TECHNOLOGY PARADIGM FOR E-WASTE MANAGEMENT IN SOUTH-EASTERN NIGERIA

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ABSTRACT

The fast-growing surplus of e-wastes around the globe has become a concern as countries struggle to seek ways to discard obsolete electrical and electronic equipment (EEE). It is estimated that Nigeria generates 1.1M tonne of e-waste annually. 75% of used-EEE are stored due to uncertainty of how to manage such items. These leftovers, containing hazardous components, lie unattended in homes, government institutions, industries, private offices, communication/entertainment businesses, educational and health-care centres, and normally mixed with domestic solid wastes, which are often disposed-off in poorly controlled open dumpsites. This is owing to inadequate planning and appraisal of management functions of such emerging wastes. Nations and regions are now embracing rethinking strategies for managing Waste Electrical and Electronic Equipment (WEEE) and optimizing finite resources.

In South Eastern Nigeria, WEEE are treated with no specific characterization in its generation, collection, storage, treatment and final disposal. The overall objectives of this study is to examine the WEEE management strategies in the region, with a view to suggesting appropriate implementable measures; conduct an inventory on the periodic quantity and categories of WEEE generated; determining the factors affecting the trend of WEEE generation and collection, and; examining the strategies in place for the final disposal and management of each category of WEEE.

Some of the identified factors influencing WEEE management strategies includes missing public awareness on e-waste toxicity; inability to distinguish between WEEE and near end-of-life EEE; government haziness to applying long-term and sustainable management approaches; absence of regional standardized recyclable facilities; inability to establish and pursue take-back programmes; false declarations of WEEE at point of entry; co-loading of near end-of-life EEE and WEEE with used vehicles, as well as, absence of regional statistics on WEEE. The study identified the specific challenges relating to the management strategies in place, control of used EEE import and relevant guidelines/legislations on WEEE. Reports for e-waste trends were complemented with data from secondary sources to enhance inventory of WEEE as well as the measures hitherto employed as the

management strategies. It suggested the need for new technology frontiers in supporting appropriate management strategies of WEEE in the region**.** Recommended strategies should reflect and encourage efficient planning, collection, storage, treatment and final disposal of WEEE, Extended Producer Responsibility programme, best practised Recycling and Environmental Sound Management options that could be implemented in an e-waste controlled environment, as well as discourage illegal importation of WEEE and counterfeit EEE.

Keywords: Waste Electrical and Electronic Equipment (WEEE), Waste Management Strategies, Recycling, E-waste Regulations

INTRODUCTION

The uncontrolled transboundary movements of hazardous wastes, some of which declared as economic goods, mostly from Europe, America and Asia are frequently sent to developing countries for disposal (GFMECD, 1995). Waste Electrical and Electronic Equipment or e-waste are some of the closest source for generated hazardous wastes in Nigeria and some countries of sub-regional economic block of the Economic Community of West African States (ECOWAS) (Basel Convention, 2012a; The Guardian, 2012; Vanguard, 2013).

It is obvious that Electrical and Electronic Equipment (EEE) have revolutionized modern living, international business, global governance, communication, entertainment, transport, education, and health care. This has been driven by unprecedented high volumes of production and usage of consumer electronic products, in particular, personal computers, mobile phones, and television sets. The access to Information and Communication Technology (ICT) has been identified as an indicator of a country's economic and social development (United Nations, 2011). The difference in access to ICT between developed and developing countries is commonly referred to as the "digital divide" (UNDPI, 2006; NESREA, 2009; Oliver and Charles, 2010; Basel Convention, 2011a). Nigeria has been undergoing rapid ICT transformation in recent years, attempting to bridge this divide by importing, from developed countries, huge volume of used and sometimes inferior EEE including discarded office electronic equipment, computing equipment, entertainment electronic equipment, mobile phones and other home appliances like television sets, microwaves, hairdryers, refrigerators, among others. Likewise, the rapid growth in the ICT sector has led to an improvement in capacity of electrical and electronic equipment but simultaneously to a decrease in products' lifetime, such that the volume of waste generated is increasing by 10% annually (Oh *et al*., 2003; Ayodeji, O., 2011). South Eastern Nigeria seemly lacks coherent waste management programme with infrastructure and resources for an environmentally sound management (ESM) of waste electrical and electronic (WEEE) arising when such imports reach their end-of-life.

Several emerging economies are now facing huge challenges in the management of e-waste which are either internally generated or imported illegally as "second hand" goods. Research has shown that most used EEE consignments imported into developing countries are mixtures of less than 25% of used functional EEE and over 75% of WEEE (NESREA, 2009; BCCCN Report, 2011). Even the so called functional products are near their end-of-life (E.o.L.), which so many of these countries have the challenge of dealing with.

The global concerns about WEEE arose following the proliferation of used electrical and electronic devices in recent decades and the rapid growth in the quantities of EEE that requires disposal throughout the world. It has been found that the United State of America discards 30 million

computers each year and 100 million phones are disposed of in Europe every year (Pennsylvania Resources, 2013; Shagun et. al., 2013). Innovation and rapid changes in technology, planned obsolescence of electrical and electronic appliances and low initial cost of near end-of-life EEE, have resulted in a fast-growing surplus of electronic waste around the globe. Cumulatively, about 500 million Personal Computers reach the end of their service lives between 1994 and 2003 (NESREA, 2009). Similar quantities of electronic wastes are expected for all kinds of portable electronic devices such as MP3 players, computer games and peripherals.

The processes of managing WEEE stream in South Eastern Nigeria are not clearly spelt out and practised. Most of what happens is that individuals, dealers and importers buy these items as fairly-used goods for direct reuse or dismantle to collect components for recycling and discard the remnants along with municipal solid wastes (ESWAMA, 2004; Osibanjo & Nnorom, 2008).

WEEE AND ITS CHEMICAL COMPOSITION

The exposure to WEEE hazardous substances in and around dismantling sites causes manifold health and safety risks for collectors, recyclers and neighbouring communities. Hazardous substances are released during various dismantling and disposal operations of WEEE and are particularly severe during the burning of cables to liberate copper and of plastics to reduce waste volumes (Basel Convention, 2011a; The Guardian, 2012). Further health and safety risks originate from the emissions of informal lead acid battery recycling, which is commonly practised within dismantling sites. Such hazards can negatively impact the environment and affect human health if not properly managed as peculiar reoccurrence in many developing countries which lack adequate infrastructure to manage wastes safely.

WEEE as composite material is not hazardous per se. However, EEE consist of complex mixture of materials and components. EEE are known to be made-up of more than 1000 different substances, many of which are highly toxic (Ongondo and Williams, 2011). Hence, the hazardous constituents present in WEEE components render it unsafe when such wastes are dismantled and processed. E-wastes are considered dangerous, because certain components of these products contain substances that are harmful, depending on their condition and handling at disposal sites. For instance, certain components can leach heavy metals like lead, mercury, cadmium and other substances into soil and ground-water causing acidification of soil (GFMECD, 1995; Basel Convention, 2011a; NESREA, 2011b; The Guardian, 2012; Vanguard, 2013). At least 734 children below the age of five, out of 5,395 within this age bracket, were confirmed killed from lead poisoning between 2010 and March 2013 in Zamfara State (ThisDay Newspaper, 2013). Furthermore, some naturally occurring harmless substances become hazardous because of their use in the manufacture of electronic equipment (e.g. chromium becomes chromium VI).

Table 1 gives a selection of the mostly found toxic substances in e-waste. Table 2 summarizes WEEE components and associated effects on human health, animals and the environment. While Table 3 gives empirical data to support Tables 1 & 2.

Table 1: A Selection of the Mostly Found Toxic Substances in WEEE

Substance	**Occurrence in e-waste**
Halogenated compounds:	
- PCB (polychlorinated biphenyls)	Condensers, Transformers
- TBBA (tetrabromo-bisphenol-A) -PBB (polybrominated biphenyls) - PBDE (polybrominated diphenyl ethers)	Fire retardants for plastics (thermoplastic components, cable insulation) TBBA is presently the most widely used flame retardant in printed wiring boards and casings.
- Chlorofluorocarbon (CFC)	Cooling unit, Insulation foam
- PVC (polyvinyl chloride)	Cable insulation
Heavy metals and other metals:	
- Arsenic	Small quantities in the form of gallium arsenide within light emitting diodes
- Barium	Getters in CRT
- Beryllium	Power supply boxes which contain silicon controlled rectifiers and x-ray lenses
- Cadmium	Rechargeable NiCd-batteries, fluorescent layer (CRT screens), printer inks and toners, photocopying-machines (printer drums)
- Chromium VI	Data tapes, floppy-disks
- Lead	CRT screens, batteries, printed wiring boards
- Lithium	Li-batteries
- Mercury	Fluorescent lamps that provide backlighting in LCDs, in some alkaline batteries and mercury wetted switches
- Nickel	Rechargeable NiCd-batteries or NiMH-batteries, electron gun in CRT
- Rare Earth elements (Yttrium, Europium)	Fluorescent layer (CRT-screen)
- Selenium	Older photocopying-machines (photo drums)
- Zinc sulphide	Interior of CRT screens, mixed with rare earth metals
Others:	
- Toner Dust	Toner cartridges for laser printers / copiers
Radio-active substances	
- Americium	Medical equipment, fire detectors, active sensing element

Substance	Occurrence in e-waste
	in smoke detectors

Source: Agency for Toxic Substances and Disease Registry, ATSDR (2013)

Table 2: WEEE Components and Associated Effects on Human Health and the Environment

S/N	Component	Effect	
		Environment	Health
1	Lead (Pb)	Accumulates in the environment Potential to leach and contaminate drinking water supplies.	• Exposure to lead, even at very low levels, is highly toxic • damage to the central and peripheral nervous systems • lead exposures can significantly reduce the IQ of school-aged children • In adults, lead exposure has been related to increased blood pressure and hypertension, conditions known to increase the risk of cardiovascular disease. • Affects blood system and kidneys in humans • Exposures can cause infertility and miscarriage • endocrine hormone disruption • Lead inhibits the various enzymes of the haemoglobin metabolism thus reducing the oxygen balance and the respiratory volume
2	Cadmium (Cd)	Danger of cumulative effects in the environment due to its acute and chronic toxicity.	• Irreversible effects on human health. • Accumulates in the human body, in particular in the kidneys. • Biological half-life of cadmium in the human body is between 15 and 25 years (measured in the kidneys) • Cadmium and its compounds are carcinogenic • Bone deformation may also result
3	Mercury (Hg)	Accumulates in living organisms and concentrate through the food chain, particularly in fish.	• Negative effects on brain functioning and development • Mercury dusts and vapours are very toxic. It is subject to almost complete absorption via the lungs. • Mercury is finally stored in the liver and kidneys and • Chronic poisoning causes malfunction of the central nervous system, the symptoms being apathy, unretentive memory, over-excitability and general trembling.

S/N	Component	Effect	
		Environment	Health
			• It has mutagenic and teratogenic potential
4	Hexavalent Chromium		• Can cause strong allergic reactions, even in small concentrations. • Acute poisoning with chromium (VI) compounds becomes apparent in the form of damage to the kidneys. • Chronic poisoning results in changes in the gastro-intestinal tract as well as in accumulation in the liver, kidneys, thyroid gland and bone marrow • Chromium(VI) compounds are highly mutagenic
5	PVC(Polyvinyl Chloride Plastics)	The production and burning of PVC products generates dioxins and furans, which contribute to air pollution	• Is an important irritant and allergen of eyes, skin and respiratory tract • Aggravates respiratory ailments. • Repeated exposure damages the liver, kidneys and spleen • Malignant tumours may occur. • definitely carcinogenic and teratogenic (deformities and skeletal changes on inhalation)
6	Brominated Flame Retardants		• Exposure to these chemicals in early life could induce neurotoxic effects • Exposure to Polybrominated Biphenyls (PBBs) is believed to cause an increased risk of cancer of the digestive and lymph systems. • The liquid produces severe, poorly healing irritation and burning of the eyes, the respiratory organs, the skin and the gastro-intestinal tract. • Deep, painful necroses form on the skin and the mucous membranes. • High concentrations cause oedemas of the glottis, larynx and lungs as well as inflammation of the lungs.

S/N	Component	Effect	
		Environment	Health
			• Bromine vapours are even more hazardous as they produce bronchial spasms and pneumonia.

Source: Adopted from the conference proceedings of the International Conference on E-Waste Control Abuja, Nigeria: The Abuja Platform on E-Waste (Working Group 1) organized by the National Environmental Standards and Regulations Enforcement Agency (NESREA) of Nigeria held between 20th -21st July, 2009

Table 3: Empirical Data to support Tables 1 & 2

S/N	Component	Data
1	Lead (Pb)	In Germany, lead is listed in pregnancy group B (risk of embryonic damage is assumed). Symptoms of chronic poisoning are lead deposits along the edge of the gums as well as colic fits and spasms. Apathy, irritability, insomnia and - in some cases - behavioural irregularities in children are indications of damage to the nervous system. Lead passes through the placenta and accumulates in the foetus. In Germany, lead is listed in pregnancy group B (risk of embryonic damage is assumed).
2	Cadmium (Cd)	In Asia, "Itai-Itai" disease is caused by high cadmium concentrations in rice. Twelve patients with Itai-Itai disease, thought to be caused by chronic cadmium poisoning (Ishizaki, A: Asian Med. J. 14:421-436, 1971), showed chromatid aberrations.
3	Mercury (Hg)	Responsible for the Minamata Bay Disease of Japan in 1962. Released Mercury chloride bioaccumulated in shellfish and fish in Minamata Bay and the Shiranui Sea, which, when eaten by the local populace, resulted in mercury poisoning. While cat, dog, pig, and human deaths continued for 36 years, the government and company did little to prevent the pollution. The animal effects were severe enough in cats that they came to be called "dancing cat fever".
4	Hexavalent Chromium	The carcinogenic effect of chromium (VI) compounds has been substantiated both in animal experiments and by epidemiological studies on groups of population subject to workplace exposure. The corresponding latency times are given as between 10 and 27 years.
5	PVC(Polyvinyl Chloride Plastics)	The US Congress passed the Safe Drinking Water Act. This law requires EPA to determine the level of contaminants in drinking water at which no adverse health effects are likely to occur. These non-enforceable health goals, based solely on possible health risks and exposure over a lifetime with an adequate

S/N	Component	Data
		margin of safety, are called maximum contaminant level goals (MCLG). Contaminants are any physical, chemical, biological or radiological substances or matter in water.
6	Brominated Flame Retardants	Due to the Michigan accident in 1973-1974, many toxicity studies on PBBs are available. Soil samples from a former PBB manufacturing site, analysed several years after the Michigan incident, still contained PBBs though the PBB congener composition was different, indicating a partial degradation of the PBB residues in the soil sample. Increased levels of polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) were found in breast milk samples in Accra, Ghana.

Adopted from the GFMECD (1995) Handbook and conference proceedings of the International Conference on E-Waste Control Abuja, Nigeria: The Abuja Platform on E-Waste organized by the National Environmental Standards and Regulations Enforcement Agency (NESREA) of Nigeria held between 20th-21st July, 2009

MANAGEMENT OF E-WASTE IN SOUTH EASTERN NIGERIA

States and local governments in Nigeria still lag behind when it comes to enacting legislation to deal with WEEE. In Nigeria, e-waste is mostly managed via municipal waste management schemes (ESWAMA, 2004; Okorhi, 2005). The Harmful Wastes Act is often sighted for the control of WEEE and other related toxic wastes (Vanguard, 2013). There is inadequate action of management functions that starts with planning, organising, leading/directing and then control of WEEE. (ESWAMA, 2004; Basel Convention, 2011a). For instance Nnorom and Osibanjo (2008) reported that the processes of managing WEEE stream in South Eastern Nigeria are not clearly spelt out and practiced. Yet again, we do not know the proportion of e-wastes which are seasonally generated and what influences their management strategies in South-eastern Nigeria.

This paper highlights the essentials for sustainable management of e-waste in South Eastern Nigeria, identifying adverse impacts of WEEE on human health and the environment, as well as listing factors influencing the generation, collection and disposal of WEEE.

Hence, the objectives of this study are:

(Primary objective)

- To examine the WEEE management strategies in South Eastern Nigeria, with a view to suggesting appropriate implementable measures.

(Specific objectives)

- To conduct an inventory on the periodic quantity and categories of WEEE generated in South Eastern Nigeria;
- Determining the factors affecting the trend of WEEE generation and collection, and;

- Examining the strategies in place for the disposal and management of each category of WEEE in the region.

THE RISING TRENDS OF WEEE

From the Basel 2011 Report, the penetration rate of personal computers has increased in the last decade by a factor of 10, while the number of mobile phone subscribers has increased by a factor of 100. The whole world is currently grappling for solutions to the ever increasing generation of WEEE, its movement from developed to developing countries and the associated impact on human health and the environment. Table 4 show categories of WEEE imported as economic goods to South Eastern Nigeria.

There has been considerable media attention based on a few reports pointing to the trade of used EEE in Nigeria (Puckett *et al*. 2003; NESREA, 2009; The Guardian, 2012). On a daily bases, an estimated 500 containers of used electronics & computers are imported into Lagos Ports (Oresanya O., 2011). In the year 2010, an analysis of containers of used EEE for categories 2-4 imported into Nigeria was conducted between the months of May and July monitoring shipment manifests and providing shipping information for about 176 containers (Basel Convention, 2011a). The results revealed that almost 60% of the containers of used EEE came in from the UK, with Felixtowe being the dominant exporting port. More than 75% of all containers came from Europe, approximately 15% from Asia, 5% from African ports (mainly Morocco) and 5% from North America. In the light of this rising trend, the National Environmental Standards and Regulation Enforcement Agency (NESREA) recently ordered an e-waste carrying vessel at the Tin-Can Island Port, Lagos to send its consignment back to the port of origin in the United Kingdom sighting the provisions of Harmful Wastes Act, promulgated after the Koko waste saga in 1988 (Vanguard, 2013). The e-waste ship carried toxic wastes (WEEE) laden containers on board designated for dumping in Nigeria. Until 2011, NESREA had intercepted and arrested five (5) ships carrying e-waste destined for Nigeria (BCCCN Report, 2011).

Table 4: The graphic below compares the categories of e-waste as used in the Swiss and EU legislation (CH ORDEE and the EU WEEE Directive) (EMPA, 2009)

Swiss ORDEE regulations	EU WEEE Directive
Household Appliances Washing machines, Dryers, Refrigerators, Air-conditioners, Vacuum cleaners, Coffee Machines, Toasters, Irons etc.	Large Household Appliances Washing machines, Dryers, Refrigerators, Air-conditioners, etc.
	Small Household Appliances Vacuum cleaners, Coffee Machines, Irons, Toasters, etc
Office, Information & Communication Equipment PCs, Latops, Mobiles, Telephones, Fax Machines, Copiers, Printers etc.	Office, Information & Communication Equipment PCs, Latops, Mobiles, Telephones, Fax Machines, Copiers, Printers etc.
Entertainment & Consumer Electronics Televisions, VCR/DVD/CD players, Hi-Fi sets, Radios, etc	Entertainment & Consumer Electronics Televisions, VCR/DVD/CD players, Hi-Fi sets, Radios, etc

Swiss ORDEE regulations	EU WEEE Directive
Lighting Equipment Fluorescent tubes, sodium lamps etc. (Except: Bulbs, Halogen Bulbs)	Lighting Equipment Fluorescent tubes, sodium lamps etc. (Except: Bulbs, Halogen Bulbs)
Electric and Electronic Tools Drills, Electric saws, Sewing Machines, Lawn Mowers etc. (Except: large stationary tools/machines)	Electric and Electronic Tools Drills, Electric saws, Sewing Machines, Lawn Mowers etc. (Except: large stationary tools/machines)
Toys, Leisure, Sports and Recreational Equipment Electric train sets, coin slot machines, treadmills etc.	Toys, Leisure, Sports and Recreational Equipment Electric train sets, coin slot machines, treadmills etc.
Medical Instruments and Equipment	Medical Instruments and Equipment
Surveillance and Control Equipment	Surveillance and Control Equipment
Automatic Issuing Machines	Automatic Issuing Machines

Legend:

	Under ORDEE since 1998
	Under ORDEE since January 2005
	Not under ORDEE but under separate regulation
	WEEE Directive implemented by Member States by August 2005 – 08

According to a survey conducted by Ongondo and Williams (2011), the four key global problems that make WEEE a priority waste stream, specifically are: global quantities of WEEE (estimates place the amount of WEEE generated globally between 20-50 million tonnes annually, with Nigeria importing 1.2M tonnes of EEE and generated 1.1M tonnes of WEEE in the year 2011 (Basel Convention, 2011b); resource impacts (with world reserves of metals such as gold and palladium in fast decline and becoming more expensive); potential health and environmental impacts (reflecting on air, land and water causing respiratory problems, affect the texture, colour and the usefulness of soil for agricultural purpose as well as a change in the taste of water and the pH of water makes it inappropriate for direct drinking/consumption); and ethical concerns (including reported incidences of child labour in informal WEEE industries/handling, especially in some parts of Africa and Asia and the illegal shipments of WEEE from affluent countries to poorer developing countries that lack the facilities to properly treat such wastes is becoming more prevalent).

LEADING PROPONENTS FOR E-WASTE MANAGEMENT IN DEVELOPED NATIONS AND EMERGING ECONOMIES

While developing nations are struggling with influx of WEEE and near E.o.L. e-devices, their counterpart in North America and Europe are promoting favourable legislation to transit WEEE from their immediate environments. For instance nations from Africa, Asia and Latin America are bound with practises of stockpiling WEEE, reuse of near E.o.L EEE, whereas those in North America and the European Union are insistent on legislations toward recycling and extended producer responsibility

(EPR) (Wagner, 2009; NESREA, 2011a; NESREA, 2011b; Basel Convention, 2011a; Ongondo & Williams, 2011).

While the countries of the north, including those of the Organization for Economic Corporation and Development (OECD), are shying away from taking full responsibility of the final disposal of WEEE (Ongondo & Williams, 2011; Basel Convention, 2011a), governments in developing countries are now sensitive to the long-term problems associated with the management of e-wastes (Bamako, 1991; Basel Convention, 2011a). This has led government of emerging economies to also develop national policies/legislations/acts/regulations/guidelines/strategies on WEEE management by keying into global and regionally organized charters, treaties, standards and guidelines of leading proponents of WEEE (Europe Union, 2006; NESREA, 2011; Basel Convention, 2011a). Some of the coordinating proponents include the Basel Convention Secretariat, Solving the E-waste Problem (StEP) Secretariat, European Union, Mobile Phone Partnership Initiative (MPPI) and Partnership for Action on Computing Equipment (PACE).

In Nigeria, the National Environmental Standards and Regulations Enforcement Agency (Establishment) Act, 2007 Act No. 25 empowered NESREA with the responsibility of enforcing all environmental laws, regulation, guidelines including monitoring and control of e-waste (NESREA, 2007). NESREA, an arm of the Federal Ministry of Environment, encourages regional bodies, States and Local Government Councils environmental bodies to adopt and domesticate this and related laws. In addition, the Nigeria Custom Service has been obligated to inspect the content of imported used-EEE to confirm its conformity to stipulated freight (Ayodeji, 2011).

STRUCTURE OF WEEE COLLECTION AND DISPOSAL PRACTISES IN SOUTH EASTERN NIGERIA.

Largely, WEEE processing in Nigeria involves ripping the equipment into various parts – metal frames, power supplies, circuit boards, and plastics, which are separated, often by hand (Ayodeji, 2011). Sometimes, technicians/scavengers employ crude recovery practises such as open burning or dumping into surface water bodies and any available space in their efforts to dispose WEEE (Basel Convention, 2011; Oresanya, 2011). Alternatively, materials are shredded, and sophisticated expensive equipment separates the various metal and plastic fractions, which then are sold to various smelters and scavengers. Recycling as is done in the developed west is yet to take root in most developing countries of the world (Osibanjo 2008). The reports of currently practised recycling technologies with best available recycling technologies showed that there is considerable potential for improvement in certain areas like ICT recycling.

There exist, in most States of South Eastern Nigeria, a structure for collecting and disposal of municipal solid waste. Under this structure, a State, through its “Agency” should collect WEEE under classified scheme (ESWAMA, 2004). Operationally, the waste disposal units in these States are responsible for locating public refuse collection depots in different parts of the State where residents dump their waste (Public Health Law, 1957). More often, the functions of the “Agency” include the collection, transport, treatment, storage (intermediate storage), dumping and recycling of waste toward the final placement of waste that is not salvaged or recycled (Okorhi, 2005). Apparently, there appear to be neither clear distinction between WEEE and domestic solid waste during collection nor any specialized arrangement in the strategies employed for the intermediate and final disposal of WEEE.

FACTORS INFLUENCING E-WASTE GENERATION, COLLECTION AND DISPOSAL IN SOUTH EASTERN NIGERIA

Near end of life E.o.L EEE and WEEE imported into Nigeria are often declared, at the state of import, as economic goods or "second-hand goods" meant as gifts/donation to individuals or groups (GFMECD, 1995). In particular, traders of used vehicles also play a role in this trade as used EEE and e-waste is often co-loaded with used cars and trucks destined for export to West Africa (Basel Convention, 2011a). According to the Basel Report (2011), Nigeria was found to be the most dominant importing country of EEE and vehicles (both new and used), followed by Ghana, whereas the UK is the dominant exporting country for EEE, followed with a large gap by France and Germany. Also, it revealed that in order to disguise such illegal exports, the labelling of used EEE itself is sometimes manipulated (e.g. false codes for used refrigerators or removal of compressors of used refrigerators in order to classify them as "not-containing CFCs") and customs declarations are given to the competent authorities only on the day the ocean carrier is to leave the port.

There are enormous quantity of WEEE streams that are imported into Nigeria through two of the busiest seaports: Lagos and Port-Harcourt. Between April and October, 2010 five ships from developed countries which carried containers with used TV sets, computers, refrigerators, monitors and vehicles co-loaded with used EEE, were intercepted in these two seaports (Basel Convention, 2011a). NESREA in January, 2013, also seized an e-waste-laden ship, from the United Kingdom, at the Tin-Can Port, Lagos. The Port-Harcourt seaport serves mostly South Eastern Nigeria. Apart from the South-West region of Nigeria with relative huge data on WEEE streams, field survey suggests that the south-east (with scanty data) serves as another major trading route of used EEE designated for the Nigerian environment.

Both the Dutch and Belgian port authorities emphasize that personnel and financial limitations are severe obstacles to achieving better export control of the problematic shipments of used and end-of life EEE (Basel Convention, 2011a). Another factor influencing the rising trend of WEEE in South Eastern Nigeria is the missing public awareness on e-waste toxicity and consumers' common habits of buying UEEE which is almost at end of life, rather than new ones (Basel Convention, 2011d).

Government is yet to pronounce an outright ban on importation of UEEE but rather developed guidelines on UEEE importation to assist the importers in differentiating between e-waste and used EEE (NESREA, 2011b; NESREA, 2013). However, the Basel Report (2011) showed that national and international import statistics do not distinguish between new and used EEE imports. On the other hand, the import and trade of used EEE is in support of the UN Millennium Development Goals as a means to foster ICT for development (United Nations Development Programme UNDPI, 2006; United Nations, 2011). The absence of a recycling plant in Nigeria, has resulted to business opportunity for the informal sector, where recycling is carried out in a crude way as commonly practised in many developing countries (Ongondo and Williams, 2011; Basel Convention, 2011a; Basel Convention, 2011d).

It could be deduced that some of the factors influencing the e-Waste Generation, Collection and Disposal in South Eastern Nigeria could be outlined as follow:

i. The missing public awareness on e-waste toxicity and consumers' common habits of buying used EEE which are at near end-of-life, rather than new ones.

ii. Inability to distinguish between WEEE and near end-of-life EEE.

iii. Government haziness to pronounce an outright ban on importation of UEEE or develop long-term guidelines on imported used EEE to assist the importers in differentiating between e-waste and used EEE.

iv. Absence of regional/state standardized recyclable facilities for WEEE in Nigeria.

v. Inability to establish and pursue take-back programmes for WEEE.

vi. False declarations at the point of entry of WEEE as economic goods or "second-hand goods" meant as gifts/donation to individuals or groups.

vii. False codes for used refrigerators or removal of compressors of used refrigerators in order to classify them as "not-containing CFCs".

viii. Co-loading of near E.o.L. EEE and WEEE with used vehicles.

ix. Indistinguishable statistical characterization of new and used EEE imports into Nigeria.

x. National WEEE trend statistics are mostly a reflection on those from the South-West region of Nigeria.

APPROACH TO ENVIRONMENTAL SOUND MANAGEMENT (ESM) OF WEEE IN SOUTH EASTERN NIGERIA

The intense trade of used EEE and better access to lower priced ICT equipment, especially in South Eastern Nigeria, requires the application of Environmental Sound Management (ESM) of WEEE. The Basel Convention Partnership Programme, particularly within the Mobile Phone Partnership Initiative (MPPI) and the Partnership for Action on Computing Equipment (PACE) has been working toward addressing the problem of differentiating between used EEE as a second-hand good and e-waste (Basel Convention, 2011a).

Best applicable ESM include systems and technologies that yield multiple gains in the field of environmental protection, working conditions and employment creation, as well as in general economic terms. Such practises encourages the formal application of the WEEE 5Rs (Reduce, Repair, Reuse, Recycle and Recover) (NESREA, 2011), minimize occupational and environmental hazards as well as promote economic benefits. In the field of waste management, EPR is a strategy designed to promote the integration of environmental costs associated with EEE throughout their life cycles into the market price of the products. EPR could be said to be an environmental protection strategy that reach an environmental objective of a decreased total environmental impact of EEE, by making the manufacturer of such product responsible for the entire life-cycle of the product and especially for the take-back, recycling and final disposal. Manufacturers are now advised to enclose leaflets information on e-waste management and champion best strategy to involving business and industry in "Corporate Citizenship Responsibility" programmes, including the EPR and the Buy-back mechanism. An introduction and enforcement of a Buy-Back mechanism could be achieved through government by introduction and enforcement of EPR policy. For instant NOKIA in Nigeria has embarked on used mobile phone collection in Nigeria in 83 buy-back centres (Osibanjo O, 2009).

Recovery, Repair, Recycling, Reuse, and sources Reduce of WEEE from end-of-life electronics collected under the EPR scheme are judged the effective solutions to the growing e-waste problem.

For instance, recycling reduces the amount of greenhouse gas emissions caused by the manufacturing of new products. Most electronic devices contain a variety of materials, including metals that can be recovered for future use. Thus provides business opportunities in e-waste/entrepreneurship (waste to wealth) such as the reuse of some computer components in assembling new ones and other parts reduced to metals for flatware and jewelry (Okorhi, 2005; Basel Convention, 2011a). By dismantling and providing reuse possibilities, intact natural resources are conserved; air and water pollution caused by unsound environmental disposal of hazardous substances from e-waste is avoided. The current challenge has been to find a mid-point for the implementation of even an "abridged" form of EPR in developing countries. This has become necessary in the light of the present high level of trans-boundary movement of e-waste into developing countries and the lack of basic or state-of-the-art recycling and waste disposal facilities.

Several research works conducted toward finding replacements to some of the inorganic components of electro-devices suggest that the use of biodegradable components would be a better choice to conventional ones. A newer push towards this is the likelihood application of organic field effect transistors (OFETs) Technology, Organic thin-film transistors (OTFTs), organic light emitting diodes (OLEDs), and organic photovoltaics (OPVs) in the manufacturing of electro-devices (Schwabegger *et al*., 2011; Maria D. A. *et al.*, 2011; Mihai *et al.*, 2012). With the application of such technologies, biodegradable materials, like carbon nanotubes and graphene sheets, which offers higher performance in terms of field-effect mobility and sensitivity, could be used as alternative to inorganic substances in the manufacturing of High mobility, low voltage operating C60 based n-type organic field effect transistors; paper substrates (applied as Low-voltage active circuits on banknotes, for anti-counterfeiting applications); insulators, semiconductors and conductors for electrical and electronic devices (Maria et al, 2011, Mihai et al, 2012).

THE NATIONAL ENVIRONMENTAL (ELECTRICAL/ELECTRONIC SECTOR) REGULATIONS S.I. NO. 23 OF 2011

The general provisions of the National Environmental (Electrical/Electronic Sector) Regulations, 2011 stipulates the prevention and minimization of pollution from all operations and ancillary activities of the Electrical/Electronic Sector (covering both new and used Electrical/Electronic Equipment) to the Nigerian environment. The primary driver of the Sector is anchored on the principles of the 5Rs which are; Reduce, Repair, Reuse, Recycle and Recover. The Regulation deeply emphasizes on the functionalism and management of EEE/Used-EEE from cradle to grave.

As part of the management procedure for stakeholder, the Regulation (2011) requires every EEE manufacturing, processing, operational, power organisation (generation, transmission and distribution) and WEEE/E-waste facility to carry out Environmental Impact Assessment, Environmental Audit Report, Maintenance Plan as well as Environmental Management Plan.

The Best Practise options encourage the application of new technology to eliminate hazardous substances in the manufacturing, processing and assembling of EEE. Corporate bodies and organizations are advised to employ recovery measures under the EPR Program in an environmentally sound manner to all damaged and disused equipment including wires, Cathode Ray Tubes (CRTs), metals, motors, transformers, plastics etc. Also, every importer, exporter, manufacture, assembler, distributor, and retailer of various brands of EEE products shall subscribe to

an EPR Program including Buy-Back scheme as specified in the Schedule VIII of the Regulation 2011 (NESREA, 2011).

NESREA is an arm of the Federal Ministry of Environment saddled with the responsibility of enforcing all environmental laws, regulation, guidelines including monitoring and control of e-waste. In the light of WEEE management, the agency issues Enforcement Notices & Reminders to contravening bodies as well as that of Suspension of Permit to operate (NESREA, 2007; NESREA, 2011; Ayodeji O., 2011).

Methodology

The area of study, South-East Nigeria, is recognised as one of the six geopolitical zones in Nigeria (North-West, North-East, North-Central, South-West, South-East and South-South) and it comprises of five states namely: Abia, Anambra, Ebonyi, Enugu and Imo States. South Eastern Nigeria is situated east of River Niger and covering an area of 29,908 square kilometres with a population of about 16,381,729 (Emodi and Dimelu, 2012) and lying on latitude 50 and 70 75´ North and longitude 60 85´ and 80 46´ East. Together, there are 95 Local Government Areas (LGAs) in these five States. Besides engaging in trade and commerce undertakings, the study area is renowned as a beacon for entrepreneurs with high output of the industrial activities in Nigeria. For instance, Anambra State boasts as one of the biggest places for informal trade in Fast Moving Consumer Goods (FMCG). The Onitsha market, in Anambra State, consist of 12 specialized markets with over 50,000 shops and an FMCG trade volume of $1.5 billion which serves most of West Africa (African Business Review, 2012). Such characterization is also visible at clusters of market in Aba, Owerri, Enugu and Nnewi where huge volumes of Electrical and Electronic Equipment are traded daily. The study area was first divided into five mutually exclusive strata of states. These are Imo, Anambra, Ebonyi, Enugu and Abia. Four (4) Local Government Areas (LGAs) were randomly selected from each stratum.

The approach of this survey is investigative through questionnaire. The research instrument comprises a set of questions delineated into three stakeholders namely: 200 End-Users of EEE/WEEE; 40 Distributers of EEE/WEEE and; 40 personnel from Monitoring Agencies of EEE/WEEE. A total of 280 questionnaires would be administered in 20 Local Government Areas (LGAs) of the five states. A population of 21% was chosen with four LGAs randomly selected from each stratum. The sample size was determined using the following formula: $s = X^2NP(1- P) \div d^2(N -1) + X^2P(1- P)$ (Krejcie & Morgan, 1970). A range of assessment methods and approaches would be employed to address the “WEEE management strategies” – including assessing, if any, Roadmap plan to the design and implementation of small to large-scale e-waste management programmes in South-Eastern Nigeria; EEE facility requirements; Effluent limitation standards; Treatment technologies for WEEE emissions; Waste control measures; Permits to trade EEE; WEEE offences and enforcement measures. There will be flexibility in the methodological approach, using qualitative and quantitative methods where appropriate. In addition to the questionnaire, participatory techniques and interview schedules of structured and unstructured questions would be employed to obtain further information.

Several parameters/variables would be used as measurements in this survey through close-ended and open-ended questions. Some of these would be included in measuring the socio-demographic characteristics of respondents, educational information, business experience, management strategies of WEEE, recycling activities, legislation and support services from government among

others. The data collection instruments would be subjected to face validity, content validity and pre-testing. These would be done in order to be certain of the rational for collecting useful data. The face validity would be carried out through observation on dump sites. The content validation would be carried out by a trial survey (test-run) using three officers from the Monitoring Agencies of NESREA, ESWAMA and LGA Environmental Health Office. A test-run survey would be conducted in Enugu State. Also, observations noted during survey would serve to give credence to the statistical data analysis. The results from survey would then be represented in tables and schema.

Specific Objective: There is inadequate action of management functions that starts with planning, organising, leading/directing and then control of WEEE (as contained in Basel Convention Report (Where are WEee in Africa?), 2011 & StEP Annual Report 2010). Therefore, the survey will consider the strategies for managing WEEE in South Eastern Nigeria in-line with the National Environmental Regulations as well as available guidelines that are designated in each State. The main research question is: What are the operational tenets applied by the monitoring agencies for WEEE management in South-Eastern, Nigeria? Harmful Waste (Special Criminal Provisions) Act Cap H1 LFN 2004; the National Environmental Protection (Waste Management) Regulations S.I.15 of 1991; the National Environmental (Sanitation and Wastes Control) Regulation S.I.28 of 2009 and the National Environmental (Electrical/Electronics Sector) Regulations S.I. No. 23 of 2011. It has sub-research questions like i) Are you aware of any of the Regulations/Laws/Legislations/Acts for WEEE Management in Nigeria? ii) Which option(s) of the National Environmental (Electrical/Electronic Sector) Regulations S.I. No. 23 of 2011 does your organization practice? iii) Are there any particular difficulties in the implementation process of e-waste management legislations/ acts/guidelines? iv) Which of these difficulties in the implementation process are peculiar to your Agency? Lack of technologies /necessary equipment; Lack of adequate manpower (Personnel); Inadequate finances; Nature of guideline options formulated by the political system v) Are the strategies for implementation appropriate? vi) Has the provisions of Harmful Wastes Act, promulgated after the Koko waste saga in 1988 been an effective legislative instrument for the control of flow of e-waste in South Eastern Nigeria? vii) In cases of non-compliance are discovered with individual/firm what likely punitive measures are usually taken? Banning; Court Action; Imprisonment; Impose fine. The variables would measure: the awareness level of WEEE guidelines as well as implementation strategies, the legislative and political rationale for e-waste management by various arms of government. The questionnaire would also seek to identify gaps in frameworks in managing WEEE as well as measure the innovative trends in managing WEEE streams. The hypothesis test of a mean would be used to test the hypotheses. It requires that the following conditions were met: i) The sampling method is simple random sampling. ii) The sample is drawn from a normal or near-normal population. Test method: The one-sample t-test was used to determine whether the hypothesized mean differs significantly from the observed sample mean. Thus, using the sample data, a one-sample t-test will be conducted that will give the standard error, degrees of freedom, test statistic, and the P-value associated with the test statistic. If the sample findings are unlikely, given the null hypothesis, the researcher rejects the null hypothesis. Typically, this involves comparing the P-value to the significance level (0.05), and rejecting the null hypothesis when the P-value is less than the significance level (0.05).

Objective 1: There is gradual and steady increase in the generation of WEEE thereby intensifying the interest for recycling to conserve natural resources and protect the environment (as contained in reports by Nnorom and Osibanjo, 2008; Ongondo and Williams, 2011; & Ayodeji, 2011). The

questionnaire is tailored to ascertain inventory flow on WEEE from the key players. The study identifies the types of e-waste that are mostly generated/stockpiled within the household by consumers and at institutions. The key research questions are: i) What is the volume of WEEE generated annually in South-Eastern, Nigeria? ii) What are the seasonally generated WEEE streams in the South-East? It has sub-research questions like i) How do you classify imported (Tokunbo) used Electrical/Electronic Equipment (EEE)? Age; Brand; Functioning/ non-functional; Country of import; Value ii) What kind of electric/electronic waste (e-waste) are you most likely to dispose off? iii) Please, give an estimate of disused or disposed Electrical/Electronic appliances between 2010 & 2014 iv) Estimate the amount (in Kg/Tons) of electrical/electronic equipment collected in 2010-2014. The volume of WEEE generated annually in South Eastern Nigeria would be captured from field measurements and supplemented with secondary data sourced from firms' records and different published sources. The proposed statistical analysis is Regression analysis using Multivariate General Linear Model at 95% confidence level using questions i&ii as dependent variables and iii&iv as independent. If P-value is less than the significance level (0.05), we reject the null hypothesis otherwise we accept.

Objective 2: The processes of managing WEEE stream in South Eastern, Nigeria are not clearly spelt out and practiced. Most of what happens is that individuals, dealers and importers buy these wastes for direct reuse or dismantle to collect components for recycling and discard the remnants along with other municipal solid wastes (as contained in reports by Ongondo & Williams, 2011; and Ayodeji, 2011). The variables measured in the questionnaire would include: identification of factors influencing the generation of WEEE in the region. Specifically, the questions arising seek to address i) What alternative approaches are in place for managing WEEE? ii) How much impact has the WEEE management strategies implementation had on the rate of e-waste generation per annum? The sub-questions are i) Do you apply any specific classification/stratification for e-waste before disposal? ii) Which option(s) of the National Environmental Regulation, 2011 does your organization practice? Recycling of e-waste; Reuse of e-waste; Recovery of e-devices; Source reduction of generated e-waste; Repair of E.o.L electrical/ electronic equipment; Landfill of waste; Incineration of waste iii) How do you discard your waste electronics devices? Keep in store room; Resell the device; Disposed with general waste; Give them to a recycler; Donate to family, friends, school, NGO iii) What type of electronic device do you recycle? Photocopier; Printers; TV; Computer; Mobile phones; Others. Proposed statistical analysis is Regression analysis using Multivariate General Linear Model at 95% confidence level using all questions on management/disposal method to be dependent variable and all questions to do with categories to be independent. Result and interpretation follows: If P-value is less than the significance level (0.05), we reject the null hypothesis otherwise we accept.

Objective 3: The uncontrolled transboundary movements of hazardous wastes, some of which declared as economic goods, are sent to developing countries for disposal (as contained GFMECD, 1995; Basel Convention, 2011; NESREA, 2011b). Purported strategies for managing WEEE types would be examined. The study will specifically assess the technologies employed as management strategies for generated WEEE types in South Eastern Nigeria in-line with best ESM practises. Also, Innovative approaches drawn from the National Environmental Regulations for strategic management of each WEEE would be measured. Some of the key questions are i) What are the likely sources of E-waste in South Eastern Nigeria ii) What are the strategies employed for the collection and disposal of WEEE in the region iii) What is the level of awareness and public education on the environmental and health problems associated with importation of near-end-of-life and end-of-life

Electrical/ Electronic Equipment. Sub-questions are i) What give rise to the attractiveness of used (Tokunbo) electrical electronic equipment in South Eastern Nigeria? Cost; Durability; Income; Accessibility ii) What is the condition of a disused Electrical/Electronic device before being discarded? Broken – Not repairable; Broken – repairable; Old (Obsolete) iii) What do you think is the most important obstacle to proper refurbishing/recycling of electronic devices in South Eastern Nigeria? Cost; Lack of legislation; Lack of technical refurbishing devices; Lack of recycling infrastructure; Availability of raw materials for recycling; Lack of market for recycled products iv) Are you aware of the various impacts (socials, economic, health and environmental consequences) of the discarded electrical/electrical equipment? v) Please, give an estimate of disused or disposed Electrical/Electronic appliances between 2010 & 2014 vi) Estimate the amount (in Kg/Tons) of electrical/electronic equipment collected in 2010-2014. Regression analysis using Multivariate General Linear Model at 95% confidence level using all questions on management/disposal method to be dependent variable and all questions to do with quantity to be independent. IF P-value is less than the significance level (0.05), we reject the null hypothesis otherwise we accept.

Justification/Expected contribution to Knowledge: Assessment of WEEE management strategies in South Eastern Nigeria would offer critical analysis on available management standards, innovations, policies, guidelines and regulations on e-wastes. It would also provide the much needed statistics on the distributive trends of WEEE stream in South Eastern Nigeria which would serve to enhance the national database on e-waste in Nigeria thereby removing guess work from governance. Furthermore, this would be much useful at the conceptual framework for WEEE and in developing a distinctly dedicated guidelines/legislative framework for tenets and Environmentally Sound Management (ESM) of WEEE.

Consequently, there is an urgent need for the introduction and enforcement of legislation at all arms of government dealing specifically with WEEE. Outcomes from this research will also be useful to enhance ESM schemes through the promotion of evidence-based strategies that would result in: exploring innovative frontiers in WEEE management toward the use of biodegradable materials as electro-Component; encouraging the setting up of green-businesses for recyclers, smelters, scavengers (dismantlers) etc.; approaching e-waste problems by deploying controlling tactics including Landfilling, source Reduction, Recovery, Repair, Recycling and Reuse options; balancing the socio-economic benefits of utilizing end-of-life EEE; putting in place control flow of secondhand electronics as well as promoting plans for the final disposal of WEEE, and; training of personnel in effective e-waste management strategies.

REFERENCES

African Business Review, 2012, “How to enter Nigeria’s booming consumer market - African Business Review” 15 MAY 2012, viewed 19, February, 2013, <http://www.africanbusinessreview.co.za/money_matters/how-to-enter-nigerias-booming-consumer-market>

ATSDR, 2013, Agency for Toxic Substances and Disease Registry, viewed 10 March, 2012, <http://www.atsdr.cdc.gov/toxfaqs/index.asp>

Ayodeji Odeyingbo Olusegun 2011, Assessment of the flow and driving forces of used electrical and electronic equipment into and within Nigeria. Master Thesis. Environmental and Resource

Management. BTU Cottbus, viewed 21, January, 2013, isp.unu.edu/publications/scycle/files/master-thesis-olusegun.pdf. Pp 1-104

Bamako, 1991, Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa. Volume 2101, I-36508. Viewed 14, January, 2014,<.www.cetim.ch/en/documents/conv-bamako-ang.pdf > pp. 242-274.

Basel Convention, 2011a, Where are WEee in Africa? *Findings from the Basel Convention. E-waste Africa Programme.* Secretariat of the Basel Convention (SBC), viewed 04, January, 2013,<www.basel.int.> pp. 1-50

Basel Convention, 2011b, Report of the Conference of the Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal on the work of its eleventh meeting, Conference of the Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal Eleventh meeting Geneva, 28 April – 10 May 2013, viewed on 20 November, 2013, < www.basel.int/Portals/4/download.aspx?d=UNEP-CHW.11-24...pdf>

Basel Convention, 2011c, Rules of Procedure for meetings of the Conference of the Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. Secretariat of the Basel Convention (SBC), viewed 04, January, 2013,<www.basel.int.> pp. 1-16

Basel Convention, 2011d, Report of the Nigeria National Training Workshop on Component 4 of the Secretariat of Basel Convention (SBC) E-Waste Africa Project; Subject: Monitoring and Control of Transboundary Movement of E-Waste and Used E-Equipment to Africa and the Prevention of Illegal Traffic.

BCCC-Nigeria and Empa, 2011, UNEP SBC E-waste Africa Project: Building local capacity to address the flow of e-wastes and electrical and electronic products destined for reuse in selected African countries and augment the sustainable management of resources through the recovery of materials in e-wastes. Contribution to components 1 and 2: Nigeria e-Waste Country Assessment. Ibadan/Nigeria and St.Gallen/Switzerland, viewed 21, January, 2013, http://ewasteguide.info/files/Ogungbuyi_2012_BCCC-Empa.pdf

Emodi A. I. and Dimelu M. U, 2012, Strategies for Enhancing Rice Innovation System in Southeast Nigeria, British Journal of Management & Economics 2(1): 1-12, 2012

EMPA, 2009, E-waste Definition. Viewed 20th November, 2013 <http://ewasteguide.info/introduction/e-waste>

ESWAMA, 2004, The Enugu State Waste Management Authority Law, 2004: A Law to Dissolve The Enugu State Environmental Protection Agency and to Establish the Enugu State Waste Management Authority and Other Matters Connected Thereto. Enacted Today, 29th July, 2004 by The Enugu State Third House of Assembly. Enugu State Government 2004, No. 8

Europe Union, 2006, Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on Shipments of Waste, Official Journal of the European Union, Viewed on 2 November, 2013 < www.eur-lex.europa.eu/LexUriServ/LexUriServ.do>

E-Waste Association of South Africa (eWASA), 2009, Towards sustainable environmentally sound e-waste management. The conference proceedings of the International Conference on E-Waste

Control Abuja, Nigeria: The Abuja Platform on E-Waste organized by the National Environmental Standards and Regulations Enforcement Agency (NESREA) of Nigeria held between 20th -21st July, 2009

GFMECD, 1995. Environmental Handbook Documentation on Monetary and Evaluating Environmental Impacts. Volume 1. GmbH, Eschborn: Deutsche Gesellschaft fur. Technische zusammenarbeit. Pp. 320 – 391

Krejcie Robert V. and Morgan Daryle W., 1970. Determining Sample Size for Research Activities. Educational and Psychological Measurement. 1970, 30, 607-610. Viewed on 23 November, 2014 < http://home.kku.ac.th/sompong/guest_speaker/KrejcieandMorgan_article.pdf>

Maria D. A., Rosa P., Serafina C., Maria M., Antonia M., Gerardo P., Luigia S. 2011, Carbon based materials for electronic bio-sensing. Materialstoday SEPTEMBER 2011 | VOLUME 14 | NUMBER 9. Published by Elsevier Ltd, ISSN:1369 7021 Pg 424 – 433

Mihai I-V, Eric. D. G., Gundula V., Siegfried B. and Niyazi S. S. Green and biodegradable electronics. Materialstoday JULY-AUGUST 2012 | VOLUME 15 | NUMBER 7-8, Published by Elsevier Ltd, ISSN: 1369 7021. Pg 340 – 346

NESREA, 2007, National Environmental Standards and Regulations Enforcement Agency (Establishment) Act, 2007 A635-655., Federal Republic of Nigeria Official Gazette N0.92 Lagos – 31st July, 2007 Vol.94, Printed and Published by The Federal Government Printer, Lagos, Nigeria FGP 125/82007/1,000 (0L 90)

NESREA, 2009, "Global Perspective of E-Waste" A Keynote Address by Dr. (Mrs) Ngeri S. Benebo Jp., Director General/Chief Executive Officer, National Environmental Standards and Regulations Enforcement Agency (NESREA) At The Eko E-Waste Summit 2011. Held on 24th February, 2011. Available as DG speech at EKO E-waste summit 09022011.pdf, viewed 12 November, 2013, < http://elri-ng.org/DG%20speech%20at%20EKO%20Ewaste%20summit%2009022011.pdf >

NESREA, 2011, The National Environmental (Electrical/Electronic Sector) Regulations S.I. No. 23 of 2011, Federal Republic of Nigeria Official Gazette No. 50 Lagos – 25th May, 2011, The Federal Government Printer, Lagos, Nigeria. FGP75/72011/400(OL47)

Oh, C. J., Lee, S. O., Yang, H. S., Ha, T. J & Kim, M. J., 2003. Selective leaching of valuable metals from waste printed circuit boards. Journal of Air and Waste Management association, 53,897-902.

Okorhi J. O., 2005, Assessment of Solid Waste Management Strategies in Selected Local Government Area of Delta State. Master Thesis. Technology Planning and Development Unit. OAU, Ile-Ife.

Oliver E. Osuagwu and Charles Ikerionwu, 2010, E-Cyling E-Waste: The Way Forward for Nigeria IT and Electro-Mechanical Industry. International Journal of Academic Research. Vol. 2. No. 1. January 2010. LCC: T10.5-11.9. Pp 142-149

Ongondo Francis O. and Williams Ian D., 2011, Are WEEE in Control? Rethinking Strategies for Managing Waste Electrical and Electronic Equipment, Integrated Waste Management - Volume II, Mr. Sunil Kumar (Ed.), ISBN: 978-953-307-447-4, InTech, viewed 23 January 2013, http://www.intechopen.com/books/integrated-wastemanagement - volume-ii/are-weee-in-control-rethinking-strategies-for-managing-waste-electrical-andelectronic-equipment

Oresanya Ola, 2011, E-Waste Management in Lagos State: The LAWMA experience. Paper presented at the 2-Day International Summit on Regulations & Management of e-Waste in Nigeria (Eko e-Waste Summit), viewed 12 January, 2013, < www.lawma.gov.ng>

Osibanjo, O & Nnorom, I.C., 2007. The challenge of electronic waste (e-waste) management in developing countries. Journal of Waste management & Research 2007:25:489-501.

Osibanjo, O & Nnorom, I.C, 2008, Electronic waste (e-waste): Material flows and management practises in Nigeria. ELSEVIER. Waste Management 28 (2008), viewed 21, January, 2013, <www.elsevier.com/locate/wasman> <www.sciencedirect.com> pp. 1472–1479

Osibanjo Oladele, 2009, Citizens' Participation, Opportunities and partnerships In E-Waste Control. The conference proceedings of the International Conference on E-Waste Control Abuja, Nigeria: The Abuja Platform on E-Waste organized by the National Environmental Standards and Regulations Enforcement Agency (NESREA) of Nigeria held between 20th -21st July, 2009

Pennsylvania Resources Council, 2013, Frequently Asked Questions (FAQ) On Electronic Waste Recycling In Pennsylvania. Available as USA discards 30 million computers.pdf viewed 12 November, 2013, < www.prc.org/easthtr/E-waste%20FAQ.pdf >

Public Health Law, 1957. Public Health: Western Region of Nigeria. Pp3129-3131, 3149-3150.

Puckett, J., Byster, L., Westervelt, S., Gutierrez, R., Davis, S., Hussain, A. & Dutta, M., 2003. Exporting Harm: The High-Tech Trashing of Asia. Basel Action Network and Silicon Recycling, 44 (1), pp. 17-35.

Schwabeggera G., Mujeeb U., Irimia-Vladub M., Baumgartnerb, M. Y. Kanburd, R. A, Stadlerc, P, Bauerb S., Sariciftci N. S., Sitter H. High mobility, low voltage operating C60 based n-type organic field effect transistors. ScienceDirect, Synthetic Metals. Available on the internet: http://www.elsevier.com/locate/synmet.

Shagun, Ashwani Kush, and Anupam Arora, 2013, Proposed Solution of e-Waste Management. International Journal of Future Computer and Communication, Vol. 2, No. 5, October 2013.

StEP, 2009, Recycling – from e-waste to resources. United Nations Environment Programme & United Nations University, Germany, viewed 6 August, 2012 http://isp.unu.edu/news/2010/files/UNEP_eW2R_publication.pdf

StEP, 2011, StEP Annual Report 2010. StEP, Secretariat c/o United Nations University Institute for Sustainability & Peace (UNU-ISP), Germany, viewed 26 November, 2012 < www.ehs.unu.edu/file/get/8661>

ThisDay Newspaper, Lead Poisoning Kills 734 Children in Zamfara in Three Years. ThisDay, Tuesday 21 October, 2014, www.thisdaylive.com [Last accessed 17, October, 2014]

The Guardian, 2012, Domestic consumption Fuels: Africa's e-waste imports, says report. The Environment. The Guardian, Monday, February 13, 2012. Pp. 48-49. <www.ngrguardiannews.com>.[Last accessed 13, February, 2012]

United Nations Development Programme UNDPI, 2006, "Millennium Development Goals (MDGs), viewed 6 August, 2012 <http://www.undp.org/mdg>

United Nations, 2011, The Millennium Development Goals Report 2011. United Nations, New York. ISBN 978-92-1-101244-6. Pp 58-64

Vanguard, 2013, FG orders return of toxic ship to UK. Vanguard On-line News: 12th January, 2013, viewed 13, February, 2013, <http://www.vanguardngr.com/2013/01/toxic-waste-fg-to-sanction-ship-owners>

Wagner, T.P. (2009). Shared responsibility for managing electronic waste: A case study of Maine, USA. Waste Management, 29 (12), pp. 3014-3021.