A FRAMEWORK FOR THE ENVIRONMENTAL MANAGEMENT OF ELECTRONIC WASTE

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ABSTRACT

With the advent and increase in the use of ICT in Nigeria, there has been a rise in e-wastes and associated environmental hazards. In order to propose a framework for e-waste management, the institutional protocols and the knowledge, attitude and practice of staff and students of the University of Benin in terms of environmental risks associated with the handling of e-wastes were investigated. . A total of four hundred and ninety-nine respondents were surveyed using a cross sectional research design. The results were analyzed using four null hypotheses, and findings have revealed that, there are no laid down institutional protocols or framework for the disposal of e-waste at the university of Benin, most staff and students have low awareness/knowledge of the environmental and health risks associated with e-waste generation and disposal. The results also revealed a general poor attitude towards e-waste management mainly due to high cost of management and the inconveniences associated with it. To address this, an institutional framework which anchored on more awareness and sensitization on e-wastes and its environmental risks is proposed for proper management of e-wastes.

INTRODUCTION

Electronic equipment that has reached their end of life becomes Waste of Electrical and Electronic Equipment (Waste-EEE), or simply Electronic Waste (E-waste). Electronic waste (e-waste) is a generic term embracing various forms of electric and electronic equipment that have ceased to be of any value to their owners (Amachree, 2013). Electronic equipment is defined as "a complex mixture of several hundred components many of which contain heavy metals and hazardous chemicals". Electrical and Electronics Equipment (EEE) have generally made life easy and convenient because of their efficiency and time saving in application. Communication systems, as they are today, would not have been achievable without electronics technology. Entertainment industry (music, radio, television, cameras, etc.) would have remained crude if not for continuing development in electronic technology (Awasthi, 2017). Household equipment, now making use of electricity and electronics, are making domestic chores (washing, cleaning, cooling, heating, etc.) continuously easier and more convenient. Electrical and electronics equipment such as computers, phones become technologically obsolete in a matter of months as a result of continuous development of new models and shorter lifespan of the products (Daliguite *et al*, 2019). This rapid technological growth leads to high rate of production of electronics equipment. Massive increase in Computer use and cell phones has led to importation of second-hand equipment from developed countries which becomes waste at the expiry date of their useful life. Umesi and Onyia (2008). Some 20 to 50 million metric tons of E-waste are generated worldwide every year (ETC, 2010). In 2016 and 2017, approximately 45 and 46 million tons of electronic waste (e-waste) was generated globally, respectively (Balde *et al*, 2017).

Mishra *et al*, (2017), suggested that with an annual growth rate of 4% to 5%, e-waste is becoming one of the fastest growing waste streams in the world. In the United States alone, 14 to 20 million personal computers are thrown out each year, with an annual increase of 3-5%. However, only some 13-18% are recycled. In the end, the disused equipment find their way into various directions, some ending up in landfills where they pose environmental and health hazards to humans, livestock and the soil. Some of these are incinerated, leading to environmental pollution

from the fumes. The 'surviving' ones find their way into poor developing countries where, possibly out of ignorance, the equipment are carelessly handled, hence posing a serious threat to human health, soil, livestock and drinking water (Singh *et al*, 2016). All this has led to serious health and environmental concerns.

Tonnes of e-waste are now generated worldwide (MICT, 2013). The increasing availability of new electronics, along with the higher number of products built with shorter life spans has resulted in the current explosion of e-waste (Daliguite *et al*, 2019). The majority of e-waste currently ends up in domestic landfills or incinerators, although efforts to divert e-waste from landfills, via recycling, have led to a largely unregulated, and oftentimes illegal, e-waste trade that dumps toxic materials from the affluent onto poorer countries in such regions as Asia and Africa (Puckett *et al*, 2002).There is environmental concern about the fate of e-waste from public and private institutions such as banks, universities, schools, public and private parastatals where the awareness on the environmental challenges of e-waste is poor on the laid down procedures for the management and disposal of e-waste in Nigeria are not followed. There is no development of responsible behavioral patterns towards the environment (Ay, 2010). However, existing literature (Gupt and Sahay, 2015) shows that to adequately evaluate the viability of introducing such schemes would require further engagement and interactions.

An investigation was conducted to evaluate the institutional protocols and the knowledge, attitude and practice of staff and students of the University of Benin in terms of environmental risks associated with the handling of e-wastes. The sole aim was to develop a framework for e-waste management.

METHODOLOGY

The study was conducted among staff and students of the University of Benin, Benin City, Nigeria. The university is located in Ovia North East Local Government Area of Edo State. Edo state is in the South-South Nigeria. It is located between latitudes 6°20.022′N and longitudes 5°36.009′E. The university has two campuses: Ugbowo campus and Ekehuan campus

Study Design

The study adopted the cross - sectional research design which allows the research to be carried out in a natural setting without the control and manipulation of the variables by the researcher. The design analyses data collected from a population or a representation subset at a specific point in time. The advantage with this design is that it allows statistical inferences to a broader population so that results can be extrapolated. Academic and non-academic staff; and students of University of Benin form the population of the study. The total population of academic staff is 1910 while the non-academic staff population is 5734 as at December 2016 (Source: record and statistic unit, registry department, UNIBEN). The number of students stands officially at about 36,001. The study was carried out for a period of 2 months (August 2017 - September 2017).

Sample Size Calculation

To calculate the required sample size, Cochran's formula was adopted,

$$n = Z^2 pq / d^2$$

The following parameters were used:

(i). Estimate of the expected proportion (p) (ii). Desired level of absolute precision (d)
(iii). Estimated design effect (DEFF) (iv). Confidence limit (usually 95% and Z score = 1.96)

The sample size formula is: $n = 1.96^2 p (1-p)(DEFF) / d^2$

To estimate the assumed prevalence of population having laptops and phones 90%, with 95% confidence limit (8% -12%) among high school students, adjusting for the design effect of 0.5 and confidence limit (usually 95% and Z score = 1.96),

$= (1.96 \times 1.96 \times 0.1 \times 0.9 \times 1.5) / (0.02 \times 0.02) = 432.$

To accommodate participants who may default in one way or the other, the minimum sample size was multiplied by a factor of 1.1 to give 475.2

Sampling Techniques

There is a total of 231 departments in UNIBEN. Using the simple random sampling technique (balloting) twenty one Departments were selected to cover the minimum sample size of four hundred and seventy five. The staff and students in the selected departments were sampled randomly giving a total of four hundred and ninety nine which is enough to meet the minimum sample size of four hundred and seventy five. The selected departments are presented in Table 1:

Table 1: List of selected departments and staff and students sampled.

S/N	Departments	No of respondents
1.	Accounting	60
2.	Banking and finance	40
3.	Centre for Educational Technology	21
4.	Centre for part time programmes	13
5.	Estate services	23
6.	Computer science	32
7.	Crop science	26
8.	Deans office (social Science)	19
9.	Deputy VC office (Academic)	7
10.	Distance learning programme	13
11.	Educational foundation	13
12.	Ekenwan office (Bursary)	22
13.	Engineering workshop	19
14.	Farm project	37
15.	Food science and Nutrition	2
16.	Estate services	18
17.	Histopathology laboratory 1	1
18.	Philosophy 15	15
19.	Quantity surveying	14
20.	Production Engineering	52
21.	Geology	32

Data Collection and Analysis

Data collection was done through the administration of a structured questionnaire to staff and students of the selected Departments. The questionnaires were screened for completeness by the researcher, coded and entered into the IBM-SPSS statistics 20.0 software for analysis. Descriptive statistics, simple percentages, mean and standard deviation were utilized to depict or evaluate the knowledge, attitude and practices of the respondents to e-waste and its associated risks.

RESULTS AND DISCUSSION

The results of the survey have shown that a total of 499 respondents were involved in the study (Table 2). This comprises 283 males and 216 females. All the respondents were graduates (Table 3) but only 56% associate e-waste with mobile phones (Table 4). The awareness of UNIBEN respondents to the environmental hazards of improper disposal of e-waste is high. Specifically, the response showed that 213(43%) were aware of the dangers e-waste posed to water and land resources respectively. Findings also showed that a majority of the respondents leave their damaged or non-working electronic gadgets such as phones at home (62%) or leave it at the repairer's place (50%). This implies that there are no proper institutional protocols and guidelines towards the efficient management of e-waste in UNIBEN. The results show that 65% of the respondents are of the opinion that the estate services department manages the waste eventually, while 45% observe that most electronics in disuse are abandoned in offices and corridors (Tables 5 & 6). However, 27% of the respondents reported that rooms and free spaces in utilities such as toilets and departmental offices are used as stores for non-functional desktops (Tables 6 & 7). The university do not pay for wastes recycling however, 35% of the respondents think scavengers do the service of recycling, based on personal observations of scavengers or staff "selling disused computer hardware components" to collectors. In a study on e-waste knowledge and attitudes in

India, (Sivanthanu, 2016) indicated that consumer awareness has a direct relationship with willingness to recycle e-waste

Table 2: Demographic characteristics of study population

Gender	*Frequency*
Male	283
Female	216

Table 3: Educational status of respondents

Level	Frequency	Percentage
Undergraduate	250	50
B.Sc.	130	26
Masters and above	120	24

Table 4: Major components of e-wastes in University of Benin

Items	Yes (%)
Mobile phones	56
Batteries	45
Computers	43
Television	10
Refrigerator	10
Light bulbs, etc.	12

Table 5: E-wastes disposal methods commonly used in University of Benin

Item	**Yes**	**Percentage**
Dump in designated places/refuse	26	5
Sell to recycler	0	0
Keep at home	307	62
Dump in river or sea	0	0
Burning/incineration	164	33
Leave at the repairers place	248	50

Table 6: University's current disposal practices for electronic waste

Item	Yes	Percentage
Recycle with an electronics recycler	-	-
Estate services disposes them	324	65
Send electronics to be reused	46	9
Dispose electronics as hazardous waste	-	-
Leave in offices or corridors and environs	224	45
Donate electronics to non-profit groups/ schools	-	-
Stores unwanted/obsolete items	136	27
I don't know	38	8
Burn them	246	49

Table 7: Items commonly disposed of or recycled

Item	Yes	Percentage
Computer flat screen monitors	132	26
Computer CRT monitors	235	47
Hard drives	324	65
Keyboards	225	45
Computer mice and other	143	29
small accessories	234	47
Scanners/photocopiers	35	7
Desktop printers	57	11
Large office printers	2	0
Fax machines	0	0
CPUs (central processing unit)	33	7
Laptops	0	0

Framework for E-Waste Management

In recognition of the threat posed by e-waste and the uncoordinated manner in which informal activities and initiatives are being undertaken by various offices, Departments and Faculties within the university , there is need to propose an institutional system framework to manage the situation. In this study, we proposed an institutional framework that will enhance and improve the process of e-waste management and effective disposal. Figure 1, illustrates the systematic process for effective e-waste management from product collection to disposal.

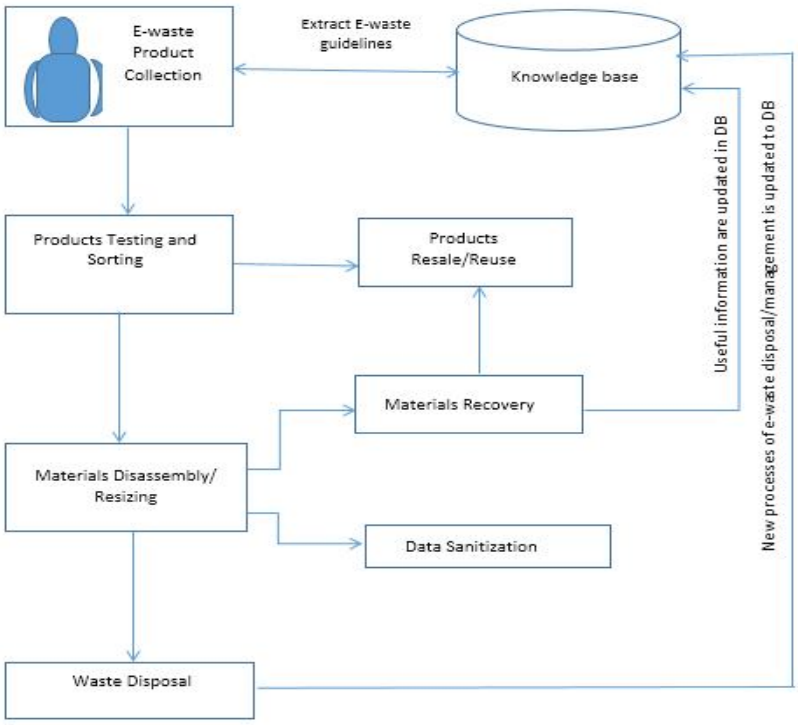

Figure 1: Proposed Institutional System Framework for E-waste Management

The Proposed framework in Figure 1, consist of the product collection Unit where the E-waste is collected according to the guidelines contained in the Knowledge Base (KB).

Knowledge Base (KB): guidelines, policies and data accumulated from the processes adopted and experiences of e-waste collectors, e-waste managers, Institutional e-waste policy makers are stored here. Useful information on the various process and experiences of these personnel are in the KB and also Information on effective e-waste management and disposal, risk involved in handling some of the electronic waste material and components, health related issues and how to prevent and manage risk involved in the different stages of e-waste management.

Product will be tested, separated/sorted with respect to size into categories for sale or as reuse materials. Materials disassembly and resizing will be done to break or loosen them into components, reduce the size of the product by dismantling them and recover useful materials and then carry out data sanitation on some of the products by cleaning or re-formatting them. The unused waste is then disposed of in safe waste storage and disposal facility.

CONCLUSION AND RECOMMENDATION

Based on the questionnaire survey and data analysis it is apparent that there are no laid down institutional protocols or framework for the disposal of e-waste in Nigerian Universities. The present study has shown that the knowledge level on the environmental risks relating to e-waste disposal among a majority of UNIBEN staff and students is low. There is a general poor attitude

towards e-waste management basically due to cost and convenience of management. In conclusion, more awareness and sensitization of e-waste and its environmental risks is needed. Also laid down institutional protocols or framework (Figure 1) for the disposal of E-wastes is proposed and established. The framework proposed in this paper could be developed. This will create awareness of e-waste management, reduce possible risk involved in the process of e-waste management and disposal and most importantly, help create a knowledge economy in the domain of discourse

However, studies should be conducted to determine the components of e-waste that could led to health hazard and also create proper awareness on preventive measures. The proposed system framework from this study can be designed, implemented and made available for University communities and to the general public at large.

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