

Decommissioning of Electronic Waste to Avoid Electromagnetic Radiation and Environmental Hazards in Cross River State

Authors: Akpo S E¹; Tawo G A²; Ojomu S A³; Utsu M M⁴

¹ International University of Management (IUM) Namibia

² Senior Lecturer: Cross River State University, Calabar, Nigeria

³ Lecturer: Cross River State University, Calabar, Nigeria

⁴ Lecturer: Cross River State University, Calabar, Nigeria

Corresponding Author: s.akpo@ium.edu.na

DOI: 10.26821/IJSHRE.11.5.2023.110501

Abstract

Decommissioning is a method of managing electronic waste which is not hazardous if it is stocked in safe storage or recycled by scientific methods or transported from one place to the other in parts or in totality in the formal sector. This paper reflects on a management technique and a model that can manage electronic waste in a sustainable approach. A systematic review analysis that employed e-waste decommissioning model was carried out to determine the efficacy of electronic waste management within the major Streets in the State capital of cross River State Nigeria; Ekpo-Abasi, Calabar, Marian, IBB, Etta-Agbor and Atimbo. The findings revealed that the volume of e-waste in circulation in major streets in the city of calabar is accumulating at an alarming rate. In some locations within the above mentioned areas, electronic waste are in the increased; 78% in Calabar road, 45% in Atimbo road, 57% in Ekpo-Abasi Street, 48% in IBB road and 42% in Marian road respectively. Besides, an average of about 600 containers approximated to be 40-foot docked to offload e-waste annually around the dump sites. The study recommended a guideline on environmentally sound testing, refurbishment, and repair of used computing equipment. Similarly, strategies that support environmentally sound material recovery and recycling of end-of-life computing equipment should be developed. Availability of technical supports in the destination dumping sites ensures full transparency, contract notification and consent prior to delivery.

Keywords: e-waste; e-waste management; decommissioning; environment hazard; recycling;

1.1 Introduction

As the world transformed into a global village, the knowledge basic economy emerged with more dependence on electrical and electronic equipment (EEE) (Sewanyana & Busler., 2007). The demand for electronic control devices has risen astronomically due to consumers' appetite for latest products [Kumar and Dixit (2018)]. It has being documented that the rapid technological advancement and the quest for more returns by firms resulted in the faster introduction of newer and cheaper products. Sadly, the lifespan of these devices has drastically reduces due low quality, thus resulting in their discarding even before reaching their useful lifespan (Forti et al., 2020). Many countries in Africa depend on refurbished EEE from developed countries to participate in the knowledge economy. However, failure to manage obsolete and unrepairable devices results in electronic waste (e-waste), whose increase is detrimental to the eco-system and human health. E-waste refers to obsolete and abandoned devices be it electronics or electrical containing toxic materials that are generally disposed of in illegal dumpsites in most developing countries (Nwagwu & Okuneye, 2016). At present, general research on e-waste management in developing countries is still in its infancy, e-waste management issues affecting most African countries emanates from lack of awareness, policy, infrastructure, the effect on public health and the eco-system as well as livelihood issues [Kiddee et al., 2014]. It has risen steadily over time and is expected to increase even more rapidly. In the year 2019, 53.6 million metric tons (Mt) of e-waste produced globally which has increased by 9.2 Mt since 2014 and it is estimated that by 2030 it will exceed to

74.7 Mt (Forti et al., 2020; Ghimire and Ariya., 2020). Survey analysis proved that many gutters and waste-bins in Nigeria occupied a higher degree of electronic waste, from common Radio sets, Televisions, Computers, Equalizers sets, Amplifiers Voltage Regulators, Turntable-sets, Audio and Recording Decks, Printers, Photocopies, Laminating Machines, Scanners, Uninterrupted Power Supply (UPS) deep freezers, Amplifier-mixers, Filament Bulbs, Multi-sockets, Phones chargers, Cross-overs gadgets, Modems etc all these appliances with their components are dumped, in gutters, dust-bins, Rivers, high ways, and they are causing unnecessary hazards` to the society.

1.2 Background context

1.2.1 The E-waste on eco-system and human health

The presence of various types of hazardous chemicals and toxic metals in the waste can pose several fatal risks to the human population and eco-system, if mishandled. E-waste is not hazardous if it is stocked in safe storage or recycled by scientific methods or transported from one place to the other in parts or in totality in the formal sector. The e-waste can, however, be considered hazardous if recycled by primitive methods [Althaf et al., 2021]. E-waste contains several substances such as heavy metals, plastics, glass etc., which can be potentially toxic and hazardous to the eco-system and human health, if not handled in an environmentally friendly and acceptable manner. In the developing countries E-waste recycling is through the non-formal sector by primitive methods that can damage the environment [Shaikh et al., 2020a,b].

An intriguing fact is that the electrical and electronic products are dumped even before their end-of-life (EoL); also, very few EoL electronics find their way to a formal recycling unit. A major chunk of such electronic products ends up in landfills or are incinerated in a waste-to-energy process.

1.2.2 Type of e-wastes

There are several sources of e-waste, including government and commercial sectors, institutional and research organizations, household, and manufacturing industries. All these sectors are growing enormously and contribute their maximum when any equipment goes obsolete. The important sources include large and small home appliances, government office, information technology and telecom equipment, medical equipment from hospitals and private sectors, industrial machines and equipment. The highest composition of e-waste consists of washing machines, dryers, vacuum cleaners, air conditioners, coffee machines, irons, etc., is about 30%, refrigerators 20%, computers, telephones, printers, CD, DVD, fax, hi-fi sets etc., 30%, televisions 10% and monitors alone contribute 10% (Kaya., 2016). The global e-waste quantity during 2019 comprises the highest percentage of small equipment followed by large equipment and temperature exchange equipment by 17.4, 13.1 and 10.8 Mt (Forti et al., 2020).

1.2.3 Decommissioning of e-wastes

The subject of Decommissioning is the better handling and treatment of E-Waste. Recycling E-Waste requires an approach geared to protecting human health and the eco-system also preserving raw materials. Specific treatment for E&EWs is necessary to avoid the dispersion of pollutants in recycled material or the waste bodies. Any establishment or undertaking treatment operations should comply with minimum standards to prevent negative environmental impacts connected with the processing of this type of waste. Operators must use the best available techniques for the treatment, recovery and recycling of E-Waste, provided that they ensure human safety and a high level of environmental protection.

2. Review of related literatures

Proper management procedures and new techniques must be apply to manage E-waste. The nation suffered severed health hazards resulting to poor management of E-waste, either from the angle of the implementation of government policies gearing towards actualization and installing of structures and technical manpower to manage E-waste, or lacking the political constraints to utilized the resources of government agencies and projects, The figure below shows rise in E-waste astronomically the percentage of e-waste in globally.

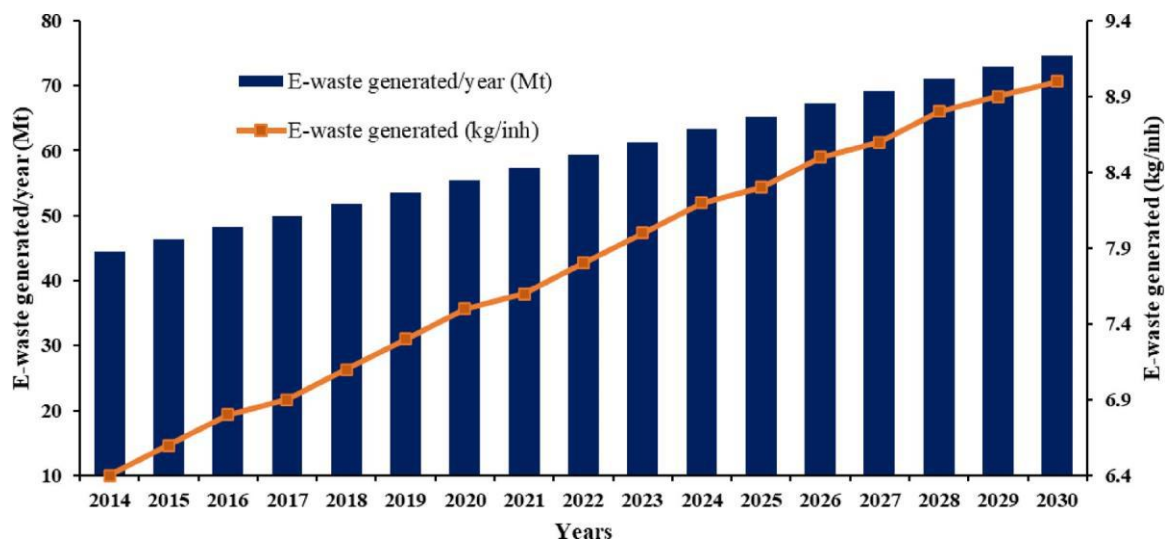


Fig. 1. Global quantity of generated e-waste (Forti et al 2020).

Generally, e-waste consists of a mixture of metals, elemental waste mainly Cu, Al, Ni, Pb, Sn, Mn and Fe, in addition to assorted waste deposition with numerous types of plastics, glass fiber, metal oxides and ceramics (Ilankoon et al., 2018; Purchase et al., 2020).

Table 1. Potential raw materials in e-waste generated globally in 2019

Metal	Amount Present in E-Waste(kg)
Ag	1.2
Al	3046
Au	0.2
Co	13
Cu	1808
Fe	20466
Ge	0.01
In	0.2
Ir	0.001
Os	0.1
Pb	0.1
Pt	0.002
Rh	0.01
Ru	0.0003
Sb	76
Total	

With increasing gross domestic product, world consumption of EEE accelerates, and its waste streams grow. The current amount of e-waste generated is about 12 million metric tonnes (Mt) per year. This is expected to increase in the coming decades at a rate of at least 4 per cent annually—a rate about three times faster than the growth of municipal waste. (Step Initiative., UNEP, 2013)

As the consumption of EEE increases, the problem of e-waste gains importance. In this regard, the Solving the E-waste Problem (Step) Initiative, hosted by the United Nations University (UNU), calculates that the volumes could grow by 500 per cent in the next decade in some countries, reaching 48 million Mt globally in 2017, of

which 4,5 million Mt is predicted to come from Latin America. (Baldé et al., 2017) E-waste requires proper treatment to manage these increasing volumes, and managing this treatment poses one of the greatest challenges for the region in the coming years.

The management of e-waste is one of the greatest challenges faced by the ICT sector. This stream requires sustainable management of products at the end of their useful lives due to the environmental, social and economic implications associated with it. It is important to understand that these wastes are heterogeneous and have specific characteristics. Therefore, its management, treatment and disposal must be carried responsibly. In general terms, this report describes the basic principles of sustainable management of e-waste that already exist and are applicable to the region [UNEP., 2013]

In 2009, Luciano Morselli defined EEE as "Any device that for functional reasons is dependent on electric currents or electro-magnetic fields in order to work properly. It becomes WEEE when its owner disposes of it, tries or needs to discard it". (Morselli et al., 2009)

Increased recycling activities due to the limited availability of natural resources have introduced the concept of "urban mining", or the activity of treating electronic waste to recover metals and other components with the aim of reusing them. While this activity could be quite lucrative and productive in countries where an industry has already been established around it, risks to the health and the environment from uncontrolled and informal processes should be taken into account. (Step Initiative., 2012).

It must be understood that safe disposal of e-waste is a collective responsibility that needs to be shared by local community, NGOs, private sector and public institutions (Ilankoon et al., 2018; Efficient and eco-friendly remediation technologies can solve the problem of e-waste (Li and Achal., 2020). Currently, a number of studies are being focused on the various aspect of e-waste beginning from womb to tomb in different parts of the world (Akram et al., 2019).

Lambrechts (2016) noted that most African countries did not have the knowledge to manage e-waste and therefore resort to dumping, which further leads to environmental degradation. In Africa, improper e-waste recycling has led to contamination of the soil and rivers through the release of toxins from lead, mercury, arsenic among others affecting the communities

Yu et al. (2017) revealed that recyclers in most African countries lacked recycling facilities and resorted to dismantling, burning, and acid leaching to recover precious metals.

According to Gerne et al (2022) the massive growth of consumer electronics has led to an ever-expanding surge of end-of-life (EOL) electronics that require recycling. E-Waste, also known as Waste Electric and Electronic Equipment (WEEE) consists of discarded products or appliances that consume power. Global E-Waste production is on track to reach 120 million tons per year by 2050 if current trends continue. Expressed in other terms, it means that by 2050, each person living on the earth will discard 12 kg of E-Waste on a yearly basis.

According to Verma the disposal of e-wastes is a critical problem faced and poses a threat to both health and vital components of the ecosystem. Disturbances in ecosystem affect the biodiversity and human survival (Verma., 2015, 2017, 2018).

Sighting the claim by Jahan et al (2013) incineration of e-wastes can emit toxic fumes and gases, thereby polluting the surrounding air. Improper recycling and recovery methods can have major impacts on the environment. Crude forms of dismantling can often lead to toxic emissions, which pollute the air and thereby also expose the workers to the harmful materials. The most dangerous form of recycling and recovery from e-waste is the open air burning of circuit boards in order to recover copper and other metals. Extraction of metals through acid bath method or through mercury amalgamation also contributes to environmental degradation. (Jahan and Begum, 2013)

In most developing countries, e-waste handlers use rudimentary means of processing e-waste through incinerating or open burning in dumpsites. The most affected and vulnerable groups are; the illegal e-waste

workers who use rudimentary means, with no appropriate tools, the general public which reside near informal recycling dumpsites, children and pregnant women (Bakhiyi et al., 2018).

3. Methodology

In the age of technology, e-waste continues to grow. Too often, as a result of dumping their electronics. This is dangerous for the environment and a waste of materials. Decommissioned equipment might not have any resale value or it may become obsolete. This doesn't mean that it is worthless, however. E-waste decommissioning protect the ecosystem, human health conditions and animals, the ecosystem depends solely in the management of the environment, reuse or recycle with minimal landfill waste remains a fundamental principle in waste management. A descriptive and inferential statistics that utilized poisson distribution was used to determine the rate of e-waste in the identified sites in the capital.

3.1 E-Waste Decommissioning model.

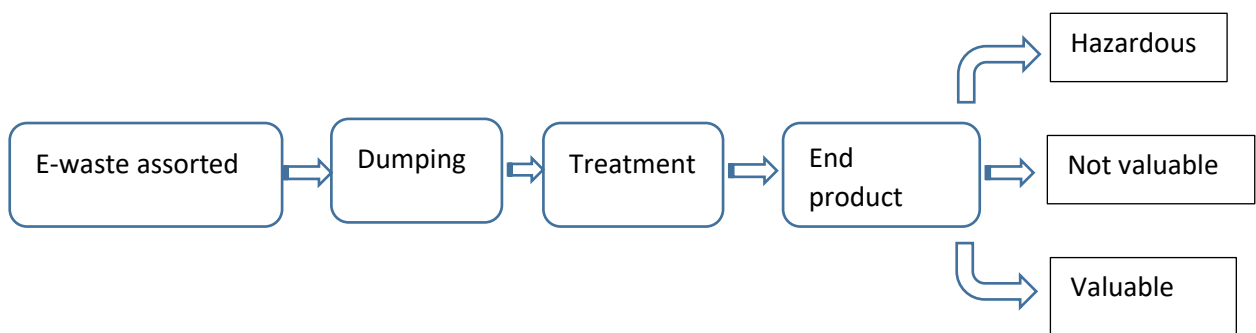


Figure 2: E-Waste Decommissioning model.

The individual items contribute to the annual production of e-waste, E (kg/year) depends on the weight of the product, M (kg), the numbers articles in service (N), and its average life expectancy (L) in years. It can be calculated using the following.

$$E = \frac{NM}{L} \tag{1}$$

The average lifespan of a computer is three years, and it produces a higher amount of e-waste as compared to electric cookers and refrigerators having life spans of 10 years.

Applying the Poisson distribution Formula the following is:

The Poisson distribution formula is applied when there is a large number of a possible outcome. For a random discrete variable X that follows the Poisson distribution, and τ is the average rate of value, then the probability of x is given by:

$$f(x) = p(X = x) = \frac{e^{-\tau}\tau^x}{x!} \tag{2}$$

Where $E = f(x) = X = x$ variable that follows the Poisson distribution

$N = \tau$ the numbers or rate of decommissioning

e is the Euler's number ($e = 2.718$),

Subject to $x = 0, 1, 2, 3, \dots, \tau > 0$.

Table 2 showing E-waste generation at difference sites in Calabar city/year

SN	Dumped site Mayne Avenue	Dumped site in Atimbo road	Dumped site Ekpo Abasi	Dumped site in Calabar road	Dumped site in Marian	Dumped site IBB	Year
E-waste generated (kg/inh)							
1	1.20	1.22	1.01	1.33	1.00	1.21	2015
2	1.30	1.25	1.11	1.37	1.01	1.23	2016
3	1.35	1.27	1.15	1.39	1.11	1.27	2017
4	1.42	1.31	1.19	1.41	1.13	1.29	2018
5	1.44	1.34	1.21	1.43	1.17	2.03	2019
6	1.50	1.35	1.25	1.47	1.19	2.05	2020
7	1.53	1.18	1.28	1.48	2.01	2.09	2021
Total	9.64	8.82	8.20	9.68	8.62	11.17	GT=53.13

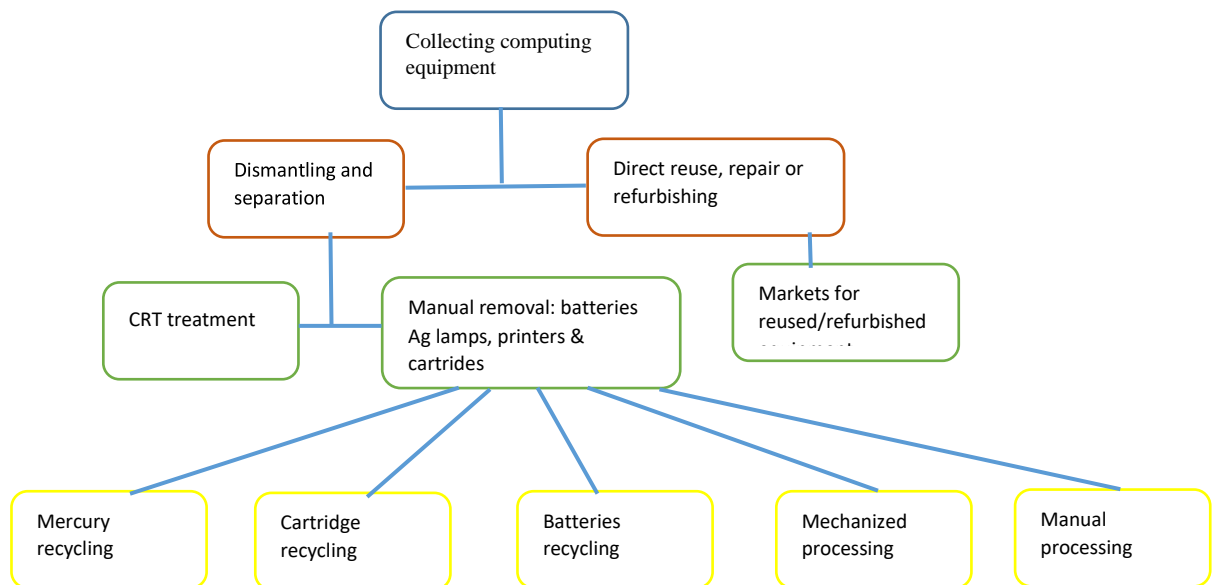


Figure 3: Decommissioning activities within the e-waste sector.

4. Findings and Discussion of Results

The volume of e-waste in circulation in major streets in the city of Calabar is accumulating at an alarming rate. A worrisome situation that called for urgent attention from the federal level, the state government lack the political freedom to resolved the alarming state of the beautiful and the ancient city of the nation Calabar, A yearly average of about 600 containers which are approximately 40-foot dock to offload e-waste annually around the dump sites cited above, analysis carryout portrait many gutters and waste-bins in the streets of Calabar are occupied with higher amount of electronic waste, from common Radio sets, Televisions, Computers, Equalizers sets, Amplifiers Voltage Regulators, Turntable-sets, Audio and Recording Decks, Printers, Photocopies, Laminating Machines, Scanners, Uninterrupted Power Supply (UPS) deep freezers, Amplifier-mixers, Filament Bulbs, Multi-sockets, Phones chargers, Cross-overs gadgets, and Modems etc all these appliances/electronic gadgets emitting EM -wave radiations along side their components are dumped landfill, in gutters, dust-bins, streams, high ways, and they are causing unnecessary hazards` to the society.

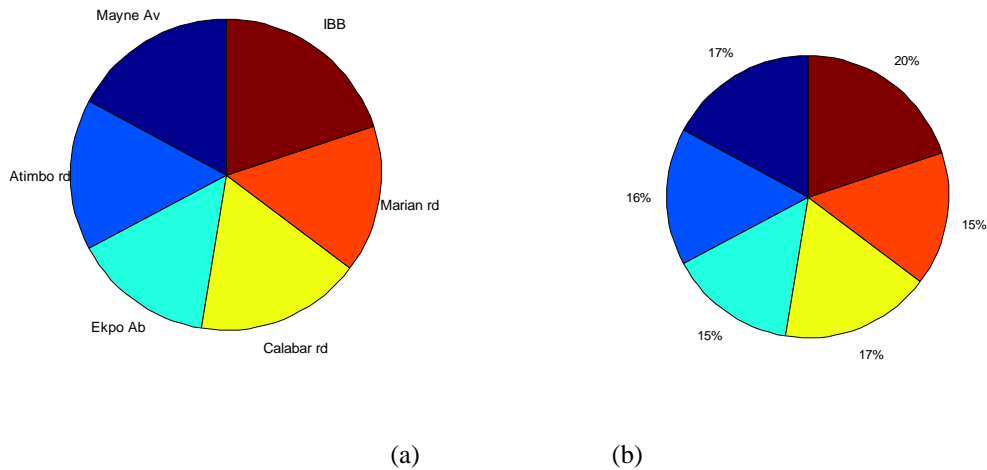


Fig 4: (a) and (b) showing the sites and percentage in value of E-waste in Calabar city

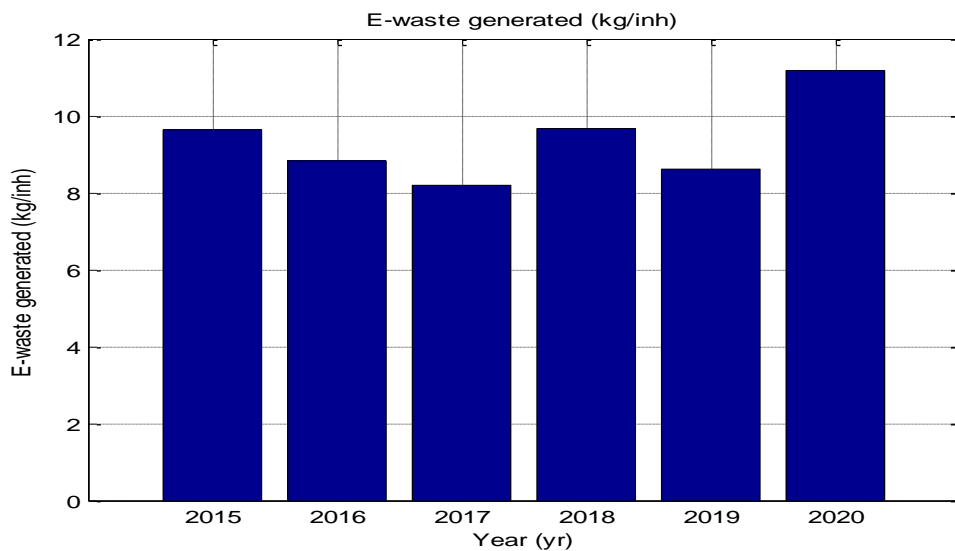


Fig 5: showing the E-waste generation and years in Calabar city

5. Conclusion and Recommendations

Electronic waste in Nigeria have it revolution from new electronic gadgets introduces in the markets, which will culminate in facing the existing gadgets out from circulation. In developed countries they are been brought back to the industries using trade-off process; a dealer or user having affiliation with the industries to recycle the gadgets back into the system. Many countries in Africa depend on refurbished Electrical/Electronic gadgets from first and second world countries to improve our economy we should adopt a system which is universally accepted and practices a modern system of managing E-waste, However, failure to manage obsolete and unrepairable EEE results in electronic waste (e-waste), whose increase is detrimental to the ecosystem and human health.

6. Recommendations

The society have the primate of using new electronic gadgets in circulation, because new features introduced to those electronic gadgets will improve on the performance of these new technology. Guidance Document on the Environmentally Sound Management of Used and End-of-Life Computing Equipment, and Partnership for Action on Computing Equipment. Guideline on Environmentally Sound Testing, Refurbishment, and Repair of

Used Computing Equipment. Procedures on Environmentally Sound Material Recovery and Recycling of End-of-Life Computing Equipment. Also ensuring that products are functional and that appropriate products are provided; availability of technical support in the country of destination; and, ensure full transparency, contract and notification and consent prior to delivery.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author, S E.

Funding

The authors received no direct funding for this research.

Author details

Akpo S E¹. s.akpo@ium.edu.na International University of Management (IUM), Namibia

Tawo G A² edwardtawomeji@gmail.com. University of Cross River State

Ojomu S A³ sundayojomu@unicross.edu.ng University of Cross River State

Utsu M M⁴. thias099ut@gmail.com University of Cross River State

Disclosure statement

No potential conflict of interest was reported by the author(s).

Citation information

Cite this article as: Decommissioning of electronic waste to avoid electromagnetic radiation and environmental hazards in cross river state. Akpo S.E., Tawo G.A., Ojomu S.A. & Utsu M.M. (2022). *Sustainable Environment*.

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