Assessment of heavy metals concentration in soil of waste disposal sites in Dutse metropolis

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Abstract

The study was conducted to assess the impact of solid waste disposal on soil quality in Dutse metropolis, with the aim of determining the trend, sources, and distribution of heavy metals such as Cd, Hg, Cu, Zn and Cr. Top soil (0-15cm) samples were collected from five different points within the dumpsites. Which were later analyzed using nitric acid (HNO3) and hydrochloric acid (HCl) at relatively low temperature in the laboratory. The concentrations of the heavy metals detected in the soil ranged from 1.39 ppm to 118.52 ppm which indicated the potential of the ground water being contaminated by leachates. Furthermore, this research reveals that there is heavy metals contamination in the study area, and these metals were detected in different concentrations. This could be attributed to continuous usage of products containing these metals nearby populace and disposal of carrier wastes by the sellers of different items within Dutse town. The higher concentration of Cd could be associated with content of Cd in the soil of the sampling sites and is due to discarding materials containing some content of it. High lead level on the other hand was due to the use of leaded batteries and renovation paints. Cr, Fe and showed no concentrations accounting for no usage and disposal of carrier materials. In general, the area is at potential risk of severe heavy metals pollution requiring immediate action.

1. INTRODUCTION

Solid waste is used to describe non-liquid waste material arising from domestic, trade, commercial and public services. It comprises of countless different materials. Dust, Food wastes, packaging in form of paper, metal, plastics or glass, discarded cloths, garden wastes, pathological waste, hazardous waste & radioactive waste [1,2]. The properties of Solid waste produced differ in different countries. The organic matter in solid waste in developing countries is much higher than that in the waste in developed countries [3]. But the waste characteristics change slightly with respect to different geographical regions and seasons. However, the influence of seasonal variation is insignificant [4]. The organic content of this waste can be converted easily to bio-manure and other useful products. Studies have been done on anaerobic digestion (Ostrem*et al*, 2004), Biomethanation [5,6] and composting [7] as suitable methods.

The soil has traditionally been an important medium for organic waste disposal [8]. Within some limits, such wastes enhance soil fertility and can improve the physical properties of soils. When waste management is properly carried out and carefully monitored to supply the crop fertilizer needs for urban farmers, it reduces their cost of production. However, lack of effective waste management in overcrowded modern cities can have substantial negative effects that include the fetid waterways emitting stench from sewage, spreading diseases and harboring vehicles that spew leaded exhaust into dust filled air [9]. The excessive input of unsorted municipal household wastes may likely lead to changes in soil physical and chemical characteristics.

Nearly all human activities generate waste, and the way in which this is handled, stored, collected and disposed of, can pose risks to the environment and to public health. Different sources such as electronic goods, painting waste, used batteries, and many others when dumped with municipal solid wastes raise the heavy metals in dumpsites and dumping devoid of the separation of hazardous waste can further elevate noxious environmental effects. Environmental impact of land filling of MSW can usually result from the run-off of the toxic compounds into surface water and groundwater which eventually lead to water pollution as a result of percolation of leachate [10,11]. Inadequate disposal of municipal solid waste and the increasing spatial and demographic growth constitute a great environmental challenge in many African cities. Solid waste handling and disposal is a major environmental problem in many urban centers in Nigeria [12, 13].

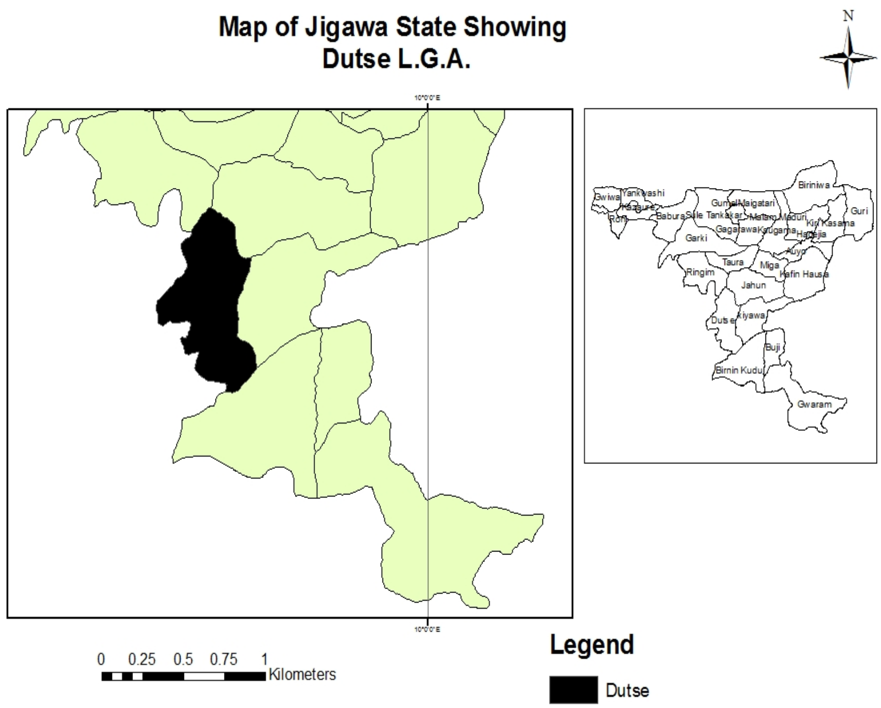
This work aims to investigate the level of ions concentration in soils from waste disposal sites in Dutse metropolis and determine the levels of heavy metals in the soil within the vicinity of the study area as well as identify the change in the concentration of the heavy metals with distance within the dump site using atomic absorption spectrophotometer (AAS).

2. MATERIALS AND METHOD

Materials: Atomic Absorption Spectrometer (AAS), Filter paper, Sieve, Plastic plates, volumetric flask, Grinder, Conical flask, Measuring cylinder, Hoe, Analytical balance, Beaker, Funnel, Hot plate, Nitric acid (HNO_3) and Concentrated. Hydrochloric acid (HCL)

Sampling Location

The soils for this study were collected from the Dumpsite near ultramodern market in Dutse. Dutse, the capital of Jigawa State is estimated to have a population of about 153,000 [14].



Reconnaissance survey

A walk around the entire area to be surveyed was made to have a sound knowledge about the study area, so soil sample collection points were selected before collection of the sample.

Sampling

Top soil (0-15cm at first and then 15-20cm) were collected and mixed in a bucket in order to get homogenous sample. The samples were collected from five different points in Zig-zag pattern within the dumpsites [15]. Samples were transferred into polythene bags, and then transported to the laboratory for analysis. The samples were spread in plates and dried in laboratory at room temperature. The dried soil was grinded and passed through an aluminum sieve with 2mm mesh. Soil samples < 2mm was later stored in a labeled polythene bags prior the analysis.

Experimental Setup

The experimental setup consisted digestion of soil sample which took place in the laboratory for heavy metal test using Atomic Absorption Spectrometer.

Sample preparation and digestion

Sample preparation and digestion was according to standard analytical method using nitric acid (HNO_3) and hydrochloric acid (HCl) at relatively low temperature to prevent the risk as reported by Tinsely, (1979).

The procedure for the analysis is as follows: 2 g of 2 mm air dried soil sample was weighed into a 50 ml capacity plastic bottles, 20 ml of 0.1M HCl solution was added and the bottle was covered very tight. The bottle was shaken for 20 min using a mechanical shaker. The sample was filtered using a filter paper to obtain a clear water solution. Using an AAS (Atomic Absorption

Spectrometer) heavy metals (Cd, Cr, Fe, Pb and Zn) were read. Atomic Absorption Spectrometer (AAS) was used as prescribed by [16] to run the mixtures at quality control in soil and water laboratory, geography department Bayero University Kano (BUK), Nigeria. The five different samples were analyzed for the following heavy metals; Chromium (Cr), Iron (Fe), Nickel (Ni), and Zinc (Zn), based on the above procedure.

Determination of heavy metals using AAS

The instrument was switched and allowed to warm up for about 15 minutes. Blank solution was first aspired into the flame of AAS to set the instrument at its reference point (zero). The standard was introduced into the flame and then the absorbance reading was taken. A calibration curve of absorbance versus concentration was prepared. The samples solutions were then aspirated into the flame and the various absorbance were taking. The concentration of the various heavy metals irons each sample was obtained from the calibration curve.

3. RESULTS AND DISCUSSION

The results obtained after the analysis of the soil samples collected from the study area is presented in table 4.1. Five soil homogenous soil samples were collected analyzed using atomic absorption spectrophotometer (AAS) as described by [16]. As indicated by the results, all the heavy metals being investigated in this study were detected in the soil samples analyzed. The results clearly reveal that the concentration of heavy metals in the soil varies with sampling point and location. The concentrations of the heavy metals detected ranged from 1.388889 to 118.5185. Generally, Zinc records the lowest concentration in sample C as seen from the table while Iron records the highest concentration in sample A.

However, the fact that these heavy metals were all detected in the soil indicates the potential of the ground water being contaminated by leachates as reported by [17].

Table 1 Concentrations of Heavy Metals In soil Samples Obtained from the Dutse dump site

sample ID	Cd(PPM)	Cr(PMM)	Fe(PPM)	Pb(PPM)	Zn(PPM)
A	15.00	5.57	118.52	8.70	2.78
B	20.00	1.85	66.67	4.34	5.56
C	20.00	3.70	75.93	6.52	1.39
D	20.00	11.11	79.63	6.52	5.56
E	15.00	5.56	79.63	4.35	2.78

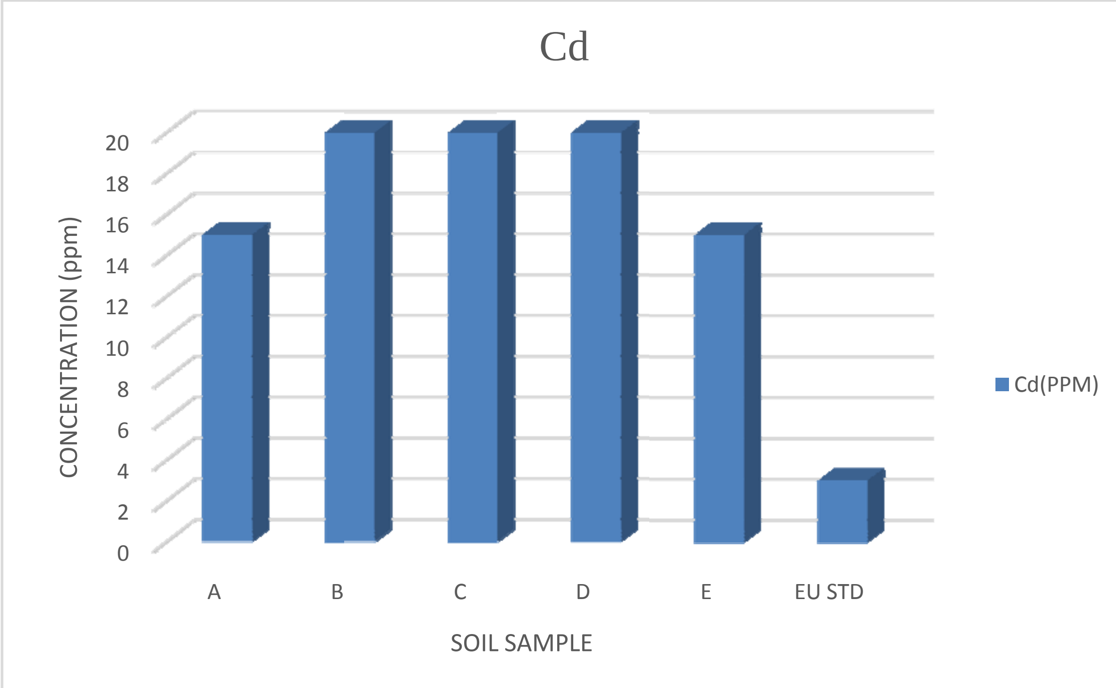


Fig 1: Concentration of Cadmium in soil samples with European Union standard.

The Figure above shows the average concentration of Cadmium as 18 ppm. From the results, it was obtained that the samples with the lowest cadmium concentration record 15 ppm. This can be observed in samples A and E as presented in figure 4.1and the highest is 20 ppm in the soil sample. The concentration of Cd in each sampling point were shown in the Fig 1 above and they are found to be higher than the permissible limit which 3.0 ppm as provide European Union 2002[18] in table 4.2.

The result indicates that there is high level of cadmium in the study area is due to dumping substances like batteries in high quantity which results to leaching into the ground. Cadmium is known to be one of the carcinogenic elements in the environment as it causes cancer and other health defect.

The main routes of exposure to cadmium are via inhalation or cigarette smoke, and ingestion of food. Skin absorption is rare. Exposure to cadmium by people living around the study area is possible through several numbers of ways like eating contaminated food, smoking cigarettes, and Cadmium is also present in trace amounts in certain foods such as leafy vegetables, potatoes, grains and seeds.

Exposure to Cadmium can cause serious adverse effect such as pulmonary and gastrointestinal irritation which can be fatal if inhaled or ingested. After acute ingestion, symptoms such as abdominal pain, burning sensation, nausea, vomiting, salivation, muscle cramps, vertigo, shock, loss of consciousness and convulsions usually appear within 15 to 30 min [19]. Table 2 tabulate the FEPA guidelines for heavy metals in the soil by [14-17, 20].

Table 2 Standard FEPA guidelines for heavy metals in the soil

sample ID	Cd(PPM)	Cr(PMM)	Fe(PPM)	Pb(PPM)	Zn(PPM)
FEPA STD	N.A	N.A	400	1.6	300-400
E.U	3.0	150	N.A	N.A	N.A

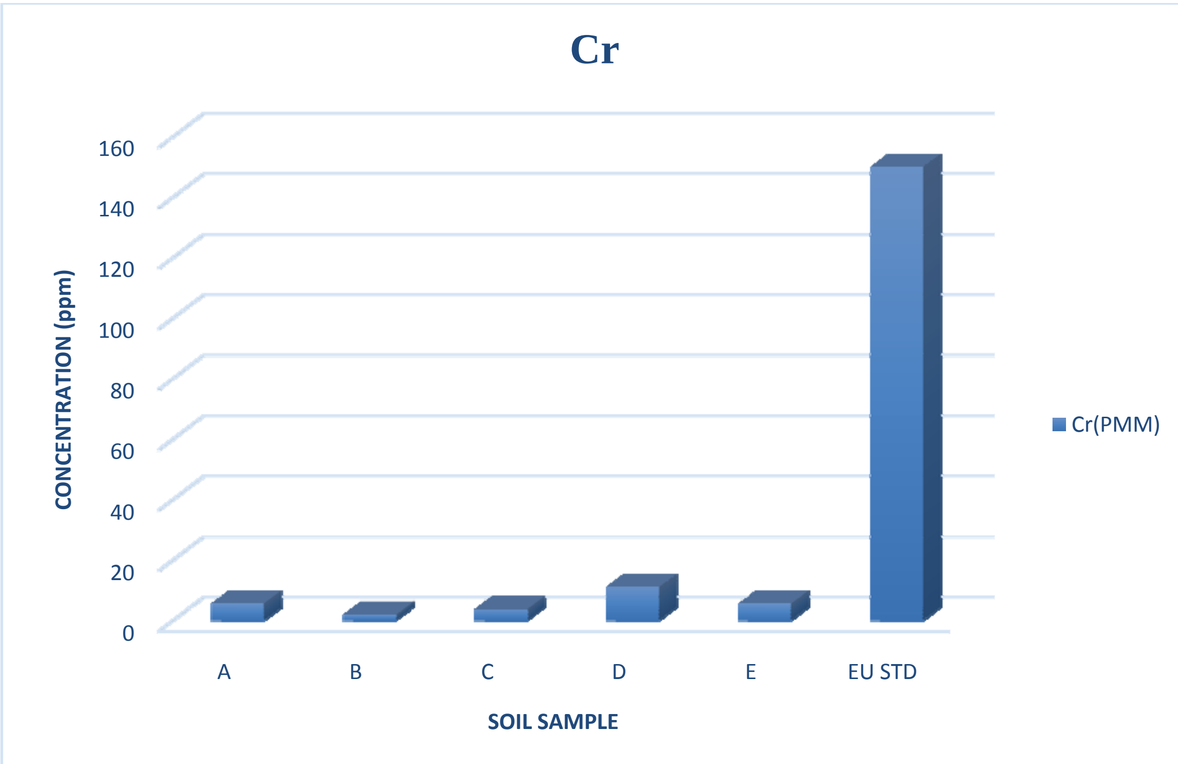


Fig 2: Chromium concentration in soil samples with E.U standard

In the fig above the content of Chromium ranges from 1.8- 11.12ppm and they found to be very much lower than European Union stand 2002 which is 150 ppm. In the study area the chromium concentration sampling point D is the highest, with 11.11 ppm and that of point B is lowest with1.8519 ppm. The result signifies that Chromium in the study area is within the permissible limit as provided by [20]. Contamination with Cr considerably affects the biological activity of the soil. The catalyses activities of chernozems and the soil's ability for cellulose decomposition are decrease. The worsening of the soil's respiration inhibits important biochemical processes [16, 17].

In small amount, chromium stimulates the growth of agricultural crops; an excess of it however promotes various diseases. A wide distribution of technical Cr in the environments unfavorable for humans and animals. In the USA, Cranks third among the pollutants by its abundance at waste disposal sites, and it ranks second (after Pb) among the inorganic pollutants. The chromium toxicity depends on its oxidation status. Cr occurs in two states in soils. The oxidation chromate CrO_2 is highly mobile and more toxic in soils and ground water. On the contrary, the reduced ions Cr (III) form either a weakly soluble hydroxide or stable complexes with soil minerals [20].

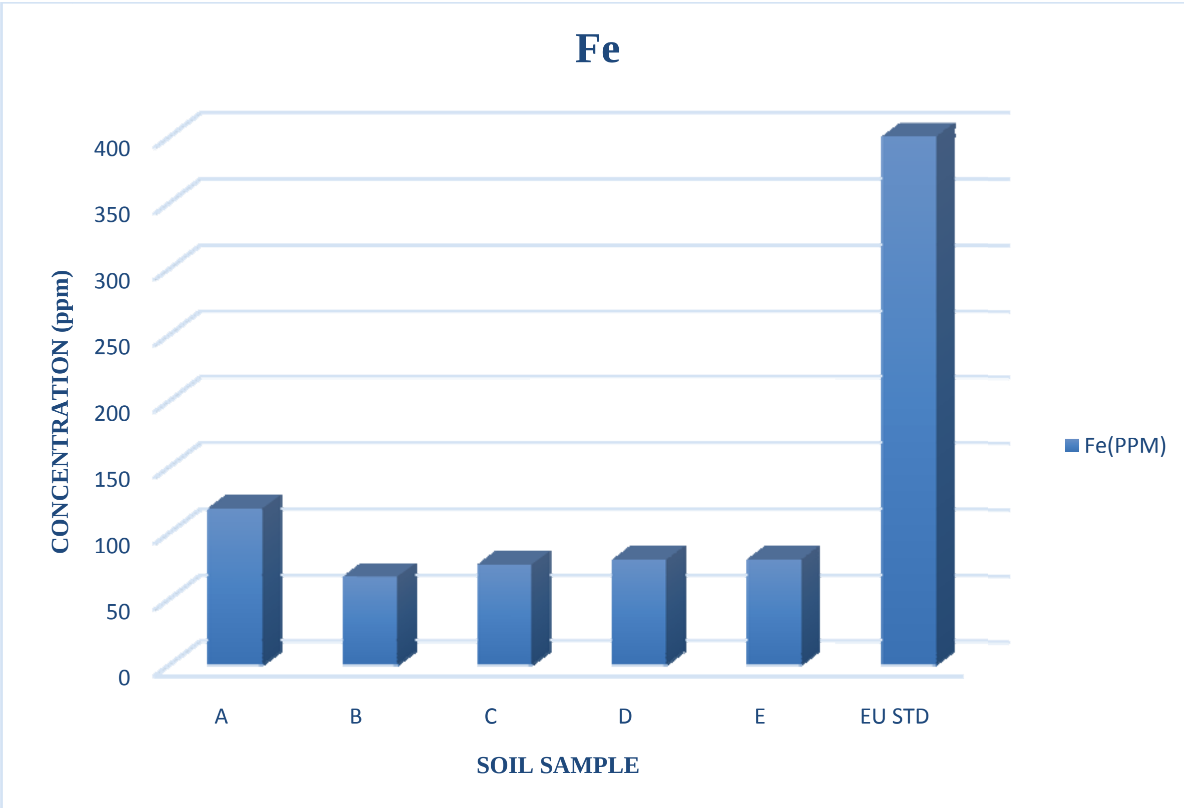


Fig 3 concentration Iron in soil samples with E.U standard

In the Figure 3 above it was shown that the iron concentration changes with sampling point meaning there is variation in the concentration in the first three (3) samples, where as in the subsequent samples is 4, and 5 the concentration is the same. Sampling point A has the highest concentration of Iron which is 118.52 ppm and sampling point B have the lowest which is 66.67 ppm.

All of the concentrations gotten in each of the five points were below the maximum permissible limit provided by Federal Environmental Protection agency as reported by [13].

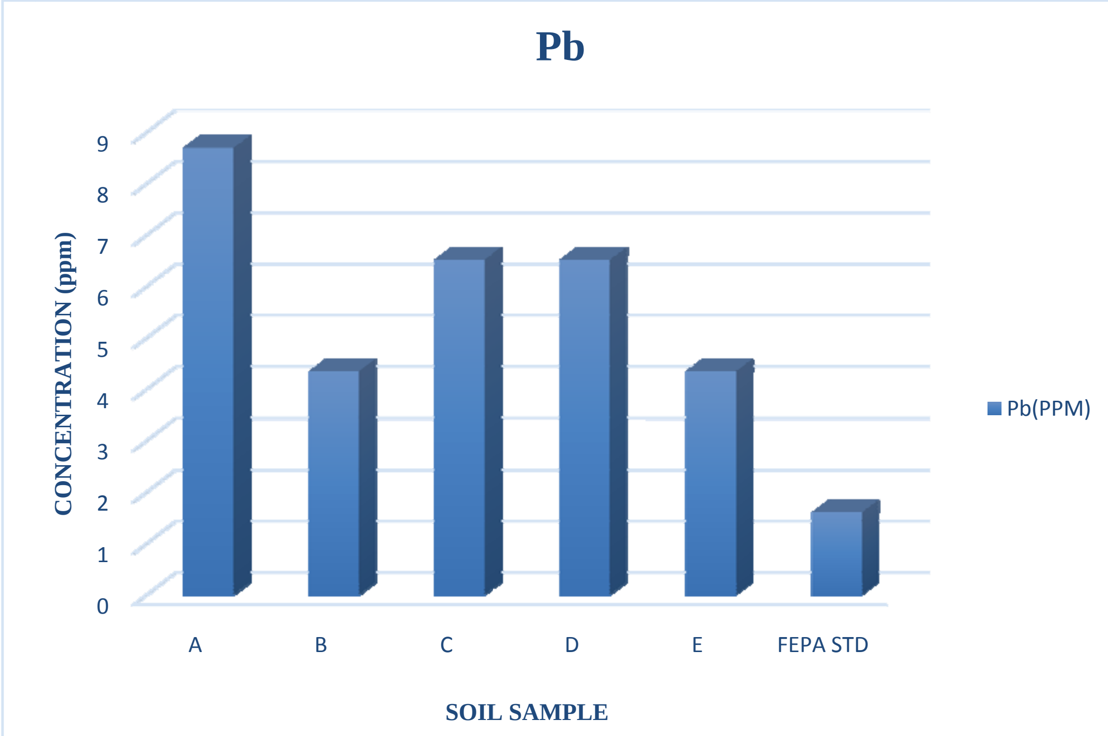


Fig 4 Concentration of Lead in soil samples with FEPA standard

From the Figure 4 it was shown that in the soil samples collected from the study area there are presence of lead concentration and the average concentration is 6.09 ppm. Sampling point B and E has the lowest values as 4.35 ppm whereas sampling point A has the highest value as 8.70 ppm respectively.

Concentrations of Lead in the samples were found to be higher than FEPA maximum permissible limit of heavy metals in the soil which is 1.6 as reported by [14].

It is indicated that there is high concentration of Lead in the study area unlike the research findings by [20] where the Lead concentration was not detected. Also this research is not in conformity with the finding of [21].

These researches show the potential of lead toxicity which may cause adverse effects when exposed. Lead (Pb) is identified as one of the most common contaminant in the environment (Ajmone and Biasioli, 2010) and its presence could be attributed to natural and anthropogenic sources such as the use of some pesticides in agricultural zone and atmospheric deposition in urban zones derived from high vehicular traffic and industrial activities.

Some of the adverse effect that might come up when exposed to lead includes lead poisoning in humans as well as chronic neurological disorders especially in feotuses and children [3, 4].

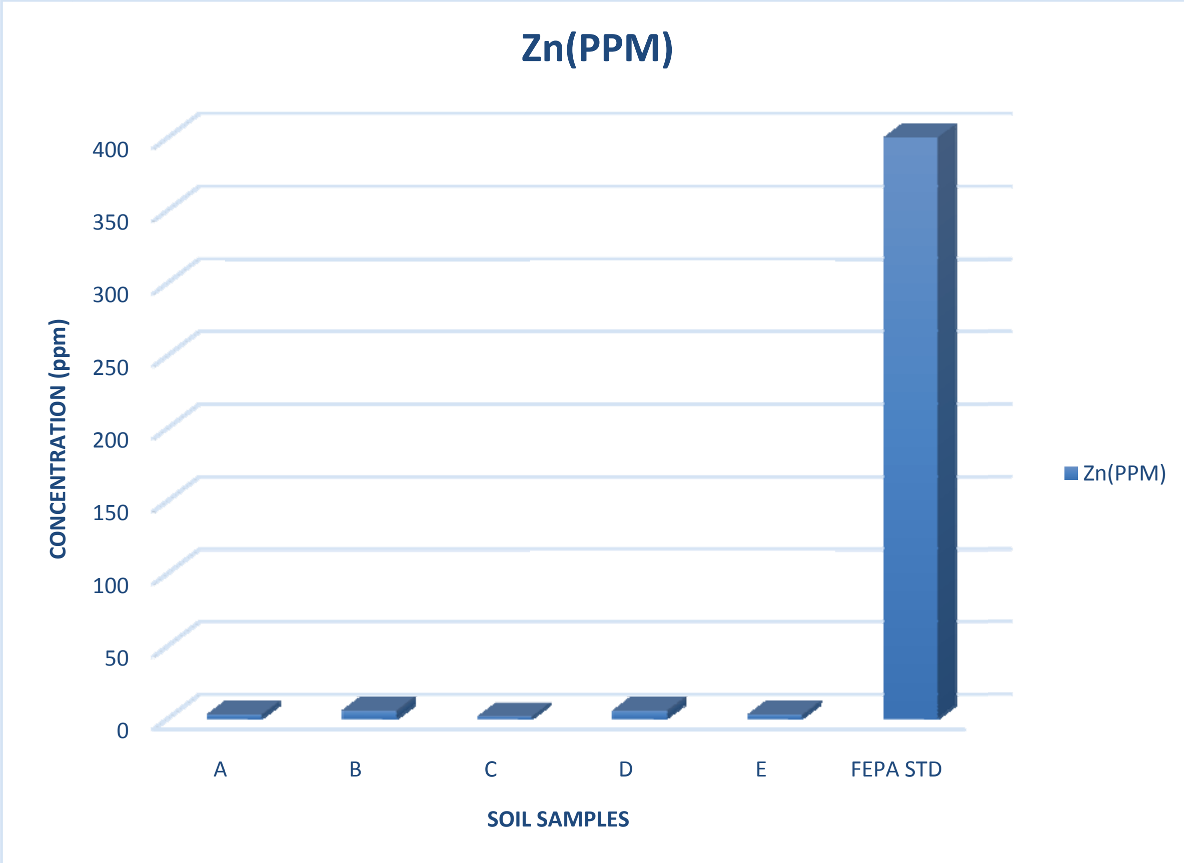


Fig 5 Concentration of Zinc in soil sample with FEPA standard

It is observed that the concentration of zinc in the study area were very minute as shown in the Fig 5 above. Sample C has the lowest concentration value as 1.39 ppm and Samples B and D have the highest values as 5.56 ppm respectively. The result in comparison with FEPA standard is very negligible as reported by [21].

4. SUMMARY

Top soil (0-15cm at first and then 15-20cm) were collected and mixed in a bucket in order to get homogenous sample. The samples were collected from five different points in Zig-zag pattern within the dumpsites using soil auger and polythene bag. The samples were then prepared, digested and taken in to the laboratory and aspirated into Atomic absorption Spectrometer for the detection Cadmium, chromium, Iron, Lead and Zinc respectively.

From the analysis it was discovered that some metals were detected in high concentrations whereas some in very minute amount as compared with E.U and PEPA standard. The analysis shows that Cd>Pb>Fe>Zn>Cr.

5. CONCLUSION

Finally, the Soils samples have average metal concentrations as Cd (15.0ppm), Cr (5.56ppm), Fe (84.07ppm), Pb (6.09ppm) and Zn (3.61ppm). This research reveals that there is heavy metals contamination in the study area, and these metal were detected in different concentrations; some are higher than others as shown above. This could be attributed to continuous usage of products containing these metals by nearby populace and disposal of carrier wastes by the sellers of different items within Dutse town. The higher concentration of Cd may also be associated with its content in the soil of the sampling sites and is due to discarding materials containing some content of it. High lead level on the other hand can be due to the use of leaded batteries and renovation paints. Cr, Fe and showed no concentrations accounting for no usage and disposal of carrier materials. Overall, the area is at potential risk of severe heavy metals pollution requiring immediate action.

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