ASSESSMENT OF SOME HEAVY METALS CONCENTRATION IN THE SOIL CONTAMINATED WITH E-WASTE IN ABRAKA, DELTA STATE, NIGERIA

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Abstract: The study investigated the concentration level of Cd, Cu, Pb and Zn in e-waste polluted soil in Abraka. The concentration of all the metals in studied site were high, but not above WHO/FAO permissible limit, except Cd. The polluted site were slightly higher than the controlled site, except for Pb and Zn that show significant difference based on the statistical analysis (t = 0.01, p = 67.71, t = 0.08, p = 94.89) for polluted soil. The summarized mean values of each metals for the polluted soil, also shows significant difference from the controlled soil (61.07, 80.76, 94.21, 103.34 mg/kg and 35.67, 55.39, 75.19, 91.40 mg/kg) for Cd, Cu, Pb and Zn, respectively. The result from the study, show that e-waste dumping has impacted heavy metal contaminant into the soil, despites its age in the soil. Therefore, more research will be done to check the concentration of these metals as the e-waste is ageing and the presence of other heavy metals from the soils.

Keywords: Dumpsite, e-waste, heavy metals, pollution, soil

Introduction

The rate of e-waste generation has increased drastically across the whole World, of which, developing countries are of paramount issue as a result of high population growth, embracement of modern life and globalization. Several hazardous substances like cadmium (Cd), lead (Pb), chromium (Cr), mercury (Hg), polycyclic aromatic hydrocarbons (PAHs) etc and non hazardous ones like zinc (Zn), copper (Cu), silver (Ag) etc, found in e-waste have a significant harmful effect on the environment, when they are not properly disposed off and also present above the permissible limit (Lim, 2010, Benedicta *et al*., 2017). The pollution of soil is mainly due to chemical contaminants (Salman *et al*., 2019). About 66% of e-waste by weight have metals like iron (Fe), aluminum (Al), and gold (Au) and nonferrous metals like copper and other precious metals of about 13% by weight (Richard *et al.*, 2013). E-waste are classified based on the weight of materials retrieved from them. Steel is composed of about 50% and plastic is about 21% (ETC/SCP, 2009). The substance that are hazardous in e-waste constitute about 1% of the total weight, while other precious metal like gold constitute 0.1%, silver 0.2% and palladium 0.005%, respectively (Vats and Singh, 2014).

Heavy metals, such as Cd, Hg and Cu present in the environment as a result of the presence of e-waste are known to be persistent, accumulative in plants, animals and humans (Richard *et al.*, 2013), and exposure to these metals and their compounds, it leads to problem in the nervous system and genitourinary system (CDPHE, 2008). E-waste, such as refrigerators, freezers and air conditioning units containing ozone depleting gases like chlorofluoro carbon (CFCs) found in land filling release gases which can cause serious environmental problems (Sheutz *et al*., 2004, Richard *et al.*, 2013).

Abraka is a University town, made of enlightened people craving after electrical electronics equipment, to meet up with modernization, there by leading to more of the e-waste littered everywhere, since there is no landfill in the community. Most of this obsolete electronic equipments are dump any how especially by those having electronic workshops, some are burnt, which also generate fumes that contains heavy metals and other polyaromatic compounds which eventually find their way into the soil and vegetation around the community. As such, herdsmen leading their cattle across the vegetation allow the animals to graze on this vegetation that are harboring this fumes that contains heavy metals, which may affect their health and also endangering the health of those consuming them. For example, Hg and Cd from studies are known to cause problem to the kidney or even kidney dysfunction (Benedicta *et al*., 2017). In fact, this study aims at assessing the levels of Cd, Cu, Pb and Zn contamination from a month old e-waste, deposited on a piece of land in Abraka community.

Materials and Methods

Description of the study area

Abraka is a University town which is one of the most developed area in Ethiope East Local Government Area of Delta State, Nigeria. The town is bounded at the north by Obiaruku, at the south by Salubi in Eku, at the west by Edo state and at the east by Aragba orogun. Abraka has low topography, the study area has a geographical location of Latitude 06.23’01 45^0 N and Longitude 007.73’09 80^0 E. Abraka has an annual rainfall of 2324 mm with its average of 403 mm, which take place in September.

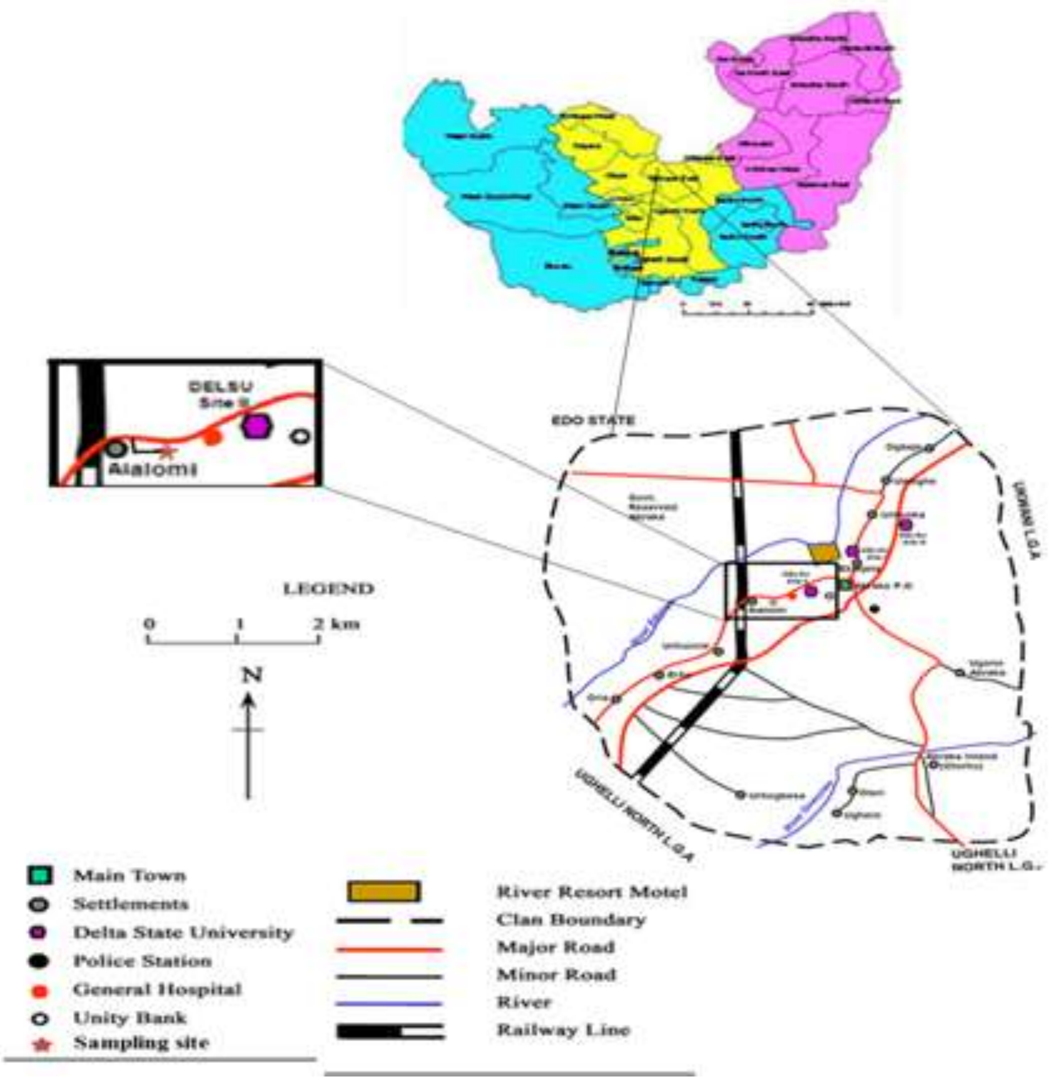

Fig. 1: The map of Delta state, Abraka and the sampling site

Fig. 2: E-waste dump site in Abraka

Soil sampling and preparation

Soil samples were collected from electronic waste dumpsite which comprises television sets, DVD player, printed circuit board, tape recorder and stabilizers from electronics workshop and a controlled soil from a piece of land void of pollution with e-waste (Fig. 2). The soil was taken from six different spot at three different depths (0 – 10 cm, 10 – 20 cm and 20 – 30 cm) to form a composite sample of three each on both sites making a total of six samples. The soil were collected with soil auger into a black polythene bag in ice pack, properly labeled and conveyed into the laboratory immediately. Then it was spread on a white sheet of paper for air drying for 5 day, after thorough mixing manually. At the completion of the 5 days, the soil samples were ground with mortar and pestle and sieved with 2 mm sieve to remove any coarse particles and any other materials that may be found on it.

Laboratory analysis

The levels of Cd, Cu, Pb and Zn were analyzed following Adaramodu *et al.* (2012). 1 g of the sieved soil were weighed into a Teflon beaker and 3 ml of nitric acid (HNO_3) and 9 ml of hydrochloric acid (HCl) (1:3) were added and heated on a hot plate at a temperature of 60-80^0 until all the fume and bubbling ceased. The mixture was left cool and filtered with No 42 filter paper into a conical flask and then mixed with 50 ml of deonized water and kept in a fridge at 4^{0}C, prior to analysis with Atomic Absrption Spectrophotometer (AAS) (Perkin Elmer 1100).

Data analysis

The results from the laboratory were tested using computer software at 95% confidence level on one tailed t-test. The mean were calculated from window 10 version of Microsoft.

Results and Discussion

Cadmium: From Table 1, it was found that Cd had the highest mean concentration (40.92 mg/kg), at depth 20 – 30 cm for polluted soil, which is higher than the controlled soil that has its highest concentration (21.34 mg/kg) at depth 10 – 20 cm. Statistically, there were minimal significant difference across depths and sites (t= 0.13, p =7.40). This shows that the probability of the e-waste contributing Cd contaminant to the soil is minimal, since the p value is greater than 0.1 The concentration of Cd on both site are above WHO/FAO permissible limit of 3 mg/kg (Benedicta *et al*., 2017), which call for alarm, because it poses risk of life to plants, animals and humans. Other values of Cd are 10.64, 9.51 mg/kg in depths 0 - 10 cm and 10 – 20 cm respectively, for polluted site and 1.76 and 12.57 mg/kg in depths 0 – 10 cm and 20 – 30 cm for controlled site, these values were in agreement with those of Richard *et al*, (2013) (1.80, 1.95 and 1.60 mg/kg) and those of Brigden *et al*. (2008) (10.00 and 3.00 mg/kg) at different site, respectively.

Copper: Copper levels was found higher in the three depths of the polluted site, 13.70 mg/kg (0 – 10 cm), 32.65 mg/kg (10 – 20 cm) and 67.06 mg/kg (20 – 30 cm), which are higher than those of the controlled site, except for depth 10 – 20 cm (39.14 mg/kg). These concentrations were below WHO/FAO permissible limit of 100.00 mg/kg (Benedicta *et al.*, 2017). Statistically, there were significant difference across depths and site (t = 0.01, p = 40.61). This indicates that the probability of the e-waste contributing contaminants of Cu to the soil is high. Studies have shown that copper can affect water bodies, the fertility of the soil, production of crop and the activity of microorganism (Fan *et al.*, 2011; Richard *et al*, 2013). It has also been implicated for liver and kidney disorder with vomiting and abdominal pain as the symptoms from chronic exposure to Cu (Richard *et al.*, 2013).

Lead: Lead from Table 1, has higher concentration in depth 20 – 30 cm (62.57 mg/kg) for polluted site than the controlled site (20.35 mg/kg), respectively. Pb concentration in depth 20 – 30 cm of the polluted soil is above the WHO/FAO permissible limit of 50.00 mg/kg (Benedicta *et al*., 2017), but none of the depths in controlled site is above the limit. This implies that the one month e-waste pollution has contributed Pb to the soil. Statistically, there were significant difference across depths and sites (t = 0.01, p = 67.71). This indicates that the probability of the e-waste contributing Pb contaminant to the soil is high. The concentration of Pb in this study is in agreement with those of Adaramodu *et al*. (2012). It has been revealed from study that Pb has impacted toxic effect on different system of the human body like hemopoietic system (anemia was impacted), peripheral nervous system (motor neuropathy was impacted) and genitourinary system (damage to all parts of nephron was impacted) (Harrington *et al*., 2003; Adaramodu *et al*., 2012). Increment in the concentration of Pb at depth 20 – 30 cm of the polluted soil shows that there was high interaction between the e-waste and the soil.

Zinc: Zinc level from Table 1, shows higher concentration in the polluted soil across the depths above the controlled soil (21.05, 17.11, 65.18 mg/kg) for polluted soil and (7.09, 53.81, and 30.49 mg/kg) for controlled soil in depths 0 – 10 cm, 10 – 20 cm and 20 – 30 cm respectively. However they are below WHO/FAO permissible value of 300.00 mg/kg (Benedicta, 2017). Statistically, there were significant difference between the two soil across depths and site (t = 0.08, p = 94.89). As such, there is high probability of the e-waste in contributing much contaminants of Zn to the soil within the one month of pollution. This also shows that as the e-waste is ageing, more contamination will occur. This result is in agreement with those obtained by Benedicta *et al.* (2017).

Table 1: Mean ± SD concentration of heavy metals from the soil on both site (mg/kg)

Depths	Polluted Site				Controlled Site			
	Cd	Cu	Pb	Zn	Cd	Cu	Pb	Zn
0 – 10 cm	10.64±13.04	13.70±12.59	17.19±11.86	21.05±11.67	1.76±2.40	2.75±2.54	8.09±10.65	7.09±11.22
10 – 20 cm	9.51±9.90	32.65±8.39	14.46 ± 7.24	17.11±7.18	21.34 ±30.45	39.14±40.08	46.74±34.19	53.81±26.89
20 – 30 cm	40.92±47.43	67.06±26.23	62.57±18.72	65.18±14.60	12.57±4.67	13.51±13.82	20.35±11.97	30.49±18.91
Instrument detection limit	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

SD = Standard deviation

Table 2: Summarised mean ± SD of each metals in relation to their depths(mg/kg)

Polluted Site				Controlled Site			
Cd	Cu	Pb	Zn	Cd	Cu	Pb	Zn
61.07 ± 47.43	80.76 ± 35.48	94.21 ± 23.42	103.34 ± 7.47	35.67 ±42.57	55.39±54.46	75.19±36.54	91.40±19.24

SD = Standard deviation

In Table 2, the concentration of the summarized mean of each of the heavy metals of the polluted soil, which ranged from 61.07 – 103.34 mg/kg which are higher than those of the controlled soil with concentration range of 35.67 – 91.40 mg/kg across the metals. This indicate that the e-waste has contributed contaminants to the soli within the period of pollution. The values of Cu were low and those of Cd were high when compared to the work done by Richard *et al*. (2013) (259.00, 871.00, 773.00 mg/kg and 4, 5, 3 mg/kg) respectively, from three differ site at Tema Community one.

Conclusion

The result from this study established that all the metals studied were present in the soil. However, while the contaminations of Cd and Cu were slight, Pb and Zn impacted a significant contamination. On the whole it can be concluded that the electronic waste contributed to the contamination of the soil by the heavy metals. It is therefore important that serious monitoring medium should be established to checkmate the dumping of e-waste in the community.

Conflict of Interest

Authors have declared that there is no conflict of interest reported in this work.

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