Original article

Electronic Waste Management in households, Khartoum State, Sudan

Awadia Gibreel AbuOsman Abbas* and Abdel Karim Sabir Ali

Department of Environmental Sciences, Faculty of Science and Technology, Al-Neelian University, Khartoum, Sudan.

A R T I C L E I N F O

Abstract

The present study was conducted to assess the status of households' electronic waste (e-waste) management and its impact on the environment in Khartoum State, Sudan. 300 households in Khartoum State were chosen for this research: 150 in Khartoum North, 70 in Khartoum and 80 in Omdurman. The data was collected using field visits, personal communication and questionnaires. The number of questionnaires distributed was 415 (33% males and 67% females). The results which was statistically analysed revealed that E-waste types in Khartoum State households were mostly dominated by fans (10.2%), mobile phones (8.5%) and fluorescent lamps (8.2%). Households' e-waste contains also some hazardous substances e.g. in lamps (Hg, Zn, Li) and mobile batteries (Li). Most of the households is normally disposed with municipal domestic wastes and undergoes the normal route of waste management. Otherwise, e-waste is stored within the houses, burnt or recycled (10.4%)or sold to scrap dealers.The questionnaire analyses indicated that the majority of respondents (77%) were aware of the environmental problems created by e-waste.

*Corresponding author: awadia.abbas@yahoo.com

Introduction

E-waste has been emerging as a new problem and issue of concern for everybody. Though being new, it has been raised as a disturbing problem for a future. As we are becoming more dependent on electronic products to make life more convenient, but on the other hand, it has also led to unrestrained resource consumption and an alarming waste generation. These products contain harmful chemicals like: Lead, Cadmium, Mercury, Plastics, Barium, Beryllium, Phosphorus and additives. Several environmental protection agencies around the world consider WEEE to be hazardous waste because they have chemicals compounds in their composition that are toxic and harmful to human health and to the environment. So, if they are not disposed of or recycled properly these toxic materials can create health as well as environmental problems (Jinhui *et al.*, 2013; Rafia *et al.*, 2013).

Sudan is expected to have generated huge volume of Electronic Waste, as its ICT infrastructure has grown

substantially in the past and is expected to grow exponentially in the future. Sudan is currently undergoing rapid advances in the use of ICTs. Starting with the active use of computers by Sudanese in 1990s, the country believes in ICT implementation in all sectors of production to increase the pace of socioeconomic development and create value for all citizens. We could mention the program such as one computer per family and electricity distribution in the whole country that may increase the use of EEE. Although Sudan is a signatory to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, at this stage not much has been done about e-waste. Sudan Environment Act, 2001, which is the basic environmental law. Currently, Sudan has no specific legislations regulating the management and safe disposal of E-wastes. However, there are legislations already developed and others being developed concerning the management of wastes in general (Abdel Hamid et al., 2009). In Sudan, as it is in the developing countries, electronic scrap is managed through various low-end management alternatives such as product re-use, conventional disposal in landfills, open burning and backyard recycling (Sepulveda et al., 2010; Mara, 2008). People in Sudan normally send their dysfunctional electronics to the electro-technicians to be repaired. It happens that they instead selling their dysfunctional appliances or reparable devices. After that, the electro technicians' garages become collecting points of E-waste that the waste-traders and recyclers are visiting periodically for bulk-purchasing purposes.

The research question: What is the current e-waste management of households in Khartoum State, Sudan? The main objective of this research is to assess the status of households' electronic waste (e-waste) management and its impact on the environment in Khartoum State, Sudan.

Methods

The structured questionnaire has been distributed through December 2014-February 2012 by a survey in Khartoum State, Sudan. 300 households in Khartoum State were chosen for this research: 150 in Khartoum North, 70 in Khartoum and 80 in Omdurman. The data was collected using field visits, personal communication and questionnaires. The number of questionnaires distributed was 415 (33% males and 67% females).The data was collected using a random sampling method. Face-to-face interviews were employed to ensure a higher response rate for data collection. It was expected that the selection of one individual per household would produce better representativeness of the sample (Valle et al., 2005) and also to avoid redundant information collected. To ensure this, while distributing questionnaires, participants were informed about the criteria of one individual per household verbally.

In this study, the first section of the questionnaire gathers the data for the distribution of participants' information. The second section collects the information about participants' possession and disposal of EEE. Specifically, participants were asked to state the number of the particular categories of electronic items (televisions, computers, and mobile phones) disposed during the past years and the number of unit(s) which they possessed (both still in use and not use). This was followed by asking them about their methods of disposal. Lastly, the reasons for the disposal of these obsolete EEE were asked. Data was statistically analyzed using SPSS Version 18. Results were presented in form of tables and figures, comparison between variables assessed using chi square and Pearson correlation tests with the level of statistical significance set at $P \leq 0.05$. The data collected from the survey is meant to be used as a tool to support the qualitative information. All information obtained may be useful for decision makers, environmentalists, educators and businessman in planning for social sustainable development.

Results and Discussion

Table I presents a summary of the participants' demographics. We successfully distributed 450 questionnaires among households and collected a total of 415 completed questionnaires. This indicates a response rate of 92%. The data collected were predominantly female (67%) and male (33%). The age group with the highest number of participants is the 18-29 age with 167 participants (40%). For education levels, the percentage of graduate and non-graduate are 71% and 29% respectively. As for the participants' remuneration details, most of the participants (66%) are paid between SD 800-SD 3000.The average household size is 6 persons per household with 70.36% of the respondents living in households of 4-8 members. Less than 2.0% lives in single member households and not more than 12.5% live in households with 9 or more members. This household size is compatible to estimation of the Sudan 5th Population Census 2008 (Central Bureau of Statistics, 2010).

Electronic appliances in households of Khartoum State, Sudan

In the past, electronic appliances were considered as luxury items and were unaffordable to the common people. However, electronic appliances provide satisfaction and increase convenience in everyday life (Widmer *et al*., 2005).. Therefore, their usage becomes more and more popular in Sudanese households (Figure 1 and 2). Figure 2 depicts categories of EEE owned by participants. Most dominant types were fans (10.2%), mobile phone (8.5%) and fluorescent lamps (8.2%). Similarly, the study by Perunding Good Earth 'PGE', (2009) found that mobile phones contributed the most to the total e-waste generation compared.

Once a household has used the EEE until its end of life, the equipment will undergo the mechanism of disposal. Most of this waste electrical and electronic equipment (WEEE) are believed to end up in the landfill sites without proper treatment as there is no adequate segregation or disposal system to convince the households to recycle and discard e-waste presently (Kalana, 2010).

For the average unwanted EEE (13%) that are still in possession by the participants (Figure 3a,b), it has an average of 0.4 for fans, 0.2 for televisions,0.2 for personal computers, and 0.8 for mobile phones (Figure 4.a,b). Again, mobile phone is leading the list. Even though these numbers are likely lower bounds, it does indicate that many households have accumulated e-waste. It also indicates that there is an increasing pile of used and obsolete EEE which can readily to enter the municipal waste stream. This result obtained is similar to the study of PGE, (2009) where it was found that the percentage of unwanted EEE presently owned by households is 23.95%. This may be explained by the tendency of participants to store EEE in their houses. This also indicates that many participants do not immediately dispose of or recycle EEE that are no longer in use. Tiep, (2015) had mentioned some possible factors that add to the hoarding of unwanted EEE are:

1) Households do not know how to dispose of it safely and conveniently.

2) Households may think that some of the internal component of the equipment can still be used and thus are kept for future cannibalization of parts.

3) Households face reluctance in disposing their WEEE as they had spent a great deal of money to purchase these items.

4) Households are waiting for collectors to purchase the discarded WEEE from them.

The fate of these used EEEs which are still possessed by participants should be given great concern because if they are improperly disposed, they may be harmful to human health and the environment due to their toxicity and growing volume.

Updating time of the EEE product

The updating rate is associated with the designed lifetime of the product. According to commonly adopted international criteria, the product lifetimes are 8 to 10 years for color TVs, 13 to 16 years for refrigerators, 8 to10 years for general washing machine, and 6 years for personal computers. The survey showed that the time to updating the electrical and electronic equipment is different.
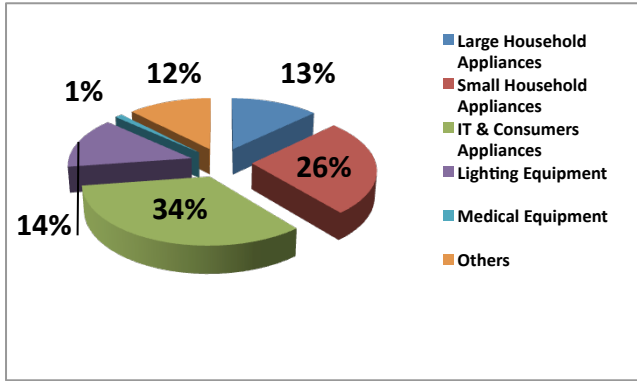
Figure 1. Composition of Households Appliances EEE in Khartoum State

Table I: Respondent's Demographic Profile

Parameter		%	Parameter		%
Gender	Male	33.3	Family size	1	1.9
	Female	66.7		2 - 3	15.2
Age	18 - 29	40.2		4 - 5	35.2
	30 – 39	30.4		6 – 8	35.2
	40 – 49	21.7		Above 8	12.5
	50 - 59	5.5	Monthly Income	Under 500	3.37
	60 - 60+	2.2		500 – 800	12.77
Education level	Illiterates	1.4		800 – 1000	21.2
	Primary school	3.6		1000 – 1500	24.09
	Secondary school	14		1500 – 3000	15.66
	Bachelor's Degree	54.2		Above 3000	22.89
	Post Graduate Degree	26.7			
Job sector	Governmental	39.8	Total		100
	Non – governmental	55.2	Total number of respondents		415

For example, the percentage of refrigerators phased out within 10 years reaches 20% and for washing machine is about 7%. The percentage of TV set phased out 6 years and above has higher percentage which is about 47%. However, there are some residents that use electrical and electronic equipment past their designed lifetime e.g. 71% of personal computer, 35% of mobile phone, and 47% of TV.
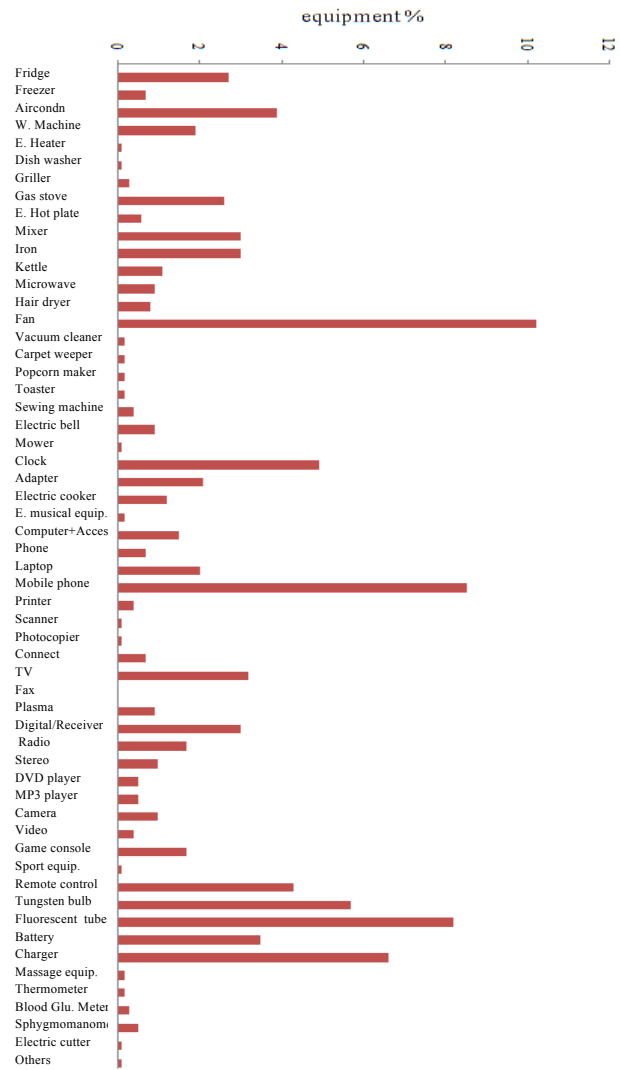

Figure 2. Amount of EEE owned in house by the participants.

The participants tended to keep their TVs much longer than PCs. The reason might be because the technology upgrading of TVs is not as fast as PCs. However, with the more competitive price of plasma TV, LCD TV or LED TV, the conventional CRT TV will soon be faced out due to the affordability of the new products..

Why the households updating their EEE?

In this study, the respondents express five reasons for updating their electrical and electronic equipment as shown in (Figure.5).The results indicated that 85% of the respondents had

updated their EEE because previous product damaged or not functioning anymore. Another significant reason stated by 64 % of the respondents is that EEE had less capacity; when new items have additional and more advance technological features (54%).This reflected that the advancement of mobile telecommunication for example, results in a high frequency of changing mobile phones because consumers are attracted by their features and stylistic expectations such as coloured screen, audio quality, bigger memory capacity, etc.

Only 43% of respondents mentioned that they had updated their EEE because their disposable income has increased, where as 49% informed that they had not been influenced by advertisements or friends to update their EEE.

Figure 3a. New and used EEE. **3b.** In/Out service household appliances.

Awareness about laws and legislations

The survey was responded mainly by the elder member of the family. The respondents answer to the question whether they were aware about the government of Sudan's environmental law. Overall, 38.8 % of respondents reported being familiar with the term environmental law and that 35.7% reported that they are unaware. 8.9% of respondents knew that there is a government policy fore-waste management, 70.4% were not aware of the policy and 20.7% did not have any idea of what the policy is all about (Figure 6a, b).

Level of Awareness towards E-Waste Concept and Components:

The majority of the respondents (77%) knew that the E-waste could create problems in the environment as well as with human health. 8% of the households replied that they did not know

about it.

The level of awareness is highly influenced by the lack of information. The survey revealed that awareness level is higher in graduates (48.6 %) surprisingly less in postgraduates (24.3 %). As regard to family income, it played appositive role in awareness indicating that the income level rises concomitantly with the awareness and stabilizes after one lag (Figure 7a, b).
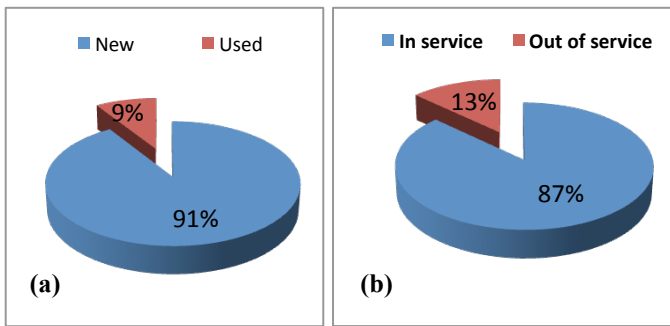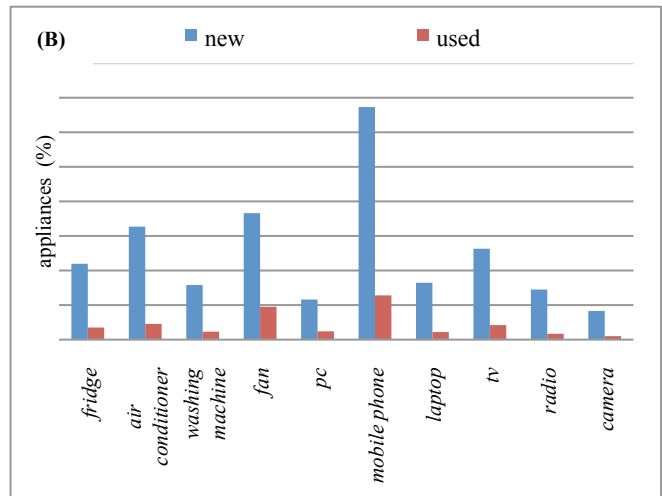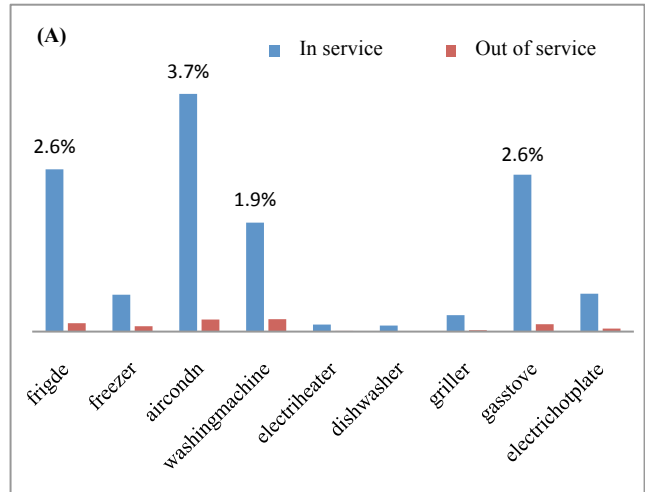

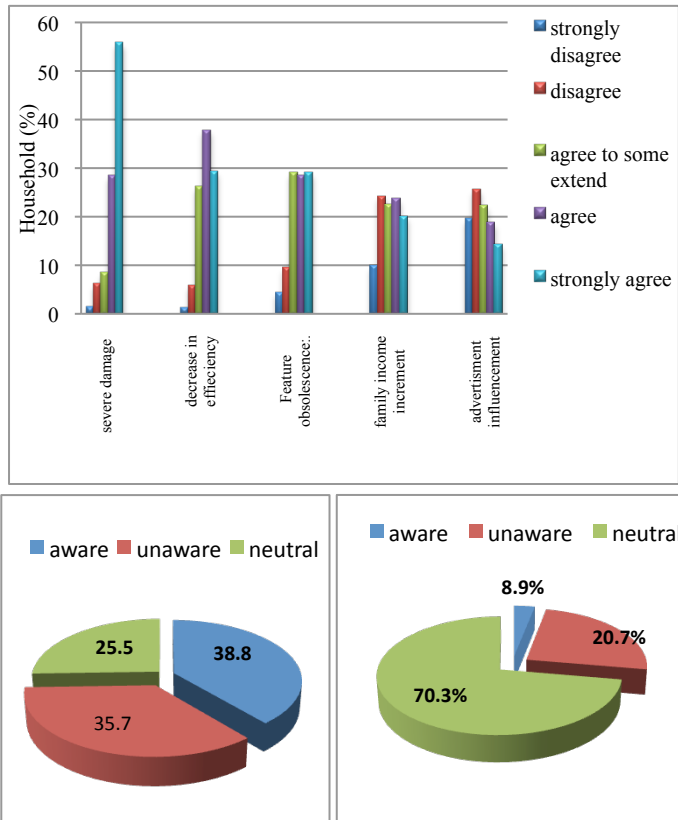**Fig. 4a**. Large Household Appliances. **4b**. Dominant EEE owned by households

Fig. 6 a. Environmental law awareness. **6 b.** E-waste policy awareness

E-waste disposal practices and channels

The household members were probed on how they dispose of their unused electronic products, 44.8% households use the regular waste collection facility to dispose them off by mixing them with solid waste and 55.2% households do not mix it with solid waste for disposal. The household's disposal channels were also analyzed73.5% of the households bartering their old non working products while buying the new one. 86.3%donate, 77.6% sell it to the second hand dealers, 74% send it to repair center, and 47.5% store it as waste at home. The fact that storage method is chosen rather than reuse or other disposal methods is a crucial factor. This indicates the lack of awareness on where to dispose of obsolete EEE and psychological factors such as the belief that e-waste has some value. On the other hand, the

literature has also shown that most consumers keep their unused or broken EEE for years before reselling or disposing of the equipment (Saphores et al.,2009). Only16.9% of the respondents use open burning and 10.4% said they use other channels of disposal (Figure 8). The higher % of exchanges indicates that the old products reach the dealers may help in implementation of e-waste management strategy.

The most dangerous form of burning e-waste is the open-air burning of plastics in order to recover copper and other metals. The toxic fall-out from open air burning affects the local environment and broader global air currents, depositing highly
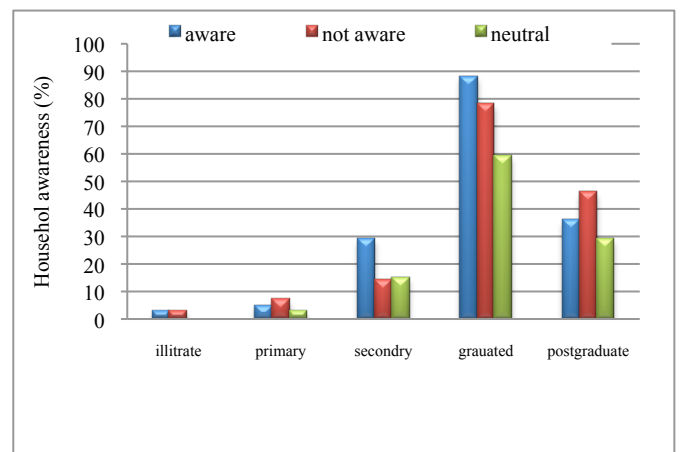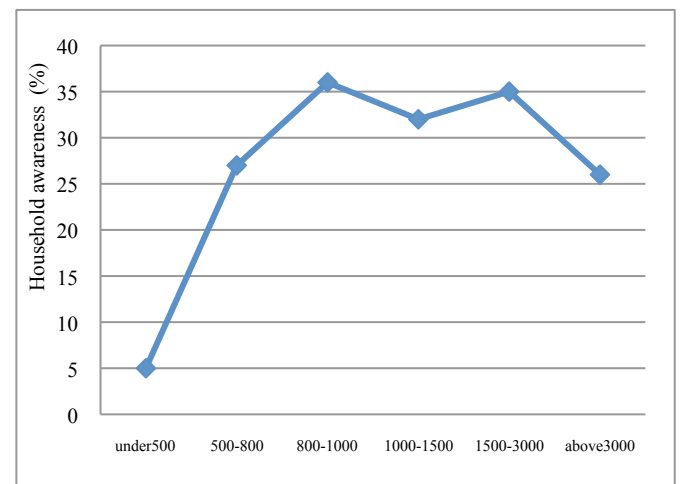

Fig. 7. (a). Household awareness as income function. **(b)**. Household awareness as a function of education.

toxic by-products in many places throughout the world

(Ramachandra and Saira, 2004).

Landfill disposal can contaminate the soil or subsoil with metals and/or toxic substances from WEEE. Some studies, such as those by the EPA (2001) and Spalvins, (2008) show that contamination by WEEE in landfills is difficult to quantify because there are many external factors affecting the decomposition of chemicals, including temperature, pressure, pH, and oxygenation of the medium, among others.
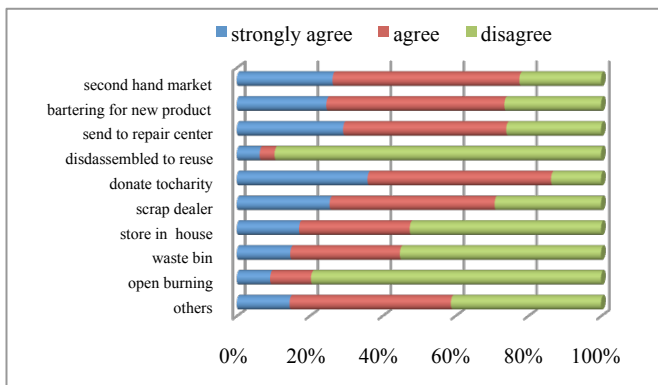
Figure 8. Disposal channels for e-waste.

Waste collection services

For waste collection services 17.3% of the respondents respond to have waste collector providing services in their area and 66.3% respondents do not have the service. Further probed to know if there standards on which they can differentiate between hazardous and non-hazardous waste, 46% were not aware of such measures, 31.8% were aware. This supports the fact that Khartoum state has waste collection system, but not convenient to households. For treating E-waste, collection centers need to be found and awareness need to be increased. Improper disposal or contact with E-waste can lead to contamination of the surrounding ecosystem and can be a major health hazard (Nagendra *et al.*, 2009). However land filling of E-wastes can lead to the penetration of heavy metals in ground water. Burning of CRT emits toxic fumes into the air (Ramachandra *et al.*, 2004).

"Ensure environmentally sound management of e-waste at all stages, including collection, storage, transportation, recovery, treatment and disposal, with appropriate considerations on health and safety aspects of those involved. Several tools have been developed and applied to e-waste management, including: LCA (Life Cycle Assessment), MFA (Material Flow Analysis), MCA (Multi Criteria Analysis) and EPR (Extended Producer Responsibility) (Kiddee *et al.*, 2013). These management tools, combined with the existing laws in different countries, can help improve the disposal of electronic waste in the world, increasing the reuse of materials and reducing environmental impacts.

Conclusions & Recommendations

Conclusion

In this study it was found that 77% of the participants were aware about e-waste concept.

The problem now is that the waste stream is permeated with WEEE and because this is disposed of in the general municipal waste, sometimes burnt and produces harmful chemicals (PCDD/PCDF) and affects the health of the collectors, repairers and informal recyclers.

Presently there is no proper infrastructure for the sound management/disposal of WEEE. Also no policy or legislation on WEEE exists in Sudan. Households in Khartoum mostly dispose of E-waste with municipal waste as well as sold to scrap dealers. Increased consumption of EEE due to its utilization in the day-to-day life of individuals has indirectly explained the increase in the generation of e-waste.

Recommendations

1. Massive awareness on the dangers of WEEE
2. Urgent need for collection centers.
3. Awareness workshops on WEEE for decision makers and regulators.
4. Develop an e-waste management strategy.
5. Develop policy and legislation for the sound management of WEEE.
6. Facilitate the formation of a cooperation of WEEE recyclers.
7. Conduct training workshops for enforcement agencies.
8. Build the capacities of relevant institutions in terms of infrastructures and manpower.

9. Create a database for WEEE
10. Establish a registration mechanism (Registry for WEEE and EEE).

References

Abdel Hamid, H.A., Donald, A. M. and Deborah-Osiro, D. (2009). Situation Report Nature and extent of environmental crime in Sudan.

Esty-Daniel, C.,Levy, M. A, Kim, C. H.,Sherbinin, A., Srebotnjak, T. and Mara,V. (2008). The Environmental Performance Index, New Haven: Yale Center for Environmental Law and Policy.

Gätke, P.(2003). Future Management of Hazardous Household Waste in Petaling Jaya: A preliminary assessment. Universiti Malaya and Roskidle University Centre (RUC) Denmark, 2003 http://ndl.handle.net/1800/147.

Gullett, B. K., Linak, W. P., Touati, A., Wasson, S. J., Gatica, S. and King, C. J. (2007). Characterization of air emissions and residual ash from open burning of electronic wastes during simulate rudimentary recycling operations. *Journal of Material Cyclesand Waste Management*, 9, 69–79**.**

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.

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

Li, J., Liu, L., Zhao, N., Yu, K. and Zheng, L. (2013). Regional or global WEEE recycling. Where to go? *Waste Management,* 33, 923–934.

McCann, D. and Wittmann, A. (2015). E-waste Prevention, Take-back System Design and Policy Approaches. Solving the E-waste Problem (StEP).

Mureithi, M. and Waema, T. (2008). E-waste Management in Kenya. Nairobi: Kenya ICT Action Network (KICTANet).

Nagendra-Guptha, C. K and Shekar, G. L. (2009). Electronic Waste Management System in Bangalore – A Review. *JK Journal of Management and Technology,* 1 (1), 11–24.

Peralta, G. L. and Fontanos, P. M.(2006). E-waste issues and measures in the Philippines. Journal of Material Cycles and Waste Management, 8 (1), 34–39.

Perunding Good Earth 'PGE', (2009).The E-waste inventory project in Malaysia, Department of Environment, Malaysia and EX- Corporation, Japan.

Rafia, A., Muhammad M. M., Rulia A., Jarita B. D. (2013).Survey and analysis of public knowledge, awareness and willingness to pay in Kuala Lumpur, Malaysia a case study on household WEEE management. *Journal of Clean Production*, 52, 185–193.

Ramachandra, T.V., and Saira,V. K. (2004). Environmentally sound options for waste management. *Environmental Journal of Human Settlement,* 3-11.

Rani, B., Singh, U., Maheshwari, R., Chauhan, A. K. (2012).Perils of electronic waste issues and management strategies.*Journal of Advance* Scientists Research, 3 (1), 17-21. At: http//www.sciensage.info/jasr

Saphores, J. D. M., Nixon, H., Ogunseitan, O. A. and Shapiro, A. A. (2009). How much E-waste is there in US basements and Attics? Results from a national survey.*Journal of Environmental Management*, 90 (11), 3322-3331.

Sepulveda, 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 equipments during recycling examples from China and India. *Environmental Impact Assessment Review*, 30 (1), 28–41.

Sinha, S. (2008). "Dark shadows of digitization on Indian horizon", In: Johri, R. (ed.),E-waste: Implications, regulations, and management in India. New Delhi: The Energy and Resource Institute pp. 23-44.

Spalvins, E., Dubey, B. and Townsend, T. (2008).Impact of electronic waste disposal on lead concentrations in landfill leachate.*Environmental Science Technology,* 42, 7452–7458.

Sudan Central Bureau of Statistics (CBS) CBS/NBHS, (2009).Statistical Report No. 3/2010Sudan Data Portal.Census.Available at:
http//www.cbs.gov.sd/sites/default/files/Publications

Tiep, H. S., Tong D. K., Ahmed, E. M. and Teck, L. C. (2015). E-waste Management Practices of Households in Melaka. *International Journal of Environmental Science and Development*, 6(11), 811 - 817.

Williams, P. T. (2005). Waste Treatment and Disposal.Chichester: 2nd edition John Wiley and Sons, Ltd.