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HOUSEHOLDS PRACTICE AND AWARENESS DIMENSION ON THE RECYCLING OF ELECTRONIC WASTE IN KANO METROPOLIS, NIGERIA

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Abstract— **Electronic waste generation has been increasing at a rate three times faster than that of general waste stream. Developing nations like Nigeria bear the consequences as it is estimated that 500 containers, each carrying about 500,000 used computers and other electronic equipment, enter Nigeria's ports every month from the United States, Europe and Asia. To this effect, The United Nations Environmental Programme (UNEP) and the Federal Government of Nigeria have announced a $15 million initiative to establish an electronic system in Nigeria, which will pioneer safe e-waste recycling in the country. It is against this background that this study was conducted to determine the households' awareness and practice towards the recycling of e-waste, as well as the most suitable collection pattern within Kano Metropolis. The data for this study was collected using Open Data Kit (ODK) mobile phone platform, which contained questions on households' characteristics, current practices regarding disposal and recycling of electronic waste as well as their awareness dimension on the recycling of e-waste. Statistical Package for Social Sciences (SPSS) was used to estimate the average number of unused households' appliances and also to analyse household awareness and practice. The awareness dimension of the surveyed households about recycling of electronic waste was determined and 97% of the households are aware of the significance of electronic waste recycling. The positive statements presented about awareness indicates a positive awareness dimension about the significance of recycling electronic waste. Among the sampled households, 23% engage in e-waste recycling, and they all do this by selling their wastes (electronic waste, inclusive) to house-to-house scavengers. Majority of the households (77.4%) do not recycle electronic waste. They either keep them at home for decoration, give them out for free, burn them or dispose them in open dumpsites. The average quantity of e-waste present in each household in Kano Metropolis was estimated to be 1.53 units. Findings from this study can be useful to the policy makers and other relevant authorities in their efforts to establish an e-waste collection and recycling programme. It was recommended that there should be a suitable pricing method per kilogramme of e-waste and scavenging should be encouraged as the collection pattern, as it is a method already practised by those recycling.**

Keywords— **electronic waste, recycling, disposal, awareness and practice.**

I. INTRODUCTION

E-waste contains halogenated compounds and heavy metals like cadmium (cadmium), mercury (mercury) and lead (lead). Electronic waste that is not handled properly can pollute soil and groundwater. It can also be harmful to humans and the environment [1]. Electronic waste burning, according to Herat & Agamuthu [2], is harmful to the environment and public health. Electronic waste (e-waste) is the fastest growing waste stream in the world [3, 4, 5].

E-waste continues to rise in Nigeria, a country that has seen a tremendous increase in its ICT level in recent years. About 500 containers a month from the United States, Europe, and Asia enter the country's ports, each carrying about 500,000 used computers and other electronic equipment. In Nigeria, e-waste is readily available on the market, which encourages the importation. There is a report that 80 million Nigerians live on less than $2 a day, yet more than 90 million of them use internet-enabled devices [6].

Estimates suggest that the world produces between 44.7 and 50 Mt of electronic waste per year [7, 8]. According to Baldé and co-workers [8], this equates to approximately 6.1 kilograms per person. Although e-waste accounts for only 1–

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3% of global municipal waste production [9], its volume is increasing by approximately 3–5% per year [2]. On average, e-waste is expected to reach 52.2 Mt by 2021 [8], which is 6.8 kg per person.

In the developed world, there are more than 900 different types of EEE [7]. We generate a proportional amount of this waste due to the demand for information and communication technologies and rapid product obsolescence [11]. According to the United Nations, the number of old computers in India will grow by 500 percent by 2020. Comparing 2007 to 2014, the number of mobile phones in China and India will increase by about 7 times and 18 times respectively [10].

When it comes to electronic waste management (reuse or recycling), Nigerian households have a bad attitude and poor practices. These items can be kept in homes for years, thrown away haphazardly, stored in waste bins and even burned. As a result of e-waste mismanagement and burning toxic substances such as lead and mercury, arsenic, chromium, cadmium and plastics are released into the environment [12]. Contaminated soil and groundwater result from this burning process, while some of it is washed into the ocean, polluting the marine environment.

Electromagnetic radiation from undisposed electronic waste continues to pollute the immediate environment, leading to a decline in the health of individuals in households [13]. An effort must be made to address the improper management of electronic waste in the study area as well as throughout the country.

II. METHODOLOGY

A. Study Area

Kano is located in the Sudan Region of Nigeria and is the country's largest city.. Location: 120-25 to 120-40N, 80-35-80-45E. This northern Nigerian city has been a major commercial and industrial hub for centuries, drawing people from all over the country and beyond. Demographic growth and waste generation will be driven by immigration and a natural growth rate of 3 percent, according to the United Nations Population Fund (UNFPA). Kano metropolis is one of Nigeria's fastest growing cities, with a population of 4.1 million [14]. Compared to the national average of 267 people per square kilometer, Kano has a population density of about 1000 people per square kilometer. It's also one of the busiest places in the city. Migrant workers are also prevalent in the city and their numbers are growing at an annual rate of 30 to 40 percent [14]. Waste generation in Kano metropolis is likely to be significant, and its management will require innovative strategies, based on these figures.

B. Determination of Sample Size

Aliu and Ajala [15] reported that cities in Sub-Saharan Africa can be divided in line with residential density. To this effect, Kano can be classified into three zones: high-density residential zone, medium-density residential zone and low-density residential zone. For the purpose of this research, one neighbourhood was chosen from each of the three residential density zones, as similarly adopted by Egresi [16].

i. High-density Residential Zones

Dorayi was selected from the high density residential zone. Dorayi is a neighbourhood situated in suburban Kano. It is as an unregulated residential area with squatter settlement which is as a result of illegal development of lands for houses. Dorayi is one of the fastest growing neighbourhoods within Kano Metropolis with overcrowded housing units and narrow streets. Dorayi is also characterised with poor sanitary practice and is mostly inhabited by low-income earners. Egresi reported in 2017 that there are 1638 households in the neighbourhood with a human population of 19,200 [16]. For the purpose of this study, 10% of the households in this neighbourhood (160 households) was used as the sample size from high populated residential zone.

ii. Medium-density Residential Zones

The neighbourhood selected from this zone was NNDC Quarters. Egresi, 2017, estimated that there are 953 households and 8,577 inhabitants in NNDC Quarters [16]. This neighbourhood contains middle-income earners and they are mainly civil servants, security personnel and business people. For the purpose of this study, another 10% of the housing units in this neighbourhood was used as the sample size from medium populated residential zone.

iii. Low-density Residential Zones

Sharada Phase I was selected from the low-density residential zones. Sharada has a well organised plan with good road network. Expectedly, majority of the residents in this neighbourhood earn high incomes. There are 856 households and 4285 people living in this neighbourhood [16]. Another 10% of the housing units in this neighbourhood was used as the sample size from low-density populated residential zone.

C. Sampling Technique

Systematic sample is mostly obtained by randomly selecting 1 unit from the first n units in the population and every nth element thereafter. This approach is called a 1-in-n systematic sample with a random start. To choose n so that a sample of appropriate size is selected, calculate:

$$n = \frac{Number\ of\ units\ in\ population}{Number\ of\ sample\ units\ required}$$

In this study, 340 households were chosen as the sample unit while the total population from the three neighbourhoods (Dorayi Karama, NNDC Quarters and Sharada Phase I) which had a total of 3447.

Therefore,

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$$n = \frac{3447}{340}$$

n=10

Thus, 10% of the housing units in this neighbourhood will be used as the sample size from the neighbourhoods and the household representative of each 10th housing unit was interviewed, as adapted from Egresi [16].

Table 1. Percentage of Respondents per Neighbourhood

Metropolis Neighbourhoods	Number of Housing units	Frequency	Percent
Dorayi Karama	1638	160	47.0
NNDC Quarters	953	95	28.0
Sharada Phase I	856	85	25.0
Total	**3447**	**340**	**100.0**

Source: Field Survey, 2020.

D. Data Collection

The main data for this study was collected from the primary source. This study used personal interviews mode for data collection as advocated by Mitchell and Carson [17]. These sources recommend the use of personal interviews because of its highest aptitude among the survey modes. It has the advantage of providing visual information and making interviewers available to clarify the information and respond to questions that may arise from the respondents during the survey [18]. Three (3) enumerators were chosen and trained on the contents of the questionnaire and assisted the researcher in administering the questions using the ODK Android Software. The data collection period lasted for two (2) weeks.

E. Open Data Kit Design

The instrument employed for this study was an online/offline platform known as Open Data Kit (ODK) software, which is an open source software for collecting, managing and using data in a resource-constrained environment. The Android version of this software was installed on the mobile phones of the enumerators, in place of the conventional paper questionnaires, to ease the collection of data.

To allay all fears, the enumerators informed the respondents about the confidentiality of their responses and assured them that their responses would only be used for research purposes. The main sections comprised of household's characteristics, awareness and practice regarding reuse and recycling of e-waste Table 2 shows the summary of the questionnaire contents.

Table 2. Summary of the CVM Questionnaire contents

Section	Description
A	Household Characteristics
B	Electronic Waste Management Practice
C	Awareness Towards E-waste Recycling

Source: Field survey, 2020.

i. Section A: Household Characteristics

This section requested the respondents to provide information about their background information such as age, gender, total number of people in household, gross monthly income of households in Nigerian Naira (NGN), highest level of education, number of household electronic appliances and number of household unused appliances.

ii. Section B: Electronic Waste Management Practice

The section was about the management and disposal of the e-waste; disposal means, and recycling practice. The main purpose of this section is to assess the current practices of households as regards to electronic equipment and the recycling channels.

iii. Section C: Awareness towards E-waste Recycling

This third section was to determine the households' awareness dimension regarding the negative effects of e-waste on humans and the environment, and also regarding the importance of electronic waste recycling. The questions were designed based on a 3-point Likert Scale. The respondents were demanded to select from "yes", "no" and "unsure".

F. Descriptive Analysis

The data for this study were exported from Open Data Kit and analysed using Statistical Package for Social Sciences (SPSS). This study used descriptive feature of SPSS in describing the statistics of the surveyed respondents. The responses on the households' characteristics, current practices regarding recycling and disposal of e-waste, awareness about e-waste recycling were all summarized and reported in form of frequencies, charts, percentages and mean distributions.

III. Result and Discussion

A. Households Characteristics

The surveyed households were distributed in three residential zones of Kano Metropolis. Table 3 presents the socio-demographic information on the 340 respondents.

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Table 3. Socio-Demographic Background of the Respondents

Variables	Frequency (n=340)	Percent
AGE		
Mean	36	
Less than 26	2	0.6
26 – 35	214	63.0
36 – 45	77	22.5
46 – 55	6	1.8
Above 55	41	12.1
GENDER		
Male	260	76.5
Female	80	23.5
TOTAL NUMBER PER HOUSEHOLD		
Two	2	0.6
Three	9	2.6
Four	98	28.8
Five	3	0.9
More than five	228	67.1
EDUCATION		
Informal Education	79	23.2
Primary School	14	4.1
Secondary School	42	12.4
College or Polytechnic	147	43.2
University	58	17.1
MONTHLY GROSS HOUSEHOLD INCOME (#)		
Mean	74,518	
20,000 – 30,000	114	33.6
31,000 – 40,000	39	11.5
41,000 – 50,000	71	20.9
Above 50,000	116	34.0

Source: Field Survey, 2020.

The average age of the respondents was 36 years. It was shown that majority of the respondents are within the age range of 26-35 years (63.0%), while those who are few in the survey are less than 26 years (0.6%). This tells us that majority of respondents were within the active age with adequate capacity to respond objectively to the survey questions. Other respondents were within the age range from 36 – 45 (22.5%), then those from 46 – 55 years are 1.8%, and 12.1% are above 55 years of age. They were not of much readiness to respond, especially to the question about age. Among the 340 participating respondents, 23.5% are females while males are 76.5%.

It was also found that in terms of family size, 0.6% live in two per household, 2.6% live in three per household, 28.8% of the respondents live in four per households, 0.9% live in five per household, followed by 67.1% who live in more than five persons per household.

Amongst the respondents, 23.2% had informal education, 4.1% completed primary school, 12.4% completed secondary school, 43.2% completed polytechnic/college, and 17.1% completed university education. It can be seen from this result that the surveyed respondents have a high level of education in general, as majority (60.3%) completed college/polytechnic and university.

The average monthly gross household income of the surveyed households was #74,518. It was also found that 33.6% earned from #20,000 – #30,000, 11.5% earned from #31,000 – #40,000, 20.9% earned from #41,000 – 50,000 and only 34.0% of the respondents' have their monthly gross household incomes to be above #50,000.

B. Households Possession of E-Waste

Amongst the surveyed households, the average possession of electronic appliances is 9.53 units while the average of households' appliances not in use is 1.53 units. Fig 1 below describes the quantity of used and unused.

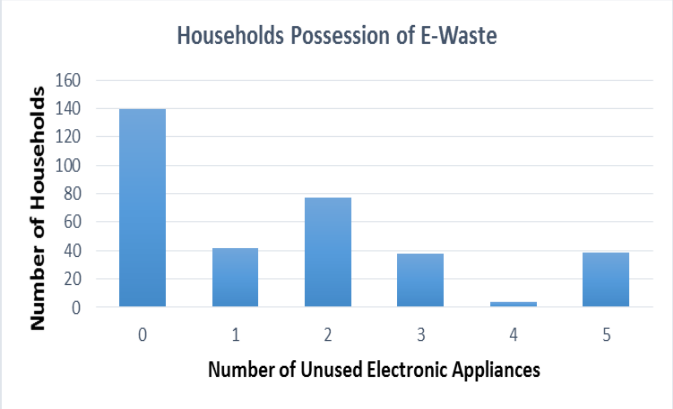

Fig 1 Households possession of E-waste

Also, 140 of the respondents have no unused electrical appliances in their households. 42 of the respondents have one (1) unused appliance each in their households. 77 have two (2) unused appliances in each of their households. 38 have three (3) unused appliances each on their households. 4 of the respondents have four (4) unused appliances in their respective

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households and 39 of the respondents have five (5) unused appliances in their houses. Based on this data, it was estimated that two hundred (200) out of the three hundred and forty (340) households sampled, have electronic waste in their houses. Also, the total number of the electronic waste in the sample neighbourhood altogether is 306 appliances. Additionally, with the foregoing average, it can be estimated that each household in the three sampled neighbourhoods have 1.53 unused electronic appliance in their house, which by implication, are electronic wastes.

C. Households Electronic Waste Disposal Means

Fig 2 presents the means of electronic waste disposal for the surveyed households in Kano Metropolis.

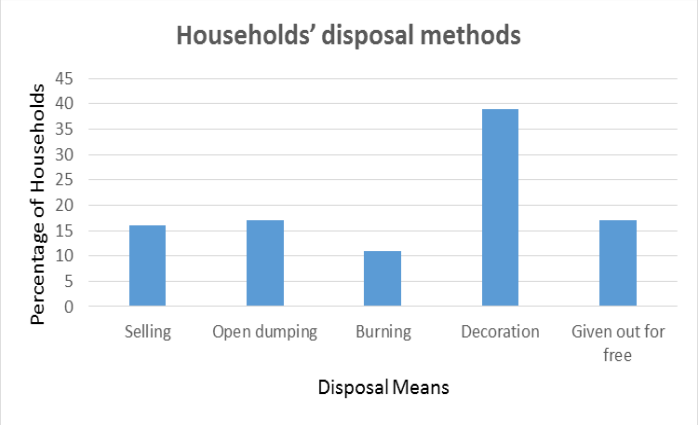

Fig 2 Households E-waste Disposal Methods

From the disposal means optioned to the households, it became evident that 16% of them sell their electronic waste to local buyers, 17% dispose of their electronic waste in open dumps and 11% burn their electronic waste. A greater part of the households (39%) keep their electronic waste for decoration to beautify their houses while 17% give out theirs for free. Thus, it can be inferred that majority of the households keep their electronic waste at home for decoration.

Disposal of electronic waste on dumpsites results in environmental pollution, water and soil contamination by heavy metals, such as cadmium, mercury, lead and arsenic. When such waste are disposed in the landfills, they contaminate the groundwater as well. Tanskanen [13] reported that in the USA, 70% of the mercury and cadmium in landfills originates from e-waste.

Primary and secondary exposure to toxic metals, such as lead, results mainly from open-air burning used to retrieve valuable components such as gold. Combustion from burning e-waste creates fine particulate matter, which is linked to pulmonary and cardiovascular disease.

Thus, this action could be averted if the households in Kano Metropolis can collect and recycle their electronic waste into valuable materials such as palladium, silver, platinum etc. instead of its improper disposal.

D. Households Electronic Waste Recycling Status

In this survey, we found out that the recycling rate of electronic is very low. Fig 3 describes the proportions of the surveyed households that recycle electronic waste and that of those that do not.

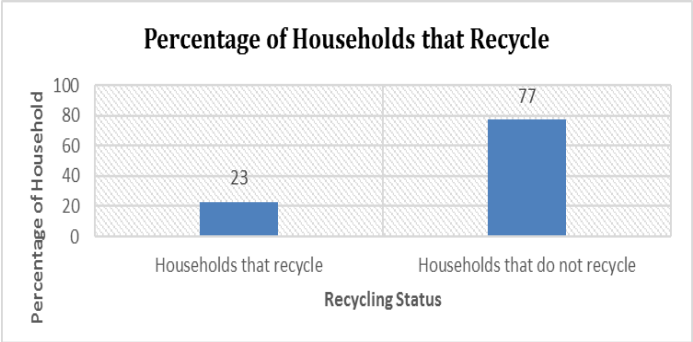

Fig 3 Households Electronic Waste Recycling Status

It was revealed that just 23% of the surveyed households recycle electronic waste while 77% do not recycle. This is an indication that most electronic waste generated among households in Kano Metropolis is misused and disposed into the environment via different means. Thus, there is need for more awareness programmes and sound policies that could encourage engagement in electronic waste recycling among households within Kano Metropolis. Awareness campaign can be done through workshops, round table discussions and seminars [19]. This can also be adopted to intimate the people about the importance and benefits of electronic waste collection and recycling programme, so as to achieve maximum participation among users.

E. Electronic Waste Recycling Channel

Fig 4 describes the proportions of the surveyed households that recycle electronic waste and the channel through which they do this.

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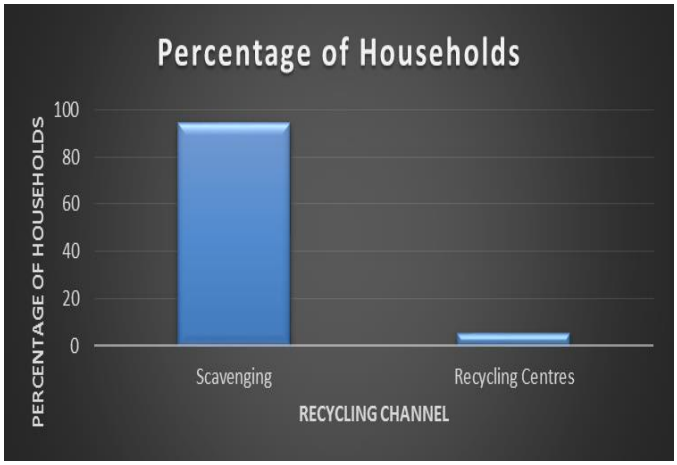

Fig 4 Electronic Waste Recycling Channel

This survey revealed that, even though the recycling rate is low, a greater percentage of those that recycle (94.7%) do this by selling their e-waste to scavengers. Thus, enhancing scavenging and ensuring adequate collection from house to house by scavengers, would be the most suitable collection pattern, as people are already practicing recycling through scavenging.

F. Awareness Analysis

During the survey, the respondents were asked to rank their awareness on the significance of electronic waste recycling into valuable materials such Palladium, Silver, Platinum, which serve as raw materials for renewable energy with the aid of one to three Likert Scale for each of the seven statements. The scale was designed based on "Yes", "No" and "Unsure" options so as to determine the dimension of their awareness. However, option "Unsure" was treated and coded as "No". Table 2 presents the households' awareness on the significance of electronic waste recycling in form of percentages and frequencies in accordance with the corresponding Likert Scale options.

Table 2. Awareness on Significance of Electronic Waste Recycling into Valuable Materials

Statement	**1 Freq. (%)**	**2 Freq. (%)**	**3 Freq. (%)**
E-waste contains toxic materials such as lead, barium, mercury, and cadmium that require proper management, as well as valuable resources that should be recovered	336 (98.8)	2 (0.6)	2 (0.6)
Recycling of electronic waste is an important way to reduce pollution and protect the environment	333 (97.9)	3 (0.9)	4 (1.2)
Recycling of e-waste will prevent humans from electromagnetic emission	256 (75.3)	73 (21.5)	11 (3.2)
Recycling of electronic waste is cheaper in the long run compared to maintaining landfilling, incinerations and other system	183 (53.8)	112 (32.9)	45 (13.2)
Recycling of electronic waste is easier as I have easy access to all recycling information	183 (53.8)	84 (24.7)	73 (21.5)
Provision of recycling facilities will improve electronic waste management	298 (87.6)	36 (10.6)	6 (1.8)
Collection of electronic waste by operators/scavengers is the best form of electronic waste management	194 (57.1)	107 (31.5)	39 (11.5)

Note: 1=Yes, 2=No, 3=Unsure
Source: Field Survey, 2020.

The results however marked the surveyed households' endorsement to the positive statements made on the significance of electronic waste recycling to valuable materials. Thus, it can be inferred that majority of the households were much aware of the importance of electronic waste recycling, as well as the likely negative environmental and human impacts of electronic waste. Hence, they have a good awareness dimension.

IV. CONCLUSION

This study began with an attempt to serve as an exploratory research to assist the Federal Government of Nigeria and United Nations Environmental Programme (UNEP) in pioneering an electronic waste recycling scheme in Nigeria. It was aimed at finding solutions to the challenges associated with the improper management of electronic waste in Kano Metropolis. 22.6% of the households respondents apply recycling concept as a means of their waste management and they all do this by selling their waste (electronic waste, inclusive) to house-to-house scavengers and they have a good awareness dimension of e-waste. It can, however, be inferred that the most apt means of electronic waste collection for the proposed electronic waste scheme should be through scavengers.

Enhancing scavenging and ensuring adequate collection from house to house by scavengers, would be the most suitable collection pattern, as people are already practicing recycling through scavenging. Electronic waste collection and recycling programme is a complex service which requires employment, technologies, collection processes and management costs, hence, these should be put in place to ensure the success of e-waste recycling initiative.

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