Journal of Environment Pollution and Human Health, 2019, Vol. 7, No. 1, 27-33
Available online at http://pubs.sciepub.com/jephh/7/1/4
Published by Science and Education Publishing
DOI:10.12691/jephh-7-1-4

Potential Effects of Computer E-Waste Disposal Management Approaches on Human Health and the Environment in Nairobi City County, Kenya

Margaret W. Maimba*, Peter M. Ngau, Fridah W. Mugo

Department of Urban and Regional Planning, University of Nairobi, P.O. Box 30197, Nairobi, Kenya
*Corresponding author: mwgacigua@yahoo.com

Received May 04, 2019; Revised June 10, 2019; Accepted June 21, 2019

Abstract Computer electronic (e-waste) is an important global challenge due to the presence of complex hazardous components that have potential negative impact on human health and the environment if not properly handled. This paper presents the potential negative impacts of computer e-waste disposal management approaches on human health and environmental degradation of the urban area. Purposive and random sampling was used for public institutions, private companies and households respectively. The formal and informal disposal sites within the Nairobi City County. The Central Government Ministries and agencies charged with the responsibility of environment and human health management including policy and legislative development and enforcement of related regulations provided the required data for this paper. The study observed that public auctions, throwing away together with county solid wastes, selling as second-hand materials, storage at the premises, donations, reuse, recycling, urban mining, refurbishment, leasing, selling to recycling facilities were the computer e-waste disposal management approaches practiced by the respondents in the study area. The study concludes that all the computer e-waste disposal management approaches practiced by the respondents are unsustainable and have potential negative effects to human health and the environment if not handled properly. Further, the study concludes that the respondents are unaware of the potential negative effects on their lives and the environment by computer e-waste disposal management approaches they use. The study recommends the establishment of a County E-waste Management Authority (CEMA) to implement a zero-waste policy. In addition, the study recommends the establishment of a two-level model of a computer e-waste disposal management system that would include a residential/commercial neighbourhood Drop Off Points (CEDOPs) and a County Computer E-Waste Recycling Centre (CEREC). In addition, Ward Computer Literacy Centres (WCLCs) should be established in all Wards to utilize spin offs from CEREC for community computer capacity building.

Keywords: *computer e-waste, disposal management system, disposal management approaches, human health, urban environment, urban mining, zero waste policy*

Cite This Article: Maimba, M. W., Ngau, P. W., and Mugo F. W. "Potential Effects of Computer E-Waste Disposal Management Approaches on Human Health and the Environment in Nairobi City County, Kenya." *Journal of Environment Pollution and Human Health*, vol. 7, no. 1 (2019): 27-33. doi: 10.12691/jephh-7-1-4.

1. Introduction

Electronic waste or e-waste describes discarded electrical or electronic devices. Used electronics which are destined for reuse, resale, salvage, recycling, or disposal are also considered e-waste. Current computing system has become an important human health and environmental consideration in urban planning and management in the recent years. There has been a massive shift to information and knowledge societies with a twist to electronic technologies as the kingpin of economic restructuring and reconstruction of social values [1]. The use of computer components and accessories has become a common feature for the public and private sector worldwide [2,3]. On the one hand, it has tremendously transformed social and economic lives in modern times towards a more networked, resource efficient and flexible modes of interaction [5]. On the other hand, it has been a fundamental pipeline to degradation of life support systems upon which sustainability of the very aspirations for social and economic advances are anchored [6,7,8]. However, finding an alternative approach to sustainable management of this waste remains elusive to many urban authorities of low-income countries, including Kenya. Ironically, existing efforts mostly focus on authorising domestic recycling systems and decreasing toxic content of processes. It has been argued that current policies are only likely to alleviate but not provide solutions to the risks to human health and environmental effects of recycling of e-waste, mostly done in the informal parts of

large cities [9]. Various global initiatives such as the Basel Convention that prohibits imports of e-waste into Africa has not provided a sustainable solution towards the increasing volumes of computer waste especially in the low-income countries. Obsolete computer technology, used, broken-down, unserviceable, rejected computers and repair of computer components and accessories are the main sources of e-wastes. However, computer e-waste is an important emerging development problem due to its three main characteristics that include its toxicity (presence of mercury, lead, cadmium, etc) nature with potential to negatively impact on human health and the environment valuable components for income generation and the large volumes of e-waste generated all over the world, Kenya included.

It is not clear how these large volumes of computer e-waste are being handled and the potential risks to human health and the environment especially in low income countries. This paper reports findings of a study that was carried out to determine the potential negative effects of computer e-waste disposal management approaches on human health and the environment in Nairobi City County.

2. Research Methodology

The collection of data was both qualitative and quantitative from primary and secondary sources. The secondary data was collected from literature review on articles related to the field of human health and environmental impacts of the computer e-waste disposal management approaches and publications such as reports. A survey (in form of a questionnaire) and interview schedules were used to collect primary data while secondary data was collected from journals, reports. The data was obtained across operations level of computer e-waste disposal management through to the national and local level decision-making arms of environment and health regimes. The structured questionnaire was administered to respondents in 11 public institutions that included (3) academic, (9) research institutions, 30 private sector enterprises and 77 middle and 79 high income households, while interview schedules were used to collect data from (5) government policy and regulatory institutions. The survey had questions related to personal information, computer e-waste disposal management approaches, level of public awareness about the potential effects of computer e-waste on human health and the environment.

To complement the views and opinions of the key informants for the institutions and private companies, published literature from experiences of other countries was considered and discussed for purposes of positioning the arguments against international perspectives of the potential impacts of human health and the environment by waste from computer components and accessories. The study used the sampling techniques based on the recommendation by scholars such as [39] and [40].

3. Results

The study set out to identify and consider the pointers toward computer e-waste disposal management approaches. It established that all the different types of computer e-waste disposal management approaches practiced by different actors (Table 1) are not sustainable except the recycling by the WEEE Centre. This has implications on the human health of those who come in contact with the waste and also the environment.

Table 1. Summary of Computer E-Waste Disposal Management Approaches Used by different Actors

Actors	Disposal management approaches	Sustainability
Public institutions	Storage	Not sustainable
	Auction	Not sustainable
	Throw away	Not sustainable
	Donate	Not sustainable
Private companies or institutions	Lease out	Not sustainable
	Sell to e-waste collectors	Not sustainable
Households	Storage	Not sustainable
	Sell as second hand	Not sustainable
	Sell to recyclers	Not sustainable
	Throw away	Not sustainable
	Donate	Not sustainable
WEEE Centre	Recycle	Sustainable
Yard shops	Purchase recycled metals	Not sustainable
Waste pickers/scavengers	Open air burning	Not sustainable
	Urban mining	Not sustainable

4. Discussions

The study observed that respondents from the public institutions, private companies, households and those living at close vicinity of the dumping site (Dandora) practice different types of computer e-waste disposal management approaches. The disposal management approaches and their potential human health and environmental effects on the urban area are discussed below.

4.1. Donations of Computer E-Waste

The study noted that the Public Procurement and Asset Disposal Act, [10,11,12] provides for donations to public institutions (such as polytechnics, technical colleges e.t.c). Households also preferred computer components and accessories disposal management approach through donations to friends and relatives. These computer donations are of poor quality given that some have broken down, some are un-serviceable, obsolete and too old to be used. This computer e-waste disposal management approach provides computers to those who would not otherwise afford the cost of a new computer and also extends the end-of-life of the computer thus delaying its disposal in the landfill. However, this type of disposal management approach has potential negative effects on human health and environmental degradation of the urban area if the poor quality, broken down, unserviceable and obsolete and too old to use computer components and accessories are not handled in an environmentally sound manner at their end of life.

4.2. Storage of Computer E-Waste

If the computer components and accessories are not dismantled, storage in itself does not have any potential negative effects on human health and the environment of the urban area. The study observed that public institutions store their computer components and accessories for about 2-3 years before the Government agency in charge of disposal management provides directives on their behalf. The storage of computer e-waste has potential adverse effects on the human health and the environment if it is broken-down/opened up and not handled in an environmentally sound manner.

The Public Procurement and Disposal Act [12] and its associated regulations [11] were found to hamper the immediate disposal of computer e-waste from public institutions. However, the public auctions provide access through sale of waste from computer components and accessories mainly to the informal recyclers (waste pickers/scavengers and the yard shop operators) who usually dismantle them using rudimentary tools without any regard to the human health or the environment. This makes the e-waste auction disposal management approach by public institutions one of the riskiest as far as human health and the environmental degradation of the urban area are concerned.

The households have a culture of storing their old or broken-down computer e-waste for more than 5years in their premises for perceived value, either physical or emotional attachment before disposal [13,14]. This is in line with the research findings of the e-waste disposal management practices of households in Meleka, in Malaysia [15,16,17]. While this type of disposal management approach may not have potential effects on human health and the environment, if not broken down, it keeps away waste from computer components and accessories from the recycling facility, a process that provides employment and secondary materials for the local industry.

4.3. Throwing away Computer E-Waste together with County Solid Waste

The study established that there were more old desktop computers with CRT display monitors still being stored in premises by respondents at the households. The same respondents indicated that they throw away the computer e-waste together with other county solid waste. This is also a practice by the Shah Community in Malaysia [18]. CRT display monitors contain a mixture of several potentially hazardous components such as copper, aluminum, and several heavy metals has similarly been reported in various literature such as in [19] and in e-waste recycling activities in China [20]. Once the CRT is thrown away with other CSW it is crushed, broken-down, weathers and leaks into the landfill, releasing mercury, cadmium, lead, copper, brominated flame retardants, antimony oxide, zinc leachate and polychlorinated biphenyls (PCBs) into the environment while plastics containing brominated flame retardants (BFRs), polybrominated diphenyl ethers (PBDEs) leach into the soil and groundwater.

The lead can also contaminate clothes of the workers mining valuable materials from the landfill and this has a potential negative effect on both their health and can adversely degrade the environment. When mixed with acid waters in the landfills, the lead ions dissolve from the broken glass of the CRTs. This is in line with the findings of [21,23] who reported that when CRT display monitors are permitted to weather in landfills, they release mercury, cadmium, lead, brominated flame retardants (BFRs), antimony oxide, zinc leachate into the soil and both surface and underground water sources. These toxic materials expose toxins to humans thus elevating health risks such as cancer, developmental and neurological disorders as reported by [18,22]. Likewise, if allowed to weather in the landfill, the LCD monitors and the laptops may release mercury and Ni-Cd ions respectively, into the water sources and soils and cause pollution of the air and food poisoning through the food chains and also negatively impact the environment.

Direct exposure to broken-down computer components and accessories has potential to affect the skin through contact, inhalation, and ingestion of chemical elements. This may lead to mercury and lead poisoning. Besides, the toxic components from computer components and accessories can remain in the environment for a long time where it continues to increase in concentration for as long as the e-waste continues to be generated thus causing environmental degradation of the urban area.

4.4. Recycling of Computer E-Waste

The increasing amount of computer e-waste has occasioned two major problems: a shortage of mineral resources for sustaining the electronic industry, and potential environmental pollution and human health risks. Recycling of computer e-waste is a disposal management approach practiced in the urban areas mainly by the urban poor represented by the waste pickers or scavengers living at or near the dumpsite (Dandora) and the yard shop operators (traders) operating at the vicinity of the dumpsite. Recycling is mainly practiced in the extraction of valuable computer components and accessories. Recycling reduces demand for the manufacture of new computers, and therefore, reduces the burden on raw material extraction used in the manufacturing of new computer components and accessories. This results in reduced demand for the manufacture of modern computers. Computer components and accessories were shipped to low-income countries such as Kenya [23], without testing for functionality [24] as *"computers for charity"* and pass through the customs. These computer components and accessories are recycled often using crude tools to dismantle them and extract the valuable elements such as gold, copper, silver and platinum among others.

Extraction of these valuable metals leads to the release of toxic components such as lead, plastics, mercury, cadmium among others which have widespread inhalation-related illnesses to humans and also degrade the environment of the urban area. This signifies that central to their disposal management approaches are connections with the recycling actors a situation that is meted with a lot of challenges especially to cities of low-income countries [26]. However, even with all toxic components removed, the computer e-waste recyclers have high levels of toxic chemicals in their blood [27,28].

Table 2. Substances Restricted for Use in Electrical and Electronic Equipment [25]

Substance	Maximum concentration values (MCVs) %
Lead (Pb)	0.1
Cadmium (Cd)	0.01
Mercury (Hg)	0.1
Hexavalent Chromium (CrVI)	0.1
Polybrominated Biphenyl (PBB)	0.1
Polybrominated Diphenyl Ether (BDE) flame retardants	0.1
Polybrominated Diphenyl Ether (BDE) flame retardants	0.1
Bis (2-ethylhexyl) Phthalate (DEHP)	0.1
Butyl benzyl phthalate (BBP)	0.1
Dibutyl phthalate (DBP)	0.1
Diisobutyl phthalate (DIBP)	0.1

If improperly carried out, recycling emits hazardous heavy metals such as lead and cadmium. Chemical stripping of chips and gold-plated components have effects on the eye and skin resulting in permanent injury and inhalation of acid fumes resulting in respiratory irritation problems [29]; and death defects [30]; contaminate the air by dioxins and heavy metals; soil pollution from lead, antimony trioxide, mercury, arsenic, cadmium, selenium, polybrominated flame retardants, cobalt and chromium. When these toxic components are inhaled or are in contact with the skin or ingestion of the elements, they directly affect human health.

Removal of precious metals from the circuit board using acids degrades the environment when dumped on the ground or and pollute water sources when dumped into water sources. According to [31,32] shredding of plastics may cause physical injuries and melting it at low temperatures may expose humans to hydrocarbons, brominated dioxin and PAHs. The same components may contaminate air by dioxins, heavy metals and hydrocarbons.

4.5. Urban Mining

Recovering elements and recycling waste from computer components and accessories from disposal sites can also reduce the burden on raw material extraction from the mining industry. This would reduce the over-reliance on virgin materials which in some countries such as Congo DRC has fueled wars. It has been reported that 300 million new computers utilised 150,000 tons of copper, 9100 tons cobalt, Li-ion batteries (for laptops), 300 tons silver, 66 tons gold and 24 tons palladium produced worldwide was consumed in manufacturing of new computers and laptops in 2008 [33]. Urban mining can, therefore, reduce total global demand for production of metals from raw materials**.** Thus, reducing greenhouse gases (GHGs) that directly contribute to climate change and alleviates adverse impacts on human health and environmental degradation [34,35]. This activity, practiced by the waste pickers or scavengers, also reduces consumption of energy because, for most elements, reprocessing consumes less power than producing new items from raw materials [36]. This has been confirmed by [37,38].

4.6. Leasing of Computer E-Waste

One of the private universities practice this disposal management approach. It is a powerful tool to maintain a desired period by enabling predictable spending patterns, introducing best environmental practices and technologies for computer e-waste disposal management and relieving private companies of the burden of safely disposing of the used computers because the vendors retain ownership throughout the lease period. The mode of disposal management approach can also eliminate upfront costs and does not have any effects on human health and the environment. This is because the computer components and accessories are not dismantled before they are taken back by the vendors. This approach needs to be studied further to determine exactly how the computer e-waste is disposed of at EoL in order to establish the level of risk to humans and the environment. The University could also follow up to ensure that the waste is disposed of in an environmentally sound manner and also engage certified e-waste collectors by NEMA only, as stipulated in [2,12].

4.7. Selling Computer E-Waste to Certified E-Waste Collectors

The National Environment and Management Authority (NEMA) licensed e-waste collectors collect computer e-waste from the private companies. This is an acceptable mode of computer e-waste disposal management approach because there is no contact of the individuals at the point of collection with the broken down or obsolete materials from computer e-waste. There is, therefore, no potential human health or environmental effects from this type of disposal management approach. However, it is important to make a follow-up on where the collectors dispose of the computer e-waste.

4.8. Selling Computer E-Waste as Second-Hand Materials

Some households were found to sell their computer components and accessories as second-hand materials. This mirrors the findings on the Shah Community in Malaysia [3]. The encouragement of a market for used computers is advocated since this would extend their end-of-life [13,14]. Use of this disposal management approach extends the computer end-of-life and ensures that the computers is accessible to those who are not able to access new technologies at a cheaper price. As long as the computer components and accessories being sold as second-hand material are not broken-down, its contents do not have any potential risks to human health and the adverse environmental effects of the urban area.

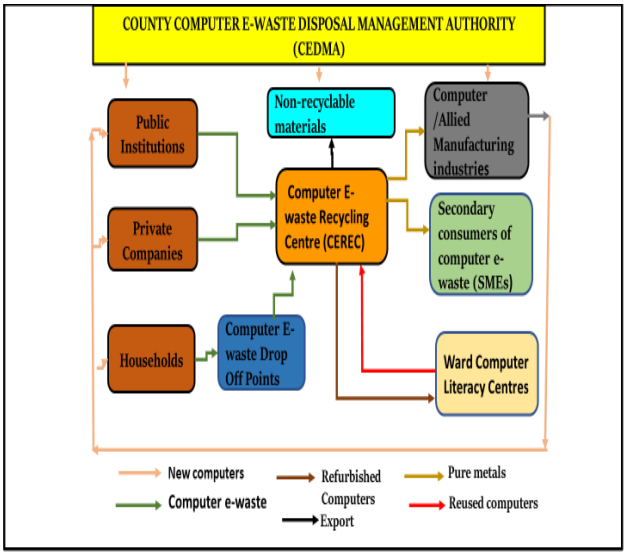
4.9. Open Air Burning of Computer E-Waste

The process of recycling through the open-air burning of computer motherboards, dismantling of printed circuit boards and cables to extract valuable materials at the vicinity of Dandora dumping site, exposes workers and residents within proximity to toxic chemicals such as lead, beryllium and tin. These compounds also contaminate the

both the soils, surface and ground water sources. The removal of computer chips and de-soldering of the printed circuit boards result in inhalation of tin, lead, brominated dioxin, cadmium and mercury and also causes air emissions of the same substances [31,32]. The writers report that recovery of steel, copper and precious metals may expose the humans and may impact on their health as a result of exposure to dioxins and heavy metals. The inhalation of toxic fumes on burning plastics may also cause asthma, skin diseases, eye irritation and in other cases long-term incurable diseases. The same chemicals have the potential to accumulate in the soil, water and food chain especially metal ions. High temperatures create a high concentration of metals in fly ash and high toxic fallout negatively impact on workers, their families and the urban environment.

4.10. Sustainability of Computer E-Waste Disposal Management

For sustainability, the study proposes that computer e-waste from all the public and private sector be taken to the county computer e-waste recycling centre (CEREC) where it would be processed in an environmentally sound manner resulting in zero computer e-waste. The household computer e-waste would be dropped off at strategic points at, residential/commercial neighbourhood computer e-waste drop off points (CEDOPs) from where it would be collected and taken to the CEREC. The computer e-waste at the recycling centre (CEREC) would be processed for reuse, refurbished, recycled for proper disposal to achieve zero e-waste to the landfill. Further, ward computer literacy centres (WCLCs) should be established in all wards to absorb the spill-offs from recycling facility for purposes of community computer literacy capacity building. The proposed sustainable computer e-waste disposal management system would provide social and financial benefits such as job creation and training opportunities to the county residents.



Sustainable Computer E-Waste Disposal Management Approaches Model

The county computer e-waste recycling centre would provide the raw materials (e.g. gold, copper, tantalum, palladium, rare Earth metals, aluminium, silver, and plastics (PP, ABS, PC, PS) to the computer/allied manufacturing industry. These metals are in short supply but crucial in the development of technologies in the computer manufacturing industries. Some of the non-recyclable computer components and accessories (e.g. lead glass funnel) would be exported to the high-income countries which have advanced technologies for recycling. The manufactured computer components and accessories are then sold to the public institutions, private companies and the households thus completing the sustainability cycle. The County Government would partner with the private sector to run the County Computer E-Waste Disposal Management System (CEDMS).

5. Conclusions

Several pointers towards potential effects of computer e-waste on human health and environment were identified. These includes the level of education and ownership of computer components and accessories; the average age of computers purchased in the institutions; duration at which they are replaced; and type of computers at the institution, private companies and the household level. Different types of computer disposal management approaches were used most of which had potential negative effects on human health and the environment.

The Public Procurement and Asset Disposal Act [12] was found to contribute towards unsustainable computer e-waste disposal management approaches because it makes available the broken down and unserviceable computers to the informal sector, where the same is dismantled using crude tools without any regard to human health and environmental degradation of the urban area. The broken down and unserviceable computer e-waste remaining after the public auctions are thrown away into the landfill. If this e-waste is allowed to weather in the landfill, it releases toxic materials such as cadmium, lead and mercury into the water sources, contaminates soils and pollutes the air thus directly and indirectly negatively impacting on human health and degrades the environment of the urban area. Recycling, reuse (through donations, selling as second hand-material) and refurbishment though not sustainable, were found to extend the end-of-life of the computer thus delaying the e-waste disposal into the landfill and reducing its potential risks to human health and environment.

The process of extraction of valuable materials from computer components and accessories through open burning was found to expose the workers and respondents living close to the vicinity of the dumping site to toxic chemicals thus compromising their health and degrading the environment through pollution of air, soils and water sources.

Leasing computers was found to remove away the potential effects on human health and the environment from the respondents since ownership is retained by the vendor until the specified time (usually 3 years for the private university). However, leasing removes the potential effects on human health and the environment once the e-waste is collected by the vendor. Urban mining was found to reduce the potential effects of computer e-waste on human health and the environment.

Lack of public education and awareness on potential risks of computer e-waste on human health and degradation of the environment was found to be the main reason households stored their e-waste in their premises, their unwillingness to pay for their disposal or handing over the same to the recycling facility (WEEE Centre) where it can be recycled using the best available technology and best environmental practices. Despite the various disposal management approaches practiced by the stakeholders, the risks to human health and the environment would continue due to the hidden flow of computer e-waste from low-income countries and the existence of the informal disposal management approaches.

6. Recommendations

The study recommends the establishment of a county e-waste disposal management system with a County E-waste Management Authority (CEMA) or a department created at the Communication Authority of Kenya or City County Office to implement a Zero Computer E-waste Policy (ZCEP) in the County. A two-level computer disposal management system would also be established namely: i) County Computer E-Waste Recycling Centre (CEREC) whose responsibility would be to ensure that computer e-waste from all actors is disposed of sustainably and ensure zero computer e-waste; and ii) strategic sites in all residential/commercial/neighbouhood areas. The computer e-waste would then be transported to the CEREC for processing in an environmentally sound manner. Any non-recyclable computer e-waste would be exported to high-income countries where it is reprocessed using best available technologies and best environmental practices. The ward computer literacy centres (WCLCs) would absorb some of the spin-offs from the CEREC for community capacity building. The CEREC and the WCLCs would be manned through private-public-partnerships. This sustainable system would translate into Zero computer e-waste or zero landfill, and hence negative potential effects on human health and the environment would be prevented. Similar studies should be undertaken in all counties of Kenya to quantify and generate information to facilitate planning for and implementation of sustainable computer e-waste disposal management. In addition, examination of those heavily involved in computer e-waste processing should be examined for possible poisoning.

Acknowledgements

This Author thanks the National Commission for Science, Technology and Innovation for the financial support for this research.

References

[1] Babayemi, J. O.. Evaluation of Solid Waste Generation, Categories and Disposal Options in Developing Countries: A Case Study of Nigeria. Journal of Applied Sciences and Environmental Management, 13 (3), 83-88, 2009.

[2] Castells, M.. The Information City: Information Technology, Economic Restructuring and the Urban-Regional Process. In B. Blackwell, The Information. Oxford, 1994..

[3] Mansell, R. Knowledge Societies: Information Technology for Sustainable Development, Oxford: Published for the United Nations Commission on Science and Technology for Development. Oxford University Press. Mansfield, E. (1963), 1998.

[4] Postman. Five things we need to know about changing technology. Retrieved from http://www.mat.upm.es/~jcm/neil-postman--five-things.html, April 16, 2016.

[5] Priyadharshini, S., Meenambal, T. A survey on electronic waste management in Coimbatore. International Journal of Engineering Science and Technology,, 3 (3), 273-294, 2011.

[6] World Commission on Environment and Department (WCED). Our Common Future. London: Oxford University Press, 1987.

[7] World Resource Institute.. World Resources, UNEP, UNDP, World Bank. New York: Oxford University Press, 1996.

[8] MacMichael. Environmental and social influences on emerging infectious diseases: past, present and future. The Royal Society, 1048-1058, 2004.

[9] Williams, E. K.. Environmental, Social, and Economic Implications of Global Reuse and Recycling of Personal Computers. Environmental Science and Technology, 6446-6454, 2008.

[10] Public Disposal Act, Nairobi, Government Printer, 2005

[11] Public Procurement Regulations, Nairobi: Government Printer, 2006.

[12] Public Procurement and Asset Disposal Act, Nairobi: Government Printer, 2015.

[13] William, E.Extending the PC lifespan through secondary markets for future work. IEEE International Symposium on Electronics and the Environment, 255-259, 2003.

[14] Hischier, R. W. Does WEEE recycling make sense from an environmental perspective: The environmental impacts of the Swiss takeback and recycling systems for waste electrical and electronic equipment (WEEE). Environmental Impact Assessment Review,25, 525-539, 2005.

[15] Tiep, H. S. Factors influencing household electronic waste recycling intention. Advanced Materials Research Vol. Advanced Materials Research, 622-623, 2012.

[16] Tiep, H. S. E-Waste management practices of households in Melaka. International Journal of Environmental Science and Development, 6 (11), 811-817, 2015.

[17] Sookman, D. A. Subtypes of obsessive-compulsive disorder: Implications for specialized cognitive behavior therapy. Behavior Therapy, 36 (4), 393-400, 2005.

[18] Kalana, J. A. (2010). Electrical and Electronic Waste Management Practice by households in Shah Alam, Selangor, Malaysia. International Journal of Environmental Sciences, 1(2), 132-144, 2005.

[19] Gaidajis G., A. KE-waste: environmental problems and current management. Journal of Engineering Science and Technology Review, 3(1), 193-199, 2010.

[20] Balakrishnan, R. B. Electrical and electronic waste: a global environmental problem. Journal of Waste Management and Research, 25, 307-317, 2007.

[21] Yadong, L. P.-C. TCLP heavy metal leaching of personal computer components. Journal of Environmental Engineering. 132 (4), 497-498, 2006.

[22] Khurrum, M. B. Electronic waste: a growing concern in today's environment. Economics Research International. 1-8, 2011.

[23] Hossain. E-waste: Bangladesh Situation. Study Report. Environment and Social Development Organization (ESDO). In D. Dewitt, D. Haglund, & J. Kirton, 2010.

[24] Osibanjo, O. N. The challenges of electronic waste (e-waste) management in developing countries. Waste Management & Research, International Solid Waste Association, 6, 489-501, 2007.

[25] European Union (EU) Directive 65/EC-Regulations. European Parliamentand of the councilon the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast),. Official Journal of European Union, 1 (7), 2013.

[26] Chawla, P.Generation amount prediction of hazardous substances from computer waste: a case study of India. International Journal of Emerging Technology and Advanced Engineering, 2 (3), 2012. Retrieved October 15, 2014, from www.ijetae.com

[27] Williams, E. K. Environmental, social and economic implications of global reuse and recycling of personal computers. Environmental Science and Technology, 42(17), 6446-6454., 2008.

[28] SVTC (Silicon Valley Toxics Coalition). Just Say No to E-waste: Background Document on Hazards and Waste from Computers, 1999. Retrievedfrom http:/www.svtc.org/cleancc/pubs/sayno.htm on October 2, 2017.

[29] Hileman, B. Electronic waste: states strive to solve burgeoning disposal problem as more waste ends up in developing countries. Chemical and Engineering News, 84 (1), 18-21, 2006.

[30] Davis, C. Why is electronic waste a problem? Earth trends, 2006.

[31] Deng, W. L. Atmospheric levels and cytotoxicity of PAHs and heavy metals in TSP and PM2.5 at an electronic waste recycling site in southeast China. . . Atmospheric Environment, 40 (36), 6945-695, 2006.

[32] Wath, S. B. Dutt, P. S., Chakrabarti T. E-waste scenario in India, its management and implications. Environ Monit Assess, 172, 249-262, 2011.

[33] Meskers, C. Umicore Precious metals Refining. Guest Lecturer presentation for e-waste recycling, 2009. Delft, Netherlands: Delft University of Technology.

[34] King, M. F. Contribution of cooperative sector recycling to greenhouse gas emissions reduction: A case study of Ribeirão Pires, Brazil. Waste Management, 33 (12), 2771-2780, 2013.

[35] Heacock, M.; Kelly, C.B.; Asante, K.A.; Birnbaum, L.S.; Bergman, Å.L.; Bruné, M.-N.; Buka, I.; Carpenter, D.O.; Chen, A.; Huo, X.; et al. E-Waste and Harm to Vulnerable Populations: A Growing Global Problem. Environ. Health Perspect. 124, 550-555, 2015.

[36] Gutberlet, J. Cooperative urban mining in Brazil: Collective practices in selective. Waste Management, 1-10, 2015.

[37] Cui, J., Forssberg, E. Mechanical recycling of waste electric and electronic equipment:. A RevMateriew. J. Hazard, 99, 243-263, 2003.

[38] Eygen, E. V. Resource savings by urban mining: The case of desktop and laptop computers in Belgium. Resources, Conservation and Recycling, 107, 53-64, 2016.

[39] Bell, A. (1993). Some experiments in diagnostic teaching. Educational studies in mathematics, 24 (1), 115-137.

[40] Mugenda, O. M. (2003). Research Methods, Quantitative and Qualitative Approaches. . Nairobi: African Centre for Technology Studies (ACTS) Press.