Generation and management of household waste electrical and electronic equipment (WEEE) in Harare and Mutare, Zimbabwe

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Abstract

This paper analyses the generation and management of waste electrical electronic waste generated in the households of Harare and Mutare. Current studies in solid waste management have focused on the waste management practices of general municipal solid waste. This study seeks to amplify current knowledge by focussing on a relatively new and emerging type of waste-WEEE. A detailed analytical study is to be undertaken in the households in Harare and Mutare. The data collection methods involved 100 questionnaires administered per suburb that solicit information on the types of WEEE generated in the households, collection of waste and disposal as well as the residents awareness regarding the environmental impacts associated with the waste. A total of 12 interviews were undertaken(6 per city) with key stakeholders involved with waste issues such as Senior health environmental officers, heads of the health departments, officials from the Environmental Management Agency, local doctors, the Ministry of Health officials and the Non Governmental Organisations. A broader perspective of consumer behaviour revealed that there was a larger proportion of WEEE generated in Harare than in Mutare. Households in Harare contributed on average 63% while Mutare contributed 36% of the total WEEE in all the suburbs considered in this study. The study revealed that there is generally lack of awareness with regard to sound management of WEEE. Most of the households indicated that they were not aware of need for the disposal of small electric and electronic equipment items and hence did not think it was essential to worry about the disposal of such items. The actual fate of the small quantities of hazardous waste generated in municipal solid waste is generally unknown and hence the environmental persistence of these hazardous compounds is one of the critical issues in their long-term management and this is true with regard to the hazardous waste generated in the households of Gweru. The study recommends education of residents on sustainable management of WEEE that involves re-use and recycling as these contribute to resource conservation.

Key words: *Waste Electrical and Electronic Waste, Re-use, Recycling, Household*

Introduction

Waste electric and electronic equipment waste (WEEE) is recognised as one of the fastest growing waste stream in the world with estimates in the European

Union (EU) between 14 kg per person per annum and it is increasing at about three times greater than the average for general municipal solid waste (Darby and Obara, 2005; Wilson, 2001). According to Truttmann *et al.,* (2006) historically the electronics industry was conceived to be a clean industry, however, it has been found to be one of the most polluting with a number of hazardous chemicals, components and processes used in the manufacture of electrical and electronic equipment. The negative impacts associated with WEEE have been recognised fairly recently and hence concerted efforts have been made especially in the developed countries, to come up with sustainable strategies for the management of this waste.

This paper analyses the generation and management of waste electrical electronic waste generated in the households of Harare and Mutare. When electrical and electronic products reach the end of their useful life, they become waste electrical and electronic equipment, which is often referred to as electronic waste (or e-waste for short). Waste electrical and electronic streams encompass a wide range of electrical and electronic waste products, home products, including some home appliances (e.g. refrigerators, washing machines and air conditioners); information technology and telecommunication equipment (e.g. personal computers, laptop computers, facsimiles, telephones and mobile phones); consumer electronic devices (e.g. televisions, radios, video cameras and audio equipment); and other household electronic equipment (e.g. vacuum cleaners, toasters, coffee machines, hair dryers, watches and irons).Electric and electronic waste represents one of the fastest growing solid waste streams in Zimbabwe's major cities such as Harare and Mutare. The demand for newer electronic products and the advanced development of information and communication technology (ICT) have resulted in tremendous amounts of WEEE that are disposed of. The disposition and management of WEEE is an emerging environmental issue of concern for the solid waste managers in the major towns and cities of Zimbabwe and the world at large (Jang, 2010; Nnorom *et al.,* 2009). In addition to the difficulties caused by the vast amount of WEEE produced, there is a danger posed by the myriad of toxic chemicals present in WEEE including metals (e.g arsenic, cadmium, chromium copper, lead, and mercury) and organic chemicals (e.g. polybrominated diphenyl ethers as flame retardants, phthalates and polyvinyl chloride). Thus concerns have been raised that toxic chemicals could leach from these wastes when

improperly disposed of or handled. This study thus aims to determine the types of WEEE generated in Harare and Mutare, to assess the level of awareness regarding WEEE and to assess management strategies for WEEE in the two cities.

Solid waste management is receiving growing attention from researchers in recent years not only because of the negative impacts associated with the waste, but also because of the socio-economic benefits which can be derived from waste recovery and utilisation. The toxic chemicals from many electronic devices can be released into the environment and could pose a significant threat to human health because of uncontrolled treatment processes (Jang, 2010; Yang *et al.*, 2008; Yeshida *et al.,* 2008). The disposal of WEEE with the rest of the municipal solid waste stream in a landfill may result in negative impacts on the environment (e.g. groundwater contamination by lead leaching and high concentrations of lead in landfill leachate).When WEEE is burnt in incinerators, heavy metals become concentrated in the ash, limiting its disposal and re-use options. In response to the growing concern posed by WEEE, this project seeks to come up with environmentally sound and economically feasible models for its management. Unlike municipal solid waste, the WEEE management system is not well established in Zimbabwe and this project seeks to fill this gap.

Current studies in solid waste management have focused on the waste management practices of general municipal solid waste. This study seeks to amplify current knowledge by focussing on a relatively new and emerging type of waste-WEEE. Most published research on WEEE has focussed on developed countries and this study seeks to come up with preliminary options for the management of household e-waste in developing countries such as Zimbabwe.

Methodology

A detailed analytical study was undertaken in the households in Harare and Mutare. The focus was on Mbare, Kuwadzana, Mabelreign and Avondale in Harare and Sakubva and Greenside in Mutare. The data collection methods involved 100 questionnaires administered per suburb that solicited

information on the types of WEEE generated in the households, collection of waste and disposal as well as the residents' awareness regarding the environmental impacts associated with disposal of the waste. In all a total of 600 questionnaires were distributed in the two cities. The questionnaires were administered in person with the researcher(s) interviewing the respondents in the households. A total of 12 interviews were undertaken(6 per city) with key stakeholders involved with waste issues such as Senior health environmental officers, heads of the health departments, officials from the Environmental Management Agency, local doctors, the Ministry of Health officials and the Non Governmental Organisations. The research was undertaken over a four month period when data was collected in both cities. The results of the survey were analysed using the statistical package for social scientists (SPSS) for descriptive and inferential statistics on the patterns of waste management emerging.

Results and discussion

Generation of household WEEE in Harare and Mutare

The types of household appliances dominant in the high income and low income areas of Harare and Mutare were categorised into nine broad groups that included large home appliances, small home appliances, IT and telecommunication equipment, consumer equipment, lighting equipment, electrical and electronic tools, medical devices, toys, leisure and sports equipment and automatic dispensers. The development of environmentally sound strategies for the management of WEEE in the households of Harare and Mutare depends on the proper characterisation of the amounts and types of this kind of waste. Several scholars have revealed that the quantities and composition can be influenced by factors that include economic conditions, availability of a re-use market, and infrastructure of the recycling industry, waste segregation programs and the enforcement of legislation (Jang, 2010). Table 1 shows the proportions (%) of WEEE generated in the high income areas (low density suburbs) and low income areas(high density suburbs) of Harare and Mutare.

Table 1: Proportions (%) of WEEE generated in the high and low income areas

Broad group of appliances	Harare		Mutare	
	High income	Low income	High income	Low income
Large scale appliances	66	34	62	38
Small home appliances	63	37	59	41
IT and telecommunications equip	72	28	68	32
Consumer equipment	58	42	54	46
Lighting equipment	61	39	57	43
Electrical and electronic tools	70	30	67	33
Medical devices	79	11	72	28
Automatic dispensers	74	36	69	31
Toys, leisure and sports equip	68	32	67	33
Total average	**68**	**32**	**64**	**36**

A broader perspective of consumer behaviour revealed that there was a larger proportion of WEEE generated in Harare than in Mutare. Households in Harare contributed on average 63% while Mutare contributed 36% of the total WEEE in all the suburbs considered in this study. The main reason for this disparity is the socio-economic affluence of these two cities and Harare, being the capital city of Zimbabwe dominates the whole country in terms of development due to the concentration of economic activity. Affluence is, therefore, a major contributor for the ability of the residents in the acquisition of electric and electronic appliances for day to day use. The most dominant pieces of electric and electronic equipment in Harare and Mutare include IT and telecommunications equipment that includes laptops, personal computers, calculators, cell phones, telephones, photocopying equipment, printers facsimiles and DVDs and VCRs; large scale home appliances which include refrigerators, washing machines, microwaves, electric heaters and air conditioners; small scale home appliances that include irons, toasters, vacuum cleaners, watches, coffee machines and hair dryers. Consumer equipment dominates in both cities, but amounts tend to be higher in the high income

(low density) areas as opposed to the low income areas (high density). In both cities there are generally low amounts of WEEE in the form of medical devices in the form of radiotherapy equipment, dialysis equipment and pulmonary ventilators since this type of equipment occurs in smaller quantities and where it is available, is given longer time spans-a situation that is characteristic of most developing countries.

Management of Waste Electric and Electronic Equipment

The extension of the product life of electric and electronic equipment by reuse is regarded as a sound means of reducing environmental pollution because fewer appliances are produced to cove consumer demand (Truttmann and Rechberger, 2006). In Harare, the most common channel for the reuse of such materials as cell phones, radios, televisions, laptops, personal computers, printers, photocopiers, calculators, cameras and refrigerators has been through selling to second hand shops and other repair shops. This study reveals that 68% and 46% of the discarded household appliances in Harare and Mutare respectively enter the second hand market. In the case of Harare, there has developed a thriving market for such second hand electric appliances in the informal sector enterprises especially in the high density areas of Mbare, Highfield, Budiriro, Dzivaresekwa, Mufakose, Tafara and Mabvuku where prices are negotiable. In the case of household appliances that could not be repaired for the second hand market, there was scope in dismantling them into spare parts for repair shops. There has been growing reputation in Harare's informal sector enterprises in Siyaso and Gazaland for having the ability to provide any type of second hand electrical repair part because these centres are a major buyers of discarded appliances. In the households in Harare, where the large home appliances such as refrigerators, washing machines, conditioners, electrical and electronic tools such as drills, welding equipment, mowers and gardening equipment as well as computers dominated, the disposal method of selling to second hand shops was preferred by 66% and 69% of the households in high income and low income suburbs respectively. These appliances were sold to second hand merchants because they would not have lost their original function and some might require minor repair to perform. It has been observed that second hand appliances are not only a common occurrence in developing countries. In the USA 20% of all

discarded household appliances produce as much as 80% of their value for reuse (Saphores et al., 2009; Li et al., 2012).In Japan, between 2002 and 2004 the export share of Japanese second hand computers has increased significantly when compared to the domestic reuse share from 8% to 265 (Yoshida et al., 2008).

A number of reasons were forwarded by households in both Harare and Mutare for disposing electrical and electronic equipment. Large household electronic equipment such as refrigerators, television sets, washing machines and computers were discarded because of malfunctioning or had broken down and this accounted for 63% of the waste. Some of the electric and electronic equipment was discarded because of the failure to meet the changing needs of the households especially in the more affluent low density suburbs of Harare such as Avondale and Mabelreign (19% of disposals) and Greenside in Mutare (15% of disposals). In the case of cell phones, most of these were also disposed because of a fault in their functioning or having broken down (33%) and because of the availability of cheaper imported models (12%).

Perceptions on the management of WEEE

The study revealed that there is generally lack of awareness with regard to sound management of WEEE. Most of the households indicated that they were not aware of need for the disposal of small electric and electronic equipment items and hence did not think it was essential to worry about the disposal of such items. This was the case in both cities where 62% and 67% in Harare and Mutare respectively did not think it was relevant to worry about the disposal of WEEE and hence gave little thought to it. In the case of larger items such as refrigerators, television sets, washing machines, microwaves, electric heaters and air conditioners, the households tended to be more conscious of the methods of disposal. Instead of discarding the items haphazardly the households tended to sell the item or have it repaired.

Table 2 shows the most common disposal methods used by the households in Harare and Mutare with regards to electric and electronic waste equipment.
Table 2 Common methods used to dispose WEEE in Harare and Mutare (%)

Table 2: Common methods used to dispose WEEE in Harare and Mutare(%)

Suburb	Open dumping	Burning	Open dumping and burning	Other
Mabelreign	46	27	16	11
Avondale	42	26	9	23
Mbare	62	16	13	9
Kuwadzana	59	22	14	5
Greenside	47	25	12	16
Dangamvura	61	19	11	9

The most common methods used to dispose small electronic waste according to Table 2, is through open dumping as indicated by the majority of the households in both cities. Burning of waste is the second most popular method of disposing waste as reported by residents in both the low income and high income areas. A number of factors were cited as influencing open dumping of solid waste. These include lack of waste disposal facilities (63% of the households), the non-existence of penalties for dumping(lack of enforcement of legal deterrents by way of penalties(12% of the households), inadequate information on waste disposal and management in general(22% of the households) and the desire to save on disposal costs. Fifty seven percent (57%) respondents identified absence of suitable municipal solid waste management facilities as the key factor responsible for open dumping of waste in all. In confirming the problems associated with collection and disposal of solid waste generated in the residential areas the Education and Publicity Officer in the Environmental Management Agency noted that:

> *'Since e-waste is disposed of in the same receptacles as the general waste stream by the household, council has not responded well to the provision of collection facilities. There are inadequate waste collection and disposal facilities that have been put in place by Council in the form of metal or plastic bins hence the open dumping of solid waste. Such open dumping of waste is improper and can result in a number of environmental and health hazards.'*

An average of 26% of the respondents reported that the Gweru City Council lacked the will to enforce penalties for open dumping of solid waste as stipulated by the Gweru City By-Laws. 22% of the respondents indicated that the main reason for open dumping of waste in Gweru was the absence of timely information on sustainable disposal options and a small number 5% of the respondents attributed waste dumping to the need to maximise profits by saving on costs. These factors have resulted in the undesired dumping of solid waste and have had negative impacts on human health and the environment.

The extent to which solid wastes can be reduced, recovered and recycled needs to be an integral part of any solid waste management system. The first step needs to be the reduction of waste at the point of generation. In the households , significantly less households reported recycling as the most friendly method of managing solid waste with waste minimisation (waste prevention/source reduction) (waste prevention/source reduction) as the more preferred option. In the more affluent households in Harare and Mutare such as Avondale, Mabelreign and Greenside 67% respondents indicated that they would source-reduce waste and 12% would prefer to recycle waste and hence 78% were considered the potential 'reducers-recyclers' in the high income areas. Waste minimisation was, overally, the most preferred in all the residential areas and it is a useful way of conserving resources by diverting waste from the landfill.

The other methods involved in source reduction take into account the attitudes of the enterprise operators in their decision whether to buy particular raw materials.The most important aspects considered included the durability of the raw materials, whether the products' package could be re-used, possibilities for re-using the products, the amount of packaging included with the raw materials, and whether the raw materials are from renewable resources. With the exception of the third, fourth and fifth methods discussed above, percentages of households for all other methods differed significantly among the households (Table 3). As an example, among all the methods, re-using waste materials was greatest with almost the same importance in Mbare, Kuwadzana, Dangamvura and Avondale with the least importance in Mabelreign.

Table 3 Households' actual methods (as percentages) to source reduce waste

Method	Avondale	Mabelreign	Mbare and Kuwadzana	Greenside	Dangamvura
Re-use waste materials	61	29	31	37	32
When buying, consider packaging	7	17	6	5	3
When buying, consider durability of product	49	52	25	38	11
When buying, consider possibilities for re-use of product	35	51	12	33	10
When buying, consider whether product is made from renewable resources	20	22	8	11	7
When buying, consider whether its package can be re-used	18	27	17	13	20
Repair things that have been damaged and re-use them	52	57	13	31	38

Table 4 shows reasons why some households chose to collect and recycle waste in the households of Harare and Mutare. The reasons given for recycling differed significantly among the spatial areas. In Mabelreign, Avondale and Greenside, the major reason that was perceived important for recycling was the desire to avoid waste. Receiving payment for materials being recycled was the most important reason for choosing recycling as a method of managing waste in Mbare, Kuwadzana and Dangamvura. However, improving the appearance of the areas was the least important reason for choosing to recycle in three of the six spatial areas indicating that recycling was mainly viewed in terms of converting waste into valuable materials rather than in terms of environmental aesthetics.

Table 4: Reasons why some households choose to collect and recycle waste materials (%)

Possible reason	Avondale/ Mabelreign	Mbare	Kuwadzana	Dangamvura	Greenside
Protect the environment	66	30	20	22	63
Protect human health	71	46	33	36	70
Avoid waste	83	39	51	40	79
Improve appearance of area	58	9	11	19	51
Save resources	69	73	40	37	66
Reduce amount of waste to be burned or placed in dumpsites	61	63	15	23	59
Reduce costs of waste collection and disposal	72	42	30	24	68
Receive payment for materials being recycled	51	77	71	68	48

Most of the enterprise operators revealed lack of recycling programs, lack of knowledge about recycling and lack of interest in recycling as the reasons why they would not recycle waste (Table 5). In Mbare, Kuwadzana and Greenside some of the important reasons given for not recycling waste included not having buyers for the waste and the lack of encouragement of recycling programmes. These responses would really be expected from such enterprises where the bulk of solid waste generated is vegetable and food waste that could not be easily recycled nor composted due to the lack of a composting culture and facilities in the households.

Table 5 Reasons for households not collecting and recycling waste materials (%)

Possible reason	Mabelreign	Avondale	Mbare	Kuwadzana	Greenside
Do not know about recycling	68	64	60	66	69
No recycling programs here	74	48	62	61	54
Not interested in recycling	66	42	45	47	69
No buyer or place to sell recycled materials	33	21	46	44	42
Recycling is not mandatory	27	26	24	34	33

There were also low levels of recycling of most of the small WEEE items and most were disposed of without extracting economic value out of them. It was established that on average 67% of the items were not being recycled and much was being disposed of with the general waste. The interviews also revealed that most of the people did not know how to recycle the smaller items of the electronic and electric equipment and hence the only option of managing such waste was though disposal in the refuse bins.

Problems associated with WEEE generated in the households

Although occurring in small quantities, hazardous solid waste can have significant negative impacts on human health and environment when improperly disposed of. The hazardous wastes pose substantial present or potential hazards to humans or other living organisms because they are non-degradable, are persistent in nature or are lethal. There is risk caused by the myriad of toxic chemicals present in some the hazardous waste generated in the households especially the e-waste because of its association with heavy

metals such as arsenic, cadmium, chromium, lead and mercury. These heavy metals have no beneficial effects in humans and there is no known homeostasis mechanism for them. These elements are regarded as most toxic to humans and animals and the human health effects associated with exposure to them, even at low concentrations, are adverse and include, but are not limited to, neurotoxic and carcinogenic actions (ATSDR, 2003a, 2003b, 2007, 2008). Inorganic arsenic is considered carcinogenic and is related mainly to lung, kidney, bladder and skin disorders (ATSDR, 2003a). The toxicity of arsenic in its organic form has been known for decades under the following forms: acute toxicity, sub-chronic toxicity, genetic toxicity, developmental and reproductive toxicity (Chakraborti *et al.,* 2007), immunotoxicity (Sakurai *et al*., 2004), biochemical and cellular toxicity (Mudhoo *et al.,* 2011 and Schwarzeneggar *et al.,* 2004).

Waste from lead and zinc batteries contains cadmium which derives its toxicological properties from its chemical similarity to zinc. Cadmium accumulates in the human body affecting several organs that include the liver, kidneys, lungs, bones (osteomalacia; osteopoiosis), the placenta, brain and the central nervous system. Other damages that have been observed include reproductive and development toxicity, hepatic, haematological and immunological effects (ATSDR, 2007). Discarded batteries, alloys and petroleum additives associated with the informal sector enterprises are linked with the heavy metal lead which has no essential function in the human body. Once in the bloodstream, lead is primarily distributed among blood, soft tissue and mineralising tissue and children are children are particularly sensitive to this metal because of their more rapid growth rate and metabolism, with critical effects in the developing nervous system (ATSDR, 2007).Mercury would be associated with batteries discarded in the households and it is one of the most toxic heavy metals in the environment. Thus far, the disposal of e-waste with the rest of the municipal solid waste may result in negative impacts on the environment such as groundwater contamination by lead leaching and high concentrations of lead in the leachate. When e-waste is burnt in incinerators, heavy metals become concentrated in the ash, limiting its disposal and re-use options (Jang, 2010). Since most of the plastic material in e-waste contains flame retardants that are mainly halogenated organic chemicals, toxic organic contaminants such as dioxins and furans may be formed during incineration and exit through the stack to the surrounding areas in the form of gaseous pollutants.

The actual fate of the small quantities of hazardous waste generated in municipal solid waste is generally unknown and hence the environmental persistence of these hazardous compounds is one of the critical issues in their long-term management and this is true with regard to the hazardous waste generated in the households of Harare and Mutare. A most serious problem associated with dumping of hazardous e-waste is that of groundwater contamination since the percolation of water through the waste results in the dissolution of chemicals in a process called leaching and in water with various pollutants in it called leachate. The percolation of water through the raw waste results in the generation of a noxious leachate that consists of decomposing organic matter combined with iron and other metals from rusty car shells and metal tins, discarded batteries, paints, cleaning fluids and other chemicals. There are a number of boreholes that have been sunk in areas close to the residential areas and tests on ground water in these areas revealed that the indiscriminate dumping of solid waste tends to increase changes in environmental pollution or contamination.

Conclusion

The study revealed that there is generally lack of awareness with regard to sound management of WEEE in the households of Harare and Mutare. Most of the households indicated that they were not aware of need for the disposal of small electric and electronic equipment items and hence did not think it was essential to worry about the disposal of such items. The actual fate of the small quantities of hazardous waste generated in municipal solid waste is generally unknown and hence the environmental persistence of these hazardous compounds is one of the critical issues in their long-term management and this is true with regard to the hazardous waste generated in the households of Harare and Mutare. In developing WEEE management strategies for the households, there is need to encourage resource efficiency and hence minimise negative impacts on human health and the environment. The extension of product life is a vital measure in the reduction of resource consumption and in the case of the Harare and Mutare households this could be enhanced through re-use and recycling of appliances. It is therefore imperative that environmental education and awareness need to be vigorously undertaken among the residents of the two cities concerning the imperatives of electric and electronic equipment waste management.

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