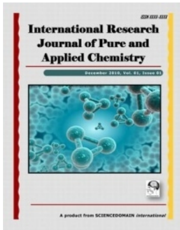

International Research Journal of Pure & Applied Chemistry
4(6): 678-690, 2014

SCIENCEDOMAIN *international*
www.sciencedomain.org

Heavy Metals Concentration at Electronic-Waste Dismantling Sites and Dumpsites in Lagos, Nigeria

E. A. Ofudje[1*], S. O. Alayande[2], G. O. Oladipo[3], O. D. Williams[3] and O. K. Akiode[4]

[1]*Department of Chemical Sciences, Mcpherson University, Sariki-Sotayo, Ogun State, Nigeria.*
[2]*Centre for Energy Research and Development, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.*
[3]*Department of Science Laboratory Technology, D.S. Adegbenro ICT Polytechnic, Itori, Ogun State, Nigeria.*
[4]*Institute for Human Resources Development, Federal University of Agriculture Abeokuta, Ogun State, Nigeria.*

Authors' contributions

This work was carried out in collaboration between all authors. Author EAO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors GOO and ODW managed the analyses of the study. Authors OKA and SOA managed the literature searches. All authors read and approved the final manuscript.

Original Research Article

Received 4th November 2013
Accepted 17th January 2014
Published 25th June 2014

ABSTRACT

The importation and refurbishing of second-hand electrical and electronic equipment (EEE) is a major concern all over the world and Nigeria is not in exception owing to the generation of e-wastes. The assessment of the levels of Pb, Cr, Ni, Cd and Zn in the dust at dismantling sites and soil from dumpsites in Lagos municipal was performed using Atomic Absorption Spectroscopy. Control samples were also taken at 1km away from each site. At the dismantling sites, the concentration of Pb, Cr, Ni, Cd and Zn were found to range between 99.63 to 141.90 mg/kg, 14.80 to 21.88 mg/kg, 30.41 to 55.68 mg/kg, 10.55 to 23.56 mg/kg and 57.61 to 111.48 mg/kg, while that of the control site ranged

**Corresponding author: Email: ofudjeandrew4real@yahoo.com;*

between 44.31 to 73.33 mg/kg, 6.62 to 13.42 mg/kg, 16.44 to 34.13 mg/kg, 5.86 to 14.40 mg/kg and 20.35 to 60.73 mg/kg respectively. At the dumpsites, the contents of Pb, Cr, Ni, Cd and Zn were found to range between 152.30 to 328.40 mg/kg, 23.94 to 30.80 mg/kg, 53.75 to 64.81 mg/kg, 24.86 to 31.40 mg/kg and from 211.46 to 306.94 mg/kg, while that at the control sites range between 74.60 to 162.90 mg/kg, 11.43 to 16.52 mg/kg, 36.91 to 41.43 mg/kg, 10.91 to 20.84 mg/kg and 116.90 to 178.31 mg/kg respectively. Heavy metals concentrations at the dumpsites were found to be higher than what was observed in the dust samples at the dismantling sites. Also, the control samples showed lower concentration when compared with the dismantling sites and that of the dumpsites. This result indicates that e-waste contributes to the concentration of heavy metals in the soil and dust sample where e-waste are being dismantled and the dumpsites where the unused electrical and electronic equipment are being disposed.

Keywords: Dismantling sites; dumpsites; E-waste; heavy metals.

1. INTRODUCTION

The production and sale of electronic appliances has skyrocketed all over the world owing to rapid development of technology. As new versions of existing products are being launched, existing versions are constantly being relegated to the back and subsequently being replaced and disposed. This has resulted in the pollution of the environment with electronic-waste. The term e-waste, e-scrap or waste electrical and electronic equipment (WEEE) is used to described any discarded electrical or electronic devices such as computers, mobile phones, television sets, refrigerators, entertainment devices, office electronic equipment to mention but a few [1,2,3]. Rapid changes in technology, changes in existing versions and planned obsolesce have resulted in a fast growing surplus of WEEE all over the globe. According to the Environmental Protection Agency, it's only about 15 to 20% of e-waste that is being recycled, while the remaining goes directly into landfills and incinerators [4]. An estimated amount of about 50 millions tons of e-waste are produced annually globally [5].

Lagos is gradually emerging as one of the top city in Nigeria that is been regarded as the home ground for all sort of electronic wastes and other toxic chemicals [5]. According to the report of Basel Action Network (BAN), over 500 shipping containers containing about 175, 000 large TV sets or 400, 000 computer monitors are being imported to Lagos on monthly basis [6]. About 75% of such shipments are classified as e-waste [6-8]. The disposal, distribution, recycling as well as parts salvaging of the discarded electronic devices are sources of social, environmental and public health challenge in Nigeria [8]. The process of disposing and dismantling of WEEE in developing countries like Nigeria caused a lot of environmental impact such as the release of liquid and atmospheric hazardous substances which end up in the bodies of water, groundwater, soil and air which affects land and sea animals, crops and human beings [1,9].

Furthermore, e-waste salvagers are exposed to lead fumes as a result of cooking circuit boards over open flames or in swallow pans [10]. Acid baths are often used to extract gold from circuit board chips, spewing even more toxic gases into the air [11] and these process release heavy metals such as cadmium, lead and mercury into the air, water and soil [12]. Some of the hazardous substances found in e-waste are presented in Table 1.

Table 1. Hazardous substances in e-waste, their sources and health effects

Hazardous substances	Sources	Health effects	References
Mercury	It is found in fluorescent tubes, flat screen monitors, mechanical doorbells and thermostats.	Sensory impairment, memory loss, muscle weakness. In-uterus exposure leads to serious deficits in motor functions and verbal domain	[1,13]
Americium	Found in smoke alarms	It is carcinogenic	[1]
Lead	Cathode ray tubes (CRTs), batteries, solder and formulated poly vinyl chloride (PVC).	It lowers intelligent quotient, attention deficits, and cognitive function impairment and causes behavioral disturbances, malaise, anorexia and can also damage some important organs such as kidney, liver, hearth and leads to death.	[1,11,13,14-16]
Cadmium	It is found in light-sensitive resistors, batteries, aviation and marine corrosion resistant alloys.	It damages the kidneys and lungs when inhaled. It can also leads to reduction in learning, behaviour, cognitive and motor skills in children.	[1,13,17]
Brominated Flame Retardants (BRF)	It is used as flame retardants in plastics in electronics.	Causes thyroid and liver problems and can leads to the impairment of the nervous system.	[1,16]
Sulphur	Acid batteries.	It causes damage to kidney, liver, heart and causes throat irritation.	[1]

It's obvious that e-waste not properly dismantled and recycled pose a serious threat to both human health and the environment. For instance, electronic cables which contain heavy metals are burned in open air and release toxic furans and dioxin. Also, cathode ray tubes (CTRs) are dismantled with hammers so as to remove copper but this process release toxic phosphor dusts into the atmosphere. Fig. 1 shows e-waste scavengers at work at Olusosun dumpsites in Lagos, Nigeria.

While there is agreement that the number of discarded electronic appliances is on the increase, there is considerable disagreement about the relative risk and strong disagreement also that curtaining trade in used electronic will improve the state of contamination. It is to this end that this research work was conducted to assess the level of some heavy metals in the dust and soil where these WEEE are being dismantled and the dump sites where the unused components are disposed. Control samples were also taken 1km away from each site. This will alert e-waste stakeholders on the danger posed by e-waste and encourage them to establish environmentally sound facilities for e-waste management.

Fig. 1. E-waste scavengers at work at Olusosun dumpsite in Lagos
(Source: E-waste country assessment Nigeria, 2012)

2. MATERIALS AND METHODS

2.1 Sample Locations

Lagos State is located in the southwest part of Nigeria in West Africa. It is on coordinates 6º27'//N3º23'45'E and covers an area of 999.6km^2. Lagos is a municipal area which originated on islands divided by creeks, such as Lagos Island, fringing the southwest mouth of Lagos Lagoon while protected from the Atlantic Ocean by long sand spits such as Bar Beach, which stretch up to 100 kilometres (62 miles) east and west of the mouth. Ikeja is the capital of Lagos State. Some of the popular places include Agege, Mainland, Ikoyi, Lagos Island, Leki, Victoria Island, Ikorodu, Epe, Oshodi, Badagry, etc. Traditionally, Lagos State is inhabited by the Aworis subgroup of the Yoruba people but due to high level of commercialization and industrialization, many people from different nationalities work and live within the territory boundary of Lagos State. The National Population Commission 2006 put Lagos population at 9.019534 million [18] while the newest report put the population at about 21 million [19]. Lagos is the second fastest growing city in Africa and the seventh fastest growing city in the word. The three dumpsites are Abule-Egba, Olusosun and Soluos in Lagos State of Nigeria. They are designated dumpsites by the Lagos State Waste Management Agency and with a capacity of about 63.67 hectares of land. The Olusosun dumpsite is one of the largest in Africa and was established in 1992. It covers about 42 hectares of Land which receives about 2,400 metric tones of waste every day. The soluos dumpsites has a capacity of about 2,250 metric tones of waste with about 350 to 500 individuals involved in the picking of waste materials. Ikeja computer village opened business in 1995/96 in the sales of new electrical and electronic equipment. But around year 2000, the market commenced the sales of second-hand electronic devices such as mobile phones, computers, TV sets etc. It has a size of about 1.1km^2 and occupies over 3,000 businesses in both new and used electrical and electronic equipment. The Ojota scrap market is well known for the dismantling and sorting of solid wastes including EEE. It is located along Lagos-Ikeja axis. Part of this market is used to dispose and incinerates waste. Burning of cables is a normal routine in this market. Alaba International market is the largest refurbishing cluster in West Africa. The metal-containing wastes are sold to collectors who then dismantled and sort out the useful parts. Cables are burn in open fire at some locations very close to this market. Fig. 2 shows the map of Lagos State showing different locations and the study areas represented by letters A to G.

Fig. 2. Map of Lagos State showing different locations and the study areas represented by letters A to G

Where A=Alaba International Market, B=Soluos dumpsite, C=Computer Village, D=Ojota Scrap Market, E=Olusosun dumpsites, F=Odo Iya-Alaro Market and G=Abule Egba dumpsites

2.2 Sample Collection

Three sets of samples were collected randomly at different locations between December 2012 and March 2013 during the dry season. First, surface dust samples were collected from four sites where electronic waste are being dismantled by sweeping the surface and this was referred to as dust sample (DM). Secondly, top soil between 0 to 10cm samples were randomly collected from three e-wastes dumpsites where the unused components are being dumped after dismantling and removal of important parts and this was referred to as soil sample (DS). Finally, samples were also collected at about 1km away from the locations where the dust and soil samples were collected and it was referred to as control sample (CS). The samples were collected in 500 ml sample bottles which has been previously washed with detergents and rinsed with distilled water and transported into the Laboratory for preparation. A total number of three samples were collected from each site.

2.3 Sample Preparation and Metal Contents Analysis

The samples were sun dried for 15 days and thereafter placed in an oven for 2 h at a temperature of 80ºC. The samples were homogenized using a mechanical grounder and sieved through a mesh size of 2 mm and kept in air-tight plastic sample bottles prior to analysis. The modified method described by Adaramodu et al. [8] was adopted for the metal analysis. Briefly, the homogenized samples were then digested by using a mixture of 5 ml of HNO_3 and 10 ml of HCl in a kjeldahl flask that contained 1 g of the sample. The contents of the flask were digested until the brown fumes of nitroxide ceased to appear. The solution was then filtered through Whatman number 42 filter paper into a 100 ml volumetric flask and made up to the mark with deionized water. The concentrations of Pb, Cr, Ni, Cd and Zn were analyzed using Buck Scientific model 210VGP Atomic Absorption Spectrophotometer. The data were analyzed in triplicate and the mean concentration values were recorded.

3. RESULTS AND DISCUSSION

The relative increase in the concentrations of heavy metals at e-waste dumpsites and dismantling sites compared with those in the soil and dust samples from 1km away (control samples) in respective sites indicate the impact of e-waste in these areas which greatly influence and contribute to the high metal contents observed. The results of heavy metals analysis of the various dust sites as well as their respective controls are presented in Table 2; while that of the soil samples and its control counterparts are presented in Table 3. The range of the concentration of lead in the dust samples ranged between 99.63 to 141.90 mg/kg. Maximum concentration of 141.90 mg/kg was observed in the dust sample collected from Alaba International Market, followed by computer village (120.45 mg/kg), then by Odo-Iya Alaro (114.31 mg/kg), while Ojota scrap market showed the least value of 99.63 mg/kg. At a distance of 1km away from each site, the concentration of lead ranged between 44.31 to 50.70 mg/kg. From Table 3, it can be seen that the concentration of lead in the three e-waste dumpsites ranged between 146.3 to 328.4 mg/kg with Olusosun dumpsite having the highest value of 328.4 mg/kg, followed by Soluos (152.3 mg/kg) and the least value was observed in the soil sample at Abule-Egba dumpsite. At 1km away from the various dumpsites, the lead concentration ranged between 74.6 to 162.9 mg/kg. Except for the lead contents at Olusosun dumpsite, other sites fall below the limit of 300 mg/kg proposed by USEPA [20] and the range of 2-200 mg/kg reported by Ebong et al. [21]. The results agree well with what had been observed by previous reports [22-24]. However, the results were higher than the range of 1.34 to 1.693 mg/kg reported by Aluko et al. [25] and 9.40 to 22.5 mg/kg observed by Adaramodu et al. [8]. The results revealed that both the dumpsites and dismantling sites contained significant amount of lead which could be as a result of the presence of lead containing substances like cathode ray tubes, batteries and solders at these sites. It is worthy to note that continues exposure to lead containing substances could be deadly. Lead is found in e-wastes such as in cathode ray tubes, batteries and solders. Effects of exposure to lead includes low intelligent quotient, muscle pains, anorexia, malaise, attention deficit, impairment of cognitive function and high level of lead exposure could cause brain damage and leads to death [11,13-15].

Table 2. Heavy metals analysis of the various dust sites as well as their respective controls

Locations	pH	Pb(mg/kg)	Cr(mg/kg)	Ni(mg/kg)	Cd(mg/kg)	Zn(mg/kg)
Odo-Iya Alaro	8.42±0.07	114.31±7.13	10.24±0.11	38.76±5.09	11.21±2.30	86.31±7.28
Control*	7.22±0.02	50.70±2.13	4.33±0.04	27.81±1.22	9.64±0.49	48.71±2.83
Alaba Int. Mkt.	9.66±0.11	141.90±5.13	21.88±1.21	55.68±4.62	23.56±2.35	111.48±9.71
Control**	8.83±0.05	73.33±1.13	13.42±0.40	34.13±2.03	14.40±1.39	60.73±4.62
Computer Village	8.32±0.14	120.45±9.42	19.65±0.55	43.24±5.21	17.91±3.04	98.62±7.27
Control***	8.26±0.20	68.46±5.02	10.51±0.01	21.52±0.93	6.80±0.72	40.53±2.20
Ojota Scrap Mkt	8.11±0.43	99.63±0.51	14.80±3.01	30.41±2.58	10.55±1.03	57.61±4.25
Control****	8.01±0.16	44.31±0.32	6.62±0.02	16.44±0.89	5.86±0.24	20.35±1.71

Table 3. Heavy metals analysis of the various soil sample as well as their respective controls

Locations	pH	Pb(mg/kg)	Cr(mg/kg)	Ni(mg/kg)	Cd(mg/kg)	Zn(mg/kg)
Abule-Egba	8.65±0.31	146.30±8.42	26.40±2.13	64.81±6.46	27.83±3.23	211.46±9.41
Control°	7.81±0.04	74.60±2.18	12.60±0.20	36.91±2.08	10.91±2.40	116.90±3.20
Olusosun	9.93±0.82	328.40±10.30	30.80±4.43	73.94±9.41	31.40±5.36	306.94±14.82
Control°°	9.64±0.36	162.90±8.46	16.52±1.04	41.43±1.26	20.84±1.81	178.31±7.09
Soluos	8.59±1.51	152.30±9.85	23.94±2.84	53.75±6.48	24.86±3.55	268.20±4.82
Control°°°	8.35±0.84	90.40±3.08	11.43±0.92	38.94±2.82	15.20±0.82	149.90±5.68

Chromium concentrations from the samples of dust from various sites are shown in Table 2. As indicated in the table, sample from Alaba International market had the highest concentration of 21.88 mg/kg, followed by 19.65 mg/kg at computer village, then by 14.80 mg/kg at Ojota scrap market while the least value of 10.23 mg/kg was found in Odo-Iya Alaro market. Also, the results at 1km away showed that the mean concentrations of Alaba Internation market, computer village, Ojota scrap market and Oja-Iya Alaro were found to be 13.42, 10.51, 6.62 and 4.33 mg/kg respectively. From Table 3, chromium concentration of 30.80, 26.40 and 23.94 mg/kg were found at Olusosun, Abule-Egba and Soluos dumpsites respectively with Olusosun having the highest value and Soluos dumpsite showed the lowest value. Chromium contents of control samples from the dumpsites ranged between 11.43 to 16.52 mg/kg. It was observed that the mean concentration of chromium (27.03 mg/kg) in dumpsites was higher than the mean concentration (16.64 mg/kg) in the dust of dismantling sites. This is to say that there is more interaction between chromium with the soil of the dumpsites than the dust of the dismantling sites. It was also observed that the values of the control (1km away) were lower than what were observed at the dismantling sites and dumpsites. This suggests that chromium might have been introduced by chromium containing e-wastes materials into the soil and dust samples. Major sources of chromium in e-waste include hardener in plastics and dye in pigments of some switches. Skin contact with some chromium (VI) compounds can lead to ulcers while allergic reaction could results in redness and swelling of the skin [26]. Chromium (VI) compounds have also been noted to increase the risk of lung cancer [8] and can also cause damage to DNA [17]. The mean concentration of chromium in this study fall below the 100 mg/kg recommended by USEPA, 100.3 to 105.0 mg/kg reported by Gitimoni and Krishna [26] but was found to be higher than 0.10 and 0.35 mg/kg reported by Adaramodu et al. [8].

The concentration of cadmium from this study is very high. The maximum value of 23.56 mg/kg was observed in the dust samples at Alaba International market and the minimum value of 10.55 mg/kg was obtained in the sample of Ojota scrap market as shown in Table 2. However, at 1km away, cadmium concentration ranged between 5.86 to 14.40 mg/kg for the dust samples. From Table 3, Olusosun dumpsite showed the highest concentration (31.40 mg/kg) followed by Abule-Egba (27.83 mg/kg) and the least value was obtained at Soluos dumpsite (24.86 mg/kg). At 1km away, cadmium concentration ranged between 10.91 to 20.84 mg/kg. The difference in the cadmium concentration at various dumpsites, dismantling sites and control samples suggests that increase in cadmium concentration may be as a result of the released of cadmium from e-wastes containing electrical and electronic equipment such a batteries, PVC, aviation corrosion resistant and light-sensitive resistors. Cadmium is a potentially long-term cumulative poison and toxic compounds of cadmium tend to accumulate in the human body causing kidney and lung damage [1,8], it is known to be carcinogenic to human health [27]. The level of cadmium from this study exceeded the 3.00 g/kg proposed by USEPA but agree with the findings of Abdallah et al. [25] in the range of 5.19 to 45.49 mg/kg. The cadmium level from this study were however higher than 0.009 and 0.42 mg/kg, 0.04 to 0.08 mg/kg reported by Umoh and Etim [28].

Zinc concentration was found to range between 57.61 to 111.48 mg/kg for the dust samples and between 20.35 to 60.73 mg/kg for the control samples in the dismantling sites as indicated in Table 2. Maximum zinc concentration (111.48 mg/kg) was observed at Alaba International market while the least value (57.61 mg/kg) was obtained from the dust samples at Ojota scrap market. Also, zinc concentrations at various dumpsites were found to range between 211.41 to 306.94.37 mg/kg and between 116.90 to 178.37 mg/kg for the control samples. For the dumpsites, maximum zinc concentration (306.94 mg/kg) was observed at Olusosun and the least values (211.46 mg/kg) were found in the soil sample at Abule-Egba as shown in Table 3. Zinc concentration at control sites were lower when compared with what was observed at the dumpsites and dismantling sites. This indicate that increase in the zinc concentration at the dismantling sites and dumpsites is greatly influenced by the released of zinc containing substances into the soil. The acceptable limit of zinc in the soil is 10-300 mg/kg. It was observed that except for zinc contents at Olusosun dumpsite, all other zinc contents from the study areas as well as that of the control sites fall within the save limit. Odkoya et al. [27] reported that the concentration of zinc in Abeokuta dumpsites was found to be between 100.80 to 226.00 mg/kg while that of the control samples ranged between 51.25 to 71.43 mg/kg which is in agreement with results of this study. Also, Adaramodu et al. [8] found out that zinc concentration in dust and out dust present at west minister electronic market in Lagos were 295. 50 and 213.00 mg/kg respectively, while that of the control sample was 78.00 mg/kg which also conform to the finding of this study. Zinc is a good essential element which is required in low quantity for body development. However, excessive intake or exposure to zinc can cause dehydration, abdominal pain, electrolyte imbalance, lack of muscular co-ordination and vomiting [28,29].

The concentration of nickel in dust sample was obtained to range between 30.41 to 55.68 mg/kg and between 16.44 to 34.13 mg/kg for the control sites which is presented in Table 2. For the dumpsites, nickel concentration was obtained to range between 53.75 to 73.94 mg/kg and between 36.91 to 41.43 mg/kg for the control soil samples as indicated in Table 3. Nickel concentration in the control sites were lower than what was observed in the dust and soil samples from dismantling sites and dumpsites respectively. This shows that the e-waste contribute significantly to nickel concentration in both the dust samples and the soil samples. The concentration of nickel in the soil and control samples fall within the world average for nickel contents in the soil (40 mg/kg) [28,30] except for the dust sample which was obtained from Alaba International market. The results from this work fall within the values observed by Gitimoni and Krishna [26] (48.9 to 50.1 mg/kg). Although, nickel is an essential element, it is also known to be harmful if inhaled in excess. Nickel at higher concentration is carcinogenic and when inhaled in large amount, it can cause damage to the brain, liver, muscle and kidney [31].

The pH of the study areas were found to range between 8.11 to 9.66 mg/kg for the dust sample at the dismantling sites and from 7.22 to 8.83 for the control samples.

On the analysis of the pH of the dumpsites, the pH ranged between 8.59 to 9.93 mg/kg and from 7.81 to 9.64 for the control sites. The solubility of metals ions in the soil could affect metal availability in a particular soil. This will in turn affect the mobility of the metal in the soil. According to Smith et al. [32], metal mobility decreases proportionally with the pH of the soil due to the formation of carbonates or insoluble organic complex and the precipitation of hydroxides.

Table 4 shows the results of the statistical analysis of the correlation between metals in the dust and metals in the soil samples. The correlation was performed at α=0.05 (two tail) and for n=7. The results indicated that Pb-dust displayed positive correlation with Pb-soil, Cr-soil, Cd-soil and Zn-soil, while Cr-dust displayed positive correlation with Pb-soil, Cr-soil and Cd-soil. Ni in the dust sample displayed positive correlation with Cr-soil and Cd-soil; Cd-dust also showed positive correlation with Pb-soil, Cr-soil, Ni-soil and Zn-soil. Also, Zn-dust displayed positive correlation with Cr-soil, Ni-soil and Cd-soil. Negative correlation was observed between Pb-dust with Ni-soil, Cr in dust showed negative correlation with Ni and Zn in the soil. Negative correlation was also observed between Ni-dust with Pb, Ni and Zn-soil, while Zn-dust displayed negative correlation with Pb and Zn in the soil samples. The positive correlation that was observed may indicate that the concentration of metals in the samples of the dust may have come from the same origin as that of the soil samples and in this study, the e-waste. On the other hand, the negative correlation may indicate that the concentration of metals in the soil and dust were from different source. This implies that for negative correlation, the natural background concentration of individual metals in the soil might be responsible for the high concentration observed and not necessarily from the e-waste.

Table 4. Correlation between the levels of metals in dusts versus soil samples

	Pb-soil	Cr-soil	Ni-soil	Cd-soil	Zn-soil
Pb-dust	0.74	0.68	-0.41	0.68	0.15
Cr-dust	0.36	0.82	-0.87	0.52	-0.28
Ni-dust	-0.58	0.19	-0.23	0.57	-0.45
Cd-dust	0.71	0.24	0.43	0.96	0.32
Zn-dust	-0.46	0.22	0.37	0.11	-0.14

Figs. 3 and 4 showed the comparative mean concentration of heavy metals (mg/kg) in dumpsites and dismantling sites with control samples. It’s obvious from the plots that there were great significant difference between the concentration of heavy metals in the soil samples, dust samples and that of the control samples. In each case, the concentrations of heavy metals in the control samples were lower indicating that the heavy metals concentration in the control site might be as results of natural sources or other means of contamination. This shows that the concentration of heavy metals at the dumpsites and dismantling sites is contributed by the presence of e-waste containing heavy metals.

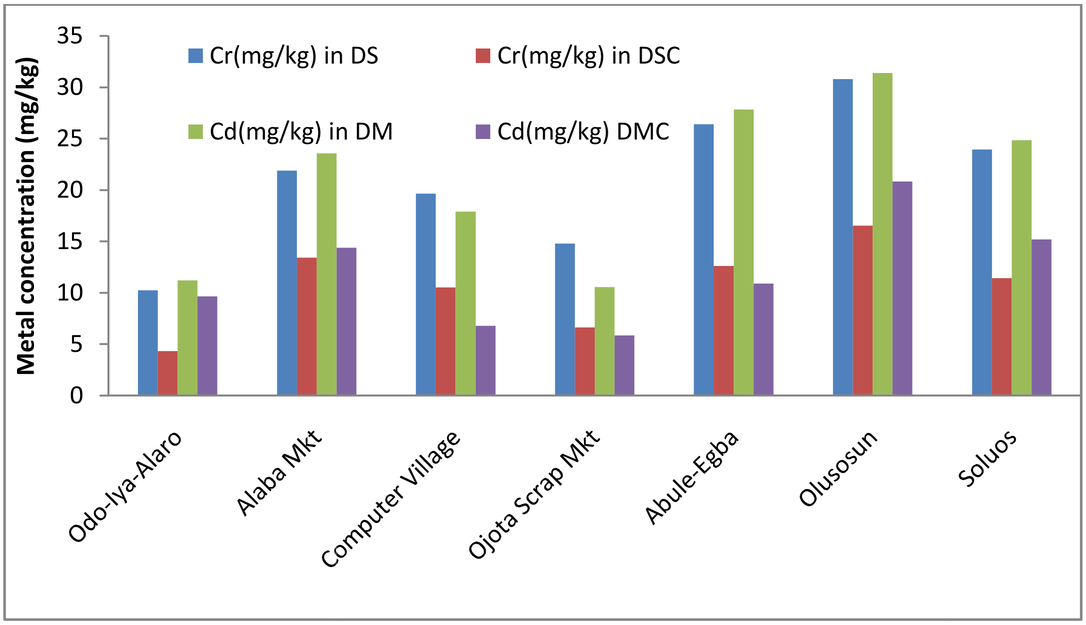

Fig. 3. Comparative mean concentration of Cr and Cd (mg/kg) in dumpsites and dismantling sites with control samples

Where DS=Dumpsites, DSC=Dumpsites Control, DM=Dismantling, DMC=Dismantling Control

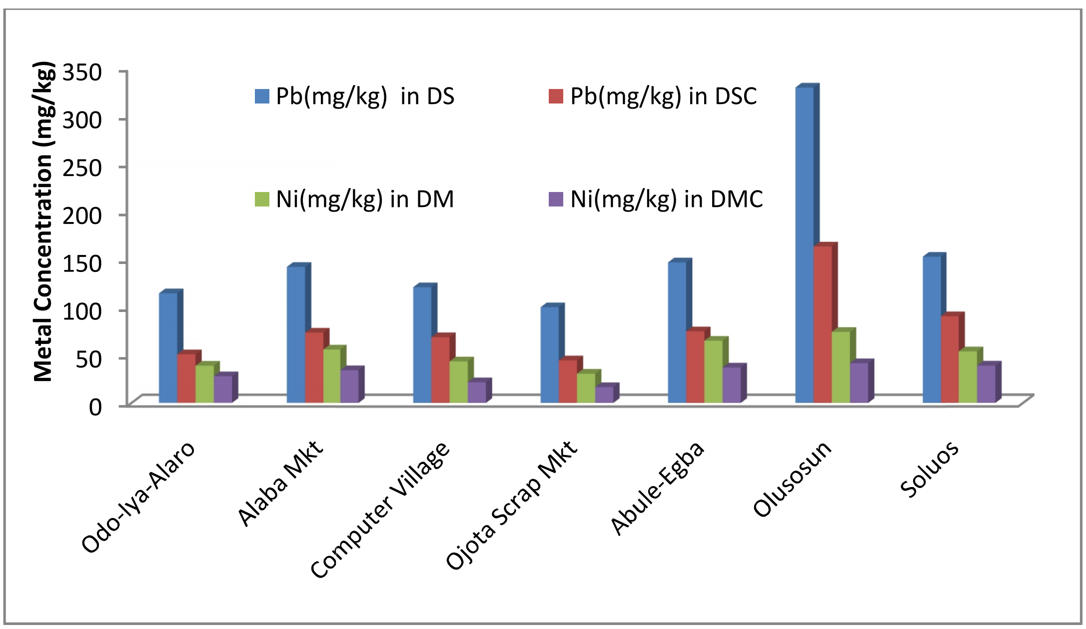

Fig. 4. Comparative mean concentration of Pb and Ni (mg/kg) in dumpsites and dismantling sites with control samples

Where DS=Dumpsites, DSC=Dumpsites Control, DM=Dismantling, DMC=Dismantling Control.

4. CONCLUSION

This study focuses on the analyses of the level of heavy metals concentrations in the dust and soil samples of e-waste dismantling sites and dumpsites. It was observed that dust samples from Alaba International market and that of the control site had comparatively higher heavy metals concentrations in comparison with other sites. This could be as a result of the large quantity of electrical and electronic equipment activities around this area. Alaba International market is known to be the home to electronic of all kinds in Nigeria. It was also observed that the concentration of heavy metals analyzed at various sites were higher than what was observed at the control sites for both the dismantling sites and the dumpsites. For the soil samples at the dumpsites, Olusosun and the control samples had the highest contents of heavy metals in comparison with other sites. High levels of positive correlation exist between the dumpsites and dismantling sites showing common source of pollution. Thus, there is urgent need to pay more attention to the chemical composition of e-wastes dismantling sites and dumpsites.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Electronic Waste.
   Available: http://www.en.wikipedia.org/wiki/Electronic_Waste. Accessed on 7/10/13 at 2:30pm.
2. Pinto VN, E-Waste Hazard. The Impending Challenge. Ind J Occup Environ Med. 2008;12(2):65-70.
3. Sinha S. Downside of the Digital Revolution; 2007.
   Available: http://www.toxicslink.org/art_view. phd?id=124. Accessed on 2013-7-10.
4. Statistics on the management of used and end-of –life electronics. US Environmental Protection Agency. Accessed on 13/03/2012.
5. Sthiannopkao S, Wong MH. Handling e-Waste in developing contries: initiatives, practices and consequences. Sci Total Environ. 2012;1147-1153.
6. Oladele Osibanjo. Executive Director, Basel Convention Coordinating Centre for training and technology transfer for the African region (BCCC-Africa). University of Ibadan at The Unveiling of The Official Logo of Eko International E-Waste Summit; 2010.
7. Its Rubbish to waste like this.
   Available: http://ipsnews.net/news.asp?idnews=40893. Retrieved 2013-05-18.
8. Adaramodu AA, Osuntogun AO, Ehi-Eromosele CO. Heavy metal concentration of surface dust present in e-waste components: The Westminster electronic market, Lagos case study. Resources and Environment. 2012;2(2):9-13.
9. Frazzoli C. Diagnostic Health risk assessment of electronic waste on the general population in developing countries scenarios. Environ Impact Assessment Review. 2010;388-399.
10. Electronic Waste Disposal.
    Available: http://www.electronicwaste disposal htm. Retrieved on 2013-7-10.

11. Electronic take back coalition. Available:http://www.electronicstakeback.com/wp-content/uploads/Q_and_A_on_Exporting_Issues. Retrieved on 2012-12-25.
12. Where does e-waste end up? Available:http://www.greenpeace.org/international/en/campaigns/toxics/electronics/the-e-waste_problem/where_does_e-waste_end_up/. Retrieved on 2013-4-10
13. Chen A, Dietrich KN, Huo X, Ho SM. Developmental neutrotoxicants in E-waste: An emerging health concern. Environ Health Persp. 2011;119(4):431-438.
14. Morgan R. Tips and Tricks for Recycling Old Computers; 2006. SmartBiz. Retrieved 2009-06-21.
15. Royte E. E-gad! Americans discard more than 100 Millions computers, cellphones and other electronic devices each year. As 'e-waste' piles up, so does concern about this growing threat to the environment. Smithsonian Magazine; 2005. Retrieved 2009-03-17.
16. Olakintan O, Innocent CN, Oladele O, Mathias S. E-waste country assessment Nigeria. e-Waste Africa Project of the Secretariat of Basel Convention; 2012.
17. Cadmium-e-waste. Available: http://www.lentech.com/peeriodic/elements/cd.htm. Retrieved on 2013-8-18.
18. Population census National Bureau of Statistics of Nigeria; 2006. Available: http://www.nigeriastat.gov.ng/nbsapps/connections/pop2006.pdf. Retrived on 2013/06/08.
19. John C. This is Africa's new biggest city. Lagos, Nigeria, Population 21 Million; 2012. Available at: http:/m.theatlantic.com/international/archive/2012/07/this-is-africas-new-biggest-city-lagos-nigeria-population-21-million/259611.
20. United State Environmental Protection Agency (USEPA). Quality criteria for water, office of water regulations and standards. Washington D.C. 20460; 1986.
21. Ebong GA, Akpan MM, Mkpenie VN. Heavy metal contents of municipal and rural dumpsite soils and accumulation by *Carica papaya* and *Talinum triangulare* in Uyo, Nigeria. Environ J Chem. 2008;5(2):281-290.
22. Uba S, Uzairu A, Harrison GFS, Balarabe ML, Okunola OJ. Assessment of heavy metals bioavailability in dumpsites of Zaria metropolis, Nigeria. Afri J Biotechnol. 2008;7(2):122-130.
23. Bamgbose O, Odukoya O, Arowolo TOA. Earthworms as bio-indicators of metal pollution in dumpsites of Abeokuta, Nigeria. Revista of Tropica Biology in 48n J San Jose; 2000.
24. Abdallah SA, Uzairu A, Kagbu JA, Okunola OJ. Assessment of heavy metals bioaccumulation by *Elusine indica* from refuse dumpsites in Kaduna metropolis, Nigeria, Nigeria. J Environ Chem and Ecotoxi. 2012;4(9):153-160.
25. Aluko OO, Sridha MKC, Oluwande PA. Characterization of leachates from a manucipal solid waste landfill site in Ibadan, Nigeria. J Environ Health Research. 2003;2(1):20-26.
26. Gitimoni D, Krishna GB. Enrichment of Cr, Mn, Ni and Zn in surface soil. Intern J of Civil and Environ Eng. 2009;1(3):145-147.
27. Odukoya OO, Bamgbose O, Arowolo TA. Heavy metals in top soils of Abeokuta dumpsites. Global J of Pure and Appl Sci. 2001;7:467-472.
28. Umoh SD, Etim EE. Determination of heavy metals contents from dumpsites within Ikot Ekpene, Akwa Ibom State, Nigeria using atomic absorption spectrometer. Intern J Eng and Sci. 2013;2(2):123-129.
29. Udosen ED. Level of Toxic Metals in *Achantina* from parts of Akwa Ibom State. J Environ Sci. 2000;12(1):68-74.

30. Bowen HJM. The biochemistry of the elements; trace elements in biochemistry. Academic Press, London, New York. 1996;173-210.
31. Dater MD, Vashistha RP. Investigation of heavy metals in water and silt sediments of Betwa River. Interna J Environ Protect. 1990;10:666-672.
32. Andreas M, Oladele O, Adeyinka A, Sidddharth P. Informal e-waste management in Lagos, Nigeria-socio-economic impacts and feasibility of international recycling co-operations. Final Report of Component 3 of the USEPA SBC e-waste Africa; 2011.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=536&id=7&aid=5070