An Evaluation of Electronic Waste Management in Ba-Phalaborwa Local Municipality, Limpopo Province. South Africa

Tshimbana T.P. Department of Environmental Sciences. University of South Africa. South Africa.
tsakani.tp@gmail.com
Tekere M. Department of Environmental Sciences. University of South Africa. South Africa.
tekerm@unisa.ac.za

ABSTRACT

Electronic waste (e-waste) has become an issue of concern to solid waste management professionals. Most municipalities in developing world face huge challenges in the management of e-waste generated from used commercial electronic devices and household appliances. An evaluation of electronic waste management in Ba-Phalaborwa Local Municipality was undertaken in this study through questionnaires, structured interviews and observations. Results revealed that a significant quantity of lighting, small household and ICT equipment is disposed in the study area. E-waste generated is stored, collected and disposed together with all domestic waste in the area. No segregation or recycling at household level of e-waste was evident. A lack of by-laws on e-waste was noted and seemed to be one of the challenges that the Municipality is facing. The study concluded that there is still no developed electronic waste management system in Ba-Phalaborwa Local Municipality.

1. INTRODUCTION

Electronic waste is one of the huge challenge facing municipalities in South Africa (Finlay and Liechti, 2008). Electronic waste commonly known as e-waste or waste electrical and electronic equipment (WEEE) refers to all old, end-of-life (EOL) electronic appliances such as information technology equipment, office machines, telecommunications equipment, consumer electronics, household equipment and accessories including their assembly, sub-assembly, components and consumables deemed obsolete or unwanted by a user (Cairns, 2005; Widmer and Lombard, 2005; Wath *et al*., 2010). E-waste consists of a large variety of common toxic substances such as barium (Ba), beryllium (Be), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), lithium (Li), lanthanum (La), mercury (Hg) and many more (Zhang and Forssberg, 1997; Puckett and Smith, 2002; Oguchi, 2007) that can contaminate the environment and threaten human health if not appropriately managed (Chan *et al*, 2007; Huo *et al*, 2007; Kiddee *et al*., 2013).

The e-Waste Association of South Africa (e-WASA) estimates for large household appliances, small household appliances, consumer equipment and ICT in South African homes amount to anything between one to two million tons, most of which enter the waste stream in the next 5-10 years (Finlay, 2005; Dittke, 2008; Finlay and Liechti, 2008). The quantity of large and small household appliances is expected to surpass that of ICT equipment as a percentage (by weight) of the waste stream (Finlay and Liechti, 2008). e-WASA warns that volumes of e-waste are likely to increase in future (Dittke, 2009; Finlay and Liechti , 2008).

According to Widmer *et al.* (2005) the lifespan of many electronic equipment has been substantially shortened due to advancements in electronics, attractive consumer designs and marketing and compatibility issues. For example, the average lifespan of a new computer has decreased from 4.5 years in 1992 to an estimated 2 years in 2005 and is further decreasing resulting in much greater volumes of computers for disposal (Widmer *et al,* 2005; Kiddee *et al.*, 2013).

Minghua *et al.* (2009) and Guerrero *et al.* (2013) indicated that municipal waste management is still a challenge for cities and towns in developing countries. This is mainly due to increasing generation of municipal waste and the burden imposed on the municipal budget as a result of high costs associated with its management (Williams, 2005; Sujauddin *et al*, 2008; Guerrero *et al.*, 2013). Williams (2005), Sujauddin *et al.* (2008) and Guerrero *et al*. (2013) mentioned the same thing that e-waste has become an issue of concern for the municipalities. Due to greater affordability of new electrical and electronic equipment and technological advancements, it is easy to purchase rather than repair electrical and electronic equipment (Williams, 2005).

While it is difficult to quantify the volume of e-waste generated globally, Bushehri (2010) and Kiddee *et al.* (2013) presented an overview of the volume of e-waste generated in a range of categories in China, Japan and US based on available information for the period 1997-2010. He estimated that over 130 million

computers, monitors and televisions become obsolete annually and that the annual number is growing in the United States (Bushehri, 2010). According to Bushehri (2010) and Kiddee *et al*. (2013) around 500 million computers became obsolete between 1997 and 2007 in the United States alone and 610 million computers had been discarded in Japan by the end of December 2010. In China 5 million new computers and 10 million new televisions have been purchased every year since 2003 (Hicks *et al*., 2005; Bushehri, 2010; Kiddee *et al.*, 2013) and around 1.11 million tonnes of e-waste is generated every year, mainly from electrical and electronic manufacturing and production processes, end-of-life of household appliances and information technology products, along with imports from other countries. It is reasonable to assume that a similar generation of e-waste occurs in other countries (Kiddee *et al.*, 2013).

The collection of e-waste in South Africa is done through several channels (Bondolfi *et al.*, 2007). In South Africa there is no official logistic provider who specialised in e-waste collection. However, the two major role players which act as collectors are consumers that bring back their old equipment and processors, refurbishers, and hazardous landfill site companies that fetched e-waste from consumers (Bondolfi *et al.*, 2007). The municipalities do not have direct collection means for e-waste but usually collect e-waste mixed with general waste to landfill sites (Bondolfi *et al*., 2007).

Although South Africa has established a number of good waste management policies and legislations most municipalities are failing to effectively manage their wastes including e-waste management (Tembon, 2012). The main legislation which comprehensively deals with waste and the environment is the National Environmental Management 107 of 1998 (NEMA) and there are regulations dealing with waste which are drawn from NEMA such as National Environmental Management Waste Act 59 of 2008 (NEMWA) (DEA, 2009). The purpose of NEMWA is to reform the law regulating waste management in order to protect health and the environment by providing reasonable measures for the prevention of pollution and ecological degradation and for securing ecologically sustainable development and to provide for national norms and standards for regulating the management of waste by all spheres of government (DEA, 2009).

One of the challenges of coming out with an e-waste legislation in South Africa is the existence of several generalised regulatory Bills which do not specifically isolate e-waste from the rest of solid hazardous waste (ITA-PEG, 2012). The current South African legislation is not specific enough to cover the management of e-waste at municipal and national level (ITA-PEG, 2012). However, it was observed that there were several manufacturers, distributors, refurbishers and recyclers who were taking self-drawn initiatives on the management of e-waste. The National Waste Management Strategy (NWMS) is the only national legislative document which mentions the ever increasing quantities of e-waste and the need to develop strategies to develop remedial solutions (DEA, 2009).

Though South Africans are aware of e-waste, there are still a large percentage of people who do not know what to do with their e-waste or what harm it can do to the environment and their health if not disposed of in a proper manner (Widmer and Lombard, 2005). The South Africa e-waste assessment recommended awareness-raising around the proper disposal of e-waste (ITA-PEG, 2012). Municipalities can also promote a greener environment by funding projects that deal with e-waste minimisation in general. Residents can play an important role in the reduction of e-waste that ends up in the landfill if they can be made aware of the danger e-waste poses to the environment and their health.

Collection points where residents will be able to take their e-waste is one of the most important part of the e-waste management processes. Special lockable containers can be placed at central collection points in the residential areas and logistical arrangements with recyclers and transporters can be made by the municipality to collect e-waste for recycling (Kang & Schoenung, 2005). The collection points process can also make sorting and separation easier. E-waste should be recycled to eliminate the flow from residential areas to the landfill. Importance of e-waste recycling such as reducing the amount of e-waste sent to the landfill can solve some of the e-waste challenges in South Africa (EPA, 2013). The management of e-waste in small rural-urban based town of Ba-Phalaborwa Local Municipality was evaluated. Generally studies in different countries including South Africa focus on big cities. However with rural urbanization e-waste generation is also increasing in small rural urban centres. This study therefore focused on the evaluation of e-waste management in the least studied rural municipalities, the case of a small town in South Africa.

2. MATERIALS AND METHODS

The study was carried out in Ba-Phalaborwa Local Municipality formerly known as Phalaborwa Municipality which is situated on the North-Eastern part of South Africa in the Limpopo Province. The information was gathered through questionnaires to the selected residents, structured interviews with municipal workers under the Environmental Health Division and field observation at the landfill site.

The systematic random sampling method was used in the administration of questionnaires. Purposive sampling was used to conduct interviews with Ba-Phalaborwa Local Municipality employees in Environmental Health Division only. Data collected through questionnaires was analysed using the Statistical Package for Social Sciences (IBM SPSS statistics version 21.0). SPSS was used to create frequency and percentage tables to analyse and represent the quantitative data. Data collected through observations was analysed descriptively. The data collected through interviews was analysed after decoding.
Waste electrical and electronic equipment (WEEE) in the study area was classified according to European Directives standards, WEEE Directive 2002/96/EC (EU, 2003). All WEEE were classified as either large household appliances, small household appliances, Information technology and telecommunication equipment, consumer equipment, lighting equipment or others (EU, 2003).

3. RESULTS AND DISCUSSION

Data collected revealed the most and the least discarded WEEE from June 2011 to June 2013 in the study area. Table 1 presents the percentage of the discarded WEEE by the respondents in the area. It was found that out of 285 respondents, lighting equipment constituted the most WEEE at 45. 1 %, followed by small appliances and ICT equipment that constituted 25.5% and 15.2% respectively. It also shows that the least discarded WEEE were the consumer equipment, large appliance and other electrical equipment which constitute 6%, 3.8% and 1.1% respectively. The type of WEEE discarded in Ba-Phalaborwa Local Municipality during the study is shown in Table 1.

Table 1: WEEE discarded by the respondents in the past 24 months

Category of WEEE	Frequency	Percentage
Small appliances	71	25
Large appliances	11	3.8
Lighting	129	45.1
ICT equipment	54	19
Consumer equipment	17	6
Other equipment	3	1.1
Total	285	100

As shown in Table 1 small household appliances are the second most discarded WEEE in Ba-Phalaborwa Local Municipality. Small household appliances are generally affordable hence respondents can afford to replace rather than repairing them. Small household appliances also have a very short lifespan with an average of three years (Kulshreshtha, 2009). The lifespan of small household appliances is short and decreasing as a result of rapid changes in equipment features and capabilities thereby causing generation of large volume of electronic waste (Waeger *et al.*, 2011).

ICT equipment is the third most discarded WEEE in the area. ICT equipment such as printers, cell phones, chargers, mouse, keyboard, monitors and PCs are discarded in large numbers due to the short lifespan and changing of designs by manufacturers within a short period of time (Sinha-Khetriwal *et al*., 2009). Wastes from ICT equipment are reportedly found in large numbers also in many areas across South Africa (Sinha-Khetriwal *et al*., 2009). According to Widmer *et al*. (2005) the average lifespan of a new computer has decreased from 4 to 5 years in 1992 to an estimated 2 years in 2005 and is further decreasing resulting in much greater volumes of computers for either disposal or export to developing countries.

Most people in the study area also prefer to replace the old cellphones, desktop computers and laptops with the new and improved ones rather than repairing them. Manufacturers at the same time are continuing to design and manufacture these devices in abundance (Ramchandra & Saira Varghese, 2004). Most people across the country replace and upgrade ICT equipment due to introduction of new and improved versions and designs, not because they are broken (Sinha-Khetriwal *et al.*, 2009).

Consumer equipment is one of the least discarded WEEE in Ba-Phalaborwa Local Municipality followed by large household appliances such as refrigerators, freezers, washing machines, clothes dryers, dishwashing machines, electric stoves and air conditioners. Large household appliances were not generated in large numbers in the study area in the 24 months studied most likely due to their long lifespan compared to small household appliances and other EEE. The average lifespan of large household appliances such as refrigerators, freezers, washing machines, clothes dryers, dishwashing machines and electric stoves is ten to fifteen years (Kulshreshtha, 2009). Electric fans, air conditioner appliances have an average lifespan of five to seven years (Kulshreshtha, 2009).

Finlay and Liechti (2008) estimate that large household appliance, small household appliances, consumer electronics and IT equipment in South African homes amount to anything between one and two million tonnes, most of which will be likely to enter the waste stream between 2013 and 2018. Ojeda-Benitez et al. (2013) state that consumer electronics and small EEE such as microwaves are the most WEEE disposed within the flow of municipal solid waste. Large household appliances such as refrigerators, washing machines, televisions and even laptops are intended for storage, sale or repair.

According to Rocha *et al.* (2009) Swiss federal Laboratories for Materials and Research (EMPA) prepared a study on estimation of WEEE generation based on the lifespan of EEE. The average lifespan is an important parameter for estimating waste flows of televisions, refrigerators, freezers, washing machines and sound systems. It is less important for mobile phones and computers, because of the much greater variability of the lifetimes of these products (Rocha *et al*., 2009). Widmer *et al.* (2005) states that generation of WEEE is growing at an alarming rate mainly in countries belonging to the Organisation for Economic Co-Operation and Development (OECD) where electronic markets are saturated with new technology. Globally, it is estimated that between 20 to 50 million tonnes of WEEE are generated each year and the figure is increasing at a rate of 3%-5% annually (Sinha-Khetriwal *et al,* 2005). Figure 1 shows the mode of electronic waste storage in Ba-Phalaborwa Local Municipality.

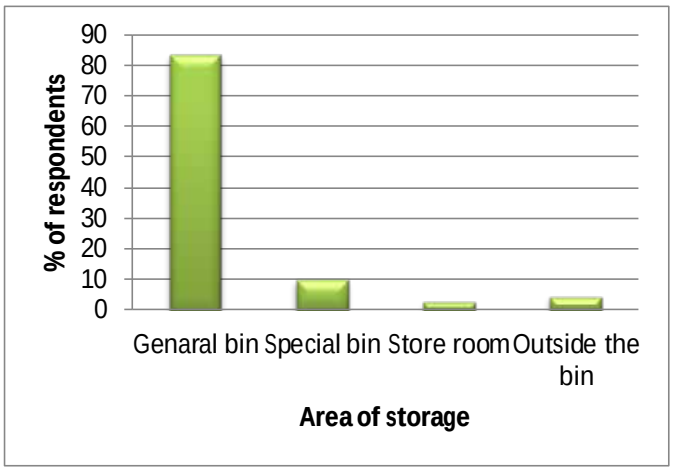

Figure 1: Mode of electronic waste storage

Most respondents discard e-waste in general waste bins since they do not have storage specifically for e-waste. Figure 1 clearly shows that 83.2% of respondents place their electronic waste in the general waste bin. The number is very high compared to the 9.8% of respondents who put their waste in the special bins designed to store e-waste for recycling. 4.3% keep their e-waste such as consumer and large household appliances outside general waste bins because of the size of the bins. 2.7% store their e-waste in the storerooms before they decide to discard them. Even short storage of e-waste in the general bins results in e-waste disposal in the landfill. Most respondents clearly indicated that all waste materials in their households are collected by Ba-Phalaborwa Local Municipality. The municipality collects e-waste as part of the general waste routine collection. Figure 2 shows the responsibility for electronic waste storage in households.

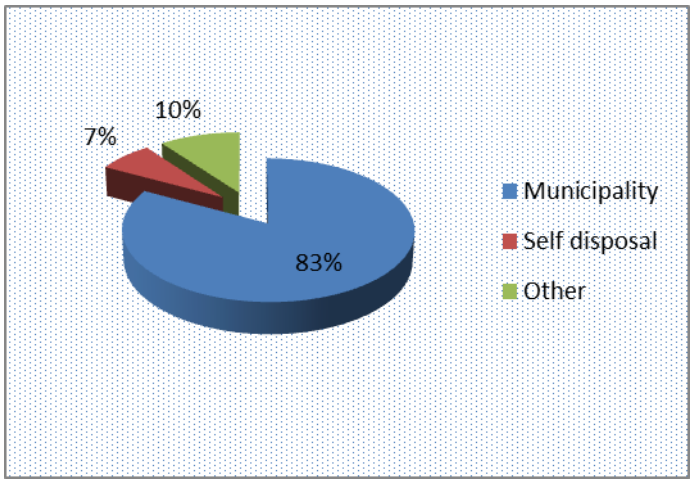

Figure 2: Responsibility for electronic waste collection in households

The Municipality collects waste including e-waste, once a week and disposes it in the landfill. There is no segregation or treatment involved. According to the Municipal workers the challenge is the storage area. The Municipality does not have any storage area where e-waste can be kept for effortless segregation or separation. A lack of separation at source results in all e-waste collected and disposed in the landfill. It can be noted that non segregation of e-waste from domestic waste is a standard practice in most developed countries (Sothun, 2012; Wath *et al.,* 2011).

In South Africa it is reported that there is no dedicated transport modes for e-waste in some small municipalities and those municipalities that are involved in e-waste processing strongly depends on middlemen and some semi-formal collectors for e-waste transportation (ATE, 2012). A study conducted in Cambodia found that the e-waste that is disposed in the general waste bin is mixed with household waste without separation and is collected and transported directly to the landfill site, which is improper management of e-waste. Waste pickers and reclaimers are confronted with potential health risks and hazards due to directly contacting hazardous materials in municipal waste (Sothun, 2012). In India it was found that electronic waste is collected on different days but all e-waste is collected, transported and disposed at the same landfill site as general waste without separation (Sushant *et al.*, 2011).

According to Kurian (2007), the future of e-waste management in developing countries depends not only on the effectiveness of local government or operators of recycling services but also on the attitude of citizens and community participation. Lack of knowledge and low level of community awareness of electronic waste can lead to increased mismanagement of e-waste by local government (Kurian, 2007).

Many people in the study area are not familiar with the term e-waste. The study also shows that respondents were not aware of whether e-waste is hazardous or not. Only 29% of residents stated that e-waste is hazardous, and the remainder was not aware of the hazard properties of e-waste to human health and the environment. Many respondents stated that they are not sure if electronic waste has an impact on either human health or environment, meaning that many respondents are still oblivious of the impact of e-waste. Kurian (2007) indicated the same for India that many communities are unaware of the danger e-waste poses to human health and the environment. The study in Guiyu (China) confirmed that improper disposal of e-waste in landfills is due to lack of knowledge and low level of public awareness (Leung *et al*., 2008).Residents still have more to learn about the toxicity of the e-waste.

Gabaitiri *et al*. (2012) stated that in Gaborone (Botswana) uncontrolled dumping and improper management of solid waste poses a serious risk to human health (Gabaitiri *et al.*, 2012). Lack of coordination between the council, landfill managers, waste collectors and the communities around Gaborone causes mismanagement of electronic waste. The communities which are considered generators of e-waste in Gaborone are unaware of the impact of electronic waste on their health (Gabaitiri *et al*., 2012). Considering the data given by respondents regarding the impact of e-waste on human health it indicates that higher percentages of residents are oblivious of the threat that e-waste poses to human health. They are not aware that electronic waste contains chemicals or toxic substances such as arsenic, beryllium, cadmium, chlorofluorocarbons (CFCs), lead, mercury, polychlorinated biphenyls (PCBs) and many more that pose serious health threats (Asente-Duah *et al*., 1992; Ecroignard, 2006; Townsend, 2011).

There are few e-waste recycling companies in Ba-Phalaborwa Local Municipality and Greater Tzaneen Municipality (e.g. Merensky Recycling and Electronic Waste Limpopo) which is the nearest town that deal with treatment and recycling of e-waste. . It was found from interviews that the Municipality does not collaborate with recycling companies in anyway. E-waste generated is collected by the Municipality and transported by municipal trucks from residential areas to the landfill site where reclaimers (formerly known as scavengers) sort the waste according to their preference and sell it to the recycling companies.

According to Goseey (2009), e-waste contain a wide range of materials and some of these are known to present potential health and safety issues for landfill workers, reclaimers and recyclers involved in the handling and treatment at e-waste. On the landfill site, reclaimers and landfill workers are exposed to different hazardous substances such as sharp objects, chemicals from electrical waste, dust, odour, noise and disease vectors such as rats and flies (Goseey, 2009). According to Sothun (2012), waste pickers, reclaimers and landfill workers are directly contacting and inhaling harmful and hazardous waste and other pollutants through their daily tasks of handling electronic waste. Reclaimers and landfill workers commonly do their daily tasks without wearing safety facilities such as gloves, mask, glasses, etc. (Sothun, 2012).

Reclaimers in Ba-Phalaborwa Local Municipality landfill were observed not taking any precautionary measures; they were sorting electronic waste without any protective equipment for their own health and safety. Ba-Phalaborwa Local Municipality does not provide reclaimers with any personal protective equipment and health measures as their activities are deemed illegal.

The reclaimers segregate the e-waste according to the waste they are interested in based on some agreement with commercial collectors who buy the e-waste. According to the reclaimers, large amounts of lighting equipment are disposed of in the landfill. However, they do not reclaim lighting equipment because it does not generate enough income compared to other WEEE. According to one of the reclaimers, large household appliances generate sufficient income but they are not disposed in large numbers at the landfill. E-waste sales range from R2.00 to R3.50 per kilogram depending on the commercial collectors or recycling company. The respondents (reclaimers) considered it proper management of the e-waste to dispose it to landfill since this is where they collect WEEE to generate income.

According to Kang and Schoenung (2005), since e-waste is hazardous in nature, it must be collected, sorted, stored and transported under controlled conditions. An efficient e-waste collection and transportation system will ensure proper recycling of e-waste (Kang and Schoenung, 2005).

The study revealed that currently there are no management strategies in Ba-Phalaborwa Local Municipality that are specific to e-waste. It was found that the Municipality does not have any management strategies or by-laws that govern the collection, transportation and disposal of e- waste but they follow the national legislation NEMWA 59 of 2008 that deals with waste management. Local municipalities are responsible for promulgating waste management by-laws and Integrated Waste Management Plans (IWMP) as required by Chapter 5 of the municipal systems Act (Van der Linde & Feris, 2010). This implies that Ba-Phalaborwa Local Municipality is responsible for all by-laws and IWMP on electronic waste management in the municipality.

It was revealed during the study that Ba-Phalaborwa Local Municipality does not have own by-laws to govern electronic waste management. It was confirmed that e-waste is not mentioned in any of the Ba-Phalaborwa Local Municipality by-laws on waste management.

Section 10 of Ba-Phalaborwa Local Municipality by-laws requires that the waste generators of the certain classes of hazardous waste submit an integrated waste management plan in order to operate or dispose the waste (Dikkte, 2007), but e-waste is not specifically listed. Ba-Phalaborwa Local Municipality management is aware that electronic waste fall under hazardous waste. They do not have by-laws that deal directly with its collection, transportation and disposal.

According to ATE (2012), there are several pieces of legislation and by-laws which govern the disposal of waste according to their classification as hazardous and non-hazardous. However, there is no specific legislation which is specifically promulgated for electronic waste. South Africa currently does not have any dedicated legislation dealing with e-waste (ATE, 2012).

4. CONCLUSION

Different types of e-waste is generated in Ba-Phalaborwa Local Municipality and according to the study lighting equipment, small household appliance and ICT equipment are the most generated. Most residents own a lot of EEE in their households and it is expected that the amount of WEEE will continue to increase in the study area as the equipment become obsolete. Supplementary electronic waste is expected to be produced in the next 5 years due to great numbers of short life EEE in the study area. Ba-Phalaborwa Local Municipality has no management strategies that are currently used in the study area to eliminate the flow of e-waste from the municipality to the landfill. It is recommended that formulation of legislation at the national level be affected so that South African municipalities, including Ba-Phalaborwa Local Municipality, be required to formulate by-laws that will deal specifically with the generation, collection, transportation, storage, treatment, disposal and recycling of e-waste.

ACKNOWLEDGEMENT

The authors would like to express their appreciation to Mr Maphangwa K.W for his advice and assistance. And to thank all the employees and residents of Ba-Phalaborwa Local Municipality, the research was a success because of their assistance and participation.

REFERENCES

Advanced Tropical Environment (ATE). (2012). Identification of the magnitude of the electrical and electronic (e-waste) situation in South Africa: A Strategic Approach to International Chemicals Management (SAICM) e-waste as an emerging policy issue. The African Institute for Sound Management and Hazardous and other Wastes and Department of Environmental Affairs. South Africa.

Asente-Duah, D.K. Saccomanno, F.F. Shortreed, J.H. (1992). The hazardous waste trade: can it be controlled? ES&T Features. *Environmental Science Technology*, 26(9):1684–93.

Bhuie, A. Ogunseitan, O. Saphores, A. and Shhapiro,A. (2004). Environmental and economic trade-offs in consumer electronic products recycling: a case study of cell phones and computers. *Proceeding of the 2004 IEEE International Symposium on electronics and the environment*, IEEE. 74 – 79.

Bondolfi, A. Schluep, M. Ecroignard, L. Finlay, A. (2007). The "Green e-waste channel" as an environmental friendly and socially responsible concept to manage e-waste in emerging economics.

Bushehri, F.I. (2010). UNEP's role in promoting environmentally sound management of e-waste. 5th ITU Symposium on "ICTs, the Environment and climate change" Cairo, Egypt.

Cairns, C. (2005). E-waste and the consumer: improving options to reduce, reuse and recycle. *Proceedings of the 2005 IEEE international Symposium on electronics and the environment,* IEEE, 237-242.

Chan, J.K.Y. Xing, G.H. Xu, Y. Liang, Y. Chen, L.X. & Wu, S.C. (2007). Body loadings and health risk assessment of polychlorinated dibenzo-p-dioxins and dibenzofurans at an intensive electronic waste recycling site in China. *Environment Science Technology*, 41:7668–7674.

Chatterjee, P. (2008). Health costs of recycling. *British Medical Journal, 337*: 376–377.

De Vos, A. Strydom, H. Fouche, C.B. and De'Port, C.S. (2002). *Research at grassroots for social science and human sciences profession.* 2nd edition. Pretoria.

Department of Environmental Affairs. (2009). National Environmental Management Waste Bill, Notice no 287 of 2009. *Government Gazette,* 525:2.

Dikkte, M. (2007). A review of South African Environmental and General Legislation governing e-waste. e-Waste Association of South Africa. Available from: http://ewasteguide.info/Dittke_2007_eWASA.

Dittke, M. (2009). A Review of South African Environmental and General Legislation governing e-waste*. E-Waste Association of South Africa.* Cape Town.

Ecroignard, L. (2006). e-WASA. E-waste legislation in South Africa [online] available.

EPA Program. (2013). The national strategy for electronics stewardship. United Nations Environmental Protection Agency.

European Union. (2003). Directive 2002/96/EC of the European parliament and of the council of 27 January 2003 on waste electrical and electronic equipment (WEEE). *Official Journal of the European Union.* 37(46):24-39.

Finlay , A. (2005). e-Waste assessment in South African case study.

Finlay, A. and Liechti, D. (2008). *e-Waste Assessment South Africa* [online]. Ewasa. Available from: http://ewasa.org/downloads/files/SA%20e-Waste%20Assessment.pdf (Accessed 07 February 2012).

Gabaitiri, L. Shangodoyin, D.K. Setlhare, K. & Sediakgotla, K. (2012). Estimation of household waste generated in Gaborone City Council. *The Journal of Solid Waste Technology and Management,* 38:249-257.

Goosey, M. (2004). End-of-life electronics legislation: an industry perspective. *Circuit World*, 30:41–5.

Guerrero, L. Maas, G. & Hogland, W. (2013). Solid waste management challenges for cities in developing countries. Waste management, 33 (1): 220-232.

Guiyu, an electronic waste recycling town in China. *Environ Health Perspect*, 115:1113–7.

Hicks, C. Dietmar, R. Eugster, M. (2005). The recycling and disposal of electrical and electronic waste in China-legislative and market responses. Environmental Impact Assessment Review, 25: 459-471.

Huo X, Peng L, Xu X, Zheng L, Qiu B, Qi Z, et al. Elevated blood lead levels of children in

ITA-PEG. (2012) ITA Industry Waste management plan version V09.

Kamara, A.J. (2006). Household participation in domestic waste disposal and recycling in the Tshwane metropolitan area: An environmental education perpespective. University of South Africa.

Kang, H.Y. and Schoenung, J.M. (2004). Used consumer electronics: a comparative analysis of material recycling technologies. *2004 IEEE international symposium on electronics and the environment.*

Kiddee, P. Naidu, R. and Wong, M.H. (2013). Electronic waste management approaches: An overview. Waste Management, 33: 1237-1250.

Kulshresshtha, A.K. (2009). Basic electrical engineering: principles and applications. India. Tata McGraw-Hill Education.

Kurian, J. (2007). Electronic waste management in India–issues and strategies. [online]. Available from:http://www.swlf.ait.ac.th/UpdData/International/NRIs/Electronic%20waste%20management%20in%20Indi a.pdf (Accessed 11 April 2012).

Leung, A. Cai, Z.W. & Wong, M.H. (2008). Environmental contamination from e-waste recycling at Guiyu, Southeast China. Proceedings of the 3rd workshop on material cycles and waste management in Asia, 73–84.

Minghua, Z., Xiumin, F., Rovetta, A., Qichang, H., Vicentini, F., Bingkai, L., Giusti, A., Yi, L., *2009.* Municipal solid waste management in Pudong New Area, China*. Journal of Waste Management 29, 1227–1233.*
Ndleve, V.P. (2008). The development of a teaching and learning programme towards sustainable living through proper waste management in schools in Giyani Area, Limpopo Province. University of South Africa.
Ogushi, Y. and Kandlikar, M. (2007). Assessing extended producer responsibility laws in Japan. Environmental Science and Technology, 3: 843-858.
Ojeda-Benitez, S. Cruz-Sotelo, S.E. Velazquez, L. Santillan-Soto, N. Nunez, M.Q. Cueto, O.R.G. and Markus, W. (2013). Electrical and electronic waste in Northwest Mexico. *Journal of Environmental Protection.* 4: 405-410.
Puckett, J. & Smith, T. (2002).The High-Tech Trashing of Asia. Exporting Harm.The Basel Action Network (BAN) and Silicon Valley Toxics Coalition (SVTC) [Online] http://www.ban. org/E- waste/ techno trashfinalcomp. pdf. (Accessed 08 February 2012).
Ramachandra, T.V. and Saira, V. K. (2004). Environmentally sound options for waste management. *Envis Journal of Human Settlements.*
Rocha, H.T.R. Gomes, F.V.B. Streicher-Porter, M. Portugal, S.M. Almeida, R.N. and Ribeiro, J.C.J (2009). Diagnosis of the generation of electrical and electronic waste in Minas Gerais State. Swiss federal laboratories for masterials science and technology. EMPA.
Sinha-Khetriwal, D.S. Kraeuchi, P. & Widmer, R. (2009). Producer responsibility for e-waste management: key issues for considering –learning from the Swiss experience. Journal of Environmental Management, 90:153-165.
Sothun, C. (2012). Situation of e-waste management in Cambodia. Procedia Environmental Sciences, 16: 535-544.
Sujauddin, M., Huda, M.S., Rafiqul Hoque, A.T.M., 2008. Household solid waste characteristics and management in Chittagong, Bangladesh. *Journal of Waste Management* 28, 1688–1695.
Tanskanen, P. (2013). Management and recycling of electronic waste. Nokia Corporation. Keilalahdentie. Finland.
Tembon, M. (2012). An evaluation of the gaps and barriers that exist between the national waste management policy and its implementation in formal and informal urban areas in the Ekurhuleni Municipality, South Africa. University of South Africa.
Townsend, T. (2011). Air and waste management Association; Environmental issues and management strategies for waste electronic and electrical equipment, 61:588. Gainesville.
Van der Walt, J. (2009). Majestic community: e-waste in South Africa. South Africa.
Van der Linde, M. & Feris, L. (2010).*Compendium of South African Environmental Legislation.2nd ed.* University of Pretoria.
Waeger, P. Hischier, R. & Eugster, M. (2011). Environmental impacts of the Swiss collection and recovery systems for Waste electrical and electronic equipment: A follow-up. *Science of Total Environmental*, 15 (10): 1746-56.
Wath, S.B. Vaidya, A.N. Dutt, P.S. Chakrabarti, T. A roadmap of sustainable e-waste management in India. Sci Total Environ 409:19–32.
Widmer, R. and Lombard, R. (2005). E-Waste assessment in South Africa: a case study in Gauteng province. Swiss global e-waste programme. Knowledge partnerships in e-waste recycling.
Williams, E., 2005. International Activities on e-Waste and Guidelines for Future Work. National Institute of Environmental Sciences, Tokyo, Japan.
Zhang, S. and Forssberg, E. (1997).Mechanical separation-oriented characterization of electronic scrap. *Resources, Conservation and Recycling,* 21 (4): 247-269.