Electrical and Electronic Waste Management

− A Case Study in University of Duhok, Iraq

Naz Abdulkareem Arif, Rafia Afroz

Department of Economics, Faculty of Economics and Management Science,
International Islamic University Malaysia, Malaysia

rafia_afroz@yahoo.com

***Abstract*-The aim of this paper is to investigate the perception, knowledge and attitude of the households towards electrical and electronic equipment waste (e-waste) management in Duhok city, Iraq. It also tried to identify current e-waste management practiced by households in Duhok. It has been found in this study that much of the electrical and electronic equipment was updated within two thirds of their designed lifetime. Most of the respondents informed that they just threw their e-waste to the waste bin. It can be concluded that all stakeholders of e-waste management, from the government and nongovernmental sectors should consider shifting the management options towards the top of the waste management hierarchy (prevention and waste minimization) by substituting the hazardous materials in e-waste and encouraging redesign of equipment for a better control of the negative impacts of e-waste.**

Keywords- E-waste Management; Awareness and Attitude; Product Life Time; Updating Time; Deposit and Disposal

I. INTRODUCTION

Electrical and electronic equipment waste (e-waste) is said to be the fastest growing waste stream in the world (Nnorom and Osibanjo 2008, Jain 2008, Cui and Forssberg 2003), with the growth rate at 3% to 5% per year (Mohan *et al.* 2008), which is three times faster than the general waste (Pucket et al. 2002), thus creating a great management challenge to most countries worldwide. Managing e-waste is a challenging task, not only due to its rapidly increasing volume, but more importantly because of its hazardous nature. E-waste contains numerous hazardous substances which may pose a threat to the environment and human health if they are not disposed of in the correct manner. On average, 9% of the weight of e-waste is made of hazardous substances such as lead, cadmium, mercury (heavy metals) and other toxic chemicals (Umweltbundesamt 2006, in Sarkar 2008).

Petroleum refinement is easily the most valuable and developed modern industry in Dohuk, Iraq. So, income level as well as standards living depend on Iraqi oil price (Izady, 2008). Recently, increasing in the income level is pushing the consumers to buy more electronic and electric equipments (EEE). In every house in Dohuk city, there are more than one TV set, refrigerators, air conditioners, personal computers and mobile phones. As a result, deposit and disposal of municipal solid waste (MSW) has become one of biggest environmental issues of today. The experiences from developed countries show that sorting of MSW should be the first step for handling this issue. E-waste is an increasing stream in MSW.

Currently e-waste recycling efforts in the Arab region have mostly been limited to random and small scale initiatives. So, the problem of e-waste management in most countries of the Arab Region is in a dire need for immediate solutions, technically financially and indeed politically. In the absence of dedicated facilities to handle hazardous waste, there is a real concern that such waste will be disposed of with non-hazardous waste, thereby contaminating landfills, soil, water, air and exposing public health to great environmental risks. The aim of this paper is to estimate the perception, knowledge and attitude of the respondents towards environment and specially e-waste management in Duhuk city, Iraq. It also tried to identify current e-waste management practiced by households in Duhuk.

II. E-WASTE MANAGEMENT IN ARAB COUNTRIES

Due to industrial developments and urban expansions in the Arab Region, the rates of hazardous waste generation are increasing. Jordan for example (a non-oil producing country with population of about 6 millions) reported in 2005 to Basel Convention (BC) a generation of 17,000 tons of hazardous waste, Tunisia on the other hand (a non-oil producing country with population of about 10 millions) reported a generation of 71,000 tons of hazardous waste, while Oman (an oil & gas producing country with population of about 3 millions) reported in the same year a generation of 242,000 tons of hazardous waste (BC, 2005). Chemical and petrochemical industries are the major source of hazardous waste generation. Small and medium size enterprises (SMEs), such as electroplating shops, tanneries, auto-repair garages, have also playing their significant share in generating hazardous waste. Unfortunately, there are no comprehensive databases and inventory projects that can reflect accurately the amounts and types of hazardous (and other) wastes generated in the Arab Region (ESCWA, 2007). The Arab Region totally depends on uncontrolled dumping and opened burning as the only means of ultimate disposal. Treatment, storage and disposal facilities (TSDF) of hazardous wastes are quite scarce in the Region (e.g., some TSDF exist in GCC countries), and when they exist are inadequate to handle the large quantities of waste produced in the Arab Region as a whole (Al-Yousfi,2003). In a nutshell, hazardous wastes have will continue to cause major health, environmental and developmental challenges for the Region.

Although there are no reliable statistics pertinent to the imminent e-wastes problem in the region, one should know that the prevalence of ICT in the Arab region although leaping is still below that of international average. From 2002 to 2007 internet subscriber rate rose by factor four in the Arab Region, and mobile phone subscribers rose over 56% in the last five years (UNEP, 2008). Consequently, there is a huge growth potential in the e-waste streams, So far, e-waste recycling in the Arab Region is still at infancy and made by the informal sector, where very few basic precautionary measures are applied to protect workers' health and/or the environment (UNEP, 2008). As the Arab Region is greatly vulnerable to military operations and conflicts, one cannot pinpoint to the dilemma of hazardous wastes of military origins, for example, Palestinian Territories and Iraq, where such a dilemma is still looming (UNEP, 2008; UNEP, 2009). In armed conflicts, hazardous waste can be generated either by the weapons used (e.g. Depleted Uranium, and the Tungsten in the Dense Inert Metal Explosive (DIME)) (and/) or from the materials built-in and/or stored in a structure that is damaged by the war (e.g., asbestos, chemicals stored in warehouses). Gaza for example has a significant legacy of such contaminated and ruined sites due to recent military bombardments (UNEP, 2009). Some sites have major problems with hazardous waste components as well as with contaminated natural media (e.g., soil, water…etc.). Each site has to be assessed separately in a systematic manner to identify specific contamination issues, exposures scenarios and corrective actions. In Iraq and in Lebanon, military targeting of industrial sites (e.g., Al-Qadissiya Site in Iraq and El-Jieh PowerStation in Lebanon) (UNEP, 2008; UNEP, 2009) produced acute terrestrial and/or marine chemical contamination in the medium- and long-terms. If not properly remediated, such sites represent a severe risk to human health, specifically to site workers, trespassers as well as neighboring communities.

Recently in Iraq, it was discovered that private contractors employed by the American forces are disposing the military wastes into the Iraqi environment. A 2009 Pentagon document estimated 5,000 tons of hazardous wastes are so far produced by the American troops In Iraq (Times News Paper, 2010). This huge hazardous waste legacy which should have been shipped back to the USA for proper treatment and disposal (in accordance with the international law), may have ultimately ended up not only in Iraq ecosystem but also within an easy reach of children, and occasionally in close proximity to irrigated farmlands (Times news Paper, 2010). Even with concerted remediation and cleanup efforts in the future, irreversible environmental health damages may have already been done chronically for several generations to come. Worth-mentioning, that there are notable and rising claims in various geographical areas in Iraq of increasing rates of cancer cases, birth defects, and illnesses linked to chemicals exposure (Times News Paper, 2010).

TABLE I ESTIMATION OF HAZARDOUS WASTE QUANTITY ON GDP BASIS

State	World Bank Classification	GDP estimates for 2006(in $million)	Estimates of hazardous waste quantity (Around 1000 tons)
Egypt	Medium-Low	107,378	214
Saudi Arabia	High	348,673	Over 697
UAE	High	164,865	Over 329
Kuwait	High	101,904	Over 203
Bahrain	High	15,828	Over 31
Oman	Medium- High	35,656	71
Qatar	High	52,722	Over 105
Yemen	Low	21,196	21
Jordan	Medium-Low	14,258	28
Morocco	Medium-Low	65,899	132
Syria	Medium-Low	34,190	68
Tunisia	Medium-Low	31,416	63
Lebanon	Medium- High	23,285	46
Sudan	Low	43,894	44
Mauritania	Low	2,713	3

Source: world Bank 2007

III. METHODOLOGY

In this study the survey questionnaire includes the questions related to the public knowledge/awareness of the environment, the EEE product lifetime, the reasons for updating and the deposit and disposal of e-waste order to provide the fundamental information of public awareness and environmental performance to the local government and decision-makers. A sample was taken in the University of Dohuk in Dohuk city including graduate and postgraduate staff. All of the residents were Iraqi citizens. The questionnaires have been distributed to 350 respondents and then collected. Of the 350, there were 332 acceptably

completed the questionnaire. Public environment awareness is one of the most important indicators for displaying many aspects of environmental status, such as peoples' knowledge, personal consideration and behavior and the local citizen's attitudes towards sustainable society as a whole. All of the information is useful for decision makers, environmentalists, educators and businessman in planning for social sustainable development (Xu, 1999). In the survey, 64% of the respondents weren't satisfied with Dohuk's environmental quality, while 36% were satisfied. In Kuala Lumpur, the majority of the households (54%) were dissatisfied with the quality of the current waste collection services (Afroz and Mehedi, 2010).

IV. RESULTS AND DISCUSSION

A. Attitude of the Respondents towards Household Waste Sorting at Source

Petroleum refinement is easily the most valuable and developed modern industry in Dohuk, Iraq. So income level as well as standards living depend on Iraqi oil price (Izady, 2008). Recently, increasing in the income level pushes resident to pay more electronic and electric equipments. In every house in Dohuk city there are more than one TV set, refrigerators, air conditioners, personal computers and mobile phones. As a result, Municipal solid waste (MSW) deposit and disposal has become one of biggest environmental issues of today. The experiences from developed countries show that sorting of MSW should be the first step for handling this issue. Waste electrical and electronic equipment is an increasing stream in MSW. Therefore, some questions in the survey were designed to obtain local public opinions and attitudes towards the handling of MSW.

The survey data revealed a positive attitude towards sorting of MSW, at the source. The percentage of the respondents choosing "I am willing to sort household wastes into separate containers" is about 40%. About 23% of the respondents selected "I will sort my household wastes if the government requires me to do it". That means that about 63% of the respondents accepted sorting of waste, at the source. About 16.3% and 20.8% of the respondents chose "It is not a proper time since there is no sorting and collecting system" and "It is impossible because of the lack of public environmental awareness even if there is a sorting and collection system", respectively (Table 2) .

TABLE II ATTITUDE TOWARDS HOUSEHOLD WASTE SORTING AT THE SOURCE

Items	Frequency	Percentage
I'm willing to sort house hold waste into separate containers	133	40
I will sort my household waste if the government requires me to do it	76	22.9
It is not a proper time since there is no sorting and collecting system	54	16.3
It is impossible because of the lack of public environmental awareness even if there is a sorting and collecting system	69	20.8
Total	332	100

B. Deposit and Disposal of Waste Electrical and Electronic Equipment

Electrical appliances provide satisfaction and increase convenience in everyday life and, as a result, their usage becomes more and more popular in Iraqi households. Rapid development of technology in electrical and electronic industries not only offers a wide range of product choices but also price choices. Now some products are available in more affordable prices. With the increase in purchasing power and the generally affordable prices of electrical and electronic equipment (EEE), the residents of Iraq are able to own more than one type of EEE or multiple units of the same type of EEE such as mobile phones. It gives individuals the opportunity to have electronic goods in their home (Kelana, 2010).

C. Product Lifetime

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 shows that the time to updating the electrical and electronic equipment is different. For example, the percentage of refrigerators phased out within 10 years reaches 55% and the figure for washing machine is about 49%. The percentage of TV set phased out 6 years and above has higher percentage which is about 33%. However, there are some residents that use electrical and electronic equipment past their designed lifetime. It was observed that much of the electrical and electronic equipment was updated within two thirds of their designed lifetime, such as 37.7% of personal computer, 51% Mobil phone, and 34.3% of camera (Table 3).

TABLE III UPDATING TIME FOR ELECTRONIC AND ELECTRIC PRODUCTS

Television	%	Refrigerator	%	Washing Machine	%	Computer	%	Mobile Phone	%	Camera	%
1 to 2	11.1	1 to 2	5.7	1 to 2	6.3	1 to 2	19.6	1 to 2	50.9	1 to 2	27.1
2 to 4	30.1	2 to 4	12.3	2 to 4	18.4	2 to 4	37.3	2 to 4	30.4	2 to 4	34.3
4 to 6	25.6	4 to 6	26.8	4 to 6	26.2	4 to 6	20.2	4 to 6	7.5	4 to 6	13
Above 6	33.1	Above 6	55.1	Above 6	49.1	Above 6	22.9	Above 6	11.1	Above 6	25.6
Total	100	Total	100	Total	100	Total	100	Total	100	Total	100

In this study, there are six reasons to update electrical and electronic equipment which is shown in Table 4. The results indicated that 52% of respondents mentioned that they had updated the EEE because previous product damaged or not functioning anymore. Another significant reason which is stated by 32% of the respondents is new items that have additional and more advance technological features. Only few respondents mentioned that they had updated the EEE because their disposable income increased, the EEE had less capacity or they had been influenced by others.

TABLE IV UPDATING REASONS FOR UPDATING HOUSEHOLD ELECTRICAL AND ELECTRONIC EQUIPMENT

Items	Frequency	Percentage
Previous product damaged or not functioning anymore	169	52
Not powerful/not enough capacity	24	7
New items have additional and more advance technological features	107	32
Increase in disposable income level	12	3
Influences by others (ex; through advertisement, friends and trend)	10	3
Other reasons	10	3
Total	332	100

D. Methods for Deposit and Disposal of Electrical and Electronic Equipment

In this study, the respondents were asked how they deposit and disposed of their EEE. The information related to this question has been presented in Table 5. Most of the respondents (39%) informed that they just throw out their old equipments to the waste bin. Another two preferred methods of e-waste disposal by the residents shown in Table 4 are “Keep in house” and “give to charity or transfer the products to relatives” is about 16% and 16% respectively. Only a small fraction of e-waste (5% and 13%) finds its way to manufacturer and recycling centre respectively as there is no efficient take back scheme for consumers and recycling facilities.

TABLE V METHODS FOR DEPOSIT AND DISPOSAL OF ELECTRICAL AND ELECTRONIC EQUIPMENT

Items	Frequency	Percentage
Keep in house	54	16
Return to the manufacturer	16	5
Recycling centre	44	13
Give to charity or transfer the products to relatives)	55	16
Waste bin	130	39
Others	33	10
Total	332	100

V. CONCLUSIONS

In this study it has been found that 64% of residents are not satisfied with the local environmental quality and about 70% of the residents would like to share environmental responsibility. As the economy expands with strong support from local environmental policy, more attention should be paid to environmental protection. The government of Iraq and the related organizations are suggested to improve their environmental performance to improve local environmental quality. It is interesting to find that 40% of the respondents are willing to sort their household waste into separate containers. The

percentage of the respondents willing to sort the waste is high and it is a welcome attitude for the environmental development of Iraq.

The amount of electrical and electronic equipment held by the city and township inhabitants has increased dramatically and most of them are phased out within product lifetime. The main reasons for them to update their products are new items have additional and more advance technological features and previous product damaged or not functioning anymore. Electronic products are very often retired early even though they still work perfectly because new products offer more or better features or have more fashionable designs (William *et al.*, 2008). However, it has been reported that normally the purchase of new equipment is driven by the desire to update new Software or other functionality (Herat S., 2007), not due to breakage of the machine (Eric, W. 2005) and at the same time it is due to the decreasing lifespan of all consumer electronic products (William *et al.*, 2008). Most of the respondents informed that they just throw out their old EEE to the waste bin. Currently, no structured mechanism is in place to handle e-waste from households compared to e-waste generated from industries. Extensive literature has proven that most consumers store their unused or broken electrical and electronic equipment for years before the equipment is resold or otherwise disposed of (Hischier et al. 2005).

Currently, there is no mechanism on a proper segregation or disposal system to encourage the public to recycle and discard e-waste. Continued generation of e-waste over time, together with lack of structured mechanisms of institutional framework and inadequate infrastructure, results in improper e-waste management. Even though at present electrical or electronic appliances are rarely disposed of indiscriminately, with little regulation in place this has created hazards to the local population as well as the environment.

As mentioned in our above discussion, main issues relating to adoption of this waste management option in Iraq includes illegal import or smuggling of e-waste, rapid growth of locally generated e-waste, indiscriminate dumping and improper disposal of e-waste, tracking down illegal e-waste recycling operators, low public perception about the adverse impacts of e-waste and low willingness to pay for recycling of e-waste. These call for a strong cooperation of government and nongovernmental stakeholders to govern this environmental issue together, as traditional governing by the government alone has proved to be too challenging for the government (Eric W, R., 2008).

It is envisioned that the implementation an e-waste management programme in the Arab region will be executed through Public-Private Partnerships, in cooperation with other entities, particularly Non-Governmental organizations (NGO). Government institutions can support this initiative by providing the necessary enabling environment for effective E-waste management. A forum is planned that will include executive levels entrepreneurs from ICT private sector enterprises, ICT government organizations, environmental agencies, and non-government organizations. A key objective of this forum is to share knowledge about E-waste management success stories, from an international, regional, and national perspective.

Recycling practices in Asian and African countries are mainly based on economic potential. In these countries, e-waste is treated as just another type of recyclable item and the process is characteristically undertaken without proper environmental procedures, often by illegal recycling operators who operate informally outside of the main business circle. This has brought many consequences such as high occupational health risks to the workers due to the exposure to hazardous materials, and negative impact on the environment and the society at large as a result of the inappropriate disposal of hazardous materials from the recycling and material recovery processes (Eric W, R., 2008). From the resource conservation perspective, such informal practices are ineffective as the percentage of recovery is low and many of the valuable materials are lost during the inefficient recovery processes. It is thus obvious that leaving the recycling of e-waste to the informal sector is not a sustainable option, both environmentally and economically.

Although e-waste recycling practices in the more economically developed countries appear to be more technologically advanced and environmentally sound compared to those in the less economically developed countries, they still pose environmental and health threats as it is impossible to recycle e-waste without any environmental impacts (Robinson, B.H., 2009). Recycling process may remove some contaminants, but some amount of hazardous substances may still be concentrated at e-waste recycling centres (Awang, A.R., 2010). However, e-waste recycling and material recovery management strategy have a relatively lower environmental impact compared to disposal (through landfill or incinerator) management option (Robinson, B.H., 2009). However, all stakeholders of e-waste management, from the government and nongovernmental sectors should consider shifting the management options towards the top of the waste management hierarchy (prevention and waste minimization) by substituting the hazardous materials in e-waste and encouraging redesign of equipment (which facilitates replacements of parts of equipment to cope with technology advancement instead of disposing items in whole) for a better control of the negative impacts of e-waste.

REFERENCES

[1] Afroz, R. and ,Masud, M.M. 2010. Using a Contingent Valuation Approach for improve Solid Waste Management Facility: Evidence from Kuala Lumpur, Malaysia. Journal of Waste Management. 31, 800-808.

[2] Awang, A.R., 2010. E-waste Management in Malaysia. Available from: http://www.unep.or.jp/ietc/spc/news-jul10/Malaysia_(Dr.RahmanAwang).pdf [Accessed November 2011].

[3] Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, BC, http://www.basel.int/.

[4] Cui, J., and Forssberg, E., 2003. Mechanical Recycling of Waste Electric and Electronic Equipment: A Review. Journal of Hazard Material, 99, 243-263.

[5] Eric, W. R., 2005. International activities on E-waste and guidelines for future work. Proceedings of the Third Workshop on Material Cycles and Waste Management in Asia, National Institute of Environmental Sciences: Tsukuba, Japan.

[6] United Nations Economic and Social Commission for Western Asia, ESCWA, "Compendium of Environmental Statistics in the ESCWA Region", http://www.escwa.un.org/, 2007.

[7] Hischier, R., Wager, P., Gauglhofer, J., 2005. Does WEEE recycling make sense from an environmental perspective? The Environmental Impacts of the Swiss Take-back and Recycling System for Waste Electrical and Electronic Equipment (WEEE). Environmental Impact Assessment Review, 25, pp. 525 – 539.

[8] Jain, A., 2008. Global E-waste Growth. In Johri, R., ed. E-waste. Implication, Regulations, and Management in India and Current Global Best Practices. New Delhi, India: TERI Press. pp. 3-22.

[9] Kelana A.J. 2010. Electrical and Electronic Waste Management Practice by households in Shah Alam, Selangor, Malaysia. International Journal of Environmental Science. 1, 132-144.

[10] Mohan, M.P.R., Garg, I., and Kumar, G., 2008. Regulating e-waste: a review of the international and national legal framework on e-waste. In Johri, R., ed. E-waste. Implication, Regulations, and Management in India and Current Global Best Practices. New Delhi, India: TERI Press. pp.169-188.

[11] Nnorom, I.C. and Osibanjo, O., 2008. Electronic waste (e-waste): Material flows and management practices in Nigeria. Waste Management, 28, 1472 – 1479.

[12] Puckett, J., 2005. The Digital Dump: Exporting Re-use and Abuse to Africa. Seattle: Basel Action Network.

[13] Robinson, B.H., 2009. E-waste: An Assessment of Global Production and Environmental Impacts. Science of the Total Environment. 408, pp. 183 – 191.

[14] Sarkar, A., 2008. Occupational and Environmental Health Perspectives of Ewaste Recycling in India: A Review. In Johri, R., ed. E-waste. Implication,Regulations, and Management in India and Current Global Best Practices.New Delhi, India: TERI Press. pp.169-188.

[15] Times Newspaper, Oliver August, Articles "America leaves Iraq a toxic legacy of dumped hazardous materials", and "US military to punish culprits behind toxic waste dumping in Iraq", June 2010.

[16] United Nations Environment Programme, Lebanon Post-Conflict Environmental Assessment, ISBN: 978-92-807-2794-4, 2007.

[17] United Nations Environment Programme, the Center for Environment and Development for the Arab Region and Europe (CEDARE) Study on E-Waste Management in the Arab Region, 2008.

[18] Williams, R., Kahhat, R., Allenby, B., Kavazanjian, E., Kim, J., and Xu, M. 2008. Environmental, Social, and Economic Implications of Global Reuse and Recycling of Personal Computers. Environmental Science & Technology 42(17), 6446–6454.

[19] Xu QH. 1999. Survey on Public Awareness in China, Beijing: China Environmental Science Press.