“Disposal of obsolete computers framework to reduce environmental effect of disposed computer materials in higher institutions of learning in Africa”

AUTHORS	Alfred Coleman
ARTICLE INFO	Alfred Coleman (2016). Disposal of obsolete computers framework to reduce environmental effect of disposed computer materials in higher institutions of learning in Africa. *Environmental Economics*, *7*(2), 62-68. doi:10.21511/ee.07(2).2016.6
DOI	http://dx.doi.org/10.21511/ee.07(2).2016.6
RELEASED ON	Friday, 03 June 2016
JOURNAL	"Environmental Economics"
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
0	0	0

Alfred Coleman (South Africa)

Disposal of obsolete computers framework to reduce environmental effect of disposed computer materials in higher institutions of learning in Africa

Abstract

Disposal of obsolete computers (DOC) in higher institutions in Africa poses a major environmental problem to many African people. The question of how to dispose obsolete computers and computer technologies in a safe manner has become a cause of concern to many African people, especially when toxic emissions pollute the air, water, and soil posing a serious health and environmental hazard to the community. This study investigates the methods of disposing and recycling of obsolete computers, and its environmental effect on plants and animals in Africa. A case study approach is used. Participants were selected from three African countries Ghana, Nigeria and South Africa based on their historical background in Africa regarding e-waste. Semi-structured, open ended interview questions were used to gather evidence from the participants regarding how obsolete computers are disposed from their institutions and the possible effect of the disposed computers on the environment. The interviews were recorded, transcribed and coded. The findings revel that the most common method of disposing obsolete computers is through dumping, dismantling of parts for resale by children and open field burning of unwanted parts. This burning process produces toxic material which is associated with high health risks. Based on the findings, a proposed Disposal of Obsolete Computers Framework (DOCF) was developed to guide higher institutions in Africa to opt for appropriate methods of disposing computers. The framework will not only assist higher institution in selecting a better option of disposing obsolete computers, but also will improve the hazardous environmental conditions which animals and plants find themselves.

Keywords: disposal, obsolete, computers, higher institutions, environmental problems, pollution, health risk.
JEL Classification: Q51, Q53.

Introduction

The importance of computers in contemporary education cannot be overemphasized in higher institutions of learning around the globe. Computers and their related technologies are now such an integral part of everyday life and an ingredient in higher education. In many higher institution found in Africa, computers and their technologies have become the tool for teaching and learning. Lecturers use it as a tool for lesson preparation, search for information on any topic, and use it as a communication tool to reach both students and administrators. Students, on the other hand, depend on computers for communication with their lecturers, search for information and use it as medium of sending assignment to lecturers. Apart from teaching and learning, most administrative functions of institutions of higher learning depend on the use of computers and their technologies for everyday transaction. Higher institutions, therefore, purchase computers and their related technologies in large volumes at frequent intervals to replace those which become obsolete. As the life span and replacement rate of computers spin around two years, it gives no option to higher institutions, but to replace them with new ones or refurbish the old ones (Brennan, Isaac and Arnold, 2002). At the end of the life span of these computers, higher institutions dispose them and purchase new ones to maintain their core business of teaching and learning.

Despite the tremendous potential that Information and Communication Technologies (ICT) have to support teaching and learning in higher institutions, it poses an environmental challenge when disposing them at the end of their life cycle. Lee et al. (2004) postulate that the disposal of computers poses two major environmental problems which are high energy consumption and high toxic component materials making their disposal ecologically unsound. Some of the environmental impacts experienced at the disposal of most computers is hazardous release of toxic materials into the environment. The hazardous toxiv material include Lead, Cadmium, Mercury, Barium, Arsenic, Beryllium, Chromium, Selenium, refractory oxides (such as SiO2, Al2O3); Halogenated compounds (Brominated Flame Retardants such as Poly Brominated Diphenyl Ethers (PBDEs); Poly Brominated Biphenyls (PBBs), and Chlorinated compounds such as Poly Vinyl Chloride (PVC). The release of these toxins is aggravated in many African countries, as African countries are becoming the final dumping destination of the world's electronic waste (Simpson, 2006). Dumping of this electronic waste is, largely, for two reasons: (1) shadow markets emerging from international and domestic recycling loop holes and (2) Asian coun-

Alfred Coleman Ph.D. in Information Technology, Associate Professor of Health Informatics, School of Computing, College of Science, Engineering and Technology, University of South Africa, South Africa.

tries like China and India imposing tighter regulations on the import, and methods of recycling e-waste in those countries.

Due to increased number of student population and high usage of computers in higher institutions in Africa, an Information Technology (IT) disposal strategy needs to be developed to address issues of computers and their related technologies disposed to create a safe working environment for both staff and students. In the absence of suitable strategies and protective measures, disposing computers and their related technologies can result in toxic emissions to pollute the air, water, and soil posing a serious health and environmental hazard (Kaushal and Nema, 2013).

Objective: The objective of this paper is to investigate the methods of disposing and recycling obsolete computers in higher institutions of learning and its environmental effect on plants and animals in Africa. Based on the findings, a proposed framework to guide the disposal of obsolete computers and their related technologies will be developed to reduce environmental hazard.

The remaining Section of the paper is structured as follows: Section 1 reviews the relevant prior literature. Section 2 presents the methodology, followed by results and discussion in Section 3. Section 4, presents a proposed Disposal of Obsolete Computers Framework (DOCF) and, finally, ends with the conclusion in Final Section.

1. Literature review

1.1. Computers disposal practices. Computers and related technologies have become integral part of teaching and learning in higher institutions in Africa. However, the disposal of these computers at the end of their life cycle has become environmental challenge to many African states. The environmental challenges are compounded by developed nations like Europe and America using African countries like Ghana, Nigeria, Kenya, Zimbabwe, Zambia, Botswana and South Africa as a dumping grounds for their electronic waste (Simpson, 2006; Claiborne, 2009; UNEP, 2009).

The environmental problems associated with computers are two-fold, as initially indicated, high energy consumption and high toxic component materials which are inherent characteristics of computers, thus, making their use and disposal ecologically unsound (Lee et al., 2004). Unfortunately, due to their sheer global quantities and current product life of roughly two years, the problems associated with such characteristics become greatly enhanced at an alarming rate (Brennan et al., 2002). Zhang and Forssberg (1999) projected that, by 2005, roughly 150 million personal computers (PCs) and work stations will be disposed in landfills in the US alone. By this same year, Gungor and Gupta (1999) predicted that every family in the US will own a computer and, given the aforementioned product life of these systems, it appears that computers are being disposed of as quickly as they are being produced.

Electronic waste (e-waste) which includes TV, computers, radios and others has adverse impacts on the atmosphere, hydrosphere, lithosphere and the biosphere. Personal Computers (PCs), Note Books and Laptops generate CO_2 during their mining, manufacturing, usage and their disposal as e-waste. This emission of CO_2 from Information Technology and computer industries is called Cyber Warming (Pravin, 2007). Cyber Warming contributes to the increase in Global Warming. It causes the heating up of the Earth. About 2% of the CO_2 emitted in the atmosphere comes from the Information Technology and computer industries. Landfills which are becoming a current method of disposing e-waste may become toxic bombs in the long run. The e-waste that is dumped into the landfill will get leached, when there is precipitation. The leachate contains heavy metals and other toxic substances which can contaminate the soil and water resources. The toxins will contaminate soil and may reach groundwater and pollute the groundwater also. Even state-of-the-art landfills which are sealed to prevent toxins from entering the soil are not completely tight in the long-term. Older landfill sites and uncontrolled dumps pose a much greater danger of releasing hazardous emissions, and they may turn into toxic bombs due to excess of CO_2 emission in the long run. Methane which is another Global Warming gas is also produced from the landfills. When e-waste is dumped into a water body or farm land, the water and food grains are contaminated. When this contaminated water and food is consumed by humans, animals or plants, it will lead to disorders, cancer, or may even lead to death. The entire food chain is affected. These toxins are bio-accumulative. The heavy metals, Lead, Cadmium, Mercury and others are known to cause damage to the nervous system, the brain, the kidneys, and can cause birth defects and cancer (Robinson, 2009). This toxic water may reach the sea or ocean, and the flora and fauna in the oceans may equally die. Flora and fauna in the oceans are the main sinks which absorb the CO_2. When flora and fauna die, the CO_2 absorption capacity of the ocean is reduced, as the carbonate shells of the organisms which act as a major sink will get destroyed. Thus, the ocean becomes warmer and it will cause the reduction in the Arctic ice. Thus, the ice melts into water increasing the volume of water in the ocean, thereby causing the ocean level rise and leading to flooding. The Permafrost in the Arctic region constitutes an abundant amount of soil-bound carbon which acts as sink which absorbs CO_2. The reduction in Arctic ice causes removal of the Permafrost, thereby absorption of CO_2 by the ocean is further reduced. This leads to further warming. So, there is more heating of the oceans. If more area of water in the ocean gets heated, then, there will be more amount of evaporation. Thus, the increase in evaporation will result in increased precipitation, flooding, storms, cyclones, hurricanes and sea level rise. Thus, the entire life cycle of the computer produces toxins and hazardous emission which have an adverse effect on the environment and even change the climate.

1.2. Current management practices and regulatory framework. The existing management practices in US and Europe exert greater economic impact on global trade and recycling due to generation of large volume of e-waste. So far, legislation on e-waste is mainly driven by certain EU countries and their allies. Most developing nations in the world are lagging behind in the development of similar regulations, particularly the enforcement of such regulations (Sepúlvedaetal, 2010). The sixth meeting of the Conference of the Parties to the Basel Convention (convened in 2002) recognized that the issue of e-waste recycling required urgent and in-depth supervision, particularly in developing countries. This program was further strengthened at the ninth meeting of the Conference of the Parties to the Basel Convention (2006), with the adoption of the Nairobi Declaration on the Environmentally Sound Management (ESM) of Electrical and Electronic Waste. By this decision, the Secretariat was requested to facilitate work and activities of EMS on e-waste, focusing on the management needs of developing countries and countries with economies in transition. The Secretariat of the Basel Convention, in consultation with selected countries in this region and the Basel Convention Regional Centers in China, Indonesia and the South Pacific, developed a proposal for a pilot project on the ESM of e-waste products (Basel Convention, 2012). Under the Basel Convention, e-wastes is classified and characterized as hazardous waste, when it contains reactive chemical components such as accumulators and other batteries, Mercury switches, glass from cathode-ray tubes and other activated glass, PCB-containing capacitors or when contaminated with Cadmium, Mercury, Lead or PCBs. Also, precious-metal ash from the incineration of printed circuit boards, LCD panels and glass waste from cathode-ray tubes and other activated glasses are characterized as hazardous waste. To address the environmental issues related to the increasing trans-boundary movements of this waste, and to ensure that its storage, transport, treatment, reuse, recycling, recovery and disposal is conducted in an environmentally sound manner, a proactive approach is essential. The plastics associated with e-waste may need to be covered, under Annex II of the Basel Convention (UNEP, 2009). Despite the existence of these agreements and conventions, the transfer of e-waste from the United States, Canada, Australia, Europe, Japan and Korea to developing countries remains relatively high (Terazona et al., 2006; Cobbing, 2008). Although Basel Convention regulates e-waste, it does not ban a country's right to export it entirely. The next Section of this paper will explain the methodology used in this research paper.

2. Methodology

In order to achieve the objectives of this paper, the researcher carried out the study in three African countries Ghana, Nigeria and South Africa. A case study approach was used. Three governments owned higher institutions in Africa were purposefully selected. These higher institutions were selected based on their geographical locations which span across the entire Africa continent and have been characterized by Simpson (2006), Claiborne (2009), UNEP (2009) as dumping grounds of e-waste by developed countries. The participants for the study were drawn from the population of ICT directors in the three higher institutions being universities. For confidentiality and anonymity requested by these participants, the names of their corresponding universities are alienated from this research. In describing population, Polit and Beck (2008) indicate that it is the aggregate of cases having a common and designated criterion that is accessible as subjects for a study. A purposive sampling technique was used in selecting the participants. Two ICT directors (director and deputy director) from each of these universities were selected. The participants were selected by their professions which was relevant to the study. The selected directors volunteered to participate in the study on the condition that their identity and their University are concealed. Data were collected using semi structured open ended interviews. The interviewees represented different roles ranging from ICT director to deputy or assistant director. The interviewees were asked to tell in their own words:

1. How obsolete computers are disposed from their institution.
2. The possible effect of the disposed computers on the environment including plants and animals.
3. Alternative means of disposing the obsolete computers, if they have the opportunity to do it again.

The interviews lasted for one hour with each interviewee and were audio-recorded and transcribed by the researcher. Integrity of data entry from the study was checked by another independent researcher. Transcripts were coded using Wolcott's (1994) method of case study analysis technique. After the initial coding, an independent researcher and the main researcher met to check the consistency of their respective interpretation of the transcripts and the codes. The researcher, then, coded the final transcripts, identified the main themes and traced possible relationships. Some broad categories of themes were identified by searching for patterns in the participants' responses. The different broad categories that were noted are discussed below.

3. Results and discussion

The main categories which emanated from the patterns identified were disposal methods of obsolete computers in higher institutions; envisaged environmental effect of disposed computers on animals and plants; and alternative methods of disposing obsolete computers. These categories will be discussed in details in the subsequent paragraphs.

3.1. Disposal methods of obsolete computers in higher institutions. The respondents indicated that computers and their technologies which are purchased and used by their institutions last within 2 to 3 years and they become obsolete at the end of their life cycle. They further reiterated that the computers have a short life span because of the fast rate at which the IT industry produces new technologies. Williams and Sasaki (2003) indicate that the main reason for purchasing a new computer is not to replace a non-functioning system, but to keep up with rapidly changing technologies. The obsolete computers, as expressed by the interviewees, are disposed by refurbishing for resale or as a donation. Another way by which the obsolete computers are disposed is by dumping them in an open space or, sometimes, by burning them.

Refurbishing, according to the interviewees, is reconditioning, remanufacturing, refreshing, repairing, recertifing computers which look like new. One respondent said "we *refurbished these computers so that we can sell them to people who cannot afford new one. We, sometimes, give them as donation to charity organization. We don't use them because of low processing speed which cannot carry the work load, as well as the cost of refurbishing"*.

This statement is echoed by Boyd and Weaver (1994) who indicate that refurbishment is generally considered more complex and of higher risk than new build.

The interviewees further stated that most of the obsolete computers are usually dumped in open space and burnt. However, before the computers are burnt on the dumping sites, young boys try to dismantle them to salvage for reusable material, components and accessories to sell at the nearby market.

Besides plastic and aluminum which are common components, it can also contain small pieces of valuable metals such as gold, platinum or copper and hundreds of other highly toxic substances like Lead, Arsenic, Cadmium, Hexavalent Chromium or Mercury. When these obsolete computers are burnt, they release highly toxic gas into the air. Again, this finding is supported by Moukaddem (2011) who indicates that those people who are working at the computer scarp-yards are exposed to a large amount of toxins everyday, while employing crude methods such as open burning and other dangerous forms of disposing obsolete computers.

3.2. Envisaged environmental effect on animals and plants. When the respondents were asked about the possible effect of the disposed computers on the environment including plants and animals. The respondents stated that Children are uniquely at risk because children comprise of the majority of those who burn or dismantle discarded computers. These children are more vulnerable to e-waste' toxicity because of their rapidly developing organs. The burning of disposed computers in open fields in Africa higher institutions magnifies the health risks associated with the burning process. It was further explained by the respondents that children are exposure to toxic metals, such as lead, mercury and other poisionous metals which result mainly from open-air burning .Combustion from burning e-waste creates fine particulate matter, which is linked to pulmonary and cardiovascular disease. One respondent stated *"Through dermal contact and inhalation, as well as contaminated food and water, Ghanaian children, exposed to computer burning, may suffer from "brain and kidney damage, respiratory illness, developmental and behavioral disorders, and, possibly, cancer"*. This is confirmed by Leung et al. (2008) that children experience respiratory ailments and are, especially, at risk of lead poisoning when exposed to inhalation of burning computers in open fields. Furthermore, intense lead exposure in children can cause vomiting, diarrhoea, convulsion, coma and, possibly, death.

Mercury is another highly toxic material found in computer flat screens and batteries (Rani et al., 2012). High levels of mercury exposure can lead to brain and kidney damage, as well as damage to the central nervous system (Kristen et al., 2013). When Mercury in computer devices meets with water or through leaching, it becomes Methylated or highly toxic methylmercury. The Methylmercury builds up in fish, shellfish and animals that eat fish. As a result, Methylmercury becomes more concentrated as it travels up the food chain where, ultimately, it is consumed by humans (Qianget al., 2009). Like Lead, Methylmercury is particularly hazardous to fetuses, infants and children, because their bodies are still developing. In fact, exposure to Methylmercury causes adverse effects on fine motor skills, thinking, language and visual spatial skills in children (Qianget al., 2009). However, one respondent stated *"the long-term health impacts on African populations are unknown not because crude methods of processing computer waste are safe or because computer waste contains innocuous materials but, largely, because no specific studies exist concerning such health impacts in African countries"*. Another respondent said, *"We don't know what the immediate health impacts are. We are hoping to test the children's blood for contaminants, but we have not secured the necessary funding"*. The next paragraph expands on alternative methods, as expressed by the respondents to minimize health hazard emanating from open field burning of computers in higher institutions in Africa.

3.3. Alternative methods of disposing obsolete computers. The respondents were asked to express their opinion on alternative methods. They would use to dispose obsolete computers, if they have the opportunity to do so. The respondents indicated that the higher institutions should first link with their local recycling centers, if there is any, and find out how these centers can dispose their old computers for them. The respondents further indicated that the old computers can be given out as donation to charity organization. A respondent from Ghana stated *"Just because a computer is too obsolete for your needs doesn't mean it cannot help someone else, donate it"*. Other respondents added the following:

- ♦ Sell it. If the old computer has some value left, the institution might be able to sell it for a bit of money.
- ♦ Repurpose it. The institution should figure out a new way to use the old machine. Install a software version to breathe new life into it and give it out to high schools.
- ♦ Keep it around for parts. The respondents suggested that the old computers can be kept in a sore house so that, if the current machine goes down for some reason, the institution will have a spare to hook up while getting it fixed or getting a new one. The institution can also use it to do things like trying or creating a network.

Upon examination and analysis of the responses from the interviewees, a proposed framework to guide the disposal of obsolete computers and their related technologies in higher institutions to reduce environmental hazard was developed.

4. The need for a proposed Disposal of Obsolete Computers Framework (DOCF) in higher institutions to guide disposal of computers

Based on the findings, the researcher proposed a (DOCF) framework to guide the disposal of obsolete computers and their related technologies in higher institutions. The DOCF is embedded in the concept of reduction, reuse, recycle, which have proven to yield many benefits in both environmental and socio-economic space. Figure 1 below provides the details of DOCF.

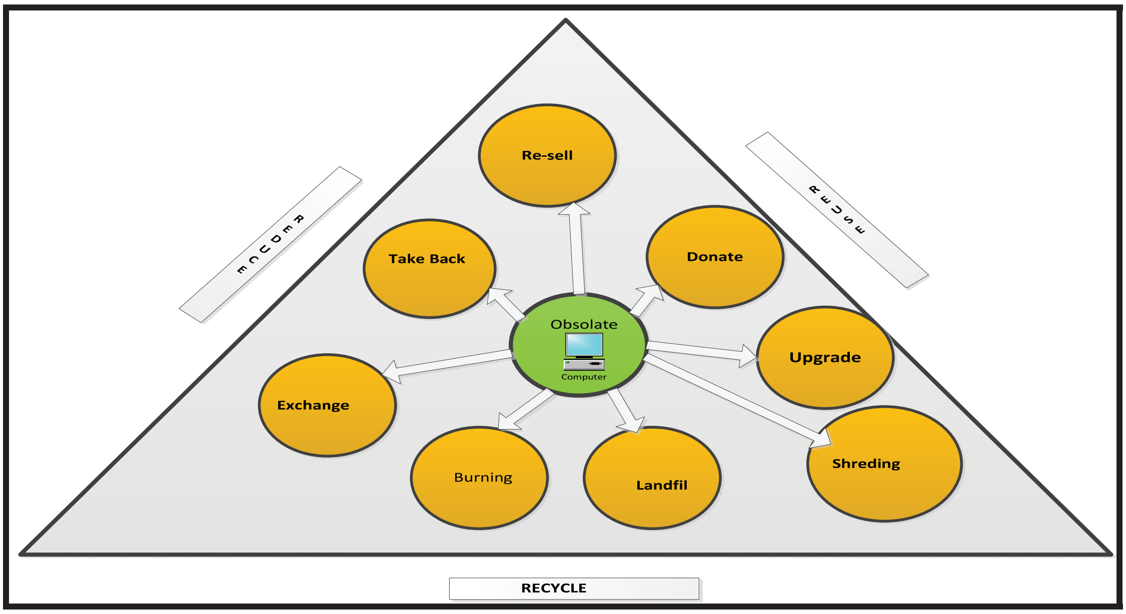

Fig. 1. A proposed Disposal of Obsolete Computers Framework (DOCF)

4.1. Reduction and reuse. Reducing the amount of computer waste relies heavily upon the reuse of computer systems that may be out of date, but fully functional. Reusing old computers can manifest itself in two main ways: by the selling or donation of old computer systems, or by up-grading existing systems (Williams and Sasaki, 2003). The key concept with respect to reuse is to meet the user's needs with existing machines, while extending that machine's life span. There are a number of organizations around the world, which focus on the redistribution of old computers. In the 1990's, Williams and Sasaki (2003) found that schools and small businesses were the greatest demand for used computers. In this DOCF, old computers can be taken back from higher institutions of learning and sold or donated to primary or secondary schools in Africa. Reselling of old computer is another way of disposing old computers. In this instance, old computers can be sent to the manufacturers of the computers for exchange of new ones. The manufactures must give the purchaser (higher institutions) some kind of trade in amount for the old one. Upgrading a computer in order to suit current technology is a choice often made only by computer specialists, due to the fact that user knowledge is required and full upgrades can, sometimes, be costly. While upgrading individual components of a computer, such as the hard drive or processor, may cost less than a new PC; upgrades which involve the addition of a Universal Serial Bus (USB) port result in the "complete upgrade" often cost more than a new system (Williams and Sasaki, 2003).

4.2. Recycling. The rate at which new computer technology changes, makes recycling using landfill methods uneconomical. Lee et al. (2004) affirm that disposal of computers in landfills is no longer an option for end of life management. This is true for higher institutions in Africa because of the high cost involved. One of the main problems encountered during a computer recycling process is the effective physical separation of components. The concept of "Intelligent Liberation" is presented by Zhang and Forssberg (1999) as a means of accurate mechanical separation of computer scrap components, such as printed circuit boards, for further recycling. Materials used in computer equipment are held together via weak interfacial bonds such as welding, fastening and wrapping, and, therefore, intelligent liberation of these materials can occur via low energy methods. One method utilizes a ring shredder which is capable of producing particles of desired shapes and sizes which can be further separated and recycled (Zhang and Forssberg, 1999).

Open burning has become an option for disposing obsolete computers in many higher institutions in Africa, as shown in Figure 1. This burning produces toxic material which is associated with health risks. It was further explained by the respondents that children are exposed to toxic metals, such as Lead, Mercury and other poisonous metals which result mainly from open-air burning. Combustion from burning computers creates fine particulate matter, which is linked to pulmonary and cardiovascular disease. However, if the burning of computers is undertaken in designated incinerators, this will alleviate, to greater extent, the problem of pulmonary diseases associated with it.

Conclusion

Having investigated the methods of disposing obsolete computers in higher institutions of learning in Africa, it was evident that the most common method of disposing obsolete computers is through dumping, dismantling of components for resale by children and people without job and burning. The burning process takes the form of gathering together all unwanted parts of computers in an open field and fire set to it. This practice was found to create health hazard for children and adult due to high toxic materials released through burning. Based on the findings, a proposed Disposal of Obsolete Computers Framework (DOCF) was developed to guide higher institutions of learning in Africa to opt for appropriate methods of disposing computers. The frameworks will not only assist higher institutions of learning in selecting a better option of disposing obsolete computers, but also will improve the hazardous environmental conditions which animals and plants find themselves in.

References

1. Anna, O.W., Leung, A.O. (2008). Heavy Metals Concentrations of Surface Dust From E-Waste Recycling and its Human Health Implications in Southeast China, *Environmental Science and Technology*, 42(7), pp. 2674-2680.
2. Basel Convention. (2012). Decisions adopted by the Conference of the Parties to the Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal: COP 6-10 and ExCOPs.
3. Boyd, D. and Weaver, P. (1994). Improving the management and operations of refurbishment projects, Proceedings of the l0th. *ARCOM Annual Conference*, 14-16, September, 1994, Loughbrough University of Technology, UK.
4. Brennan, L.B., Isaac, D.H. and Arnold, J.C. (2002). Recycling of Acrylonitrite-Butadene-Styrene (ABS) and High-Impact Polystyrene (HIPS) from waste computer equipment, *Journal of Applied Polymer Science*, 86, pp. 572-578.
5. Claiborne, R. (2009). *E-Waste in Africa, U.S. Trash is Ghana's Problem*, ABC NEWS, August 2, 2009. Available at: http://abcnews.go.com/GMA/Weekend/story?id=8215714&page=1.4.

6. Cobbing, M. (2008). *Toxic tech: not in our backyard, uncovering the hidden flows of e-waste*, Greenpeace International, Amsterdam.
7. Gungor, A. and Gupta, S.M. (1999). Issues in environmentally conscious manufacturing and product recovery: a survey, *Computers and Industrial Engineering*, 36, pp. 811-853.
8. Kaushal, R.K. and Nema, A.K. (2013a). Game theory-based multi-stakeholder planning for electronic waste management, *Journal of Hazardous, Toxicand Radioactive Waste*, 17, pp. 21-30.
9. Kristen, G., Fiona, C.G., Peter, D., Marie, B. and Maria, N. (2013) Health consequences of exposure to e-waste: a systematic review, *Lancet Glob Health*, 1, pp. 350-361.
10. Lee, C.H., Chang, C.T., Fan, K.S. and Chang, T.C. (2004). An overview of recycling and treatment of scrap computers, *Journal of Hazardous Materials*, B114, pp. 93-100.
11. Lundgren, K. (2012). *The global impact of e-waste: addressing the challenge*, International Labor Office (ILO), Geneva.
12. Moukaddem, K. (2011). Children on the frontlines: the waste epidemic in Africa, (Sept. 9, 2011). Available at: http://news.mongabay.com/2011/0909-moukaddem_ewaste.html.
13. Polit, D.F. and Beck, C.T. (2008). *Nursing Research: Generating and Assessing Evidence for Nursing Practice.* Philadelphia: Lippincott Williams & Wilkins.
14. Pravin, V. (2007). Recycling E-waste a Gold Mine Business, 2007.
15. Qiang, L., Jia, C., Ke, Q., Xu, H.M. and Guang, L. (2009). Chromosomal aberrations and DNA damage in human populations exposed to the processing of electronics waste, *Environmental Science and Pollution*, Research 16, pp. 329-338.
16. Rani, B., Upma, S., Raaz, M. and Chauhan, A.K. (2012). Perils of Electronic Waste: Issues And Management Strategies, *Journal of Advanced Scientific Research*, 3, pp. 17-21.
17. Robinson, B. (2009). E-waste: An assessment of global production and environmental impacts, *Science of the Total Environment*, 408, pp. 183-191.
18. Sepúlveda, A., Schluep, M., Renaud, F.G., Streicher, M. and Kuehr, R. (2010). A review of the environmental fate and effects of hazardous substances released from electrical and electronic equipment during recycling: Examples from China and India, *Environmental Impact Assessment Review*, 30, pp. 28-41.
19. Simpson, J. (2006). Toxics Alert: Africa Emerging as E-Waste Dumping Ground, (Dec. 2006). Available at: http://enews.toxicslink.org/news-view.php.
20. Terazona, A. Murakami, S., Abe, N., Inanc, B. and Moriguchi, Y. (2006). Current status and research on E-waste issues in Asia, *Journal of Material Cycles and Waste Management*, 8, pp. 1-12.
21. UNEP. (2009). Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. United Nations Environment Programme. Available at: http://www.basel.int/, 2009.
22. Williams, E. and Sasaki, Y. (2003). Strategizing the End-of-life Handling of Personal Computers: Resell, Upgrade, Recycle. In Kuehr, R. and Williams, E. (Eds.). *Computers and the Environment: Understanding and Managing Their Impacts*. London: Kluwer Academic Publishers.
23. Wolcott, H.F. (1994). *Transforming Qualitative Data:Description, Analysis, and Interpretation*. Thousand Oaks, CA: Sage.
24. Zhang, S. and Forssberg, E. (1999). Intelligent Liberation and classification of electronic scrap, *Powder technology*, 105, pp. 295-301.