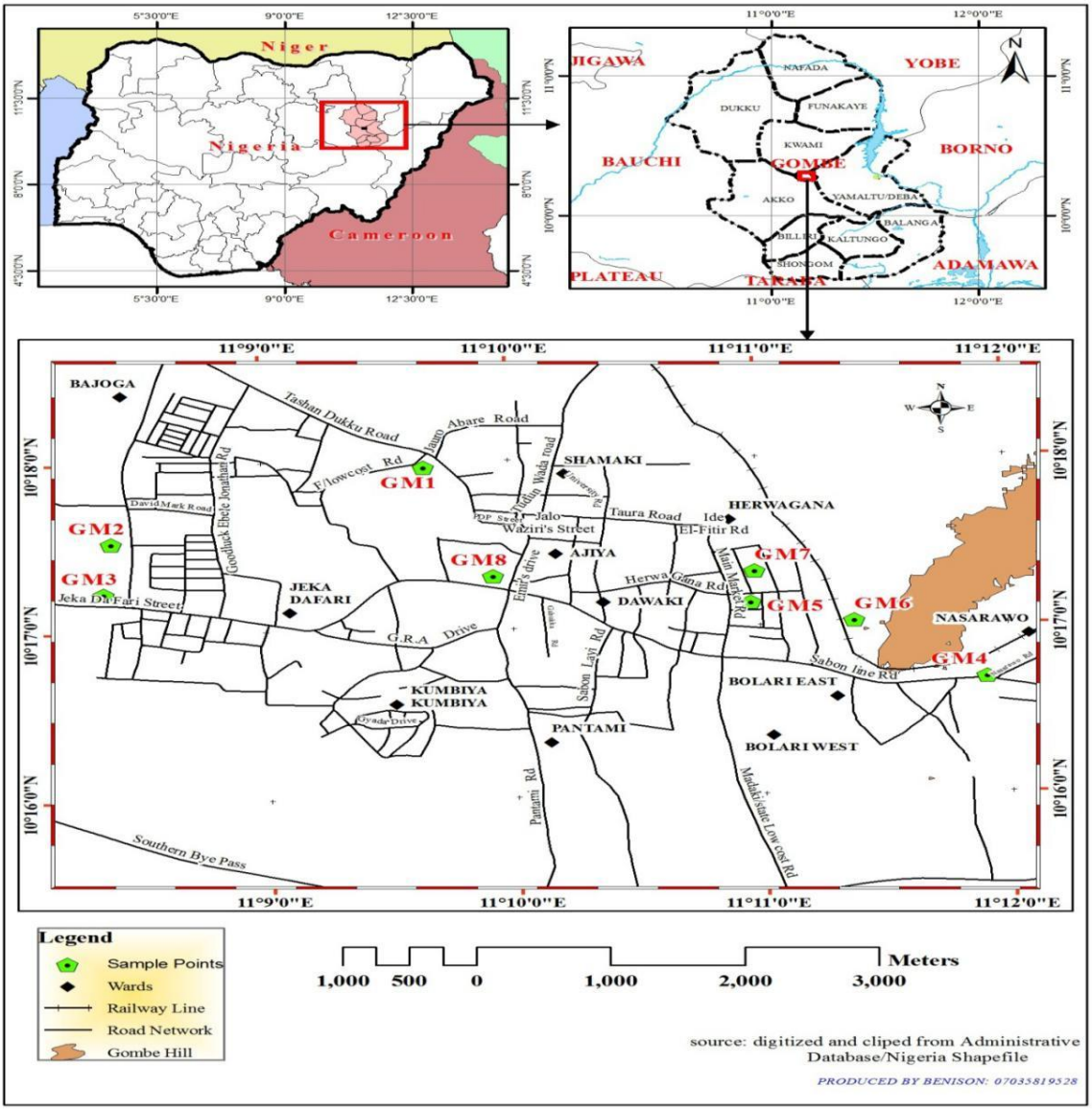

Figure 1: Map of Nigeria showing Gombe state and Gombe metropolis.

MATERIALS AND METHODS

Atomic Absorption Spectroscopy (AAS) was used in this study because of accessibility, high specificity an easy sample preparation, ease of operation and low detection limits. ASS technique involving the absorption by free atoms of an element of light at a wavelength specific to that element, or put more simply, it is a means by which the concentration of metals can be measured, the energy and wavelength is described by the Planck equation (Njoroge, 2007).

$$E_1 - E_0 = h\nu = \frac{hc}{\lambda} \quad (1)$$

where $E_1 - E_0$ is the energy difference between the two levels (and $E_1 > E_0$); h is Planck's constant, 6.624×10^{-34} Js^{-1}; ν is the frequency of the radiation; c is the velocity of light in a vacuum, 2.9979×10^8 ms^{-1}, and λ is the wavelength of the radiation in meters.

When a sample or sample solution is burned in a flame or heated in a tube, the individual atoms of the sample are released to form a cloud inside the flame or tube. Atoms in the cloud move at high speed and collide with each other, and absorb over a very narrow range of wavelengths. The width of a typical absorption line is about 0.001nm. For atomic absorption instrument purposes, an emission source with an emission line of the same frequency and a width of about 0.001nm is normally used. This requirement is satisfied by an emission spectrum of the element of interest, generated by a hollow cathode lamp (HCL) or electrode less discharge lamp (EDL).

Sample collection

Sixteen (16) soil samples were collected from top soil of eight different metals scrap yards and their respective control are in Gombe metro Polis head quarter of Gombe State, Nigeria such as GM-1 Tashan Dukku, GM-2 Behind TashanBauchi, GM-3 inside TashanBauchi, GM-4 Tashan DadinKowa GM-5 Tashan Bus main market A GM-6 Tashan Bus main market B and GM-7 Makera main market and GM-8 Tsohowarkasuwa bola jari. Global position system (GPS) was used to determine the location of each sampling point. 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.

Table 1: Sample codes, name and co-ordinates

STATION CODE	NAME	LATITUDE	LONGITUDE
GM1	TashanDukku	10.299	11.161
GM2	Behind TashanBauchi	10.297	11.155
GM3	TashanBauchi	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

Sample Preparation

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 digests were allowed to cool after which were filtered using Whatman filter paper and the volumes were made up 100 mL with distilled water. Digestion of reagent blank was also performed in parallel with the soil samples keeping all the digestion parameters the same without the samples. The samples were then submitted for heavy metals analysis. (Cools and DeVos, 2010).

Sample Digestion

A volume of 100ml of the sample was measured using a 100ml volumetric flask and put in a conical flask and 20ml of aqua raga, a concentrated solution of nitric acid (HNO_3) and hydrochloric acid (HCl) in a ratio 1:3 was then added. 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 Ogundel et al. (2015).

Sample Analysis

Analysis of heavy metals in soil samples collected was done using Atomic Absorption Spectrophotometer (AAS) model: Buck-205 from the department of biochemistry Gombe State University (G.S.U.) Gombe, Hydrochloric acid (HNO_3), Nitric acid (HCl), Analytical balance, Kjeldahl heating mantle, Whatman filter paper, Funnel, 300 mL Kjeldahl flasks, sample containers (Cools & 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 AAS. (Ogundele *et al.*,2015).

Elemental Concentration (EC)

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

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

$$EC = \frac{\text{Instrument reading (mg/kg) – Blank (mg/kg) x final volume prepared (ml)}}{Weight\ of\ the\ sample\ (g)} \quad (2)$$

Contamination Factor (CF)

The contamination factor (CF) is a pointing factor to the contamination level of trace element in the soil samples. It is calculated using the mathematical expression in the following equation (3):

$$CF = \left(\frac{C_x}{C_r}\right)_{sample} \quad (3)$$

Where $C_x$isthe mean concentration of elements from sampling sites in the study area and *Cr* is the concentration of the examined element in the reference environment (Odat, 2015).The CF values are classified as:

- Low contamination factor (CF < 1)
- Moderate contamination factor (1≤ CF < 3)
- Considerable contamination factor (3 ≤ CF< 6)
- Very high contamination factor (6 ≤ CF) Rahman,et al. (2012).

Pollution load index (PLI)

The Pollution Load Index (PLI) is obtained as concentration Factors (CF). The PLI of the study area were calculated by obtaining the n-root from the n- CFs that was obtained for all the metals. A PLI value> 1 is polluted, while value of<1 indicates no pollution Harikumar et al. (2009). In General Pollution Load Index (PLI) was developed by (Tomlinson et al., 1980) is given by the following equation (Tomlinson et al., 1980).

$$PLI = \sqrt[n]{CFIxCF2\ xCF3 \ldots x \ldots CFn} \quad (4)$$

Where, CF=Contamination Factor; n=Number of Metals; C Metal=Metal Concentration in Polluted Sediments; C = Background value of that Metal.

Geo-Accumulation Index (I_{geo})

Geo-accumulation index (I_{geo}) values permit the assessment of degree of soil contamination with respect to global standards. I-geo is calculated from equation (5)

$$I_{geo} = \log_2 \left(\frac{Cn}{Bn \times 1.5}\right) \quad (5)$$

where, Cn is measured total concentration of the examined element 'n' in the studied soil, Bn is average shale geochemical surrounding value for concentration of the trace elements and 1.5 is the factor compensate for the surrounding data (correction factor) due to lithogenic effect Golekar, et al. (2013). The geochemical background concentrations values of trace elements in soil are the average concentration of the elements in the shale (Turekian and Wedepohl, 1961).

The I_{geo} values are classified as:

- Uncontaminated ($I_{geo} \leq 0$)
- Uncontaminated to moderately contaminated ($0 < Igeo \leq 1$)
- Moderately contaminated ($1 < I_{geo} \leq 2$),
- Moderately to heavily contaminated ($2 < I_{geo} \leq 3$)
- Heavily contaminated ($3 < I_{geo} \leq 4$)
- Heavily to extremely contaminated ($4 < I_{geo} \leq 5$)
- Extremely contaminated ($I_{geo} \geq 5$) respectively Rahman,et al. (2012)

RESULTS AND DISCUSSION

An Atomic Absorption Spectroscopy (AAS) analysis has been effectively used in determining the trace elements presence in the surface soil of the eight metal scrap yard and their corresponding control points in Gombe metropolis using AAS Buck scientific 205. The sites at which the samples were collected has been named and coded as indicated in the Table 2 below. Also table 3 below shows the elemental concentrations of the elements as measured from the all soil samples, the result 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.

Table 2: The samples locations with their corresponding codes

Location	Sample Codes
Dukku Motor Park (tashanDukku) GM 1	
Behind Bauchi Motor Park	GM 2
Inside Behind Bauchi Motor Park	GM 3
Dadinkow Motor Park	GM 4
Gombe new market bus Motor Park A	GM 5
Gombe new market bus Motor Park B	GM 6
MakeraGombe new market	GM 7
Gombe old market bola jari	GM 8
Control points/location (C)	
Dukku Motor Park (TashanDukku)	GM 1 C
Behind Bauchi Motor Park	GM 2 C
Inside Behind Bauchi Motor Park	GM 3 C
Dadinkowa Motor Park	GM 4 C
Gombe new market bus Motor Park A	GM 5 C
Gombe new market bus Motor Park B	GM 6 C
MakeraGombe new market	GM 7 C
Gombe old market bola jari	GM 8 C

C = control points/ location

Table 3: 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

ND – Not Detected

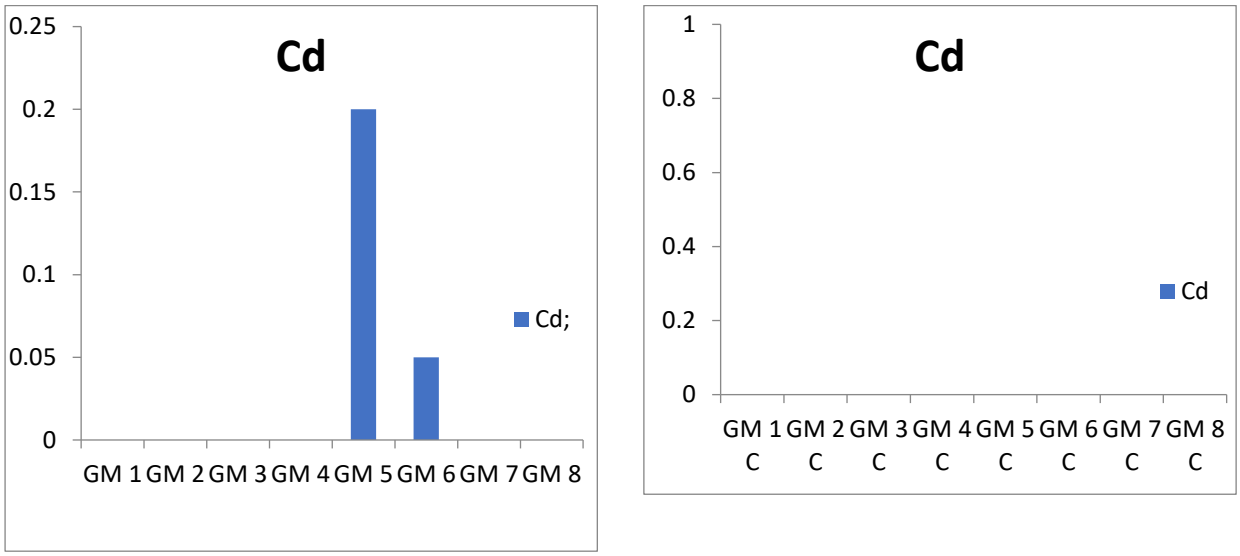

Figure 2a and b: Comparison of Concentrations of Cadmium in the metal scrap yard and it corresponding control point.

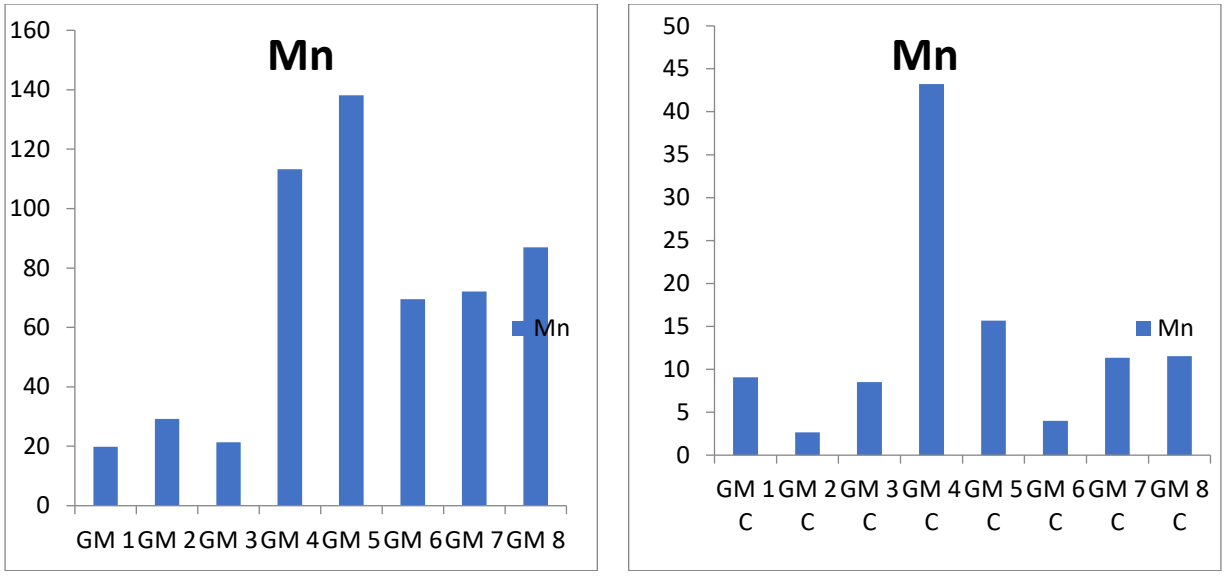

Figure 3a and b: Comparison of Concentrations of Manganese in the metal scrap yard and it corresponding control point.

Table 4 below shows 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. And figure 2 and 3 showed the impact of metals scrap yard in the presence of heavy metals

Table 4: 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	19.040	4.416±1.511
Cd	2	0.125	0.150	0.125±0.019
Co	2	0.040	0.000	0.04
Cr	5	0.460	0.970	0.460±0.084
Ni	BDL	BDL	BDL	BDL
Mn	18	41.022	135.490	41.022±9.712
Pb	10	2.685	5.710	2.685±0.442
Mg	13	15.815	27.550	15.000±2.806

BDL= Below Detection Level

CONCLUSION

According to the Atomic Absorption Spectroscopy (AAS) outcome of this study, the research showed that, the presence scrap metals have significant on the concentrations of heavy metals, the heavy metals concentration in Gombe metropolis determined 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. On the other hand the evaluation of the concentrations of the heavy metals (Mn> Mg> Cu>Pd> Cr> Cd> Co) in the study area have shown that the scrap metals have impact on the presence of heavy metals in soil. Hence concentrations of the metals in the sampling location were larger than those determined in the control area. As of the analysis, it was notice that there is the essential need to have adequate information on the heavy metals concentration of top soil of metal scrap yard, since it has impact on heavy metals concentration due to the presence and duration of the scrap metals at the location. This would assist people implicated in this trade, since of the potential health hazards/risk they are out to.

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