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Chapter

E-Waste Management in Different Countries: Strategies, Impacts, and Determinants

Shireen Ibrahim Mohammed

Abstract

Over the last two decades, the electronic equipment has increased dramatically around the world, which causes increasing in e-waste as well. This increasing has affected the environment badly. E-waste disposal has become one of the most critical issues and concerns have raised of it because most of these products do not biodegrade easily and they are toxic. Different strategies have been followed in many countries in order to solve the e-waste problem. Understanding these strategies can help to plan better for e-waste management correctly. Awareness of people about the e-waste impacts is crucial, because it can ensure people participation in managing the e waste process. This research has carried out in order to introduce to the e-waste impacts on environment and human health, and the importance of people awareness about these impacts. In addition, it shows many strategies that have been used in different countries to manage the e-waste, choosing the successful one to focus in order to benefit from it. Furthermore, a surveying has been carried out to exam people awareness in Iraq about the e-waste impacts. Finally, recommendations to manage e-waste successfully have been added.

Keywords: e-waste management, e-waste impacts, e-waste disposal, formal and informal recycling

1. Introduction

E-waste is informal but popular term. It refers to any electrical or electronic equipment which are in the end of their useful life. Globally, markets of electronic and electrical equipment have grown dramatically. While these products lifespan has become shorter, they are ending up in rubbish dumps or recycling centers. Concerns of the e-waste bad effects have raised around the world. Twenty to fifty percentage of e-waste has been generated per year around the world [1]. It has become a big threat on environment and human health [2]. The major reasons of e-waste growing amount are: Short lifespan of the electronic products [1], growth of population, economic development, and consumption patterns changing [3]. Many countries have followed different approaches to solve the e- waste issue. This research has shown some of these strategies and the successful one has been chosen to focus in order to benefit

from it. In addition, a surveying has done to exam the awareness of people about the e-waste effects on their health and environment. Furthermore, recommendations have been added to manage the e- waste successfully.

2. E-waste impacts

E-waste can be classified according to their physical and chemical constituent. The compositions of e-waste include: Metals such as [Copper, Iron, Tin, Nickel, Lead, Aluminum, Zinc, Silver, Gold, and Palladium], Plastics, Metal-plastic mixture, Cables, Screens (CRT and LCD), PCB, Pollutants, Wood, and Refractory and Oxides...etc. [4].

E- waste contaminants can be classified into three types [4]:

- Primary contaminants such as the heavy metals and halogenated compounds.
- Secondary contaminants, which produced by products or residues that are produced as a result of the improper recycling process such as poly aromatic hydrocarbons (PAHs), dioxins, and poly halogenated aromatic hydrocarbons (PHAHs).
- Tertiary emissions or contaminants: Compounds which are used for recycling. These compounds must be handled properly in order to avoid bad impacts on environment and health such as aquaregia, nitric acid, cyanide, hydrochloric acid, thiourea, and bromide in the metal recycling leaching process [5].

The unsuitable recycling activities of e-waste such as open burning and manual dismantling cause soil and river pollution. This is discovered by finding fire retardants in soil and river sediments in Vietnam [6]. Soil pollution also was found in china near the e waste recycling area [7]. By observing the heavy metal concentration in the air, it found that in e-waste open burning site the levels of these metals are higher, and the air pollution in these areas was higher [8]. Also it was found that in e waste area that the PCBs and BFRs levels in indoor dust were higher than non-e-waste area [9]. In addition, it was discovered that the illegal dismantling of e-waste with open-air burning have bad impacts on the groundwater [10], and surface water [11].

Several studies have indicated that e-waste has bad effects on the human health. By testing the blood, hair and urine, it have discovered that people who live near the e waste sites have high \sum mPAEs concentration in their urine than other people who live in non e waste site [12]. In addition, carcinogenic metabolites has exist in the respondents internal hair [13]. Furthermore, exposure to the heavy metals has caused acute and chronic effects such as respiratory reproductive problems, cardiovascular, and irritation [14]. Studies have shown by testing the DNA of workers who recycling e-waste, there is a correlation between damage of DNA and duration of e waste processing in informal e-waste recycling site [15, 16, 17]. E-waste also causes spontaneous abortions, premature births, and reduced birth length [18].

3. E-waste recycling

Recycling the e-waste seems to be good solution in many countries as long as a valuable items can be extracted from it. E-waste recycling is very important for

environment sustainability and for economic recovery. The efficient recycling of electronic scrap has been regarded as a major challenge for many countries.

Recycling is the most important key to reduce the e-waste. It has environmental benefits at all stage in the life cycle of the electronic products, from the raw materials from which they are made to their final methods of disposal. Recycling also contributes in reducing water and air pollution which is associated with creating new equipment from raw materials [1]. Generally, people in some countries realize that there is a value generating from different types of household solid waste [19]. So informal peddlers and formal collectors pay to consumers for their waste. Then they sell to refurbishes, brokers, scrap dealers, and recyclers.

Recycling in the world can be divided into two types: Informal recycling and formal recycling.

3.1 Informal recycling

The informal recycling of e-waste consider as a way to extract value from waste electrical and electronic equipment. Informal sector is illegal because it is outside of official institutions [19]. The majority of the informal recyclers are from rural areas and most of them are women and children [20]. This type of recycling includes labor intensive and dangerous manual dismantling of equipment. In this kind of recycling, simple tools are used such as chisels, hammers, and screwdrivers in order to achieve swift separation of the different materials [21]. This sector uses substandard processes and does not have the appropriate facilities to safeguard human health and environment, so it causes risk for recyclers and for environment [19, 20, 21]. Informal recycling sector has grown in many countries such as china, Bangalore, Chennai, India, Nigeria, and Pakistan. Informal recycling effects can be shown in **Figure 1**.

There are several reasons for informal recycling increasing [19, 20, 21] include

- Awareness lacking of collectors, recyclers and consumers of dangerous improper of e- waste handling.
- Appropriate management absence of e-waste recycling.
- No effective take-back programs for end –of-life electronic equipment and obsolete.
- Absence of interesting in e-waste managements by IT companies.

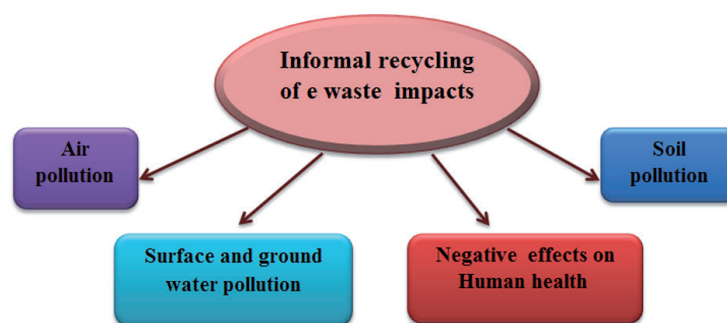


Figure 1.
The effects of informal recycling.

- Implementation laxing in e-waste specific legislation.
- Most recyclers are from rural areas and most of them are women and children.

3.2 Formal recycling

Formal e-waste recyclers can be defined as all companies designated recycling that are included on the e-waste dismantling enterprise list and have a treatment license, which are issued by provincial environmental protection bureaus [20, 22]. Formal sector recycling process are safer for both workers and environment, because it is controlled by the governmental regulation and financing [22]. However, formal recyclers have to bear all the cost (collecting, transporting and disposing of hazardous fractions), while informal recyclers bear less expensive recycling practices. This is because informal recyclers benefit from the reduced costs in terms of recycling technology, collection, pollution, and control systems [23].

4. E-waste management system in different countries

Countries are divided into developed countries and developing countries.

4.1 E-waste management system in developed countries

The best e-waste management can be found in European union. For example, best e-waste management systems can be found in Switzerland and the Netherlands [1, 24]. The European Union has a law for requiring companies and manufacturers to prepare to disposals from e-waste by special mechanisms [1]. It has restricted the use of certain hazardous substances in electronic and electrical equipment. In addition, they put a law for the WEEE companies to set up systems for the WEEE treatment and producers. This system is to be responsible about their products over the entire

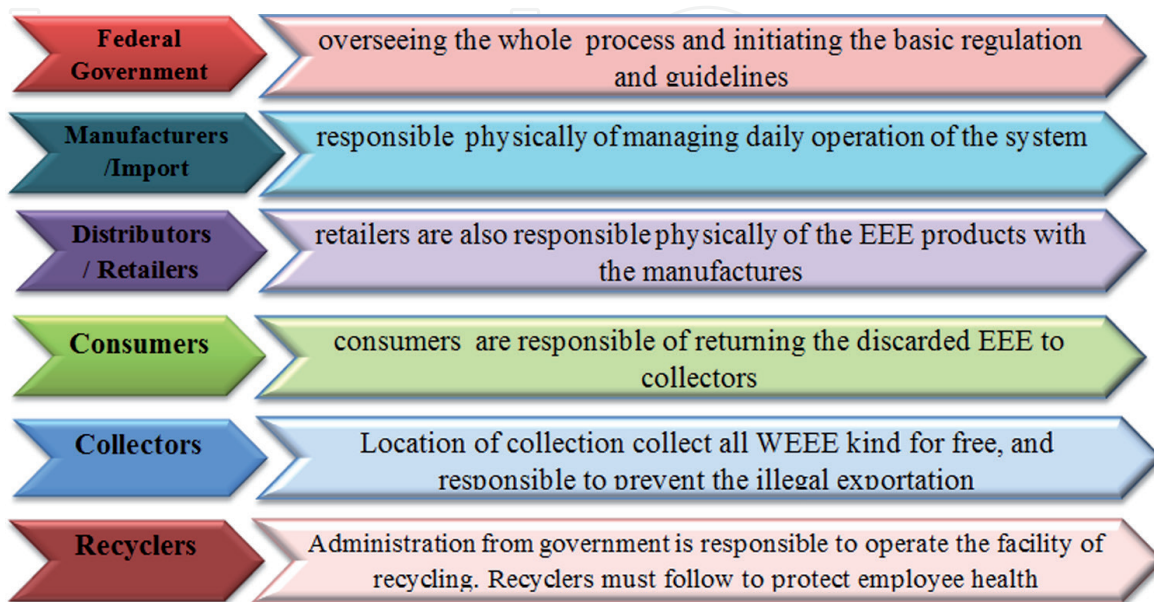


Figure 2.
E-waste management system in Switzerland [1, 24].

lifecycle of their products from design to use till disposal. In other words, Extended Producer Responsibility (EPR), which can be defined as “the producer’s responsibility for a product is extended to the postconsumer stage of a product’s life cycle” [1, 24].

As far as Switzerland is concerned, it has long experience for applying the EPR for e waste management. In Switzerland every sector has its own role and responsibility as shown in **Figure 2**.

In Switzerland, there are three producers responsibility organizations (PROs) (The Swiss Association for Information, Communication and Organizational Technology (SWICO recycling), the Swiss foundation for waste management (SENS), and the Swiss lighting recycling foundation (SLRS) [25]. These organizations are responsible of the e-waste management. The EPR system has initiated by EEE producers voluntarily in order to manage e-waste. This system has many advantages include [22, 25, 26]:

- its clear system, each one has its own responsibilities of all actors.
- by implementation the advance recycling fee ARF principle, the financing is done.
- accepted and comprehended system and covers wide range of EEE
- control the mechanisms exist for emissions and health hazards.
- monitoring the financial and material flows
- prevent the illegal e waste dumping to the non-OECD countries for recycling
- producers of EEE had Initiated an organized system to manage the e-waste. For instance, reducing the CFCs’ emissions from refrigerators and air conditioners.
- The not-for-profit SENS system has managed by members, are the importers, manufacturers, distributors and wholesalers.
- Consumers have to dispose the e-waste through retailers or by collecting it at a located collection points, and they have to pay the ARF for purchasing a new product. So they bear the responsibility of the final financial for e-waste management.
- The recyclers are responsible for environmental sound management of the e-waste. Their focusing is on the efficient materials recovery with reducing the final remains which end to the landfills or to the incinerator. E-waste then is sorted into categories and invoices are send to SWICO and SENS accordingly.
- recyclers must adhere to the standards of emission and safety measures.
- Recyclers operate recycling facility that is authorized from the cantonal government and licensed by the PROs. Government takes the overseer role without involving in day-to-day activities.
- The federal government contributes in guidelines framing for the major involved actors and assigns the key legal responsibilities to them.

- Switzerland cantonal government has the power for issuing and revoking permits of recyclers.
- Disposers are the incineration and landfill facilities, who receive the e-waste processes remaining. They have to follow the safety norms. un-processed e-waste is not allowed to be in the landfilling. in Switzerland, land filling of is completely banned [22].

E-waste in other developed countries nearly the same with some different. In Germany, strict rules have set in order to manage the e-waste. The e-waste is collected directly from individual households without any charging from consumers for e waste disposing, and the collecting points numbers are depending on the population density and local conditions [22]. Informal collection is not allowed. After collection stage, e-waste are handover to the producers. Then e-waste is separated to five different containers. They divided to five according to the categories that are specified in the Act [22]. In the US, The US disposes from e-Waste in developing countries, which causes problems in environment and health in these regions [1]. In Japan, the Ministries of the Environment, Economy, Industry, and Trade have enacted the Basic Law in order to promote recycling and conserve resources to tackle with landfill capacity issues and resource scarcity. The main purpose of this law is to establish recycling-based society, minimize the e-waste generation, and maximize the use of secondary materials [27]. E waste Infrastructure management includes: collecting, logistics and reprocessing technologies. The retailers responsibility is collecting the EoL products from the household to the regional aggregation stations. Also there are many associations to collect the electric home appliances which are appointed by the government. There is end-user-pays principle which makes consumer pay for cost. The consumers can buy a recycling ticket in order to give it to the agent of collection while they discard their e-waste. For instance, if consumer wants to discard his computer, he should contact the manufacturer or he can take it to the post office. Then, it is routed to be recycled in the recycling facility of the manufacturer [28].

4.2 E waste management system in developing countries

In developing countries, there is no specific legislation to deal with e-waste. Developing countries do not have the required infrastructure and technical capacities for waste removal in safe ways, which has caused health problems in these countries such as neurological and respiratory, cancer, disorders, and birth defects [29]. So it has become crucial to prevent the illegal imports of WEEE. In some cases, recycling cost exceeds the revenue that is recovered from materials especially in countries which have strict environment regulations. So the end of e-waste are dumped in countries where standards of environmental are low or nonexistent including Asia and West Africa [29]. Basel Convention which is an international accord, has prevented the exportation of hazardous waste to the poor countries since 1992. The exportation is continued to export what they called it “second-hand goods” as long as the exportation of reusable goods is allowed. But in reality EU Commission estimated that nearly 75% of the second hand goods are broken and cannot be used again or just have short second life to work [1, 29]. E-waste importing from developed countries has found in developing countries because it’s considered as a type of livelihood by the residents. Absence of formal recycling in developing countries, makes the e waste and informal waste treatment thrived near the residential areas [4]. Informal recycling processes and informal treatment are done

without any knowledge about the hazard that affects the environment and human health in some developing countries such as Indonesia and Cambodia who have not specified law to manage the e-waste [30, 31]. Lacking of data about the amount of material flow of e-waste and lacking of awareness, have affected on the e-waste management in developing countries [32, 33]. Because of the political challenges, technological, and financial, most of developing and under-developed countries are unable to manage the e waste in a way that does not affect the environment and human health [34].

in Africa there is an ineffective infrastructure of the e-waste management. There is no constant system for e waste collection, separation, storage, sorting, and disposal of e-waste. In addition, there is nearly no enforcement effective to regulate the e-waste management and disposal. In Africa e-waste management is reregulation, and rudimentary [35]. Recycling includes disassembly of WEEE without taking into account the hazardous chemicals. For instant, printed circuit boards (PCBs) are heating to recover chips, plastics are melted and burned to isolate metals, this burning sends dioxin and other toxic gases into the air which causes pollution to the environmental and human health. While parts that are dumped in landfills, allows the remained heavy metals to harm the area and life. So, in order to protect public health and the environment, the National Environmental Management Waste Bill in South Africa has implemented for reforming waste management legislation [1].

In Bangladesh the most popular method of e waste management is the dumping into landfills, a small amount of e-waste are recycled. Fresh drives have initiated by policymakers in order to increase the disposal of e-waste, one of these policies is adopting stringent for e-waste management policy [34]. Bangladesh is responsible of 7% of e-waste dumping annually all over the world [36]. Different types from of e waste are produced in Bangladesh every year. it produced from different sources such as mobile phones, televisions....etc. The majority of these wastes are dumped in landfilling or in open water [36].

E-waste management system in Bangladesh can be divided into three categories include:

- Reuse: reselling the e waste after repairing the used electronic and products [37].
- Recycling: Recycling of e-waste is necessary but it is not common process across the country [38].
- Dumping and Landfilling: most of electronics which include computers and mobile phones are disposed of in the litter bins. While medical wastes are burned [34].

In India, only 2 percent of India's total e-waste are recycled because of the lack of legislation and poor infrastructure. This has led to a waste of the diminishing natural resources [39]. In India, several stakeholders are involved in managing the e-waste, so it originates from many sources and does not follow single set path. Most of the e-waste end up with scrap dealers and traders for economic benefits, which end to unorganized sectors [22]. Problems that faces the e-waste management system are lack information about flow and quantum of e-waste, poor infrastructure, poor implementation rules of e-waste, and producers shirking of proEPR [40].

As far as China is concerned, China has made good efforts in order to have better collection and recycling of e-waste in public and private sectors [41]. China's government has issued many of environmental laws and technical guidance related to e-waste management. The most important include [20]:-

- cataloging the import of waste including: the second- hand electronic equipment and e-waste in a list of prohibited imported goods for processing or trade.
- prevent pollution and control the WEEE. This is done by providing a list for environmental measurement to minimize the pollution during the storage, recycling, and final disposal of e-waste.
- prevent and control the pollution caused by electronic and information products. The purpose of this policy is to reduce the using of hazardous and toxic substances in electronic appliances in order to reduce the generated pollution in the manufacture, and recycling of these products.
- Administrative measures to prevent pollution caused from waste electrical and electronic equipment. This is to prevent pollution caused by the transport, storage, recycling, disassembly, and disposal of e-waste. This policy applies for companies who need treatment licenses that is confirmed by local environmental departments...etc.

5. Methodology and result

E-waste problem in Iraq does not different from the situation in other developing country. The problem is the same including: There is no specific legislation to deal with the e-waste, the required infrastructure and technical capacities for e-waste removal in safe ways are not available, experience lacking in recycling the e-waste, and lacking of data about the amount of material flow of e-waste. All these reasons have affected on the e-waste management in Iraq. So the methodology in this research has only focused on the awareness of people in Iraq about the e-waste impacts.

E-waste impacts awareness of people in Iraq from different generations was measured as shown in **Table 1**. The samples of 500 people were chosen randomly to answer the questions. The three points scale questionnaire: 1 = Yes, 2 = No, 3 = Do not know or Not sure. Except the last question which was about the end of their end life mobiles and laptops in specific.

No.	Questions	Yes = 1%	No = 2%	Not certain or Do not know = 3%
1	Do you know what the e waste meaning before the explanation	80	15	5
2	Do you know the negative impacts of e waste on people health and environment	20	35	45
3	Do you with Recycle and reusing different types of e waste	89	3	8
4	Do you separate the e-waste to be recycled later	10	90	0
5	Do you need to enhance your knowledge about the e-waste effects	97	0	3
6	What do you do with your end life mobile or laptop?			

Table 1.
E-waste impacts awareness in Iraq.

Note: This surveying has carried out from 25 to 5-2022 to 10-6-2022.

The result shows that high percentage of people know what is the e-waste meaning, but only 20% of them aware about the negative effects of it on environment and human health. Although the majority of people are with recycling idea and reuse of e waste, only small percentage separate it. Most people admit that they have to enhance their knowledge about the e-waste effects. The last question was asked to have knowledge about the end of their end- life mobiles and laptops in specific. Their answers were different, but they can be divided into three answers: some of them damage their end-life devices and threw in the rubbish. Few of them said that they give their end-life devices to the mobiles sellers or laptop sellers to benefit from the health parts of it. Other mentioned that their end-life devices ended to be with informal collector to make use of them.

6. Discussion and recommendations

According to the result of this surveying, people need to know the causes of environment pollution and its impacts on their health. They need to understand more about e-waste effects and e-waste managements. These two terms are connected with each other, they affect the human health and environment weather in negative or positive way.

Below are some recommendation to manage e-waste successfully:-

- An aggressive legislation must be taken for new technological solutions. Evaluating the present laws and making the suitable modification periodically.
- Increasing the public awareness through education on e-waste and recycling. This is can be done by educating people about how to recycle and dispose electronics and teach them the right behavior to become more responsible towards environment.
- it is the government duty to provide the infrastructure for formal e waste treatment and recycling and encouraging the EEE producers in order to focus on the Extended Producer Responsibility EPR [42].
- In order to have successful formal recycling plant: technical support, guidelines, and financial support, must be exist for treatment processes improvement [43].
- Reuse can gives higher environmental advantages and consider as a safer term in collection of e-waste.
- guidelines must be suggested about the treatment options and technologies to manage the e waste.
- units for recycling of waste EEE must be established.
- consumers must be aware about the hazardous components in products providing with instruction about handling the equipment after its use to prevent e-waste from discarding in garbage bins with other rubbish, stringent provisions are needed

- restricting the second-hand electronics importing, prohibiting the old or used electronic products importing, except electronics that are used for research purposes and in academic institutions with allowable certification from Environment department
- The best example about the e-waste treatment is changing it from primitive practices to developed system such as the pyro metallurgical or hydrometallurgical as occurring in China [4].
- each improvement in each system can be reduce the negative effects of e waste treatment [44].

7. Conclusion

E- waste increases every year at an alarming rate, it is a global problem and needs global solution. So efforts must be taken to minimize illegal dumping. Most developed countries have developed legislations and policy guidelines to control the hazardous chemicals using in these products, and to manage the e-waste after discardation. The European Union has successes in implementing a uniform legislation for e-waste management. Switzerland led the way to establish a successful and formal e-waste management system followed by Germany and Japan.

As far as developing countries are concerned, there are many legislations are existed in developing countries, but they do not come together with enforcement. Most developing countries do not have the similar regulations particularly in their enforcement. In addition, special centers for e-waste processing are not available, facilities scarcity to extract the precious metals from e-waste are not available too. An accurate data of e-waste flows is not available which is a major required for e-waste management system.

By connecting the local and the national regulations, improvement in e waste management can be achieved in developing countries.

People behavior influences e-waste management. Behavior is identified as one of the important factors which affect the e-waste management funding [45]. Awareness of people can ensure that consumers participate in managing the e waste process. So the methodology in this research has focused on people awareness of the e waste. It is the responsibility of government to notify people of their duties and make them aware about e-waste impacts on health and environment due to unsuitable disposal of e-waste. Awareness lacking leads to engagement lacking in re-use and recycling inefficient product use, and lacking of engagement from consumer end. E-waste can be a great energy source if it treated appropriately.

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