

# Concentration of Heavy Metals in Waste Ashes from Five Sections of a Major Incineration Ground at Maikunkele, Minna, Niger State, Nigeria

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**Abstract:** This research investigates the concentrations of some trace metals present in waste ashes collected from five different sections of a major incineration ground at Maikunkele, Minna, Niger State, Nigeria. Waste ash samples from the sites were collected and prepared using standard analytical procedures and analytical grade reagents were used for digestion. An atomic absorption spectrophotometer (AAS) was used for the analysis of the trace metal (Zn, Cu, Pb, Cd and Ni) content of the samples. The mean concentrations of trace metal in the ash samples differed significantly amongst sites which ranged from 34.1-104.4 µg/g (Pb), 2.9-7.9 µg/g (Cd), 94.6-206.7 µg/g (Cu), 49.7-87.0 µg/g (Ni) and 590.1-2622.0 µg/g (Zn). These mean concentrations were found to exceed critical level for agricultural use at site 1 (Cd and Zn), site 2 (Cd and Zn), site 3 (Ni and Zn), site 4 (Cd, Cu, Ni and Zn) and site 5 (Cd, Cu, Ni and Zn). Further research is thus required to determine the plant-availability of these metals in the ash and to assess the wider environmental and health implications of open burning of waste as a means of producing ash for agricultural purposes.

**Keywords:** Trace Metals, Waste Ashes, Maikunkele, Incineration and Nigeria

## 1. Introduction

Waste is any unacceptable material purposely thrown away for disposal [1]. It could take the forms of refuse, garbage and sludge [2]. Cities in Nigeria, being among the fast growing cities in the world [3] are faced with the problem of waste generation. However, some wastes may eventually become resources valuable to others once they are removed from the waste stream [4]. The basis of the rag picking trade and sifting of refuse at landfills for recovery and resale is of very fundamental historical waste management practice which is still functioning in many countries at highly organised commercial basis [5].

Waste is generated universally and is a direct consequence of all human activities. Wastes are generally classified into solid, liquid and gaseous. Gaseous waste is usually vented to the atmosphere, either with or without treatment depending on composition and the specific regulations of the country involved. Liquid wastes are normally discharged into sewers or rivers, which in many

countries is subject to legislation governing treatment before discharge [5]. Solid wastes, the subject of this research, are primarily disposed off to landfill, because landfill is the simplest, cheapest and most cost-effective method of disposing of waste. They are also often incinerated in incinerators or on an open field [6].

Waste-to-energy units and incinerators are not so much waste disposal facilities, yet waste reduction units. After incineration, the non burnable part of civil strong waste stays as slag. Two sorts of slag are created amid incineration: fly powder, which gathers noticeable all around contamination control gadgets which "clean" the gasses delivered amid the ignition of the waste; and base cinder, which gathers on the base of the burning unit and involves roughly 75 to 80 percent of the aggregate fiery debris. EPA studies demonstrate that fly fiery remains for the most part contains the most elevated amassing of inorganic synthetic constituents. Metropolitan waste

ignition fiery debris is intermittently expelled from the incinerator and normally land arranged, either in a MSW landfill or a "monofill" particularly proposed for the powder. This strategy presents potential dangers to human wellbeing and the earth because of the dangers of inward breath close burning and transfer locales [7]. Air contamination is of a noteworthy general wellbeing concern in numerous substantial urban communities around the world. Then again, by and large just a little consideration has been given to this issue in creating nations. Case is the situation of Alexandria city in Egypt where two metropolitan strong waste (MSW) dumpsites were situated at the east and west bearings of the city. One of the fundamental exercises prompting this issue incorporates testimony of manure and incineration of MSW, which contain large amounts of overwhelming metals. Such exercises have a tendency to expand the essential foundation levels in the encompassing rural area heading to unfriendly worldly and/or spatial varieties of substantial metals levels in soils. Barometrical affidavit of anthropogenic determined chemicals is a vital wellspring of ecological contamination. It adds to the heap of contaminations in urban overflow [8].

City Solid Waste administration relies on upon the normal for the strong waste including the gross creation, dampness substance, normal molecule size, concoction sythesis and thickness, in which learning of these, typically helps in transfer arranges [9].

In a few ranges, the barometrical statement of toxins has come to levels which are lethal to human and life forms. Along these lines, the estimations of the fluxes of contaminations from the climate in urban and non urban situations can help in the evaluation of air quality and can be utilized to focus spatial, transient and occasional variability of contamination sources [10].

Soil constitutes some piece of imperative ecological, environmental and rural assets that must be shielded from further debasement as on sufficient supply of solid sustenance required for the world's expanding populace. Substantial metals can influence both the yield of harvests and their structure. In this manner determination of the essential status of a developed area must be made with a specific end goal to recognize yield-restricting lacks of fundamental micronutrients of plants become on contaminated soils [11].

Some substantial metals are crucial in follow sums, in particular Zn, Cu and Mn for plants and likewise Co and Ni for creatures. On the other side, Cd has not been known not any capacity for either plants or creatures [12]. High centralizations of metals get to be poisonous to plants and perhaps are hazardous to human wellbeing. Various instances of wellbeing issues identified with natural Cd harming have been accounted for [13]. A percentage of the metals are phototoxic and some are dangerous to both plants and creatures through their entrance into the natural pecking order [14].

Benchmark information for the event of overwhelming metals as contaminants are required as one of the criteria

for evaluation of discriminating substantial metals levels in farming soils. Throughout the most recent two decades, the investigation of the sources, fluxes and pathways of overwhelming metals on both national and worldwide exploration groups a reaction of an incredible worry about contamination and conceivable wellbeing effects [15].

Ecological contamination information have a tendency to shift broadly and to be subjected to different sorts of vulnerabilities because of a few variables, for example, separation from contamination sources and pathways, common foundation variety, contamination development or debasement over the long run. Natural variability delineates the accurate variation contamination levels between populace units [16].

The aim of this present research is to provide data on the levels of certain trace metals present in the municipal solid waste incineration of ash used in agricultural production and to assess the pollution status of the amended sites.

## 2. Material and Methods

### Sample Collection

The ash samples were collected in April, 2013 from a major municipal solid waste incineration ground located at Maikunkele district of Minna which represents an area with high population density associated with increased commercial activities and high refuse disposal rate. The ash samples were collected randomly from five evenly distributed sections of the dumpsite. At each point, the waste ashes were removed at the surface. The five samples were collected the same day and kept in neatly labelled polythene bags to avoid contamination during transportation and were taken to the laboratory.

## 3. Digestion

At the laboratory, the waste ash samples were air-dried for two weeks to remove its moisture content, gently ground using a clean porcelain mortar and pestle to obtain fine particles and were passed through a 2 mm plastic sieve to remove stones and other remaining coarse particles. 1g of the dried fine sample (in triplicate) from each sample was poured into a graduated test tube of 100 cm<sup>3</sup> capacity and were added 10 cm<sup>3</sup> of concentrated nitric acid (HNO<sub>3</sub>) of high purity. The mixture was allowed to soak for 2 hours before being transferred to a hot plate set at 95<sup>0</sup>C and then allowed to slowly evaporate over a period of 30 minutes. The solid residue obtained was then digested with 20 cm<sup>3</sup> of the mixture of HNO<sub>3</sub> and HClO<sub>4</sub> (3:1) for 20 minutes before heating in a fume cupboard. The hot plate was slowly raised over a period of 1 hour until the perchloric acid start to escape leaving behind a clear solution. The mixture was then allowed to cool to room temperature and was filtered using whatman filter paper into 100 cm<sup>3</sup> volumetric flask and was made up to the mark with distilled water. The concentrations of metals in digested soil samples were determined using atomic absorption spectrophotometer [17].

## 4. Results and Discussion

**Table 1.** pH of Waste Ash Samples From the Five Site.

Sampling Sites	pH values
Site 1	9.67
Site 2	10.01
Site 3	9.71
Site 4	9.40
Site 5	9.75

**Table 2.** Mean Concentration ( $\mu\text{g/g}$ ) of Trace metals in Waste Ash Samples.

Locations	Pb	Cd	Cu	Ni	Zn
Site 1	78.0 $\pm$ 0.84 <sup>b</sup>	3.5 $\pm$ 0.17 <sup>c</sup>	97.4 $\pm$ 0.85 <sup>d</sup>	65.8 $\pm$ 0.96 <sup>d</sup>	2622.0 $\pm$ 0.37 <sup>a</sup>
Site 2	73.4 $\pm$ 0.67 <sup>c</sup>	6.0 $\pm$ 0.21 <sup>b</sup>	115.2 $\pm$ 0.16 <sup>c</sup>	49.7 $\pm$ 0.03 <sup>c</sup>	590.1 $\pm$ 0.18 <sup>c</sup>
Site 3	34.1 $\pm$ 0.18 <sup>c</sup>	2.9 $\pm$ 0.10 <sup>c</sup>	94.6 $\pm$ 0.78 <sup>c</sup>	76.1 $\pm$ 0.14 <sup>c</sup>	869.1 $\pm$ 1.31 <sup>c</sup>
Site 4	104.4 $\pm$ 0.35 <sup>a</sup>	7.9 $\pm$ 0.11 <sup>a</sup>	144.3 $\pm$ 0.23 <sup>b</sup>	77.3 $\pm$ 0.49 <sup>b</sup>	2377.3 $\pm$ 0.46 <sup>b</sup>
Site 5	42.1 $\pm$ 0.72 <sup>d</sup>	3.2 $\pm$ 0.25 <sup>d</sup>	206.7 $\pm$ 0.65 <sup>a</sup>	87.0 $\pm$ 0.10 <sup>a</sup>	849.6 $\pm$ 0.95 <sup>d</sup>
EEC	300	3	140	75	300

Values are mean  $\pm$  SD of three determinations

EEC = Maximum permissible levels according to the European Council Directive 86/278

Table 1 revealed the result of pH of the waste ash concentration which shows that the pH value of the waste ash sample from the incineration site 2 is high, that is, alkaline which may be due to the nature of waste burnt at the sites. The pH contents of the waste ash obtained from this study ranged from 9.40-10.01. It is thus observed that the ash can be used as a liming agent to reduce the soil acidity and raise the pH of the soil high enough to interfere with plants ability to take in nutrients and also aid in improving the water holding capacity of the soil. The result of the analysis presented in Table 2 shows the mean concentrations of trace metals in waste ash samples from the incineration sites. Among all the trace metals analysed, the concentration of zinc (2622  $\mu\text{g/g}$ ) detected in the first incineration site was the highest while cadmium (2.9  $\mu\text{g/g}$ ) detected in the third site was the lowest. Similar results were reported by Adjia *et al.* [18], in which highest concentration of zinc (2110  $\mu\text{g/g}$ ) and lowest concentration of cadmium (0.48  $\mu\text{g/g}$ ) were detected in waste ash obtained from the same sites used for peri urban agriculture in Ngaoundere, Cameroun. The mean concentration of lead in the waste ash samples in site 1, 2, 3, 4 and 5 were 78.0, 73.4, 34.1, 104.4 and 42.1  $\mu\text{g/g}$  respectively. Site 3 was found to have the lowest mean concentration of lead while site 4 was found to have the highest concentration. Comparison of the lead content with European council regulations for compost shows that lead concentration in all the sites are below the maximum permissible limits of 300 $\mu\text{g/g}$ . Therefore, no waste ash could be classified as Pb-polluted. Cadmium content obtained from this work has the lowest mean concentration of all the metals in the sites ranging from (2.9-7.9 $\mu\text{g/g}$ ). The highest cadmium concentration was observed in site 4 while the lowest was detected in site 3. Comparison of the cadmium content with

the council regulations on compost shows that the cadmium content all exceed the maximum permissible limit of 3 $\mu\text{g/g}$  except for site 3 (2.9 $\mu\text{g/g}$ ). The mean concentration of copper in the sites ranged from 94.6-206.7 $\mu\text{g/g}$ . This was quite lower than that observed by Geoffrey [19] where the copper concentrations present in wastes obtained from selected dumpsites in Bida which ranged from 293.33-366.67 $\mu\text{g/g}$ . The highest copper concentration was observed in site 5 (206.7  $\mu\text{g/g}$ ) and the lowest was detected in site 3 (94.6 $\mu\text{g/g}$ ). Comparing the copper concentrations with the European council regulations of 140 $\mu\text{g/g}$ , it was observed that the concentrations of copper in sites 1 (97.4 $\mu\text{g/g}$ ), 2 (115.2 $\mu\text{g/g}$ ) and 3 (94.6 $\mu\text{g/g}$ ) were below the maximum permissible limit while sites 4 (144.3 $\mu\text{g/g}$ ) and 5 (206.7 $\mu\text{g/g}$ ) exceed the maximum limit. The mean concentration of Nickel ranged from 49.7-87.0 $\mu\text{g/g}$ . The highest nickel concentration was detected in site 5 while the lowest was observed in site 2. Comparing these concentrations with the European council regulations of 75 $\mu\text{g/g}$ , it was observed that sites 1 and 2 were below the maximum permissible limits while sites 3, 4 and 5 all exceeded the permissible limits. Zinc content which was observed to be the highest concentration of all the metals analysed ranged from 590.1-2622.0 $\mu\text{g/g}$ . The lowest zinc concentration was observed in site 2 while the highest was detected in site 1. All these were found to be above the European council regulations on compost for zinc 300 $\mu\text{g/g}$ . The recurrent use of biosolids or composts has been reported to contaminate soils used for agricultural purposes [20].

## 5. Conclusion

The results of this research show that waste ash used as fertilizer offers important benefits as a liming material because of its high pH. However, it is clear that there is a potential problem of trace metal contamination because of the excessive concentration of these trace metals found in waste ash obtained from the various incineration sites used for agricultural production in Minna. Consequently, people depending of food crops cultivated in soils amended with these waste ash as their source of food are indirectly ingesting these trace metals in near toxic amounts. There is also the risk of contamination of surface and groundwater. Therefore there is high risk on the environment and health implications associated with the use of these waste ashes in amending soils used for food crop production.

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