Pollution-Level-Assessment of Heavy Metals from Solid Waste in Soil and Crops at Ugwuaji Dumpsite, Enugu South L.G.A of Enugu State, Nigeria

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Abstract
Heavy metals pollution is a global environmental concern as a result of contamination of the soil as well as plant uptake of these elements. The aim of this study is to examine the level of heavy metal pollution in soil and maize plants caused by these heavy metals accumulation as a result of municipal solid waste deposition at Ugwuaji, Enugu South L.G.A of Enugu State. Experimental research method was used which involved the sample collection and laboratory analyses of soil and maize leave samples at different distances of 1,2,3,4 and 5m apart at the solid waste dump site. The result of the laboratory analyses indicates that the soil is presently contaminated with the heavy metals: Cd, Cr, Ni, Pb and Hg. The implication is that the waste dump has degraded the soil quality in Ugwuaji and environs, thus creating possible health challenges to the people.
Keywords: Heavy metals, Soil contamination, Anthropogenic activities, Landfill, Accumulation rate, Uptake
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1.0 Introduction

In Africa, there are several thousands of tons of solid waste generated daily (Myung, 2008). So many of them ends up in open-dumps, water or wetlands, where it contaminates ground water and surface water bodies. At that position, it poses major health risks in the environment. The solid waste generation rates, which is available only for select cities and regions, are roughly 0.5 kg per individual per day in some instances getting as high as 0.8 kg per individual per day (Adjial *etal.,*2008). Though this may appear tolerable in comparison with about 1-2 kg per individual per day generated in developed countries, greater number of wastes generated in Africa are not properly collected through municipal collection systems due to poor management, monetary irresponsibility, failure of equipment, or insufficient funding or budgetary allocation to waste management.

In Nigeria, high- and low-value recyclables are usually recovered most especially through the scavengers and reused. However, these recovered recyclables constitute only a small portion of the total waste generated. Research has shown that the greater majority of the waste is mixture of organic. In principle, these wastes could be changed into compost or they be used to produce biogas. However, in circumstances where basic solid waste management systems hardly exist, it is very hard to promote novelty and/or innovation, even when it appears conceivably cost-effective to carry out. Furthermore, many hazardous materials are thrown away alongside general waste all over the country. This situation is particularly a dangerous condition that obscures the waste management problem in Enugu state.

All through Enugu South local government area of Enugu state, the generation of solid wastes surpasses the collection capacity. This is partly as a result of rapid urban population growth. Whereas only a few of the population are living in rural areas, the population in the urban areas grows wilder than the rural population. Nevertheless, the issues of increasing demand are complicated by inoperative collection trucks and poor management programmes and designs in Enugu. Though in the state, few trucks are functional, the ones that are operational fails to collect refuse from every resident of Enugu South L.G.A especially in the rural areas.

Ideally, for health purposes, waste collection be a daily routine. Not meeting up with this, makes the task and cost of managing solid waste in Enugu even more discouraging. Generally, services are received by city center and the richer neighborhoods whenever it is available. In neighborhoods where the poor lives, refuse or wastes not collected accumulates at the side of the roads, while some are burned, or disposed-off in unlawful dumps which affects the aesthetics of the neighborhoods and damage public health. Manual sweeping of the street by municipal workers or shopkeepers can help decrease these effects in the most public areas however, road-side waste accumulation in many cities in Enugu and Nigeria at large has got to the point that resembles those that produced epidemics in European municipalities about 500 years ago (Ogundiran and Osibanjo, 2008).

Majority of the solid wastes generated in Enugu urban including that from Enugu south local government area are disposed-off in the purported sanitary landfill (unlined landfills with no groundwater protection, leachate recovery, or treatment systems) located at Ugwuaji; very few ends up in open dumps. The other dumps are found on the ends of the cities, surface waterbodies, occasionally in areas that are ecologically sensitive, or places it threatens the groundwater supplies. In most cases, they present grounds for rats to breeding, flies, and other disease vectors organisms. The fact that some of these wastes are burned sometimes, smoke from burning refuse affects the people living in around the areas and maybe damaging to their health as the smells degrade their quality of life.

There are many waste pickers in the informal sector while some recovery and reuse of materials is usually for personal use. The scavengers are extremely exposed to disease organisms or vectors, sharp objects and other potential hazards present in the waste, most especially as they are generally wastes from different people in the different areas. In some parts of the state, some municipalities are now handled with a combination of limited private public partnership (PPP) of these services, with some recorded success. Even at that, the poor collection strategy has left many residents (both poor and the wealthy) to throw their generated wastes to anywhere without considering the side effects it has on both the soil and the crops that we and other animals feed on. Due to the fact that the waste is made of different materials, different substances come out of the wastes. Out of them, heavy metal is of paramount importance in this study. Heavy metals are found everywhere in the environment owing to the mutual human and natural activities that increasingly expose human populations to their effects through different means (Nwajei and Gagophein, 2000; Alloway, 1995). The presence of metals from in the municipal solid waste streams are from a diverse source. Used batteries, electronics, broken ceramics, damaged light bulbs, house dust and paint fries, lead stops like wine bottle covers, spent motor oil, plastic, and some ink and glasses can all bring metal pollutants/contaminants into the municipal solid waste streams. According to Anikwe and Nwobodo (2006), manure that come from the organic material in these municipal solid waste would unavoidably contain these elements, though they appear at a very low concentration after most pollutant/contaminants are removed. Many of the trace elements such boron, zinc, copper, and nickel are important for the growth of crops however, in small amounts. In higher concentrations, the metals may adverse effect plant growth. Many other trace elements such as arsenic, cadmium, lead, and mercury are elements of concern mostly due to their potential in harming soil organisms, man and other animals that may eat crop contaminated from the soil pollution.

The cumulative rise in the concentrations of some trace elements, particularly in their mobile form can cause severe environmental issues that may affect the soil, vegetation, animal, surface and ground waters. The major source of environmental contaminants is the metals particularly lead, zinc or copper, in addition to antimony, arsenic, mercury, cadmium, thallium, gallium, and others. In other words, high concentration of metals in soil is a very important source of environmental contaminations. Gradually, the vital sources of environmental pollution with high concentration of heavy metals emanating from the municipal solid waste and burning waste stream and pollution effluents are now a known issue.

Soil as the combination of the component of minerals, organic matter (i.e humus), living microbes, air and water is essential for healthy and sustainable populations. Soils that have cultivated on for several years maybe poor in nutrients like, boron, zinc and copper, and municipal solid waste-composts could alleviate such deficiency. Other benefits involve the improvement of the physical characteristics of the soil like increase in the water-holding capacity, improvement in chemical characteristics like the retention capacity of the nutrient, and microbial activity stimulation which can increase the growth of plant and decrease the pollutant leachates into water supplies. Municipal solid waste compost can potentially limit harms to plant growths by binding trace contaminants or pollutants and organic compounds that are toxic (Afolabi, 2006).

However, it is the concern for the impacts of heavy metal pollutants through food chain to man and animal that actually called for this research work. The study is geared towards carrying out a systematic solid quality test and investigating the metal concentration in the crops and then comparing the concentrations in both soil and crops within the vicinity of the dump sites in Enugu South.

2.0 The Study Area

The Nike village of Ogui happen to be the foremost settlement in Enugu and has been in existence since the time of the Slave Trade. Enugu State is located is in the Southeastern region of Nigeria. It is bounded by Kogi and Benue states on the north, Anambra by the west, Ebonyi by the East and Abia State in the South (figure 1). Enugu is its capital. The word Enugu is coined from the two Igbo words Enu and ugwu which means “hill top’ signifying the Enugu city’s mountainous topography. The name Enugu was derived after Enugwu Ngwo where the coal was found under. After Nigerian independence in 1960, Enugu was made the Eastern region capital. A series of adjustment of the territory between 1967, 1976 and 1991 made Enugu to become the capital of what we now know as Enugu State (Arrous and Ki-Zerbo 2009).

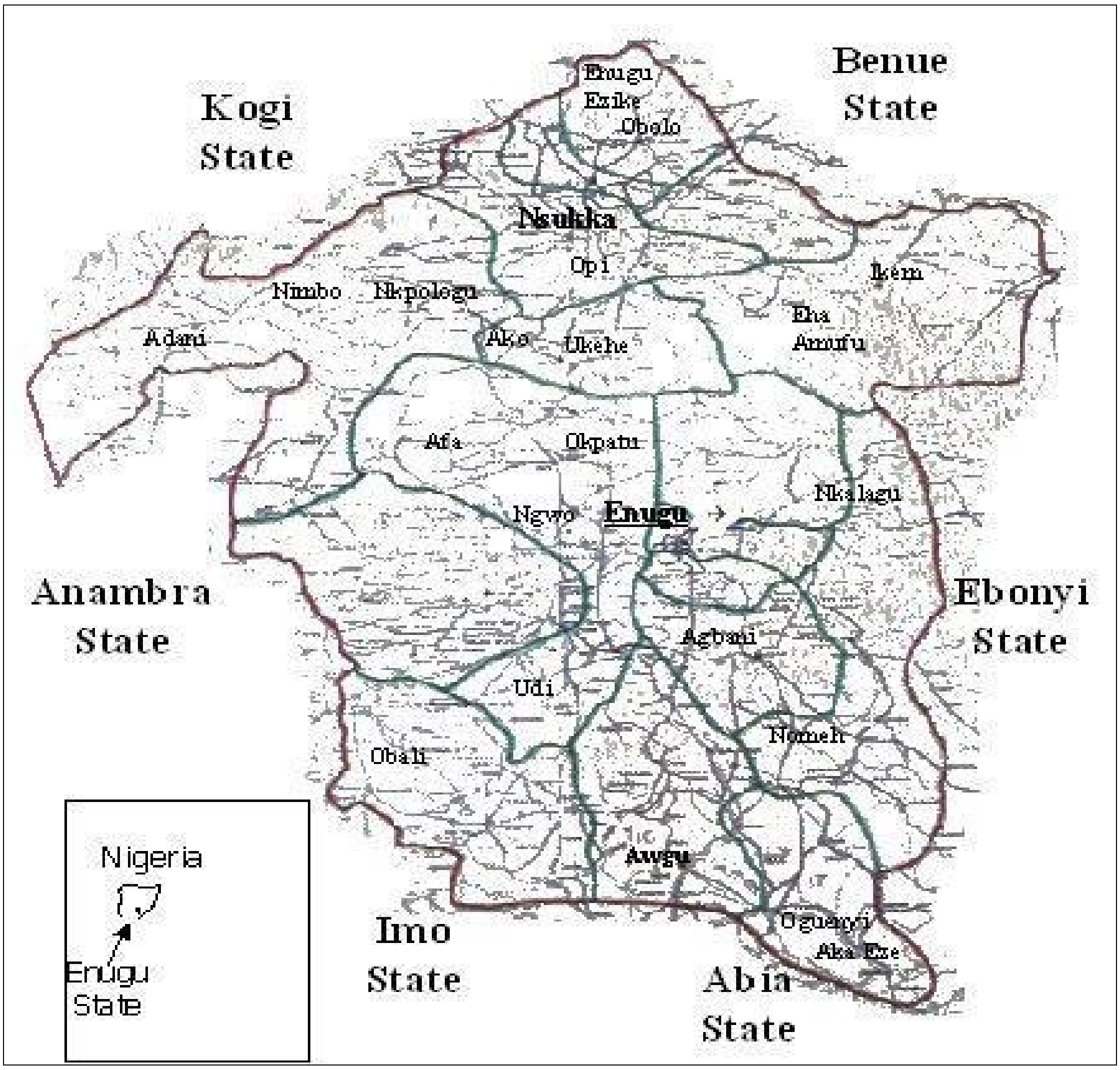

Figure 1: Map of Enugu State.
Source: Enugu State Ministry of Land and Housing (2011).

Enugu south L.G.A is one of the seventeen (17) local government areas located in Enugu State. It is an agrarian local government situated in the undulating lowlands of south-east flank of Enugu state bordered in the north, east, south and west by Enugu North, Nkanu East, Nkanu West and Udi LGAs respectively as shown in Figure 2. Enugu south LGA is topographically characterized with natural scenery and sun-dappled. It has an area of 383 km2 — Density: 723.5 persons/km2 and a population of 277,119(NPC, 2006).

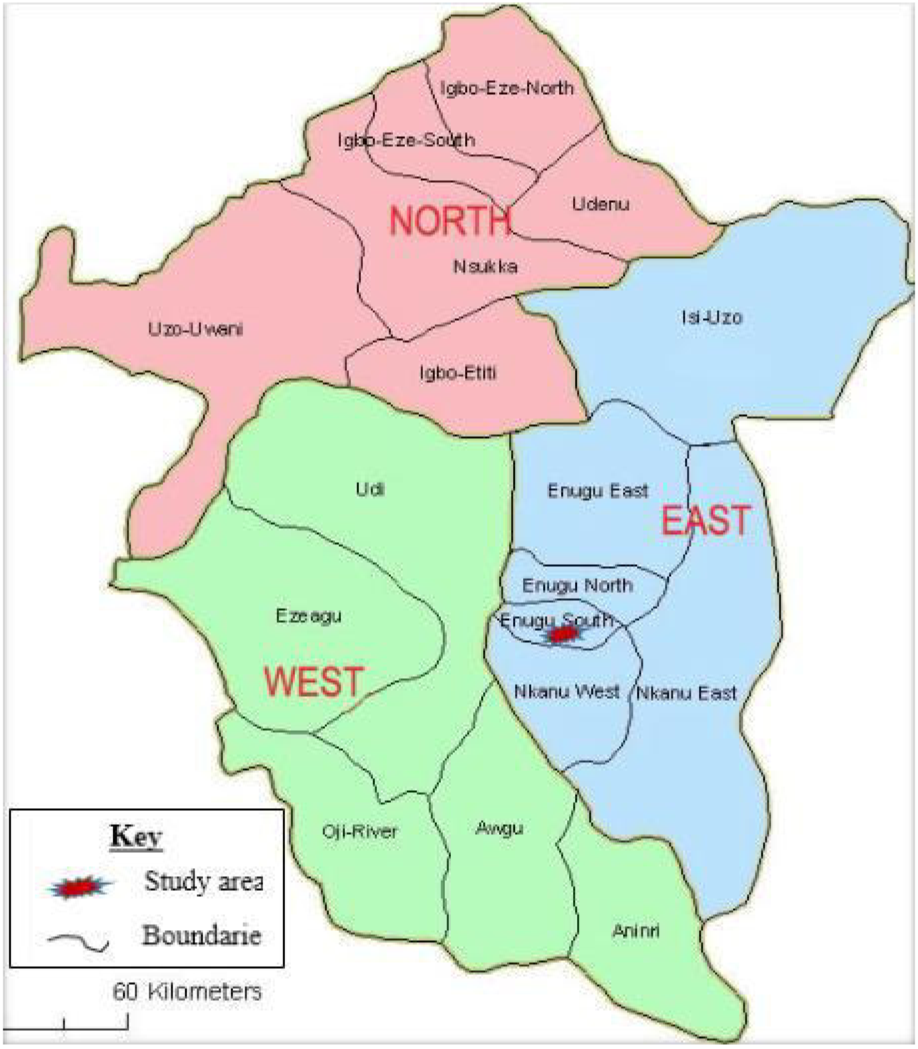

Figure 2: Map of Enugu South L.G.A
Source: Enugu State Ministry of Land and Housing, 2011.

2.1 Soils and Vegetation
The soils in Enugu south L.GA comprise shallow and stony lithosols seen on the level grounds of the cuesta and frequently cultivated. Soil in some parts of Enugu south is swampy and usually water logged. This necessitates the cultivation of some water-loving crops there. Other communities cultivate other types of crops that best fit their landscape.

In numerous parts of the local government area, soil erosion is rampant. It displays in rills alongside the road embankments, in mass wash traversing through compounds and farmlands, and in gully, occasionally very dramatic, along decisive areas, channel and zones. The main gullies are situated on the edges of the extremely friable sandstones that give-up effortlessly to erosion and encourage gullying on slopes even those as low as 5A°. About 65% of the whole area coverage experience sheet erosions.

On the highlands of Enugu south, he vegetation covers expand via its rocky parts to connect with the undulating stones in the zone and it appears to be of the semi-tropical rainforest type. The area is typically green and complemented in some parts of the place by a characteristic grassy vegetation. Fresh water swamp forests occur in some part of Enugu south. There appears to be a number of ecological problems. Apart from soil erosion, hazards of excessive stones exist in many corridor parts of Enugu south local government area, and rain fed massive waterlog in other areas. Due to urban sprawl, deforestation becomes an anthropogenic hazard that has unpleasantly affected balance in the ecological system and future of agriculture in the area.

2.2 Description of Ugwuaji Dumpsite
The Ugwuaji dumpsite is located along Ugwuaji axis of the ever busy Enugu-Portharcourt express way which falls within Enugu South Local Government Area. The dumpsite is within the living areas of the communities and is not lined nor basement-prepared for selective absorption of toxic substances as seen in Figures 3 and 4.

Hence, it is susceptible to releasing pollutants to close-by water and to the air via leachates and dumpsite gases respectively. All manner of wastes starting from residential to commercial and industrial are dumped at the site in mixed form.

Figure 3: Dump site at Ugwuaji in Enugu south LGA showing burnt heaps of solid waste.

Figure 4: Dump site at Ugwuaji in Enugu south LGA showing polyethene heaps in solid waste.

3.0 Materials and Methods

This study used an experimental research design. Ugwuaji dumpsite is a purported sanitary land fill located in Enugu south L.G.A of Enugu State. Collecting samples from the whole sites where farming is taking place in the area may be cumbersome though not technically impossible. While this can happen at least within the context of this work, it was not considered ideal to use the entire crops and soil samples in the area. Two samples, soil and leaves of the maize plant that grew within vicinity of the dumpsites were collected. To prevent volatilization, oxidation and absorption on the walls of the container the samples were stored under a cool condition and the analysis done within three (3) days period. The instruments used to collect the samples for experimental research include: measuring tape, auger for collecting soil sample and knife for the maize plat leaves. Polyethene bags were used to store the soil and plant samples to be carried to the laboratory. To validate the instruments, new polyethene bags free of oil and grease or even other sources of water than the samples were used. The bags were covered and kept at room temperature to avoid volatilization and condensation. Laboratory experimental tests were carried out on the samples of soil and maize leaves collected from the study area to determine the level of pollution and the concentration of heavy metals in the plants so as to establish the risk posed by farming within the vicinity of the dumpsite.

3.1 Heavy Metal Test of the Sample from Soil

In other to test for the heavy metal concentrations in the soil, Atomic absorption spectroscopy (AAS) was used. The method described here is adopted from Aksoy *et al* (2012). The particulate samples of the soil were dried on the air and then made to pass via a 1 mm sieve made of stainless steel. Different grams of each soil samples were laid into a conical flask of 150ml. A mix of HNO_3: $HClO_4$: HF was added in a ratio of 3:1:3. The chemical mixture was laid on a hot plate for 3hrs at 80 degrees centigrade. The digests were sieved into 100ml standard flask and were made to mark with deionized water. In the filtrate and the residue soil samples, heavy metals were analysed using AAS. The water sample was also tested with the same device and the concentration of the heavy metal determined.

3.2 Heavy Metal Test of the Sample from the Plant

To test for heavy metal concentration in the plant sample, the experimental technique described by Aksoy *et al* (2012) was used. Using a microwave digestion system, 0.5g of the sample was digested with 10 milliliters (ml) of pure HNO_3. The conditions for the digestion are; the power at 100% which is the maximum power was at 1200 W with the ramp time at 20 minutes and pressure at 180 *psi* following the temperature at 210^oC and the hold time at 10 min. The solutions were allowed to evaporate close to dryness in a beaker, after the digestion process. The volume of each of the samples was adjusted to 10ml with the use of 0.1 M HNO_3. The determination of the elements in all samples under the test were done using a Varian Inductively Coupled Plasma – Optical Emission Spectrometry (ICP-OES). As a quality control check, after every10 samples, the stability of the device was evaluated by checking an internal standard. There were also reagent blanks prepared in to detect any potential contamination in the course of the digestion and analytical procedures. All the chemicals that were used in this study were of a good analytical reagent grade. Peach leave was used as reference material and too all the analytical procedures performed for reference materials. Sample analysis were done in triplicates.

4.0 Results and Discussion

Table 1: Heavy metal concentrations of soil samples near the dumpsite

Parameter (ppm)	**Soil**									
	1M		2M		3M		4M		5M	
Cd	0.04	0.03	0.02	0.04	0.02	0.00	0.01	0.01	0.01	0.00
Cr	0.02	0.02	0.00	0.00	0.00	0.01	0.03	0.02	0.04	0.02
Ni	0.50	0.30	0.72	0.71	0.20	0.02	0.01	0.01	0.00	0.00
Pb	0.70	0.05	0.08	0.04	0.00	0.02	0.02	0.00	0.00	0.00
Hg	0.00	0.01	0.01	0.01	0.00	0.01	0.03	0.02	0.02	0.02

Heavy metal concentrations in the soil are connected with biological and geo-chemical cycles and are affected by human activities like agricultural practices, industrial activities and waste disposal techniques (Zauyah *et al,*2004). Zea Mays (Maize) is the predominant plant species on the site, Hence the presence of other plant species was random. The concentration of heavy metals in soil is shown in Table 1. Soil contamination with Cd was present and obvious at distance one and two meters from the dumpsite. While it was least present at distance three, four and five meters from the dumpsite respectively. Generally, the concentration of Cr in soil was found to be present at distance one, four and five metres which happened to also be a close range vicinity to the waste dumpsite and absent at distance two and three metres from the dumpsite respectively. Also, soil samples collected at one, two, three and four metres away from the dump site were contaminated with Ni, while that collected at distance five metres was devoid of Ni contamination. It can also be seen from table 1 that Pb was present in the soil at distances 1, 2, 3 and 4 meters away from the dumpsite while it was absent at distance five meters from the dumpsite, (Table 1). Mercury (Hg) was present in the soil samples collected at various distances away from the dumpsite.

Table 2: Heavy metal concentrations in maize leaves samples near the dumpsite

Parameter (ppm)	Maize leaves									
	M1		M2		M3		M4		M5	
Cd	0.06	0.04	0.03	0.03	0.01	0.01	0.02	0.01	0.01	0.01
Cr	0.01	0.01	0.01	0.01	0.01	0.50	0.30	0.05	0.10	0.02
Ni	0.07	0.01	0.61	0.01	0.08	0.00	0.10	0.10	0.00	0.00
Pb	0.006	0.04	0.03	0.03	0.01	0.02	0.01	0.01	0.01	0.01
Hg	0.05	0.03	0.02	0.20	0.20	0.20	0.00	0.00	0.00	0.10

Concentration of Pb in the maize leaves ranged from 0.01 at some distances away from the dumpsite to 0.06ppm. However, Cd was totally present in the maize leaves at all distances away from the dumpsite. Heavy metal accumulation in the maize plant leaves taken from Ugwuaji dumpsite varies significantly from one element to the other (Table 2). Ni has the highest contamination level in the maize leaves with a concentration of 0.08ppm at 3M distance away from the dump site. Cr and Pb were also found in high amounts above detection limits in the leaves of the maize plant, while Cd and Hg were also present in large concentrations as seen from the tables.

Table 3: Variations in heavy metal concentration of both soil and maize leaves.

Parameter (ppm)	**Maize leaves**					**Soil**				
	M1	M2	M3	M4	M5	1M	2M	3M	4M	5M
Cd	0.06	0.03	0.01	0.02	0.01	0.04	0.02	0.02	0.01	0.01
	0.04	0.03	0.01	0.01	0.01	0.03	0.04	0.00	0.01	0.01
Cr	0.01	0.01	0.01	0.30	0.10	0.02	0.00	0.00	0.03	0.04
	0.01	0.01	0.05	0.05	0.02	0.02	0.00	0.01	0.02	0.02
Ni	0.07	0.61	0.08	0.10	0.00	0.50	0.72	0.20	0.01	0.00
	0.01	0.00	0.00	0.10	0.00	0.30	0.71	0.02	0.01	0.01
Pb	0.01	0.03	0.01	0.01	0.01	0.70	0.08	0.00	0.02	0.00
	0.04	0.03	0.02	0.01	0.01	0.05	0.04	0.02	0.00	0.00
Hg	0.05	0.02	0.20	0.00	0.00	0.00	0.01	0.00	0.03	0.02
	0.03	0.20	0.20	0.00	0.10	0.01	0.01	0.01	0.02	0.02

As seen in table 3, it is obvious that both Cd and Hg are present in both soil sample and maize leaves at all distances from the dumpsite at Ugwuaji, but Cd was present at concentrations of 0.01ppm at four and five meters and 0.02, 0.03 and 0.04ppm respectively at one, two and three metres from the dumpsite showing that there is contamination of the soil and maize leaves by these heavy metals at all the distances from the dumpsite respectively. Chromium (Cr) was found to have a concentration of 0.01ppm on the maize leaves at distances 1, 2, 3 and 5 metres from the dump site while it was absent at distances 2 and 3 metres in soil samples but present in the remaining distances. Though it was also observed that Nickel was present in the leaves of the maize plant at concentrations of 0.07ppm at 1m, 0.61ppm at 2m, 0.81 at 3m, it was entirely absent at 5metres. In comparison to the concentration of nickel in soil, it was found that Ni was absent in the soil samples obtained from distance 5 meters as compared to its concentration in plants. Hence it can be deduced that waste containing nickel might have been splashed on the leaves of plants at distance one and two metres away from the dumpsite. At distance three metres which had nickel concentration of 0.20ppm, 0.01ppm at 4 metres. Lead (Pb) is present at concentrations of 0.06ppm,0.03ppm and 0.01ppm in maize leaves at distances 1, 2 and 3 metres from the dump site and was also found in concentration of 0.01 ppm at distance four and five metres. However, lead is present at concentrations 0.70ppm and 0.08ppm in soil samples at a distance of one and two meters, and 0.02ppm at a distance of three and four metres and absent in soil samples at distance five meters. This could be attributed to the soil type present in the study area which is clay soil, and tends to immobilize the heavy metal (lead), limiting its availability to the plant for absorption and making it absent in the maize leaves. Mercury (Hg) was present in both the soil and maize leaves but absent in the maize leaves at distance four metres from the dump site.

The reduction in the concentration of heavy metals in the soil at certain distances could be attributed to leachate process as well as rainfall influence. According to Akan *et al*, (2013), heavy metal concentration reduced as distance increased from waste dumpsite as leachates find its way into the soil and underground aquifer but this is not in alignment with the findings of this research. This study found heavy metal concentration in soil at various distance intervals to vary irrespective of the distance away from the waste dumpsite. Pb and Cd normally do not accumulate in the topsoil but, human activities like waste dump can accelerate their concentrations in the soil (Al-Turki *et al,* 2004). Human activities contributions to Cd and Pb contaminations of the environment can consequently be significant more than natural input (Bakırder *et al*, 2013). Since Cd is not considered an important element for human well-being, its toxicity alongside lead are documented (Dessuy *et al*, 2011). Different studies have reported uptake of heavy metals, including Cu and Pb, by crops and vegetables like water leaf, Maize and Amaranthus species from contaminated soil sites like waste dumpsites and animal waste dump-sites (Xiong *et al*,2005). Vegetables are capable of absorbing metals from polluted soil sites in addition to deposits on the leaves and other parts of the vegetables as it is exposed to the air from a polluted environment (Abdullahi *et al*,2009). Ademoroti (1995) reported that vegetables that grow on contaminated soils absorb significant quantity of heavy metals in roots and leaves. The uptakes and bio-accumulations of heavy metals in vegetables is affected by some factors like the atmospheric depositions, climatic condition, levels of heavy metals in the soil, nature of soil and age of the plants at the time of the harvest (Ademoroti *et al*, 1995). The values obtained for heavy metals in maize plant in this study were low when compared to similar studies such as that of Okoronkwo *et al*. (2005) though their studies were on the leaves of cocoyam and cassava. Therefore, this shows that there are differences between concentrations in selected plant tissues (influenced by some factors) of the heavy metals and also a correlation between the concentrations of some of the heavy metals in the plant and that in the soil. The high concentrations of heavy metal in the leaves of the vegetables and certain other plants are typically as a result of result of constituents of the wastes in the dumpsite, which keeps changing due to increase in population and consumption patterns. It is therefore, ascertained that consuming the vegetables and other edible plants grown on such polluted/contaminated sites may be unsafe for human health (Akpofure *et al*, 2012).

5.0 Conclusion and Recommendations

Concentration of Cr, Ni and Hg were significant while the concentration of Cd and Pb were not significant in the soil sample at Ugwuaji dumpsite. Accumulation of metals in the maize leaves sampled from the Ugwuaji dumpsite differs significantly amongst the elements evaluated. The concentration of heavy metal found in soil and maize leaves samples in and around the dumpsite could be attributed to poor management practices of solid waste disposal which are harmful to humans, plants and animals. They are carcinogenic, cause brain disorders, liver impairment and sometimes death. Although some of these heavy metals are biologically essential to plants and man if taken in moderate quantities, they can be toxic when present in large concentrations. The high level of heavy metal concentrations in the dumpsite call for proper attention for the fact that people dump inorganic wastes indiscriminately on the site. Therefore, efforts should be geared towards determining the accumulation rate of heavy metals in plants within the study area. To handle heavy metal contaminations and reduce their dietary toxicity, practices like phytoremediation and/or bioremediation that have proved potentials to degrade and detoxify some contaminants should be adopted. From the findings of this research and to reduce the impact of solid wastes on soil samples and the plants at Ugwuaji environs;

i. it is important to construct a standard sanitary landfill away from residential farming areas than the open dump practice of waste disposal practiced at Ugwuaji.
ii. A holistic environmental and social impact assessment (ESIA) of the study area can help to assess the implications of the improper disposal of wastes at the site.
iii. Wastes to be disposed should be adequately sorted and properly disposed to avoid hazardous chemical leachates into the environment.
iv. Appropriate awareness and enlightenment should be given to the people living within the vicinity on the dangers of farming in the waste dump and its environs. The community dwellers should be involved in the fight against indiscriminate disposal of solid waste at Ugwuaji dumpsite.
v. Existing waste management policies and regulations in Enugu State needs to be adequately enforced by regulatory authorities in the state.

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