Evaluation of the Environmental Impacts of Electronic-Waste Management in Lagos Using Alaba International Market and Ikeja Computer Village as Case Studies

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ABSTRACT

The main aim of this research was to assess the extent of the problems associated with inappropriate e-waste management and recycling practices. Electronic wastes (E-wastes) are generated from products that are designed for use with a maximum voltage of 1000 volts for alternating current and 1500 volts for direct current. These wastes contain hazardous materials such as lead, mercury, cadmium, brominated flame-retardants, valuable metals such as aluminium, nickel, copper, and certain precious metals such as gold, silver and platinum group metals (PGMs) which pose both human and environmental health threats. They have negative impacts on the health of workers and nearby residents; hence, residents of buildings located around and beside e-wastes dumpsites were randomly selected for this study. Well, run-off and borehole water samples as well as soil samples from different sites in Alaba international market, and Ikeja computer village in Lagos, Nigeria were analyzed for zinc, lead, iron, copper, nickel and chromium. Using additional information from questionnaires and interviews, impacts of e-waste dumps on the health of workers and residents near the study areas were investigated. The results were analysed using descriptive frequency count and tables which confirmed the presence of heavy metals in soils and water samples of the case study areas and hence appropriate recommendations were outlined to address the menace of e-waste disposal and as well as the need for improvement in e-waste management and recycling for economic opportunities and improved health standard within the Lagos Metropolis.

Keywords: E-wastes, Environmental health, Heavy metals, Hazardous materials, Lagos metropolis

1.0. Introduction

E-waste is chemically and physically distinct from other forms of municipal or industrial waste; it contains both valuable and hazardous materials that require special handling and recycling methods to avoid environmental contamination and detrimental effects on human health. About 90% of homes in Nigeria possess obsolete electronic devices such as an outdated computer, printer or a mobile phone which are probably not in use but constitute e-wastes. These wastes are becoming a common sight, giving birth to what some experts are predicting to be the largest toxic waste problem of the 21st century (Schmidt, 2002). E-waste pollutants are released as a mixture, and the effects of exposure to a specific compound or element cannot be considered in isolation. However, a more complex understanding of the interactions between the chemical components of e-waste is needed. Exposure to e-waste is a complex process in which many routes and sources of exposure, different lengths of exposure time, and possible inhibitory, synergistic, or additive effects of many chemical exposures are all important variables. Sources of exposure to e-waste can be classified into three sectors: informal recycling, formal recycling, and exposure to hazardous e-waste compounds remaining in the environment (i.e. environmental exposure). Exposure routes can vary dependent on the substance and the informal recycling process (Kristen *et al.*, 2013).

E-wastes which are considered hazardous to both humans and the environment are the livelihood of the host community where the e-waste is disposed. The scavenging of e-waste materials by the host

community is an economical aspect of e-waste that cannot be ignored. Though there are potentially valuable metals present in some e-wastes, adequate methods are required for disposal and management.

Nigeria, where this study is being carried out, is home to over 150 million people (Index mundi, 2011) with increasing use of e-gadgets. Lagos, the commercial hub of the country, with about 15 million inhabitants has the highest number of e-gadgets users and no doubt generates the highest quantity of e-waste in Nigeria. Besides the fact that the e-wastes is locally generated by consumers in Nigeria, a large quota of e-waste is either unintentionally or intentionally imported as used Electrical and Electronic Equipment (EEE) (Schmidt, 2006). Recently, the mounting threat posed by the existing methods of informal recycling and disposal methods has attracted the media (Puckett *et al.*, 2005).

Studies under the direction of the E-waste Africa project (Wasswa and Schluep, 2008; Magashi and Schluep, 2011) revealed that there is a steady increase of EEE in Africa, specifically in Nigeria. According to Schluep *et al.* 2009, the amount of e-waste generated will keep increasing in the future, especially in Lagos which is the home to one of the largest IT markets in West Africa – Ikeja computer village. This computer village became popular in 2003, two years after the Global System for Mobile communications (GSM) services was launched in Nigeria. Presently the rate of importation of used electronics in Nigeria is alarming. Un-reusable goods (wastes) destined for recycling are exported into Nigeria in the name of reuse. The city of Lagos is one of the biggest cities, and the fastest-growing, in the world (Lagos State Government, 2011) is economically the most important city in Nigeria and has a regional importance as well for other West African countries. The availability of seaports such as Apapa Port or Tincan Island Port also contributes to its position as a major actor in the international trade amongst other West African countries. Lagos also shares a border with some West African countries such as Bénin and Cameroun and thus acts as a channel through which goods are exported. This role as a major population and e-commerce centre for goods and services is also reflected in the amount of e-waste generated and recycled in Ikeja Computer village and within Lagos. With the absence of an indigenous technological industry, the import and refurbishing of ‘second-hand’ electronics is a sure way of providing Nigeria and its neighbouring countries with IT at affordable prices. This is not good at all considering the negative health impacts that could result from exposure to the toxic chemicals from e-waste. The challenge is that electronic waste stream is an emerging body of knowledge in the field of waste management therefore; established data is presently limited on the number of e-waste generated among other forms of waste. E-waste is presently more an informal sector hence the reliance on import figures, can sometimes not reflect the true status of the influx of e-waste across borders in Nigeria. Data on the economic importance and size of informal e-waste recycling among the professions in e-waste is difficult to collect because both activities are carried out almost simultaneously. This results in estimates among stakeholders about the number of informal e-waste recycling practitioners working part-time or full-time in Lagos. Despite these difficulties, this study attempts to assess the economic benefits and health hazards inherent in informal e-waste management. The economic benefits of re-using extracted materials far out-weigh extracting the raw materials from mines and converting them for manufacturing purposes so proper management of e-waste is very crucial economically. Improper disposing and recycling of e-waste has some serious health and legal implications. Landfilling and incineration have the resultant effect of leaching of toxins from decaying materials into groundwater and the soil. This study also investigates the impact of e-waste dumps sites and other related activities in the residential and commercial areas under study. This study not only assesses the dangerous effect of e-wastes to the health of Lagos residents; the (economic) opportunities available in investing in e-waste management in Lagos; and ways of effectively disposing e-wastes within the city of Lagos, it also proposes a legislative and regulatory framework to effectively implement e-wastes management in Lagos, Nigeria. This study seeks to contribute to the achievement of the Basel Convention which ensures that the management of hazardous waste or its trans-boundary movement is consistent with the protection of human health and the environment where it is disposed of (Basel Convention, 2011).

2.0. Methodology

This research combines both quantitative and qualitative methods. Quantitative survey data enabled sample opinions from the target population. The use of key informant interviews was also utilized as a measure of reliability and validity of data. Conceptual information needed for this research was also

gathered from books, Journals and online articles obtained from web pages of internationally recognized organizations in e-waste management. Questionnaires were distributed to dealers in electrical and electronic items, residents, repairers of electronic items around Ikeja-Computer village, and Alaba international market on how they dispose-off their e-wastes. Analytical tests were then carried out on these soil and water samples collected around the dump sites.

2.1. Study areas

Alaba International Market sample site (A) lies between latitude N 6 ° 27' 11.0016" and longitude E 3 ° 23' 44.9988" while the Ikeja Computer Village sample site (B) lies between latitude N 6° 35' 46.4856" and longitude E 3° 20' 25.6776" in Lagos State, Nigeria. These locations were chosen as case studies because of their size, location, level of international recognition and peculiar economic activities. Ikeja Computer village is a transit point for electronic devices to all 37 states in Nigeria and neighbouring West African countries.

2.2. Method of data collection

To determine the target population, two methods of sampling were employed: stratified random sampling and quota sampling. Stratified random sampling was applied to determine the primary stakeholders in the electronic industry in Ikeja and Alaba International Market Lagos, Nigeria, and they were chosen according to their profession and activities in the electronic industry. Applying the quota sampling method helped to further specify the target group by dividing them into the stakeholder groups. A total of 100 questionnaires were administered to four major identified groups in the informal management of e-waste. The groups included Electronic Importers, Electronic Repairers, Computer and Photocopying Services and Local recyclers (waste scavengers). Two key informants were interviewed in this study. One of them, the Chairman of Scavengers Association (local recycler), male, aged 46, was interviewed at Alaba International Market dumpsite, Lagos State. The other, an electronic repairer/refurbisher, male, aged 35, was interviewed at Ikeja Computer Village.

2.3. Data distribution

A cross sectional survey was carried out in the area. A total of 100 residents located around the two study areas were randomly selected for interview using structured questionnaire, visual observation was also made to investigate the effects on their health. A total number of 100 questionnaires were administered and all the 100 questionnaires were recovered. The type of questionnaire administered was face-to-face questionnaire administration and paper and pencil questionnaire administration, where items were presented on paper. The questions were closed ended meaning the respondent pick an answer from a given number of options. The questions were arranged to flow logically from a given number of options. The questions were arranged to flow logically from one to the next and to achieve the best rates, questions flow from the least sensitive to the most sensitive.

2.4. Data analysis

The data were analysed using seventy five questionnaires among the respondent which were both male and female, thus was done randomly and at different location. Simple descriptive statistic was used to obtain the frequency, percent response and a bar chart showing how the responses are distributed. This was done using Microsoft Excel 2013 package.

2.5. Collection of samples

Soil and water samples were collected for *ex situ* analysis. Well, run-off and boreholes water samples were carefully collected by cleaning the outside of the nozzle of the tap and then water was allowed to run for some time, and then wide mouthed pre-cleaned bottles were used for the sampling and subsequently labelled properly. Five soil samples were collected in duplicates from the two different dumping sites using pre-cleaned wide mouthed containers, labelled and transported after collection to the laboratory for preparation and analyses. Locations 1 and 2 were at the dumpsite at Computer village in Ikeja while 3, 4 and 5 were at the dumpsite at Alaba International market (see Plates 1 to 5).

Plate 1a: Discarded mobile phones at case study dumpsite

Plate 1b: Discarded electrical wires at case study dumpsite

Plate 2a: Dismantling and collection of valuable e-wastes parts for recycling

Plate 2b: Section where e-wastes are dismantled for valuable materials for recycling

Plate 3a: Burning of e-wastes for extraction of copper at one of the sites

Plate 3b: Burning of e-wastes for extraction of copper at the second site

Plate 4a: Animals feeding on plants and discarded food items at case study site

Plate 4b: Cattle feeding and drinking on e-wastes sites materials

Plate 5a: Gutter passing through the case study dumpsite

Plate 5b: Collection of water from dumpsite gutter as sample for this study

Plate 5c: Collection of water from well from E-Wastes dumpsites as sample for this study

2.6. Physico-chemical parameters of water samples

2.6.1. Total alkalinity

50 ml of water sample was taken in a 250-ml conical flask. Mixed indicator was added and the titration was performed with HCl solution to a pink endpoint.

2.6.2. Total acidity

50 ml of water sample was poured into a 250-ml conical flask. To this was added 2 drops of phenolphthalein indicator and titrated with 0.02N NaOH solution to light pink.

2.6.3. Total solids determination

A clean Petri-dish was dried at 100°C in an oven for thirty minutes. It was cooled in a desiccator for forty minutes. The dish was weighed. 10ml of water-sample was put in the dish. It was placed in the oven for drying at 105°C. The sample was dried and then cooled in the desiccator. The residue was weighed to a constant weight.

2.6.4. Total dissolved solids determination

The water-sample was filtered into a clean conical flask. A clean Petri dish was dried at 105°C in an oven, cooled in a desiccator and then weighed to constant weight. 10 ml of the filtrate was poured into the dish and dried at 180°C to constant. It was cooled and reweighed.

2.6.5. Suspended solids determination

Dissolved solids were subtracted from total solids to obtain suspended solids (SS).

2.6.6. Dissolved oxygen determination

The water-sample was poured into a 250-ml bottle until the bottle was filled to the brim. 1 ml of MnSO_4 solution and 1 ml of alkali-iodide-azide reagent were added well below the surface of the sample. The bottle was stoppered and its content was mixed by inverting it several times. The solution was allowed to settle for two minutes. 2 ml of concentrated H_2SO_4 was added and the solution was mixed very well. 50 ml aliquot of the solution was taken for titration. This was titrated with sodium thiosulphate until a straw colour was reached. Two drops of starch solution were added. The blue solution was titrated with standardized sodium thiosulphate solution to colourless (APHA, 2005).

2.6.7. Biochemical oxygen demand

4 ml each of phosphate buffer, magnesium sulphate, calcium chloride, ferric chloride, sodium sulphite and ammonium chloride was added to 4 litres of distilled water in a polyethylene bucket to make dilution water. The dilution water was agitated by shaking it for three minutes to permit dissolution of atmospheric oxygen into it. A clean standard flask was filled half-way with dilution water and 100ml of water-sample was added to it. The standard flask was then filled with more dilution water to the 1-litre mark. This diluted sample was poured into a 300 ml amber bottle until it was full to the brim. The bottle was stoppered and incubated at 20°C for 5 days. Another transparent 300 ml bottle was filled to the brim with the diluted sample. 1mL of MnSO_4 solution and 1ml of alkali-iodide-azide reagent were added below the surface of the diluted sample in the transparent bottle. The bottle was stoppered, shaken by inverting it a number of times, and allowed to settle for two minutes. 2 ml of concentrated sulphuric acid was added and the solution was mixed by inverting the bottle a number of times. 50 ml aliquot of the solution was taken for titration. This was titrated with standardized sodium thiosulphate until a straw colour was reached. Two drops of starch solution were added. The blue solution was titrated with standard sodium thiosulphate solution to a colourless end-point to determine DO_0 at the beginning of the twenty days. At the end of the 5 days, the sample in the incubator was brought out and opened. 1ml of MnSO_4 solution and 1ml of alkali-iodide-azide reagent were added well below the surface of the sample in the amber bottle. The bottle was stoppered and allowed to settle for 2 minutes. 2 ml of concentrated sulphuric acid was added and the solution was mixed by inverting the bottle several times. 50 ml aliquot of the solution was taken for titration. This was titrated with sodium thiosulphate until a straw colour was reached. Two drops of starch solution were added. The blue solution was titrated with standard sodium thiosulphate solution to a colourless end-point to determine DO_5 . A blank was prepared in a transparent bottle for DO_0 . Another blank was prepared in an amber bottle and incubated with the sample for DO_5 .

2.6.8. Chloride determination

Morh's method was used where 25 ml of water sample was pipetted into a 250-ml conical flask. This was supplied with 2 drops of chromate indicator. The standardized AgNO_3 solution was put in a burette and used to titrate the sample to a brick red endpoint. AgNO_3 solution is also titrated against a blank.

2.6.9. Hardness determination

25 ml of water sample is pipetted into a 250-ml conical flask. 4 ml of the buffer solution and two drops of the indicator are added in turn with shaking. This is titrated with standardized 0.01M EDTA.

2.6.10. Chemical oxygen demand

25 ml of sample is placed in a reflux flask. 0.5 g H_2SO_4 , several glass beads and 2.5 ml sulphuric acid reagent are added. It is shaken to dissolve H_2SO_4 . It is cooled while mixing to avoid loss of volatile materials. 12.5 ml 0.0417M $K_2Cr_2O_7$ solution is added and mixed. The flask is attached to condenser and cooling water is turned on. 35 ml sulphuric acid reagent is added through open end of condenser. Continue swirling and mixing while adding acid. Mixture should be mixed thoroughly before applying heat to prevent blow-out of flask. Open end of reflux is covered to prevent entrance of foreign material. Mixture is refluxed for 2 hours. It is cooled, the condenser is washed down with distilled water, reflux condenser is disconnected and mixture is diluted to twice its size (total of 70 ml distilled water). It is cooled to room temperature and excess $K_2Cr_2O_7$ is titrated with standardized FAS using 2 to 3 drops indicator. Colour changes from blue green to reddish brown. Similarly, a blank with all reagents added to 25ml of distilled water is titrated (APHA, 2005).

2.6.11. Nitrate determination

Nitrate determination was carried out using Brucine method. 5 ml of the effluent was diluted to 25 ml with distilled water and 5 ml of the dilute aliquot was mixed with 1mL of NaCl solution, 10 ml of H_2SO_4 solution, 1 ml of brucine-suphanilic acid and then 9 ml of distilled water was added. The resulting solution was kept over boiling water bath at 95°C for 30 minute. The solution was allowed to stand, cooled and the solution was poured into an absorption cell and the absorbance of the solution was measured at 410 nm. This procedure was repeated for all the effluents.

2.6.12. Phosphate determination

Ascorbic acid method was used where 100 ml of the water sample was taken into a 250 ml conical flask. 8 ml of the combined reagent was added and stirred. The solution was poured into an absorption cell and the absorbance of the solution was measured at 880 nm. For the construction of a calibration curve, the same procedure was repeated for a blank (distilled water) and a series of standard containing 0.4, 0.8, 1.2 and 1.6 and 2.0 mg/l of pure phosphate.

2.6.13. Conductivity and pH of soil

10 g of the soil sample was weighed into a 50-ml beaker and 10 ml of distilled water was added. The mixture was vigorously stirred and allowed to stand for 30 minutes with occasional stirring. The conductivity of the suspension was measured. Thereafter, the pH meter was calibrated with buffers 4.01 and 9.21. Then, the pH of the suspension was determined.

2. 6. 14. Organic carbon in soil

0.2000 g of air-dry soil was weighed. 10 mL of 0.167M $K_2Cr_2O_7$ was added. 20 ml of concentrated H_2SO_4 was added and the solution was swirled gently. It was allowed to stand 30 minutes. The suspension was diluted with 100 ml of distilled water to provide a clearer suspension for viewing the endpoint. 10 ml of 85 percent H_3PO_4 was added. 10 drops of ferroin indicator were added. The solution was titrated with 0.5 M Fe^{2+} to a burgundy endpoint. A reagent blank was run following the above procedure without soil. The results were corrected for total organic carbon.

3.0. Results and Discussion

3.1. Physico-chemical parameters of water and soil from the two study sites A and B

From the results of the physico-chemical parameters in Tables 1 and 2, the pollution level in the water and soil at sites A and B were high.

Table 1: Physico-chemical parameters of water from the two study sites A and B

Test	W1	W2	W3	W4	W5	WHO Limit
Ph	6.61	6.96	6.24	6.43	6.51	6.5-8.5
Conductivity ($\mu\text{S}/\text{cm}$)	261	1047	669	393	296	120
Chlorine (mg/l)	62.0	402	238	119	76.9	75-100
Total suspended solids (mg/l)	264	1027	1071	626	361	500
Total dissolved solids (mg/l)	166	693	439	254	189	500
Total acidity ($\text{mg CaCO}_3/\text{l}$)	27.0	23.4	32.4	5.40	30.9	Nil
Total alkalinity ($\text{mg CaCO}_3/\text{l}$)	143	299	130	65.0	182	30
Total hardness (mg/l)	197	395	181	98.4	247	150
Dissolved Oxygen (mgO_2/l)	7.8	5.7	7.5	7.6	ND	Nil
Chemical Oxygen Demand (mgO_2/l)	48.9	151	94.6	132	170	10
Biological Oxygen Demand (mgO_2/l)	36.1	41.2	59.3	51.5	95.4	6
Phosphate (mg/l)	0.477	1.26	2.01	1.65	2.49	0.03
Nitrate (mg/l)	25.7	332	663	295	2.04	10

ND: not detected

Table 2: Physico-chemical parameters of soil from the two study sites and A and B

Test	S1	S2	S3	S4	S5
pH	5.99	7.10	7.56	7.68	7.71
Conductivity ($\mu\text{S}/\text{cm}$)	1352	7209	2703	1802	2253
Total organic carbon (%)	0.198	0.454	0.992	0.751	1.16

3.2. Level of heavy metal contamination of water and soil at the study sites

In the water samples (Figure 1), the concentrations of iron which ranged between 0.799 mg/l at a location in site B and 2.380 mg/l at a location in site A all exceeded the WHO limit of 0.30mg/L (WHO, 2006). Lead was only found in one location at site A with the concentration of 0.170 mg/L and this exceeded the WHO limit of 0.01 mg/l. The concentrations of chromium which ranged between 1.806 mg/l at a location in site A and 3.982 mg/l at a location in site B all exceeded the WHO limit of 0.01 mg/l. The concentrations of copper (0.012 mg/l to 0.056 mg/l) and concentrations of zinc (0.134 mg/l to 0.272 mg/l) were all below the WHO limits of 2.00 mg/l and 3.00 mg/l respectively. Nickel was below detection limit at all the locations. The percolating water may also mix with the liquid that is squeezed out of the waste due to the weight of the material. Thus, leachate is a liquid that contains dissolved and suspended materials that, if not properly controlled, may pass through the underlying soil and contaminate sources of drinking water, as well as surface water.

In the soil samples (Figure 2), the concentrations of iron which ranged between 1,466 mg/kg at a location in site A and 8,160 mg/kg at a location in site B were all very high. The concentrations of lead ranged between 13.1 mg/kg at a location in site A and 88.2 mg/kg at a location in site B, and only one location at site B exceeded the Dutch standard of 85 mg/kg. The concentrations of copper ranged between 11.5 mg/kg at a location in site A and 378 mg/kg at a location in site B, and only one location at site A did not exceeded the Dutch standard of 36 mg/kg. The concentrations of chromium ranged between 313 mg/kg at a location in site A and 564 mg/kg at a location in site B, and all exceeded the Dutch standard of 100 mg/kg. Nickel was below the detection limit at all locations. Uncontrolled scavenging and open burning of waste, either for volume reduction or for metal recovery, are two of the most usual causes for increased health risks.

Food crops, fruits and vegetable are cultivated at and around these dumpsites for human consumption. Also, as seen in Plates 4a and 4b, animals feed on plants and food wastes, and also drink water at these e-wastes dumpsites. Contaminants like Cd, Cu, Ni, Pb and Zn can alter the soil chemistry and have an impact on the organisms and plants depending on the soil for nutrition (Voutsas *et al.*, 1996, Sharma *et al.*, 2009). There is therefore a high tendency of heavy metal uptake by plants and vegetables through bioconcentration as well as bioaccumulation in animals that feed at these sites (Syeda *et al.*, 2014). These can be transferred through biomagnifications to humans that feed on these plant and meat products, in addition to direct consumption from the contaminated underground water.

Figure 1: Comparison of heavy metals in water with WHO standards

Figure 2: Comparison of heavy metal in soils at case study sites with WHO standards

3.3. Impacts of E-wastes activities at Alaba international market and Ikeja computer village on human health

According to WHO (2006), cadmium level above 0.003 mg/l in water has harmful health effects such as neurotoxin, hypertension, carcinogenic, tetragenetic, mutagenic, liver and kidney dysfunction; chromium above 0.005 mg/l results in chronic toxicity (above 5 mg/l), bleeding of the gastrointestinal tract, cancer of the respiratory tract, ulcers of the skin and mucus membrane; copper above 2.0 mg/l result in toxic taste, unpalatable for consumption; lead concentration above 0.01 mg/l (high blood levels) can inhibit haem synthesis, cause irritation, mental retardation, brain damage, and produce tumour; nickel above 0.02 mg/l is carcinogenic, and negatively affects reproductive health. E-waste contains both valuable and hazardous materials that require special handling and recycling methods to avoid environmental contamination and detrimental effects on human health (StEP, 2005 & 2011).

The findings from the questionnaire showed that the Source of water in the study area are from three source majority is from deep well. 75% of the respondents depend on well while 25% depend on borehole water. Majority drink water from boreholes and sachet water, however the water table of this community is very low (about 6 feet deep), you can easily get water, thus it is easier for the heavy metals to seep into the underground water source, while they use the water from the well for washing, cooking, bathing and other house chores.

There is no presence of pipe borne water at those sites and this is very dangerous to the health and well-being of the people of these communities. There is need for an urgent construction of a well purified portable water source for the people of these communities to avert disaster in the future.

96% of the respondents said yes about their awareness that the e-wastes dump has a negative effect on their health and the environment in general, 4% said they do not know or aren't sure because they do not know how the waste water coming out of the dump site can have an effect on them as they had been living there for a long time and nothing had happened to them and the e-wastes activities going on there is their source of income.

Findings from the questionnaires, 98% of the respondents are experiencing discomfort in breathing and visibility due to the burning activities of the e-wastes scavengers to extract various types of metals for financial purposes (Plates 3a and 3b). The direct effects are poor sight, asthmatic symptoms, regular coughing, and other respiratory ailment, heat rashes due to their perpetual closure of their windows. 80% of the residents within Alaba Rago community would likely consider moving out of their houses to a better location, because of the poor management and negative effects of the e-wastes dump activities that hinder them from enjoying the neighbourhood. Some are used to the activities and can still leave in the environment for a while. 74% of the respondents said yes to the contamination of the surface and ground water, most of the residents are aware that the e-wastes dumps has a negative effect on their underground water, 20% said they do not know, while 6% said they are not sure because they do not know how the waste water coming out of the dump site can have an effect on them. Researchers analysed 373 toxic waste sites in India, Indonesia and the Philippines, where an estimated 8.6 million people are at risk of exposure to lead, asbestos, hexavalent chromium and other hazardous materials. Among those people at risk, the exposures could cause a loss of around 829,000 years of good health as a result of disease, disability or early death (Chatham-Stephen *et al.*, 2013).

Figure 3: Symptoms of diseases regularly experienced by residents around the e-waste dumpsites

The prevalence of diarrhoea and nausea, vomiting, eye irritation, malaria and typhoid fever were very high (Figure 3). These were the common environmental and health problems at those e-wastes dump sites. However, a significant number of the respondents said they have experienced people with asthmatic symptoms and other respiratory diseases which could be linked to the activities of the

burning of the electronic wastes to retrieve copper by the scavengers. A few respondents also said they have recently been noticing an increasing number of sudden deaths, diagnosed to be high blood pressure mostly among shop owners, though some linked it to fetish acts among the shop owners, but the fact could be as a result of the accumulation of some heavy metal in their body system. While some females were said to have experienced miscarriages at various times, this could also be directly linked to the accumulation of heavy metals in their blood streams.

3.4. Economic benefits and financial implications of E-waste

The results showed that 90% of electronic importers and 74% of electronic repairers agreed that e-waste is a valuable economic asset. This is quite interesting because according to other observations at Ikeja Computer Village, more than 50% of the electronic goods imported are destined for refurbishing and dismantling.

In an interview with a key informant who was a refurbisher by profession at the Ikeja Computer Village, he was happy with the electronic goods he just ordered. He responded *“well.....I will say yes and no....yes because people can buy them easily and people believe that second hand goods last longer than the new ones....maybe because they feel that it has already been tested and so it is good. And I will say no because... most times, the good second hand electronics are very few....so I am left with a lot of bad electronics to deal with”*.

His response indicated that despite the challenges of being saddled with obsolete electronic materials, this was still a favourable alternative for consumers to buying brand new electronic devices.

On the flip side of things, this generates another level of income for both the electronic importers and the electronic repairers. 90% of local recyclers (waste scavenging) and 95% of computer and photocopying services also agreed that e-waste is valuable to them. The response of the computer and photocopying services operators is intriguing because they offer services directly to the end users. Thus it is quite understandable that they would find the end results of the e-waste recycling process more profitable as it offers cheaper electronic alternatives (such as photocopier, computer sets) to purchase of new devices.

It was observed that during this manual recycling process for e-waste the extracted materials (Plates 1a, 1b, 2a and 2b) were utilized in three major ways:

1. Exported or sold as spare parts for new products,
2. Kept in storage for local electronic repairers or
3. Resold to electronic importers who in turn export them to neighbouring countries.

Besides exporting extracted materials for sale to neighbouring states and countries, they were also kept in the storage as spare parts for electronic repairers who often needed them for repair purposes. 100% of electronic importers, computer and photocopying services and local recyclers (waste scavenging) agreed to this. Interestingly, 92% of electronic repairers agreed that this was true. Perhaps the 7% who disagreed believe that because e-waste travels murky waters and involves a lot of players, the answer that extracted materials for sale to neighbouring states and countries were also kept in the storage as spare parts for electronic repairers may not be entirely true. 93% of local recyclers (waste scavenging) and 92% of electronic repairers agreed that extracted materials from waste after recycling are resold to electronic Importers. 71% of electronic importers and 70% of computer and photocopying services also agreed to this. Most times, the electronic importers package the extracted materials and resell them to neighbouring states and countries as second hand wares.

These responses indicated that the utilization of e-waste goes beyond the professions interviewed in this study. It involves both the consumers within the country and businesses outside the country. Though the e-waste trade involves collective participation from all stakeholders, it is obvious that the local recyclers (waste scavengers) are at the bottom of the e-waste trade. Besides scavenging at the dumpsites and seeking out homes willing to dispose of their used electronic devices, they only get what the electronic importers and the electronic repairers perceive to be of no-monetary value. To ascertain the level of financial impact e-waste has on this group, the assessment of the impact of

scavenging for electronic parts based on their financial status was carried out. 96% local recyclers (waste scavengers) agreed that scavenging does have a positive impact on their financial status. This implies that scavenging for electronic parts was mainly carried out by individuals in the local recyclers (waste scavenging) profession. It was discovered that at the dumpsite in Alaba, waste pickers (local recyclers) sort waste according to their importance and types. These are subsequently bought by manufacturers and private companies as attested by the Chairman of Scavengers Association *“we sell them to manufactures and factories. For example, the bottles go to glass companies and sometimes drug manufacturers.”*

3.5. Practice of informal recycling of e-waste in Nigeria

Like their counterparts in China, India and Pakistan, informal recycling of e-waste in Nigeria is mainly practiced for economic reasons. The rapid evolution of electronic devices and the ‘throwaway’ habit that is being cultivated around the globe ensures that this practice will continue for a long time except drastic and determined steps are taken to address the issue. For countries such as Nigeria who lack indigenous formal recycling plants, the prevalence of manual and informal recycling will continue to be one of the means of recycling e-waste thus exposing humans and the environment to poisonous chemicals inherent in decomposing electronic devices.

The total respondents across the four professions interviewed agreed that e-waste was valuable to them. Recycling can recover reusable components and base materials, especially Cu and precious metals (Mavropoulos and Newman, 2015). The financial value it offers is perceived to be more than the health hazards they face during the process of manual recycling of e-waste (Morgan, 2006). As at the time of writing this report, Nigeria lacked an environmental regulation or legal framework targeting e-waste as a special waste stream. There are existing laws that regulate the transboundary movement of toxic, hazardous and radioactive wastes and the achievement of environmentally sound management of hazardous substances. However, none is specific to the presence and management of e-waste. Even though NESREA gave out a regulatory guideline for importation of electronic devices, the lack of an effective implementation system is leveraged as a loophole in the continuous importation of “second hand” electronic devices that can no longer function and therefore classified categorically as e-waste (NESREA, 2011).

Although Nigeria has ratified the Basel Convention on Trans-boundary movement of hazardous waste and their disposal, it has not taken determined steps to address the growing need for a formal e-waste recycling plant as well as addressing the rising environmental pollution that is taking place as a result of improper disposal methods. Perhaps it could be reasoned that because Nigeria basically imports its technology, the implementation of the Basel Convention would mean laying bottle neck rules on the importation of ‘second hand’ electronic devices which may be detrimental to the local industries that depend on it. Most indigenous industries such as the computer and photocopying services as well as surrounding countries depend on the importation of these ‘second hand’ electronic devices. One major problem Nigeria faces is the domestication and implementation of agreements or treaties it signs. The political and legislative will to implement is quite lacking. On the flip side, this could also mean a critical look at developing the IT industry indigenously which can lead to growth (Information Systems Security, 1993).

A number of factors affect the effective management of e-waste in Nigeria, the key one being low environmental consciousness. This has had adverse effects on the effective management of waste in general and e-waste in particular in Nigeria. The citizens of Lagos state are aware of only the periodic monthly environmental sanitation exercises which are mandatory and subject to fines but they are quite clueless of any other environmental regulations. So it is not a surprise that respondents from the interviews do not know of any environmental laws governing the state. For example in response to the question: “Is there a national government policy against mixing up e-wastes with other waste?” 95.0% of the total respondents disagreed that they were not aware of any policy addressing separation of waste. But indeed, there is such a law. The Federal Republic of Nigeria Official Gazette on National Environmental Regulations 2009, Part 5, Section II C clearly states that: *“...it shall be an offence for an owner or an occupant in care of premises or in control or management of a business to fail to segregate waste for proper management”* (Ministry of Environment, 2009). This law as well as other laws governing various activities that could cause environmental harm is clearly stated in the document. Awareness by the regulatory authorities of these regulations is very deficient towards

increasing environmental consciousness. Hence the regulations only remain on paper but never really get to be implemented.

4.0. Conclusions

From this study it can be concluded that all E-waste contains some valuable components or base materials and these are environmentally important, because they provide an incentive for recycling. All E-waste contains some valuable components or base materials, especially copper. It can also be concluded that the informal recycling occurs predominantly among the poor, and may result in a human health risk or environmental pollution. The extracted materials from the e-waste dumpsites were utilized in three major ways: Exported or sold as spare parts for new products, kept in storage for local electronic repairers, or resold to electronic importers who in turn export them to neighbouring countries. Also the wastes are burnt to recover precious metal, mainly copper. E-waste pollutants are released as a mixture, and the effects of exposure to a specific compound or element cannot be considered in isolation. Majority drink water from boreholes and sachet water, however the water table of this community is very low (about 6 feet deep), you can easily get water, thus it is easier for the heavy metals to seep into the underground water source, while they use the water from the well for washing, cooking, bathing and other house chores. There is no presence of pipe borne water at the study sites and this is very dangerous to the health and well-being of the people of these communities. There is need for an urgent construction of a well purified portable water source for the people of these communities to avert disaster in the future.

This study therefore reveals different health conditions such as diarrhoea, malaria, typhoid fever, eye irritation, kidney disease, lung disease, skin rashes, nausea, vomiting, increase in blood pressure and brain damage/tumour associated with exposure to e-waste. People living in e-waste recycling towns or working in e-waste recycling and those residing close to the dumpsites are exposed to the risks of these health conditions. Understanding the hazards of e-waste, the impacts of its disposal, and the dangers of informal or careless recycling will help reduce or prevent disease outcomes associated with exposure to e-waste components. The activities at the e-waste dumpsites at Ikeja computer village and Alaba International market release very high concentrations of heavy metals which exceed safe limits thereby exposing huge populations of people that do businesses or reside around those dumpsite to e-waste associated health conditions.

There is lack of indigenous formal recycling plants and this result in the prevalence of manual and informal recycling which will continue to be one of the means of recycling e-waste thus exposing humans and the environment to poisonous chemicals inherent in decomposing electronic devices. Legislative measures, laws and rules on zoning, land use, and waste regulation to control the location and management of e-wastes dumps should be made are very important.

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