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E-waste flows, resource recovery and improvement of legal framework in Pakistan

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ABSTRACT

Electronic waste (E-waste) is becoming most rapidly expanding solid waste stream of the world. Pakistan receives thousands of tons of E-waste from developed countries like the USA and Europe. At present, quantification of E-waste imported to Pakistan and materials recovered from such waste is not well defined. Therefore, the objectives of this research include estimation of E-waste flow and assessment of potential quantities of recyclable metallic and non-metallic components. As a result, it was found that, on average, 95,415 tons of E-waste is imported into Pakistan annually. It contains a variety of metals such as gold, silver, copper and non-metals like plastics and glass as well as hazardous materials. It was also found out that all the recycling activity takes place in informal sectors without any consideration to environmental pollution and safety of workers. Improvements in the existing legal framework regarding import and recycling of E-waste have been proposed. These proposals include take back, prohibition of illegal import and good environmental management.

1. Introduction

Electronic items are developed, applied, sold and used at a very high rate worldwide. Thus, it can be said that it is the fastest growing market in the world (Kahhat et al., 2008; Kang and Schoenung, 2005; Williams et al., 2008). According to some references, 30–50 million tons of electronic items are discarded annually (Fogarasi et al., 2014; Menikpura et al., 2014). China is the leading country to produce electronic waste (E-waste) and it is expected that China will produce 15.5 and 28.4 million tons of E-waste in year 2020 and 2030 respectively followed by Europe, the USA and Japan (Zeng et al., 2016). It is anticipated that by the year 2030, developing countries will discard twice as many computers as compared to developed countries (Sthiannopkao and Wong, 2013).

The Basel Convention on the Control on Transboundry Movement of Hazardous Waste and their Disposal, signed by 178 countries, imposes its signatories to keep the hazardous waste within their countries and dispose it off safely. Still many developing countries have not adopted strict ban on E-waste import. Recently the E-waste problem has grown to more than two dozen small countries and regions (Zeng et al., 2015).

High cost of proper disposal and lack of labor push many developed and industrialized countries to export bulk of E-waste to developing countries such as China, India, Pakistan and Nigeria, violating the Basel convention. The approximate export routes, major E-waste exporters and potential E-waste sites are known well enough (Widmer et al., 2005). Karachi (Pakistan), Guiyu (China) and Mumbai, Ahmedabad and Madras (India) are major E-waste receiving sites. Taiwan acts as a redistribution destination for E-waste originating from Japan and South Korea, whereas, Singapore as a redistribution site for waste coming from North America and Europe.

Pakistan has emerged as a cheap E-waste exporting site. Hence, it receives the bulk of E-waste from the Europe, Australia, and the USA which is often shipped through Hong Kong or Singapore. The personal computers and other obsolete electronic items are imported under the title of “second-hand equipment” to Pakistan (Abbas, 2010). In practice, the bulk of imported obsolete electronic goods are sent to the recycling industry, where only the 2 percent of them are reused (2002). The remaining computers are, then, broken down to recycle the metals and plastics. All of the recycling work is done manually and no protective equipment is employed (Abbas, 2010).

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Unfortunately, there has been very limited research in Pakistan on such alarming issue. There is a lack of first-hand knowledge regarding the amount of E-waste imported to Pakistan and a lot of research is needed regarding environmental impacts of E-waste recycling, its legislation aspects and working environment involved in E-waste recycling. Therefore, the purpose of this research is to know and explore and understand such important issues related with E-waste in Pakistan.

2. E-waste components, environmental impacts and legislation

E-waste contains more than 1000 substances, which include a variety of materials like metals, plastics and glass (Vadoudi et al., 2015; Wang and Xu, 2014; Widmer et al., 2005). Metals contained in E-waste can further be divided into several types e.g. ferrous, non-ferrous, toxic, ordinary, precious etc.

There are about 55 kinds of metals contained in E-waste ranging from common to rare and precious metals (Oguchi et al., 2012). A shredding and separation analysis conducted on E-waste from City of Hitachi, Japan revealed that 12.6 t of E-waste contains 45% ferrous metal and 10% non-ferrous metal (Oguchi et al., 2012). E-waste also contains precious metals like gold, silver and copper. Early personal computers used to contain almost 4 g of gold which has now been reduced to only 1 g. These old computers are also a good source of copper, therefore, almost one ton of E-waste may contain 0.2 ton of copper in it (Widmer et al., 2005). E-waste contains 17 times more gold and 40 times more copper than gold and copper ores respectively. Since, the older computer processors have higher amounts of gold in them hence, Pentium 1 processors are the most expensive ones (Informal, 2015). However, it is possible to make the recycling industry more cost effective yet safe for workers by adopting some good E-waste management practices. Plastic is a major portion of Non-Metallic Fraction (NMF) of E-waste, because typical electronic equipment contains almost 10–30% of plastic by weight. These plastics may contain several polymers ranging from a few to as many as 21. These polymers include polystyrene, polycarbonate blends and polypropylene. Presence of such polymers makes the recycling process quite difficult (Wang and Xu, 2014).

According to some studies, E-waste contains 0.5-3% of glass (Menad et al., 2013), while some other researchers claim to have found up to 11% of glass fraction in E-waste (Wang and Xu, 2014). Glass in E-waste is of two types; CRT glass and LCD glass. CRT glass comes from the televisions and monitor screens while LCD glass comes from the mobile phones. Both of them, CRT and LCD glass, consist of oxides of silicon, aluminum, sodium, calcium, lead and nickel in varying percentage. However, the most important material that can be extracted from LCD screens is Indium (Cucchiella et al., 2015).

Informal recycling of E-waste poses a threat to the air, soil, water and the human health. China is considered to be the most affected country in this regard (Song and Li, 2014). Televisions, circuit boards, electronic equipment cables and many other electronic items are made up with various types of plastics that include Acrylonitrile Butadiene Styrene (ABS), Polyethylene, and Polyvinyl Chloride. Uncontrolled burning of such items, during recycling, causes the formation and direct emission of toxic substances, commonly known as dioxins, such as Polychlorinated Dibenzo-p-Dioxins and Dibenzofurans (PCDD/F), Polybrominated Dibenzo-p-dioxins and Dibenzofurans (PBDD/F) (Labunska et al., 2015). Guiyu, China is reported to contain the highest levels of such dioxins ranging from 65 pg/m^3 to 2765 pg/m^3 (Robinson, 2009).

Most of the E-waste contaminants dispersed in the air are in the form of dust particles. E-waste workers get exposed to such contaminants through skin absorption, inhalation and ingestion (Robinson, 2009). One of the very dangerous contaminants is lead (Pb), which is absorbed by E-waste workers, especially children, living in the areas of informal and manual recycling. The blood lead level (BLL) is found to be significantly high in the children living in such environments (Huo et al., 2007). These children also suffer from high cadmium level in their blood (Robinson, 2009). Higher levels of dioxins found in human milk, hair and placentas also pose a very serious health risk. These contaminants reach to the soil, rice, eggs and fish, which ultimately threatens the human health (Robinson, 2009).

The awareness about the effects of E-waste has increased throughout the world since the EU has imposed regulatory control over it. However, there is still very limited legislation regarding E-waste in developing countries (Chung and Zhang, 2011). Legislation regarding E-waste in EU came into force in 2004. Most of the countries in the EU are signatories of the Basel Convention, hence, they comply with the restrictions on import of hazardous waste and their disposal. A European Recycling Platform (ERP) was established in 2003 by companies like Hewlett Packard, Sony, Braun etc., which enabled electronic producers to take their waste back as directed by EU directives (Nnorom and Osibanjo, 2008). Finland amended the Finnish Waste Act (1072/1993) to incorporate WEEE into the legislation (Ylä-Mella et al., 2014).

The USA, although not a signatory to the Basel Convention, has mixed policies regarding E-waste and its trade to other countries. Almost 25 out of 50 USA states have enacted laws pertaining to E-waste. However, these state laws do not constrain E-waste producers from its trade to other countries like China, India and Pakistan (Sthiannopkao and Wong, 2013). A Responsible Electronic Recycling Act (HR2284) was presented in American Congress in September 2010 but has not been approved yet (2015b).

China is considered to have limited legal framework in this regard and have banned the import of dozens of electronic items since 2000. These items include scrapped computers, panel displays, television sets, refrigerators, monitors and ovens. Illegal recycling activities are also prohibited there, so the violators are fined heavily. China also employs Extended Producer Responsibility (EPR) that encourages manufacturers to take-back, recover and dispose of the waste (Chung and Zhang, 2011).

Sri Lanka has policy of importing only those items which fulfill a certain safety criteria. The organizations are encouraged to import high quality products and materials to minimize the waste, and they also have internal collection and storage facilities for collection of discarded items (Mallawarachchi and Karunasena, 2012).

Pakistan is also a signatory to the Basel Convention and has its own relevant legislation regarding E-waste imports. The Pakistan Environmental Protection Act, 1997 (PEPA 1997), National Environment Policy (2005) and Import Policy Order (2016) prohibit the import of hazardous waste to Pakistan which includes the E-waste as well (Sthiannopkao and Wong, 2013). But somehow, many prohibited items are still being imported to Pakistan under the very attractive name of “second-hand items”.

3. Data and methodology

3.1. Selection of data collection regions

For this study, a number of regions in Pakistan related to E-waste were selected. Selection was made on the basis of following factors: (1) availability of national entry point (see Fig. 1); (2) potential of E-waste generation; (3) intensity of collection, availability of E-waste markets; (4) distribution of E-waste; and (5) availability of E-waste recycling facilities. Selected regions include modern and urban areas like Karachi, Lahore, Rawalpindi, Faisalabad, Multan, Peshawar etc. These regions are potential hubs for generation, collection and recycling of E-waste.

3.2. Framework for data collection and its source

There are dozens of items that come under the heading of E-waste. Among them, only those are selected which form the major portion of E-waste imported to Pakistan. This includes desktop computers, laptops/notebooks, computer monitors, Liquid-Crystal Display units

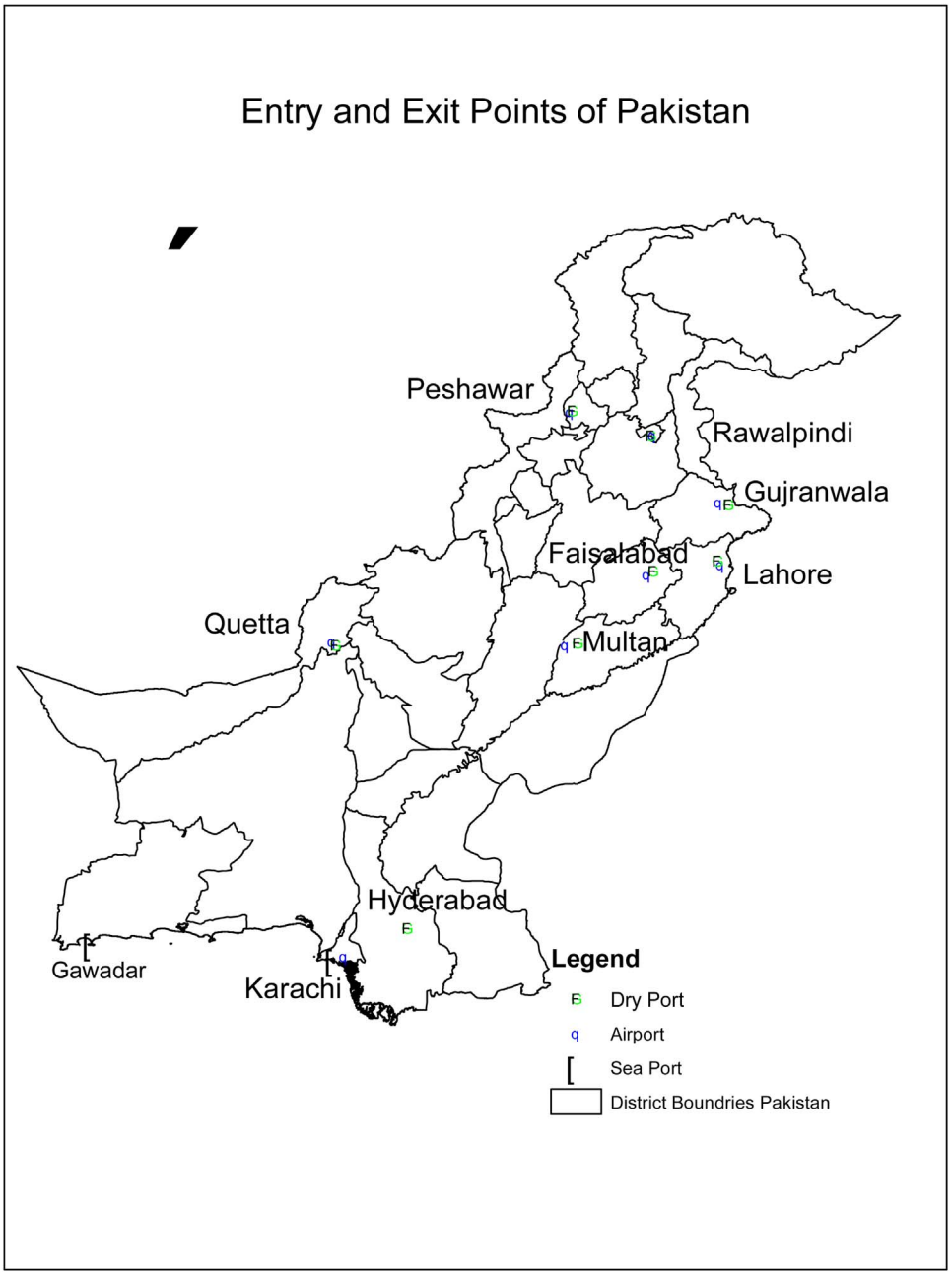


Fig. 1. National Entry and Exit Points of Pakistan (Feb. 2015).

(LCD), televisions (TV), ink-jet & laser-jet printers, scanners, computer keyboards, computer mice and power cables.

Three years' data from July 2011 to June 2014 was collected from Pakistan Customs, Lahore office. The secondary source used was "Web Portal for Import and Export" run by Federal Board of Revenue (FBR), a revenue division of Government of Pakistan. Each item is referred to by its Pakistan Customs Tariff (PCT) Code. This data was obtained in the form of data log files. These files include the following details: date of arrival; name and address of importer; quantity and volume of imported items; country of origin; import value; customs duty and other taxes paid; and the description of the imported items.

3.3. Interviews and field surveys

Almost one hundred interviews were conducted of individuals, who were engaged in the E-waste industry. People interviewed are including simple workers who dismantle the E-waste items, owners of recycling facilities and storage go-downs, transporters, scrap dealers and resellers of E-waste items.

Lahore and Karachi are seen as two major cities dealing with the E-waste activities. Karachi alone handles the largest share of E-waste received in Pakistan because of the fact that it hosts two of the major sea ports of Pakistan; Port of Karachi and Port Qasim. Similarly, major hubs of E-waste in Lahore i.e. *Misri Shah* and *Daroghawala* were visited for data collection and interviews.

3.3.1. Estimation of electronic waste generation

Quantification of annual E-waste import, in Pakistan, was carried out from the collected data. The data regarding the import was used for this purpose. The quantification of each item's weight is not easy, therefore, the average weights of items are considered as is shown in Table 1. The average weight of each item was multiplied with the amount of E-waste items imported. Hence, the weight of a particular item imported to Pakistan in a year was estimated in such a way. Same method was employed for all the other items. By adding weights of all the items for each year gave the total amount of E-waste in that one

Table 1
Average weights of electronic Items.
Guide, E-waste (2015a,b).

Item Name	Weight (Kg)
Desktop Computer	9.9
Laptop	3.5
Computer Mouse	0.05
Keyboard	1
Printer	6.5
Scanner	6.5
Monitors	14.1
LCD	4.7
Televisions	31.6

particular year.

3.3.2. Estimation of component materials in E-waste items

Estimations of weight of substances that can potentially be extracted from E-waste are conducted to evaluate its recycling scope and the reuse of E-waste. Typical percentages of the various materials found in different E-waste items are given in Tables 2 and 3. These tables are used to quantify each type of material that may possibly be obtained from the E-waste.

Typical percentages of various metals, as taken from Tables 2 and 3, were then multiplied with the amount of total E-waste imported to Pakistan. This resulted in estimated quantity of each component that is found in E-waste generated in Pakistan.

4. Results and discussion

4.1. Item wise annual import in Pakistan

An average of three years data (2011–2014) of different electronic items imported in Pakistan is shown in Table 4. It can be seen that on average 2.37 million computer mice are imported to Pakistan, followed by 1.27 million keyboards. These items are directly sold in the market. On average, 1.42 million personal computers are imported to Pakistan, while a quarter of million laptops are being received in Pakistan as E-waste.

4.2. Weight wise annual import in Pakistan

The average of annual import of E-waste in Pakistan is 95,415 tons, according to the estimation. The year wise import of each item is shown in Table 5, while the three year average is shown in Fig. 2.

It is interesting to note in Table 5 that the import of televisions (TV) is on the rise. This may relate to the fact that as TV technology is getting obsolete and is gradually being replaced by LCD (Liquid-crystal-display) and LED (light-emitting diode) TVs, therefore, its disposal and hence, its recycling is increasing. It can be seen in

Table 5 that out of the total tonnage, 35,522 tons are personal computers followed by 34,717 tons of cables. Although highest in number, the computer mouse contributes the least with respect to weight i.e. 119 tons (Table 4).

Table 3
Typical percentages of various metals In electronic items (2015a).

Metal	Fraction (%)
Ferrous	36
Aluminum	5
Copper	4
Lead	0.29
Gold	0.00024
Silver	0.0012
Mercury	0.00007

Table 4
Number of units of various items imported to Pakistan

Item Name	Unit	Year			Average	Average (Million)
		2011 – 12	2012 – 13	2013 – 14		
PCs	No.	1,341,377	1,317,130	1,604,114	1,420,874	1.42
Laptops	No.	228,407	274,237	259,313	253,986	0.25
Keyboard	No.	1,114,795	1,497,661	1,212,557	1,275,004	1.27
Mouse	No.	2,727,913	2,217,411	2,167,319	2,370,881	2.37
Cables	Ton	30,887	47,767	25,495	34,716	–
Printer	No.	206,899	175,118	204,228	195,415	0.19
Scanners	No.	45,793	35,822	59,510	47,042	0.04
Monitors	No.	993,824	1,153,503	954,140	1,033,822	1.03
LCDs	No.	118,962	55,417	34,269	69,549	0.07
TVs	No.	91,860	160,613	356,486	202,986	0.20

Table 5
Average weights of various items imported to Pakistan.

Item Name	Year (Tons)			
	2011–12	2012–13	2013–14	Average in 2011–2014
Personal Computer	33,534	32,928	40,103	35,522
Laptop	799	960	908	889
Keyboard	1115	1498	1213	1275
Mouse	136	111	108	119
Cables	30,887	47,767	25,496	34,717
Printer	1345	1138	1327	1270
Scanners	298	233	387	306
Monitors	14,013	16,264	13,453	14,577
LCD	559	260	161	327
TV	2903	5075	11,265	6414

4.3. City-wise average annual import

Karachi receives the major portion of E-waste imported to Pakistan. It receives, on average, 85,291 tons (89.39% in total) of E-waste per year. Lahore is the second largest E-waste importer with average 5807

Table 2
Typical percentages of various plastics in electronic Items (Wang and Xu, 2014).

Item Name	Acrylonitrile Butadiene Styrene (ABS) %	High Impact Polystyrene & Polypropylene (HIPS) %	Polycarbonate/Acrylonitrile Butadiene Styrene (PC/ABS) %	Poly Styrene (PS) %	Others%
PCs	44	3	22	5	26
Laptop	28	0	1	8	63
Keyboard	28	0	1	8	63
Mouse	28	0	1	8	63
Printer	32	8	38	14	8
Scanner	32	8	38	14	8
Monitor	69	0	20	4	7
Television	4	8	0	15	73

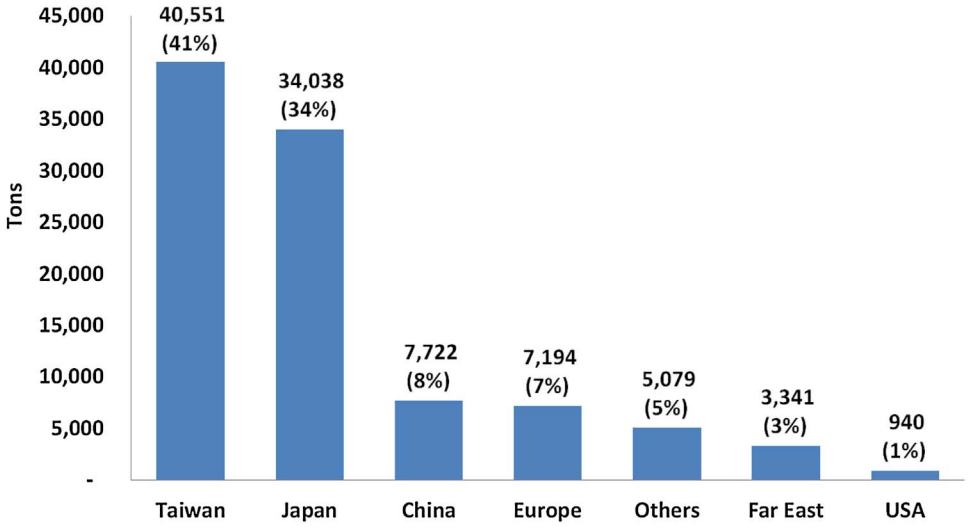


Fig. 2. Leading exporters and percentage of E-waste to Pakistan (2011–2014).

Table 6
Average E-waste (in tons) imported to various cities of Pakistan.

City	Quantity (Tons)	Percentage
Karachi	85,291	89.39%
Faisalabad	583	0.61%
Islamabad	1,155	1.21%
Lahore	5,807	6.09%
Multan	40	0.04%
Peshawar	1,075	1.13%
Rawalpindi	1,403	1.47%
Sialkot	32	0.03%
Quetta	24	0.03%
Hyderabad	03	0.00%

tons (6.09% in total) of E-waste per year. Other cities of Pakistan receive comparatively small amounts of E-waste. Table 6 shows the 3 year average quantity (2011–2014) and percentage of E-waste imported to major cities of Pakistan.

4.4. Countries exporting E-waste to Pakistan

Taiwan is the leading exporter of E-waste to Pakistan with an average quantity of 40,551 tons (41%) followed by Japan with 34,038 tons (34%). It is interesting to note that the world's largest exporters of E-waste i.e. the USA and Europe, import much smaller amounts to Pakistan. This is due to the fact that the discarded items from these countries are delivered to Singapore and Taiwan from where this waste is redistributed to the other developing and under-developed countries like China, India, Pakistan, Bangladesh, Nigeria and Sri Lanka. Major exporters of E-waste to Pakistan with respect to tonnage and percentage of waste for the last 3 years are presented in Fig. 2.

4.5. Material recycling potential from imported E-waste

Different materials that may potentially be recycled are present in the E-waste. Total potential of these materials is given in the following sections. Obviously, this activity comes up with different job opportunities for several thousand people.

4.5.1. Plastic

Various types of recyclable plastics that are potentially available in imported E-waste are given in Table 6. These plastics include Polystyrene (PS), Acrylonitrile Butadiene Styrene (ABS), High Impact Polystyrene and Polypropylene (HIPS) and Polycarbonate Blends (PC/ABS). Total of every type of plastic that is estimated to be possibly available in the E-waste in Pakistan has also been tabulated. Monitors are the major source of these plastics, as can be seen in Table 7, followed by the Personal Computers (PC).

Table 7
Average potential quantities of various types of plastics in E-waste imported to Pakistan (2011–2014).

Item Name	Quantity (Ton)					
	Total Plastic	ABS	PS	PC/ABS	HIPS	Other
PC	1,173.70	516.43	58.69	258.21	35.21	305.16
Laptops	27.98	12.31	1.40	6.16	0.84	7.27
Keyboard	546.25	152.95	43.70	5.46	0.00	344.14
Mouse	66.83	18.71	5.35	0.67	0.00	42.11
Cables	0.00	0.00	0.00	0.00	0.00	0.00
Printer	317.38	98.39	44.43	73.00	66.65	34.91
Scanners	46.73	14.95	6.54	17.76	3.74	3.74
Monitors	2,452.3	1,692.06	98.09	490.45	0.00	171.66
LCDs	97.85	67.51	3.91	19.57	0.00	6.85
TVs	507.98	0.00	76.20	0.00	40.64	391.15
Total	**5,236.97**	**2,573.32**	**338.31**	**871.28**	**147.08**	**1,306.99**

4.5.2. Metals

The annual average of quantities of metals that is possibly be available in E-waste are presented in Table 8. Ferrous metals make up the largest portion with 21,851 tons followed by Aluminum and Copper with 3034 tons and 2427 tons, respectively. It is interesting to note that 145.68 kg of gold is also potentially available in E-waste produced in Pakistan which is worth 600 Million Pakistani Rupee. In total 29,262 tons of metals can be extracted from this E-waste which makes E-waste a very attractive commodity for recyclers and resellers.

Table 8
Potential annual average quantities of various metals in E-waste imported.

Metal	Quantity	
	Ton	Kg
Ferrous	21,851	21,851,442
Aluminum	3034	3,034,922
Copper	2427	2,427,938
Lead	176	176,025
Gold	0.146	145.68
Silver	0.728	728.38
Mercury	0.042	42.49
Others	1770	1,770,907
TOTAL	**29,262**	**29,262,151**

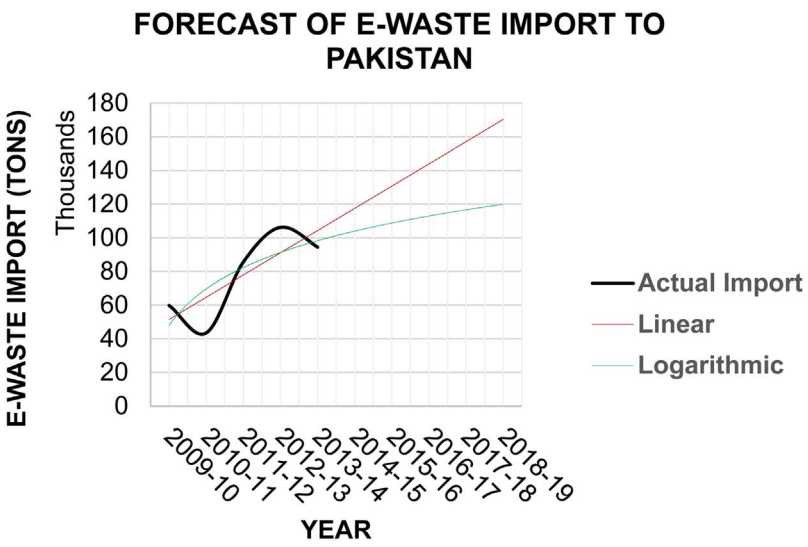


Fig. 3. Forecast of E-waste Import to Pakistan.

4.5.3. Glass

Studies show that almost 0.5–11% of E-waste consists of glass component (Menad et al., 2013). Using the higher value, 7456 tons of glass is available per year in E-waste recycled in Pakistan.

4.6. Forecast of future flow of E-waste in Pakistan

As discussed earlier, Pakistan has become very cheap site for E-waste import from around the world. Reviewing the 5 years (2009–2014) import data of various E-waste items, it can easily be deduced that import of E-waste is going to increase enormously in coming years, as Fig. 3 shows the extent of this increase. If we take the growth rate of E-waste import to be linear, then the amount of E-waste imported to Pakistan may get doubled by the year 2020, whilst if we consider it to be logarithmic, it will increase up to 20% of the current import.

4.7. Environmental issues related to E-waste

Collection, handling and recycling of E-waste provides a livelihood for thousands of people associated with this industry. Although these activities are financially beneficial for some, conversely, there are some environmental effects as well. Below some of the environmental impacts of this industry are shown.

4.7.1. Air pollution

Recycling of metals, plastics and other valuable materials involves some very crude and informal methods. Many items are burnt in uncontrolled conditions. This uncontrolled burning causes the air pollution. Following are some observations made after surveying various E-waste markets.

4.7.2. Uncontrolled burning

It was observed that power cables and wires coated with rubber casing are burnt to obtain metals. Their uncontrolled burning produces very poisonous gases which create problems in breathing. These cables are usually covered with lead casing, that after burning releases lead oxides into the air along with the fumes of oxides of metals underneath the rubber casing. Circuit boards and mother boards are also burnt to separate metals printed in them, hence causing the release of dioxins. It was observed that such open burning of waste items produced so dense fumes that a wide area of the recycling territory becomes so suffocated that even people living some few yards away feel difficulty in breathing, not only the workers doing such open burning. Many times, such uncontrolled and careless burnings have caused incidents of fire. The probability of such incidents increase in summer, as told by the workers involved in the market.

4.7.3. Human health

Thousands of people are involved in Pakistan E-waste industry. They are working without knowing the danger they might face in their lives. Upon surveying, some of the serious concerns regarding the human health which were observed are as follows:

1. Workers are working without any protective gear or clothes which expose them to direct contact with the substances released during burning.
2. Due to the smoke produced during recycling activity and unhygienic condition of most of the markets, workers suffer from coughing, headaches and skin diseases. Most of the workers were found to have suffered from skin itching and sore throats.
3. Direct exposure to toxic released during burning makes them vulnerable to serious maladies like lungs disorders and nervous system failure.
4. Workers are in a constant danger of getting burnt while performing the unprotected open burning.
5. While striping off the power cables and wire casings, workers are more prone to get injured by sharp tools like blades and paper-cutters.

4.7.4. Social impacts

Workers normally have to work for long shifts of 10–12 h a day which causes social damage in to their life. They seldom take Sundays off. People working in E-waste recycling markets in Pakistan are range from age of 10 to above 60. This is a direct violation of labor laws, child protection laws and human right laws.

4.7.5. Working environment

The working environment in most of these markets is usually found to be below the acceptable standard. Workers are deprived of their basic rights and necessities. There are no proper sanitation conditions and most of the markets lack proper wash rooms. Most of them are forced to work in the open air, without any proper shade or roof, and are exposed to sun and the rain without any kind of shelter.

Those who are working inside the shops lack proper ventilation and lighting facilities. The workers have to use very sharp tools, hot equipment and contaminated objects with their bare hands exposing them to injuries and diseases. They are involved in uncontrolled burning of electronic items without any proper face and nose mask. Coughing has become a permanent part of life for them, unfortunately.

Workers performing unguarded hammering of items, are constantly in a danger of getting struck by any perilous items e.g. when dismantling a LCD monitor or TV which has been placed in the sunlight for a quite long time may cause serious injuries, as exposing the LCD and TV screens to extended sunlight renders them liable to get explode.

4.8. Comparison of E-waste management between Pakistan and other countries

Still E-waste management is a major problem and issue throughout the world. Various countries have conducted E-waste studies and solved some of the problems related to it. For instance, China being the leader in E-waste production has overcome E-waste import and conventional recycling activities also known as backyard recycling. Policies have been placed to control import and production of E-waste. But still a considerable backyard recycling exists in China. Studies have also been conducted to minimize E-waste impacts. It is estimated that 8 million ton E-waste is being produced in China at present (Duan et al., 2016).

Ghana is another country which is threatened by informal recycling activities. Although there have been E-waste studies in Ghana but still workers are under a great deal of threat due to lack of legislation and poor management (Yu et al., 2016).

A material flow approach study shows that India is also a victim of informal and backyard recycling activities. The use and reuse of electronic items is so complex that it ultimately falls in the hands of backyard recyclers, where it becomes very difficult to estimate E-waste quantity. E-waste legislation and regulation is barely present (Yedla and Kapoor, 2011).

On the other hand, countries like Australia, Canada, Japan, South Africa and Russia are generators of E-waste. They have better legislation regarding E-waste and have labor laws implemented in this field. They have controlled recycling activity. Yet these countries are involved in export of E-waste to developing and under-developed countries due to their lack of labor and the high cost of sophisticated E-waste recycling.

Pakistan, also, has to face many problems which most of the developing and under-developed countries are dealing with. There are no considerable E-waste studies conducted so far. E-waste estimation is very difficult and backyard recycling is at a very high level. Labor laws and E-waste legislation are scant. A brief comparison of E-waste management between Pakistan and some of other countries is given in the Table 9.

4.9. Bottlenecks in E-waste management in Pakistan

Some of the key problems which hinder proper management of E-waste in Pakistan are as follows:

4.9.1. Lack of awareness

Awareness and attitude of the general public towards a problem is as vital as their practice in that matter. E-waste management is severely lacking this aspect in Pakistan. General public is buying and discarding electronic items at an enormous pace without proper disposal. This problem arises due to the lack of awareness as is the case in the country. It is the need of the time that recycling workers, scrappers, manufacturers and general public consumers must be educated on handling, collecting, disposing and the impacts of E-waste (Iqbal et al., 2015).

Table 9
A brief comparison of E-waste management between Pakistan.

	Pakistan	India	Australia	China	Canada	Ghana
E-waste management study	No	Yes	Yes	Yes	Yes	Yes
Conventional recycling activities	Very high	High	No	Very less	No	Very high
Legislation	No	No	Yes	Yes	Yes	No
Labor Law	No	No	Yes	Yes	Yes	No
Import regulation	No	No	Yes	Yes	Yes	No
Public Awareness	Low	Low	High	Average	High	Low

4.9.2. Lack of system to regulate the import of E-waste

Import Policy Order (2016), issued by Federal Government of Pakistan, does not even define or mention the terms “E-waste, electronic waste and WEEE”. Although this order puts a ban on all the hazardous items restricted by Basel Convention but still it does not comprehensively covers the list of items related to E-waste. Hence, this makes regulation of import of E-waste not only difficult but in many cases impossible (Pakistan 2017). The problem was faced by the authors while obtaining data of E-waste imported to Pakistan, since the wasted electronic items were not even mentioned under the one heading of E-waste.

4.9.3. Lack of technical expertise in E-waste area

Technical expertise and awareness of the problem go hands in hands. Due to lack of awareness in general public as well as E-waste stakeholders, there are a very few who hold expertise in the field of E-waste management. Immense effort had to be made by the authors to get hands on technical support from inside and outside of the E-waste industry.

4.9.4. Inadequate regulatory measures

Once an electronic item is imported, it needs to be analyzed and investigated that whether it is allowed or not in its present condition. For instance Cathode Ray Tubes (CRTs), as seen in Shershah Scrap Market (Karachi), are imported without even assessing its hazardous contents. Moreover, these CRTs are stored in the E-waste markets, without recycling them for more than a year, in open sunlight which makes them more prone to damage and release of hazardous contents.

4.9.5. Weak implementation of law

Although there exists lack of proper definition of E-waste items in Import Policy Order (2016) but it at least recognizes the items banned as per Basel Convention. Government of Pakistan has also defined particular environmental standards and labor laws. But still these laws are not implemented well which adds up to the problems related to E-waste (Umair et al., 2015).

4.9.6. Lack of interest from government to control E-waste issue

There exists a lack of interest from Government’s side when it comes to handle and manage the E-waste. This can be considered as a root cause of poor E-waste management. Over the years import of E-waste has been increasing in Pakistan. Neighboring countries such as China, India and Sri Lanka have already taken serious steps to address this issue. Pakistan could not so far add list of items need to be checked and regulated under the heading of E-waste in the Import Policy Order.

4.9.7. Lack of coordination among different stakeholders

General public, collectors, refurbishers, recyclers, scrappers, importers, manufacturers and Government institutes are a few stakeholders in the E-waste industry (Umair et al., 2015). There is no coordination between these entities when it comes to E-waste management, while coordination between them is the core of it.

4.9.8. Less research

There has been none to a very minimum research on issue related to E-waste in Pakistan. Government of Pakistan needs to invest and encourage more on research and case studies which will help in bringing all E-waste stakeholders on a common ground that will ultimately make

the way for proper E-waste management.

4.10 Proposed regulatory framework for E-waste handling

The legislation regarding import of E-waste and its implementation in Pakistan is lacking in many aspects. Increase in imports of second-hand and discarded electronic items are becoming more of a problem, which is why its flow into the country must be regulated. Some of the steps that may be adopted to improve the legal framework in this regard are proposed here:

4.10. Take-Back

Legislation is required to encourage manufacturers of electronic items for the mandatory buy-back of electronic items. Manufacturers may reuse, recycle and ultimately dispose them of safely.

4.10.1. Controls on import

Legislation is needed to prevent import of hazardous and seriously deteriorated items. Importers involved in import of such items should be fined or punished accordingly.

4.10.2. Good environmental management

Detailed legislation is required for procedures to be adopted for handling, storing, sorting and transport of discarded items (e.g. CRTs, LCDs, LEDs, and Televisions etc.). It should be made mandatory that toners and ink cartridges of copying devices (e.g. scanner, printer) must be preserved during their handling.

4.10.3. Controlling illegal imports

Illegal trade of used electronic items must be stopped. It should be ensured that Import Policy Order (2016) must be obeyed for import of any item to the Pakistan.

4.10.4. Enhancing E-waste workers health conditions

Detailed enactment needs to be made for E-waste dealers, traders, scrappers, collectors and recyclers to maintain good in-house environmental conditions in their go-downs, workshops and markets. Protective gears for workers should be made mandatory.

5. Conclusion

By analyzing and interpreting the primary data obtained from Pakistan Customs and markets related to E-waste collection, handling and recycling, it can be concluded that E-waste is becoming more of a major concern for Pakistan since it has become one of the leading E-waste disposal destinations.

Average E-waste imported to Pakistan is 95,415 ton per year and it is expected to increase in future. Personal computers and power cables contribute to the highest percentage by weight (37% each) for E-waste followed by monitors (15%). Karachi is the largest E-waste import city of Pakistan and receives 89% of total E-waste. Taiwan (41%) is the leading E-waste exporter to Pakistan followed by Japan (35%). This E-waste is a source of various metallic and non-metallic components e.g. Gold, Silver, Copper, Plastics etc. Ferrous metals constitute the largest portion of E-waste (22.9%) followed by Glass (7.8%) and Plastics (5.5%).

All of the E-waste recycling happening in Pakistan is private and informal. There is not even one sophisticated and well-controlled E-waste recycling unit working in Pakistan. Recycling is being done manually by the cheap labor in small, congested, ventilation deficient and unsafe units. A major portion of it is restricted to big cities like Karachi, Lahore and Faisalabad. E-waste recycling market benefits Pakistan at national as well as individual level as it yields billions of rupees in revenue, whereas collection, handling and recycling of E-Waste offers a livelihood to thousands of people associated with this industry. Although these activities are financially beneficial for some, at the same time, there are some environmental impacts of it as well. It not only pollutes air, water and soil but also poses a great health threat to workers involved in this recycling business.

Most of all, there is a lack of a proper legal framework and its implementation in Pakistan. Increase in import of second-hand and discarded electronic items is becoming more of a problem; which is why its flow into the country needs regulation. This can be achieved by controlling the import of hazardous and seriously deteriorated items and by having a check on illegal import. Manufacturers may be encouraged to take-back electronic items to reuse and recycle them and a good housekeeping and safe working environment should be maintained in recycling businesses.

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