A Review of Electrical and Electronic Waste Management in Sri Lanka

M.B Samarakoon

***Abstract*—**Electrical and Electronic wastes (e-waste) are created due to the rapid increase of technology and economic activities in developed and developing countries in the world. This creates a new environmental challenge called e-waste management. There should be a special collection system, and a management option to handle them properly for a sustainable development. However, presently, Sri Lanka does not have a sustainable e-waste management strategy. Therefore, the objectives of this study were to identify the major types of e-wastes, their different waste components, and current e-waste management practices in Sri Lanka. The study was totally based on review of previously published journal papers, news paper articles, reports on e-waste management, books, and some websites. The study revealed that currently, Sri Lanka has not implemented a proper e-waste management system. Hence, there is an urgent necessity to develop a sustainable e-waste management plan to solve environmental, social, and economical problems which have been immerged due to the unmanaged e-wastes. The results of the study revealed that there are nine major types of electrical and electronic appliances which produce e-waste in Sri Lanka. Moreover, the major types of pollutants which are found in each type of appliance can be broadly classified in to two as hazardous and non- hazardous wastes. Improper handling of e-waste can cause harm to the environment and human health because of its toxic components. Although the current emphasis is on end-of-life management of e-waste activities, such as reuse, servicing, remanufacturing, recycling and disposal, upstream reduction of e-waste generation through green design and cleaner production must be introduced to enhance a sustainable e-waste management system for Sri Lanka.

***Keywords*—**E-waste, Inventory, Recycling and Reuse, Waste Components

I. Introduction

IN the last two decades, the global growth in electrical and electronic equipment production and consumption has been increased exponentially. This is largely due to increasing market penetration of products in developing countries, development of a replacement market in developed countries and a generally high product obsolescence rate, together with a decrease in prices and the growth in internet use. Electrical and Electronic waste (e-waste) is defined as any discarded, obsolete, or broken electrical or electronic devices. As per current estimates, e-waste is growing almost three times the rate of municipal Solid Waste globally [8]. Generally, e-waste comprises both white goods such as refrigerators, washing machines and microwaves, and brown goods which consist of televisions (TV), radios and computers that have reached their ends for their current holder [3].

Due to the significant growth in investments, consumption and exports in Sri Lanka, the generation of e-waste from general consumption of the large household appliances represent the largest proportion of waste, followed by information and communications technology equipment and consumer electronics has been drastically increased within the country [4]. As a result, the general consumption of electrical and electronic products such as computers, mobile phones, and televisions has been increased in the country. Sri Lanka is now dealt with the huge problem of e-waste both locally generated and internationally imported. Overall, these hazardous wastes are currently disposed hap hazard manner in roadsides, dump yards and sometimes in home gardens [8]. However, trading of used electronic items has become a common practice and the number of sales centers had increased notably within past few years [4].

The composition of e-waste is very diverse and differs across product lines and categories. The toxicity of many of the chemicals in e-waste is unknown. The release of toxic materials to the environment through emissions and effluents has a great potential to cause health impacts to the humans and environment. There is generally low public awareness of the hazardous nature of e-waste management techniques used in developing countries like Sri Lanka. At present some telecommunication companies and household appliances companies in Sri Lanka had moved on with successful collecting systems for used electrical and electronic while, considerable amount of e-waste continues to be recycled in the informal sector. The objectives of this study were to identify the (i) major types of e-waste, (ii) different waste components in each category, and (iii) management methods for different e-wastes in Sri Lanka. The following Materials and Methods were used in order to accomplish the above objectives.

II. Materials And Methods

The management of e-waste has become an environmental concern in many developing countries as urbanization continues to take place. Hence, this study was conducted to identify the major types of e-waste, different types of waste components and management methods of e-waste in Sri Lanka. The manufacturers, sellers, consumers, policy makers, and informal sectors were the considered sectors in this

Dr. Methsiri Samarakoon is with the Department of Civil Engineering of General Sir John Kotelawala Defence University, Sri Lanka (corresponding author's phone: +94770479433/+94717034640; e-mail: methsiris@gmail.com/methsirisa@yahoo.com).

research. The information required for the study was collected by reviewing previously published journal papers, news paper articles, books, and some websites. Further, the data was gathered from the sources such as the reports on the e-waste inventory project in Sri Lanka, annual report of Central Bank of Sri Lanka, and environmental quality reports of Central Environmental Authority (CEA) of Sri Lanka. Understanding e-waste management and to determine the best approach are difficult tasks due to lack of study and reliable data on e-waste management system in Sri Lanka.

III. Results And Discussions

A. *History of e-waste management in Sri Lanka*

Sri Lanka has a long history about generation and management of e-waste since the electrical and electronic appliances are entered the Sri Lankan market. However, there was no efficient e-waste management system in Sri Lanka until 1992. Sri Lanka approved the Basel Convention on the Control of Transboundary Movements of Hazardous Waste and their Disposal in 1992 and had taken many steps to ensure implementation of its provisions. Like other developing countries in Asia and Africa, Sri Lanka is now confronted with the huge problem of e-waste both locally generated and internationally imported. Trading of used electronic items has become a common practice and the number of sales centers had increased notably within past few years. While there have been some initiatives to set policies and regulations for e-waste management, overall, these hazardous wastes are currently disposed hap hazard manner in roadsides dump yards and sometimes in home gardens. A significant increase in the importation of electrical and electronic appliances to the country has been observed within the past few years.

In this aspect, Sri Lanka is increasingly pulling ahead of the flock. A national policy on e-waste management has already been drafted and plenty of public private partnerships have been established to manage the e-waste in a sustainable way. The Ministry of Environment and Renewable Energy and the CEA are heading the efforts as policy makers and enforcers of the law [1]. In addition to achieving a draft policy for e-waste management, the next best thing that Sri Lanka engaged in was the "Electronic Waste Management Project" implemented under the purview of the CEA. This project has been able to sign MOUs with 14 partner organizations in an effort to manage the e-waste in Sri Lanka. The partner organizations comprised of telecommunications industry (Telecom, Mobitel, Dialog, Etisalat, Hutch, and Lanka Bell), home appliances industry (Singer and Abans), office appliances industry (Metropolitan, E-Wis, Virtusa, and ABC Trade & Investments), and service providers (Geo Cycle and Green Link) [1].

B. *Major types of e-waste in Sri Lanka*

The composition of e-waste is very diverse and differs across product lines and categories. Overall, it contains more than 1000 different substances. However, it has not been identified all the types of e-wastes in Sri Lanka yet. The following section describes the dominant types of e-waste generated specially from household, industrial, and commercial sectors. This section includes some of the results of the report of household survey conducted in 2007 by the Secretariat of the Basel Convention in collaboration with the Government of Japan. This report consists of the component one of a four year project on the "Development of a National Implementation Plan for Electrical and Electronic Waste Management in Sri Lanka".

(i) Personal Computers

Personal computers (PC) entered the Sri Lankan market beginning from mid 80s to late 80s with a hand full of brands with limited capacities and options. Currently, Sri Lanka has about 300,000 PC units per annum with 30% used, 20% branded and 50% assembled locally with the annual growth rate of 8% -10 % in the country. Department of Census & Statistics of Sri Lanka has conducted a survey and results showed that 3.8% of the household use PC in 2007. In addition, the results shown that the ratio of PC to Notebook in the country is 12-15: 1.

(ii) Printers

Printers are first entered to the Sri Lankan market as Dot Matrix, followed by Laser and Bubble Jet/Ink with the annual capacity of about 130,000. The annual growth rate is about 5-7%. The approximate life time of a printer is about 1-8 years depending on the type and current ratio of PC: Printer is about 5:1 in the country.

(iii) Televisions

The first Television channels named as Independent Television Network and Rupavahini were established in Sri Lanka in 1980s introducing televisions at commercial and household levels. Liquid Crystal Display and Plasma Type monitors reached the market in the recent past and the majority of the TV based e-waste is of Cathode Ray Tube type. Current market size of TVs in the country is about 350,000 – 400,000 units per annum with annual growth rate of 6.0% - 8.0%. Estimated life time of a TV is 15 – 20 years.

(iv) Mobile Phones

Mobile Phones were introduced the country in early 90s at commercial scale. Current market size is 1.0-1.2 million mobile phones per annum. The current subscriber base is 5.413 million units amounting to 28% penetration. Estimates show that the penetration rate will reach 40% by the next few years. Current market size is 1.0-1.2 million Mobile Phones per annum. The estimated life span of a mobile phone is 2 years.

(v) Refrigerators

Sri Lanka has a long history for the market of refrigerators. Refrigerators were first imported to Sri Lanka at commercial level since post World War II, and with the introduction of the open economy in 1977, local manufacturing as well as imports of refrigerators increased tremendously. Currently,

the market size is 250,000-275,000 units per annum with the annual growth rate of 4-6%. About 5% of the total imports are used refrigerators and the estimated life span of a refrigerator is 15-25 years.

(vi) Air-Conditioners (A/C)

There are different categories of A/C systems as industrial, commercial and domestic and also different types as Window or Split. Current market size is 40,000 – 50,000 units per annum with the annual growth rate of 4 % - 6%. The estimated life span of an A/C machine is about 5-15 years.

(vii) Photocopying Machines

These are widely used in the commercial and industrial sectors rather than household level. The current market size is approximately about 6000 units per annum with a slow annual growth rate of about 2 % - 4%. Estimated life span of a photo copying machine is 5-10 years.

(viii) Washing Machines

The market for washing machines increased tremendously during last 5-7 years with the improved living standards of the people. The current market size of washing machines is 60,000-70,000 per annum and the annual growth rate is about 6% - 8%. Estimated life span of a washing machine is 15-20 years.

(ix) Batteries

The different types of batteries in the usage of Sri Lanka include Auto, Domestics & Consumer and Industrial types. The market size of auto batteries is about 600,000 per annum with varying capacities from 35A - 200A with an annual growth rate of around 04% - 06%.

Different types of waste components in each category

(i) Personal Computers

The different types of components that can be extracted from an obsolete PC includes: non ferrous metals (Copper/Aluminium) and ferrous metals (Steel/Iron); plastics & rubber; capacitors; circuit boards (heavy metals such as Cu, Ni, Pb, Ag, Au); external cables (Cu, Al); bearing; hazardous materials such as phosphor powder, leaded glass, circuit boards and cables; liquid crystals from Liquid Crystal Display monitors and fluorescent tubes.

(ii) Printers

The different types of components that can be extracted from an obsolete printer include: non ferrous metals; ferrous metals; plastics; clothing and ribbon; capacitors; glass; circuit boards; and external cables. Most of the wastes are hazardous in nature.

(iii) Televisions

The different types of components that can be extracted from an obsolete TV include: glass; metal (Cu, Fe, Al, Pb, Au, and Cr); plastics; Silicon; and Polychlorinated Biphenyls. Televisions that are available in the market are mainly divided into 03 different technologies namely Cathode Ray Tube (CRT), Liquid Crystal Display (LCD), and Plasma type. The obsolete CRT type has Ag in the Cathode Ray.

(iv) Mobile Phones

The different types of components that can be extracted from an obsolete mobile phone include: non ferrous metals; ferrous metals; plastics; capacitors; glass; circuit boards; external cables; re-chargeable battery; key board; phone housing; charger; and Liquid Crystal Display. In Sri Lanka, most of the parts required for repairing are imported at large scale thus resulting in discharging a lot of e-waste components into the environment.

(v) Refrigerators

Most of the old refrigerators entered to Sri Lanka until late 1990s contained Chloro–Floro-Carbons (CFCs) and Hydro-Chloro-Floro-Carbons (HCFCs) as the coolant and insulating agents. Both of these gases are categorized as Green House Gasses (GHGs) causing tremendous damage to the Ozone layer leading to global climate changes. The obsolete refrigerators discharge e-waste to the environment and cause problems on human and the environment.

(vi) Air-Conditioners (A/C)

As about 95% of A/C is metal, the proportion of e-waste generated by an A/C is reasonably low.

(vii) Photocopying Machines

Main waste products coming out of a photocopying machine is the toner consisting plastics, polyethylene; Ferric Oxide and Cadmium Sulfide. An obsolete photocopier consists of circuit boards, wires, motors, glass sheet, drum and ebonite rolls.

(viii) Washing Machines

Washing machines are made up of steel or plastic and hence, the proportion of e-wastes that are generated by washing machines is relatively low. However, obsolete washing machines contain some waste parts including circuit boards, wires, motors, and drum.

(ix) Batteries

Obsolete batteries contain plastics, rubber, polymer, Lead (Pb), Sulphuric Acid, paper, glass, Carbon – Rods, Nickel (Ni), Cadmium (Cd), Lithium (Li), Zinc (Zn), Silicon (Si), Tin (Sn), Antimony (Sb), and Manganese (Mn).

Hazardous nature of the e-waste

Overall, e-waste contains more than 1000 different substances which fall into "hazardous" and "non-hazardous" categories; significantly, the toxicity of many of the chemicals in e-waste is unknown. E-waste is of concern largely due to the toxicity and carcinogenicity of some of the substances if processed improperly. It has been recorded that up to 38 separate chemical elements are incorporated into e-waste items. Toxic substances in e-waste may include Lead, Mercury, Cadmium, Polychlorinated Biphenyls, Brominated Flame Retardants. A typical computer monitor may contain more than 6% lead by weight, much of which is in the lead

glass of the CRT. Polychlorinated Biphenyls (PCBs) have been identified as carcinogenic and capacitors, transformers, Poly Vinyl Chloride (PVC) insulated wires, PVC coated components that were manufactured before 1977 often contain dangerous amounts of polychlorinated biphenyls. Brominated Flame Retardants that are mainly present in printed circuit boards and plastic casings are bioaccumulating in fatty tissues and biomagnifying up to food chains in combination with their toxicity and persistence make this class of chemicals of high concern to the environment and human health [8]. Environmental and health impacts cause by some elements and chemicals present in e-wastes are given in table 1.

Current e-waste management methods in Sri Lanka

Sri Lanka has implemented "Electronic Waste Management Project" under the purview of the CEA. Under this project, CEA has signed agreements with some companies in telecommunications industry, home appliances industry, office appliances industry, and service providers. Presently, e-waste in Sri Lanka comprises of personal computers, printers, televisions, mobile phones, refrigerators, air-conditioners, photocopying machines, washing machines, and batteries. The best method that can be adopted to control the generation of e-waste is "polluter pays principle" (PPP). Some of the e-waste management practices in Sri Lanka under the "Electronic Waste Management Project" are described below.

Softlogic PLC together with Think Green, which is an exporter of e-waste approved by the CEA, has taken steps to implement environmentally friendly e-waste disposal mechanisms. The products under consideration here are mobile phones and their accessories, and they are being collected at the designated services centres of the Soft Logic PLC. There are 140 service points all around the country and the first batch of waste was estimated at 483 kg. In addition, these organizations are increasingly involved in community awareness campaigns which motivate the consumers to participate in the programs effectively [1].

Singer Sri Lanka together with the CEA implemented the "National Cooperate e-waste Management Initiative". Singer Sri Lanka was the first to collect e-waste in Sri Lanka, and now has collected over 60 tonnes since its involvement. They also conduct public awareness campaigns to attract more consumers to their activities. Singer does these mainly through its nationwide outlets [1].

With initiatives to save electricity, especially through the use of energy saving bulbs, Sri Lanka recorded a high demand for CFL bulbs. As suggested by CEA, over a million of CFL bulbs are being used in Sri Lanka every month. Higher demand for consumption has resulted in a higher disposal rate.

TABLE I
HEALTH EFFETS OF E-WASTES

E-toxin	Health effects
Arsenic	Arsenic is a known cancer-causing substance (carcinogen). It is known to cause skin and lung cancer.
Brominated Flame Retardants	Brominated Flame Retardants act as hormone disrupters. Children exposed to these substances show increased risk to thyroid disease and neurobehavioral disease
Cadmium	Breathing high levels of Cd can cause lung damage and death. Long term exposure to low levels of Cd can cause elevated blood pressure and kidney damage. Cadmium is a known carcinogen.
Chromium	Chromium has a variety of effects depending how it enters the body. Chromium is a carcinogen if inhaled. Chromium may also cause DNA damage.
Halogens	These substances are of concern because of the possibility that toxins such as dioxins and furans may be created and released burning.
Lead	Initial symptoms of exposure are anorexia, muscle pain, malaise, and headache. Long-term exposure to lead decreases the overall performance of the nervous system. High level exposure causes brain damage and death.
Mercury	Short term exposure to all forms of mercury causes lung damage, nausea, vomiting, diarrhea, increases in blood pressure or heart rate, skin rashes, and eye irritation Long term exposure permanently damage the brain, and kidneys.
Polyvinyl Chloride (PVC)	When burnt it produces highly toxic dioxins; research is finding if PCV is a hormone disruptor

(Source: [8])

Identifying this opportunity, Orange PLC in collaboration with Nordic Recycling AB of Sweden, has established South Asia's first ever CFL and fluorescent bulb recycling plant. This plant is located in Pitipana, Rideemulla, in Homagama South, Sri Lanka. It holds the capacity to recycle up to 30million bulbs per year [1].

A pioneering environmental program is being implemented under the purview of the CEA in collaboration with a network of 5000 schools in Sri Lanka. This program will enable access for students to actively participate in managing e-waste at a school level. This has proven to be a very effective mechanism, since it collects a lot of e-waste from households through children, while creating awareness among children and parents on the importance of managing e-waste [1].

Further, there is a registered e-waste recycling factory in Sri Lanka, which recycles all types of e-waste (except CFL and tube bulbs), was able to recover 35,724 kg of plastic, 58,526 kg of metal, 83,358 kg of glass out of the total e-waste collection of 177,609 kg in 2012. Furthermore, out of the total quantity of metal, around 6,368 kg of complex metal were exported for refinement to the world's largest precious metal refinery. In addition, they earned foreign currency by trading the extracted gold, silver, palladium, and copper in the London Bullion Market (LBM) and London Metal Exchange (LME). The rest of the materials were sold to different companies in the country, which reuse these materials for a variety of products. This factory has also

created new jobs for skilled and unskilled personnel as well [7].

In addition, CEA has organized several e-waste waste drop-off events where customers can hand over their used e-waste items to the seller/producer. In addition, there are e-waste collectors and exporters who are registered under CEA, who go to the customer directly and buy back the e-waste. One of the main features of the e-waste policy that is of interest is the identification of the significance of PPP. In public policy literature, PPP has been identified as one of the most sustainable ways of tackling social, economic, and environmental problems. Inclusion of such mechanisms in to the policy is a positive indicator that shows Sri Lanka is on the right track [1].

Policy framework for e-waste management

The policies for e-waste management in Sri Lanka have been developed up to some level; however, most of the policies are still at the draft level. In addition, a plenty of public private partnerships have been established to manage the e-waste in a sustainable way. The Ministry of Environment and Renewable Energy and CEA are heading the efforts as policy makers and enforcers of the law [1]. While most of the ground rules in the policy are common to other policies in developing countries, one significant aspect is the defining protocols for resource mobilization. One of the ways to minimize the generation of e-waste is of applying the PPP. This helps to create revenue from efficient and effective e-waste management and defining suitable financial instruments to generate revenue and promote efficient use. Some of the commercial companies such as Singer Sri Lanka and Abans are promoting "buy back" program, where discounts are given for old electrical and electronic items when they buy a new ones.

Future activities to be carried out on e-waste management

CEA has already taken the following initiatives to establish a strong e-waste management system throughout the country [8].

National Level e-waste management program

- CEA invited the private and public sector stakeholders who are dealing with e-waste to join the national level corporate e-waste management program by entering in to an MOU with the CEA.
- Leading companies in telecommunication sector, IT sector (software, hardware and It venders) and electrical and electronic venders have already informed the CEA their willingness to join with the national level program.
- This program will be launched under a common logo and a theme. " Ensuring e-waste free environment"
- Each and every stakeholder company joining with the national level corporate program should ensure proper lifecycle management of e-waste, complying the internal regulations as well as international rules and regulations stipulated with respect the e-waste and hazardous waste in order to earn the right to use the common logo for their corporate activities.
- Through this program it is expected that these organizations would expand the existing e-waste collection network and identify suitable locations to install waste collection centers, while also improving collection mechanism.
- It is expected to carry out joint initiatives and individual initiatives to conduct awareness programs amongst general public by means of several promotional modes as per the conditions and closures given in the MOU.

Basel Secretariat has agreed to provide funds for establish a collection system within the Western Province as a pilot project and the project proposal has been submitted to the regional office of the Basel Secretariat for processing.

IV. Conclusions And Recommendations

This study was conducted to identify the major types of e-waste, different waste components in each category, and management methods for different e-wastes in Sri Lanka. The results of the study revealed that there are nine major types of electrical and electronic appliances which produce e-waste. These appliances are widely used in household, industrial, and commercial facilities. The major types of pollutants which are included in each type of appliance can be categorized broadly as hazardous wastes (heavy metals such as Cu, Ni, Pb, Ag, Au, Cr etc, persistent organic pollutants, and polychlorinated biphenyls) non- hazardous wastes (ferrous metal such as Iron and Steel, non-ferrous metals such as Copper and Aluminium, plastic, rubber, glass etc). Improper handling of e-waste can cause harm to the environment and human health because of its toxic components. Presently, the e-waste management system in Sri Lanka includes recycling, reuse, servicing, exporting for refinement to the world's market, and disposal. However, these steps are not sufficient at all to manage all the quantity of e-waste generated in the country. Hence, the following recommendations are made to increase efficiency and effectiveness of the current e-waste management practice. These recommendations include; development of new policies and guidelines on managing e-waste, incorporate the e-waste management practice in to the Municipal Solid Waste Management practice, develop pilot scale recycling plants, and introduce methods for upstream reduction of e-waste through green design and cleaner production.

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Dr. Samarakoon is a Sri Lankan citizen and born in Matale, the Central Province of Sri Lanka. The date of birth is 13th November 1979. The author has obtained his Doctor of Philosophy degree in the field of Hydraulic and Environmental Engineering from the Graduate School of Science and Engineering, Saitama University, Japan in 2011. Also, author has obtained his Master degree in the field of Environmental Engineering and Management from School of Environment Resources and Development, Environmental Engineering and Management Program, Asian Institute of Technology, Bangkok, Thailand in 2008. In addition, author has obtained his Bachelor degree in the field of Civil Engineering from University of Peradeniya, Sri Lanka in 2005.

He is a Senior Lecturer of Department of Civil Engineering of General Sir John Kotelawala Defence University, Sri Lanka. His research interests include Water Resources Management, Wastewater Treatment and disposal, Solid Waste Management, Air Pollution, and E-Waste management. He has produced about 20 referred international and local Journal publications to his credit. Dr. MB. Samarakoon has supervised 10 Master students and 1 PhD projects and examined more than 5 undergraduate research projects.

Dr. Samarakoon is an Associate Member of Institute of Engineers, Sri Lanka (AM-7649). Dr. Samarakoon is awarded Monbukagakushosho Scholarship in 2008 by the Japanese Government for a Doctoral Degree. Also, Dr. Samarakoon is awarded Her Majesty the Queen of Thailand scholarship in 2006 by the Royal Thai Government for a Master Degree. In addition, he was awarded for the best presentation at 11th International Summer Symposium in Tokyo Japan in 2011 for his research presentation.