Public Perception of E-Waste Management and Disposal Practices in Accra Metropolis, Ghana

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ABSTRACT

The electrical/electronic industry is one of the fastest growing sectors in the world today. The increasing demand for newer electrical/electronic equipment and the shorter lifespan of these products leads to the generation of large volumes of e-wastes (electrical and electronic wastes) in the environment. Unlike the developed nations, there is lack of public awareness and proper legislation to effectively manage these wastes in most developing nations, including Ghana. In this study, a survey was carried out on 800 respondents to determine their knowledge of e-waste management practices and the effects on humans and the environment. The results generally revealed a low level of awareness, with most participants showing little or no interest in their environment. The majority of respondents identified reselling and recycling of used electrical and electronic equipment (UEEE) as the most appropriate and safe disposal methods. There was a correlation between level of education and knowledge of: (i) toxic chemicals in e-waste, (ii) human health and environmental impact and (iii) disposal methods for e-waste using a Chi-square test, a fact emphasized by Principal Component Analysis (PCA). Thus, there is the need for programmes to educate and create general awareness for this class of wastes as a potential source of pollutants.

Keywords: E-Waste, Awareness, Disposal, Perception, Environment, Education

Introduction

The waste from electrical and electronic equipment (WEEE) is now the fastest growing waste stream all over the world (Darby and Obara, 2005; Nnorom and Osibanjo, 2008; Saphores *et al.*, 2012). The exponential growth in e-waste generation is a result of shorter product lifespan (Wang *et al.*, 2010) and rapid advancement in technology (Osibanjo and Nnorom, 2007: Otsuka *et. al.*, 2012) which creates high market demands for newer brands, thereby increasing the rate of obsolescence (Wong *et al.*, 2007; Otsuka *et. al.*, 2012). Consequently, large quantities of this class of waste are produced and in most cases inappropriately managed in developing countries. Currently global generation of e-waste is predicted to rise by 16-28% yearly (EEA, 2003; Nnorom *et al.*, 2009).

Whereas most developed countries have formulated effective legislation regarding WEEE management, established recycling infrastructure and enforced strict adherence to the principle of extended producer responsibility (EPR), the same cannot be said of developing countries (Afroz *et al.*, 2013). Thus, the management of WEEE has become a serious environmental concern in many nations including Ghana. Presently, Ghanaians who desire to have innovative consumer electronics, like the rest of the world, have resorted to the importation of these goods on a large scale, leading to an increased volume of e-waste. The handling of this e-waste has been poor because of the informal processes involved in the disposal and management of these products. The high toxicity of some components released through burning, disassembling, recycling, etc. in an uncontrolled manner could have a devastating impact on ecological and human systems (Wath *et al.*, 2011; Hidy *et al.*, 2011; Bhat and Patil, 2014).

Consequently, the importance of establishing a regulated WEEE management framework has been recognized, but in Ghana the progress with regards to legislation, the collection system, and the construction of formal recycling facilities is constrained. Public knowledge or awareness is one of the key inputs in the design of effective framework for e-waste management. Hence there is the need for a study of public perception, awareness and disposal practices of e-waste in Ghana. The survey outlines the disposal methods, public knowledge and awareness of e-waste and its environmental impacts within Accra, the capital city of Ghana.

Methods

Study Population

The study population of the chosen demographic area comprises 1,848,614 individuals within the Accra Metropolis (Ghana Statistical Service, 2012).

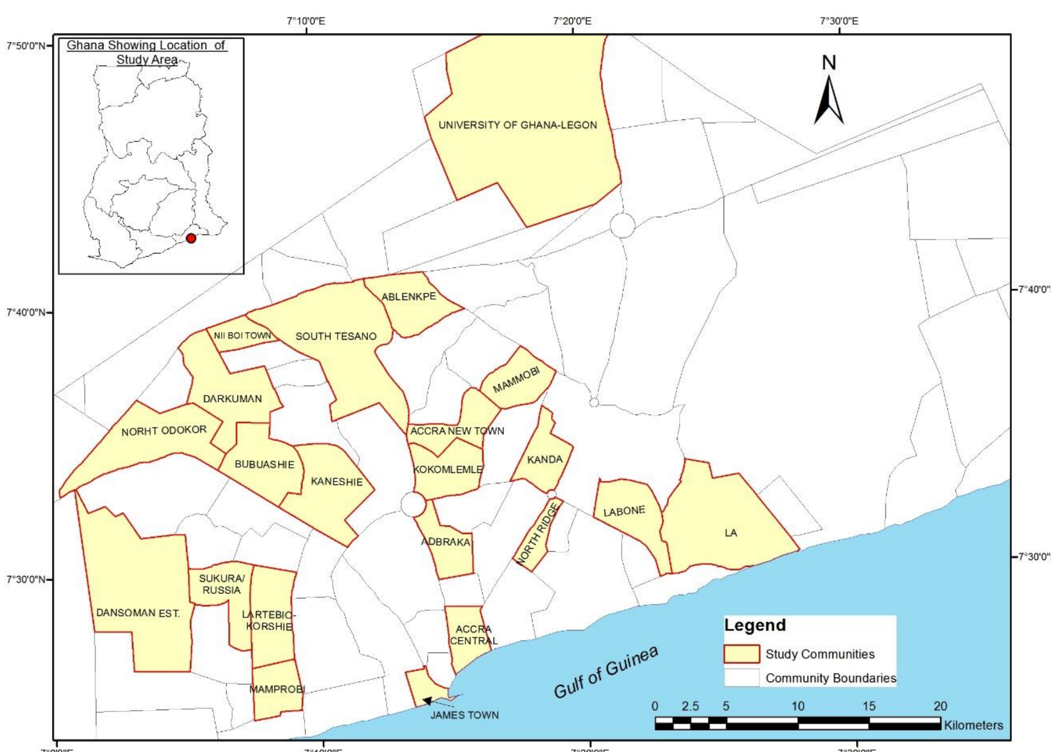

Fig. 1: Map of Accra Metropolis showing study communities

Sampling Method

Out of the total population, 800 respondents, consisting of students, workers and traders were selected from the Metropolis through a convenience sampling technique for the study. According to Leedy and Ormrod (2005), a sample size of 400 is appropriate for a target population size beyond 5000. In this case, all the 11 sub-metros (Table 1) in the Metropolis were considered. The communities (Fig. 1) in each sub-metro were grouped into two based on their income levels. Group 1 consisted of high income and Group 2 of middle and low income areas. Both random and purposive sampling methods were used to select 2 communities in each of the 11 sub-metros, one from each category. The purposive sampling was employed to ensure easy access to specific sections of the population [i.e. students, traders and workers in four (4) sub-metros]. Thus, Legon (University of Ghana Campus), Makola and Kaneshie market centres as well as North Ridge (Non-Formal Education Division and Geological Survey Department) were selected.

Table 1: Accra Sub-metros and their communities

Name of Sub-metro	Communities
Ablekuma Central	Laterbiokorshie, Sukura
Ablekuma North	Darkuman, Odorkor
Ablekuma South	Mamprobi, Dansoman
Asheidu Keteke	Jamestown, Accra Central
Ayawaso Central	Accra Newtown, Kokomlemle
Ayawaso East	Kanda, Mamobi
Ayawaso West	Abelempe, Legon
La	La, Labone
Okaikoi South	Bubuashie, Kaneshie
Okaikoi North	Tesano, Nii Boi Town
Osu Klottey	Adabraka, North Ridge

Survey Instrument and Data Collection Method

Structured questionnaires were designed and used to collect information from the public. The survey instrument focused on common electrical/electronic products used by participants, methods for disposing of their electrical and electronic appliance, and knowledge and awareness of toxic substances in e-waste and their effect on human health and the environment. Prior to the data collection, the survey instrument was pretested on 20 individuals to fine tune it. The study objectives were explained to volunteers and their consent to participate in the study was sought before the administration of the questionnaires. The questionnaires administered had four parts (Table 2).

Table 2: Overview of questionnaire

Data Group	Description
Personal data	Gender and educational background.
Information on electrical and electronic products	Type, brand, quantity, period of usage, whether acquired brand new or used (second hand) and mode of disposal at the end of useful life.
Disposal Practices	How e-waste is disposed of, effectiveness of mode of disposal, appropriate or not and reasons, suggestions for better disposal practices if current method is not appropriate.
Awareness of toxic substances and their effect on man and the environment	Knowledge of toxic substances in e-waste with examples, their effects on man and the environment.

Data Analysis

The data collected were analyzed using the Statistical Package for Social Studies (SPSS) Software (version 20.0). The data were subjected to descriptive statistics. A Pearson Chi square was computed to determine the relationship between demographic features on the various issues investigated and further expanded with principal component analysis.

Results and Discussion

Background Information of Respondents

A total of 800 respondents participated in the study, comprising 430 (54.0%) males and 370 (46.0%) females; all had some level of education (Table 3).

Table 3: Background Information of Respondents

Variable	Gender	Total number of Respondents	Percentage (%)
Sex	Male	430	53.8
	Female	370	46.2
Educational level	Primary	221	27.6
	Secondary	217	27.1
	Tertiary	362	45.3

E-waste Disposal Practices

Effective management programmes regarding e-waste disposal require the acquisition of the necessary data which includes existing disposal practices, consumers' perception of these practices and their attitude (willingness) towards appropriate end-of-life (EoL) e-waste management strategies and policies by government. However, data collected from the field survey revealed that there was limited awareness of the prevailing e-waste disposal practices among the respondents. Majority of participants were unaware of the e-waste disposal channels in their communities. This showed that many had little or no concern about their environment, which could be due to lack of education on WEEE. Among the 323 (40.4%) participants who were aware of how their neighbours managed their e-waste (Table 4), the males (22.5%) were more conscious of their environment than their female counterparts.

Table 4: Knowledge of e-waste disposal practices

	Responses			
Gender	**Yes**		**No**	
	Number	Percentage	Number	Percentage
Male	180	22.5	250	31.2
Female	143	17.9	227	28.4
Total	**323**	**40.4**	**477**	**59.6**

Overall, nine (9) e-waste disposal methods were identified (Table 5). Reselling of used electrical and electronic equipment (UEEE) to 'scrap boys' was popular among the people. This was due to the mode of collection by mobile scrap dealers. Usually, these scrap boys move from house-to-house in search for UEEE. Other common disposal methods were dismantling/recycling of e-waste materials to retrieve precious parts.

Perception on e-waste disposal practices

Individuals' perception of issues is very important because it forms the basis for their behavioral pattern and practices. Thus, the respondents' perceptions about the prevailing e-waste disposal practices were likely to influence their choice of disposal method; this was an area for which the study sought information. The survey indicated that the majority of participants perceived the reselling and dismantling/recycling of UEEE as the most appropriate disposal methods (Table 5). They revealed that apart from preventing wastage of useful parts, these practices had no negative impact on the environment. Some also asserted that this procedure also provided a source of livelihood for others. Another observation was that recycling was mainly carried out in a rudimentary manner. This could result in the release of a cocktail of toxic chemicals and particles into the environment and its related environmental problems, unlike elsewhere where e-waste recycling methods are combined with appropriate technology to minimize environmental impact (Kuper and Hojsik, 2008; Gaidajis *et al*. 2010).

Table 5: Perception on e-waste disposal methods

Disposal practices	Acceptable	Unacceptable	No Response	Total
Bury	3	6	-	9
Burn	6	20	-	26
Donation	19	10	-	29
Indiscriminate dumping	2	16	1	19
Dispose at dump sites	31	46	7	84
Dismantle/ Recycle	82	8	3	93
Repair and Reuse	7	-	1	8
Reselling	84	26	4	114
Storage	4	1	-	5

On the other hand, only a few people thought it unsafe to bury, burn or dump e-waste arbitrarily. According to some respondents, no harmful gases are released into the atmosphere when e-waste is buried, while to others, burning prevents indiscriminate disposal of e-waste. Hence, it could be inferred that most of the respondents were not aware of what happens when they dispose of their waste.

Several of the respondents thought it safe to dispose of e-wastes at dump sites, though they acknowledged this was not the best method. However, Robinson (2009) reported that mixing e-waste with household wastes for land-fill or incineration will gradually result in the leaching of toxic substances into the soil and subsequently into groundwater. Gaidajis *et al.* (2010) also indicated that the implementation of the appropriate Toxicity Characteristics Leaching Procedure (TCLP) test had revealed that e-waste discarded at urban waste dumping sites did not produce leachates with heavy metals concentrations exceeding the environmental limit. However, the e-waste management practice involving the compression before or during discarding in landfills may increase the leachate volume due to the disturbances of several electronic circuit parts.

Furthermore, all the respondents who mentioned repair and re-use (Table 5) said it was good because it is easier and consumers tend to save money they would have spent buying new equipment.

Knowledge of Toxic Substances in E-waste

Less than half (40.2%) of the participants were aware of the toxic chemicals present in e-waste whereas the majority had no knowledge at all. (Table 6). This disparity could be due to poor sensitization programme in Ghana.

Table 6: Knowledge on toxic chemicals in e-waste

Variable	**Respondents**	
	Number	**Percentage (%)**
Yes	322	40.2
No	478	59.8
Total	**800**	**100.0**
Number of respondents who could mention one or more toxins	220	28

Table 7: Knowledge about Toxic chemicals in e-waste

Toxic chemicals	**Frequency**	**Percentage**
Chemical elements (As, Cr, Cu, Pb, Li, Hg, Si, S, Zn)	87	10.8
Ozone depleting substances (e.g. CFC)	145	18.1
None e-waste substances (e.g. cyanide, crude oil, methane)	214	27.8

As-arsenic, Cr-chromium, Cu-copper, Pb-lead, Li-lithium, Hg-mercury, Si-slicon, S-sulfur, Zn-zinc

The low level of respondents' awareness of toxic substances in e-waste and their effects on human health and the environment was further revealed by their responses to related questions. When asked to mention some of the toxic substances in e-waste and their negative impact on the environment and human health, the number of respondents who could mention one or more toxins in e-waste decreased further (Tables 6 and 7). Most of the participants displayed their ignorance by mentioning non-e-waste containing substances like cyanide and methane.

The study also revealed that the number of respondents who were aware of the adverse impacts of e-waste on human health and the environment was very low especially at a time when there is increased awareness of the problems associated with electronic waste management globally (Nnorom, 2009). Only 42.7% of the respondents said they knew about the dangers posed by e-waste to humans and the environment. This number was far below the 59% of participants reported in a similar study carried out by Afroz *et al*. (2013) in Malaysia. Moreover, only 19.9% and 22.9% out of the 342 respondents could mention some of the effects e-waste has on human health and the environment respectively (Table 8). On the other hand, with regards to harmful effects of e-waste on human health, most of the respondents were aware of cancers, respiratory and cardiovascular diseases, etc. (Table 9).

Table 8: Awareness of the adverse impacts of toxic chemicals on human health and the environment

Variable	Respondents	
	Number	Percentage (%)
Yes	342	42.7
No	458	57.3
Total	**800**	**100.0**
Number of respondents who could mention some of the effects of e-waste on human health	159	19.9
Number of respondents who could mention some of the effects of e-waste on the environment	183	22.9

Table 9: Effects of e-waste on human health

Health effects	Frequency	Percentage (%)
Cardiovascular diseases	7	4.4
Reproductive/Growth effects	5	3.1
Central nervous disorders	7	4.4
Kidney related diseases	1	0.6
Respiratory diseases	47	29.6
Cancers	85	53.5
Other diseases	67	42.1

Table 10 shows that a larger number of the participants were more conversant with environmental effects related to the atmosphere. They mentioned air pollution and various impacts of climate change, such as global warming, the greenhouse effect and the depletion of the ozone layer. This is not surprising because of the heightened sensitization campaign about climate change carried out in the country by the government, educationists and non-governmental organisations (NGOs) in the past decade.

Table 10: Effects of e-waste on the environment

Environmental effects	Frequency	Percentage
Air Climate change Air pollution	143	78.1
Water Acid rain Water pollution	32	17.5
Land Soil infertility, land degradation, increased soil acidity, retardation of growth in plants, bio-extinction and desertification	78	42.6
Others (e.g. destruction of the ecosystem, bush fires)	37	20.2

Relationship between educational level and respondents' knowledge about e-waste issues

Chi-square was used to establish whether there was a relationship between the educational level of the participants and the under-listed variables:

- Knowledge of toxic chemicals in e-waste (TC)
- Knowledge of human health and environmental impact (HE)
- Knowledge of disposal of e-waste (DP)

The nominal and ordinal nature of the data, coupled with the requirement to identify the characteristics among various survey questions, necessitated the use of the chi-square (a test of goodness of fit) to establish whether or not an observed frequency distribution differs from an estimated frequency distribution. The following generalized hypothesis was tested:

H_0: The observed distribution follows the expected (there is no preference among observed frequencies)

H_1: The observed distribution does not follow the expected (there is a preference among observed frequencies).

The analysis show that the relationship between level of education and the aforementioned variables was significant (Table 11) Thus, the null hypothesis of similarity in outcomes was rejected.

Table 11: Chi-Square Test Results

	TC	HE	DP
Value	18.125	21.459	15.653
Df	4	12	4
Asymp.Sig. (p-value)	0.00	0.00	0.00

Principal Component Analysis (PCA)

Using principal component analysis (PCA), two factors were developed to summarize seven survey questions on e-waste issues. Table 12 summarizes these results.

For PCA, the value of Kaiser-Meyer-Olkin (KMO) measure of sample adequacy was 0.63, which meets the limit of 0.600 conventionally held as a critical value. Bartlett's test of sphericity showed that principal component analysis could be applied to the data at the $p < 0.001$ level. Two principal components were identified using Varimax with Kaiser Normalization for the seven variables (Table 12). The principal components accounted for 61.7% of the total variance in the variable set.

The first factor (PC1) reflects awareness of the effect of e-waste chemicals on the environment. It is based on four questions and it accounts for 47.2% of the variance in the original variables. The second factor (PC2) captures general perceived disposal methods from three questions. This factor explains 14.5 percent of the variance in the analysis. The PCA analysis further suggested that the knowledge of the general populace about e-waste chemicals was more predominant than that of disposal methods. Furthermore, the level of participants' awareness of possible e-waste chemicals and disposal methods was high and significantly correlated with their level of education. As a result, policy makers should increase educational activities on e-waste related issues if they want to minimize both the environmental and health impacts of e-waste among the population.

Table 12: Results from Principal Components Analysis of E-Waste Awareness, Environmental effects and Disposal Methods

Survey Items and Principal Components	Eigenvectors and scoring coefficients	% Varance Eigenvalue
PC1 – Knowledge on E-Waste Chemicals		
Knowledge about Toxic Chemicals in E-waste	0.943	47.2
Identification of Toxic Chemicals in E-waste	0.741	2.672
Knowledge of effects of e-waste on Health and the Environment	0.943	
Effect of E-Waste on the environment	0.419	
PC2 – General Disposal Methods		
Knowledge of Disposal of E-waste	0.754	14.5%
Method of Disposal of E-waste	0.610	1.399
Perceived Reasons Why Method of Disposal Is recommended	0.666	

Conclusion

The soaring quantum of e-waste generated in Ghana, which is characterized by complex chemical composition, poses great concern in terms of the detrimental effect on human health and the environment. The study revealed that the male respondents were more conscious of the environment than the females. There was also a general lack of awareness about this subject among respondents, with many showing little or no interest in preserving the environment. Nine (9) disposal channels were identified, with reselling being the most popular, followed by dismantling and recycling. The majority of participants also exhibited limited awareness of toxic chemicals in e-waste and their effects on human health and the environment. A Chi test analysis also showed that there existed a relationship between level of education and awareness of possible e-waste chemicals and disposal methods. Overall, the findings of the study indicate the need for effective and sound management of e-waste practices as well as the implementation of requisite comprehensive national strategies. This will require the participation of both the government and citizenry. Therefore, for a successful implementation of an effective e-waste management programme, there is the need to identify the existing disposal practices, conduct an educational campaign on proper e-waste disposal methods and toxic metals emanating from e-waste as well as their implications for human health and the environment. Finally, it is imperative to carry out sensitization programmes to ensure public compliance with government policies on e-waste.

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