# A Review of E-waste ganeration and recycling process of precious metals.

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## ABSTRACT

Waste from end-of-life electronic and electrical equipment's known as E-waste is a quick growth of electronic and electrical waste (E-waste) are generated 50-60 MMT world-wide at 3 to 5% increasing growth rate. Printed circuit board (PCBS) are the highly valuable precious components of E-waste. E-waste has produced toxic gas to the environment and these cause to human health. E-waste generation is major issue world-wide. E-waste is classified as a hazardous waste but other categories E-waste also has a significant potential of metals recovery velue. The majority of E-waste is recycled in the unregulated informal sector and results in significant risk for toxic exposure to the recycles. The aim of this study was to documents the extend of the problem associated with inappropriate E-waste recycling and management.

**Keywords**— E-waste, E-waste genaration, Precious metals recovry.

## I. INTRODUCTION

New products of information and communications technology (ICT) and other e-products are being introduced continuously into the current market, while previous products are swiftly becoming obsolete. The amount of e-waste produced is, therefore, rapidly increasing every year. E-waste is primarily described as the waste generated by all parts and items of electronic and electrical equipment (EEE) that have been discarded without the intention of being reused. It is also known as waste electrical and electronic equipment (WEEE) and e-scrap in different parts of the world. E-waste encompasses a diverse range of electronic devices, such as telecommunications and information technology equipment, large household items, lighting equipment, automatic dispensers, medical devices, monitoring and control devices, as well as consumer electronics, including electronic and electrical tools, sports and leisure equipment, toys, mobile phones, and computers.

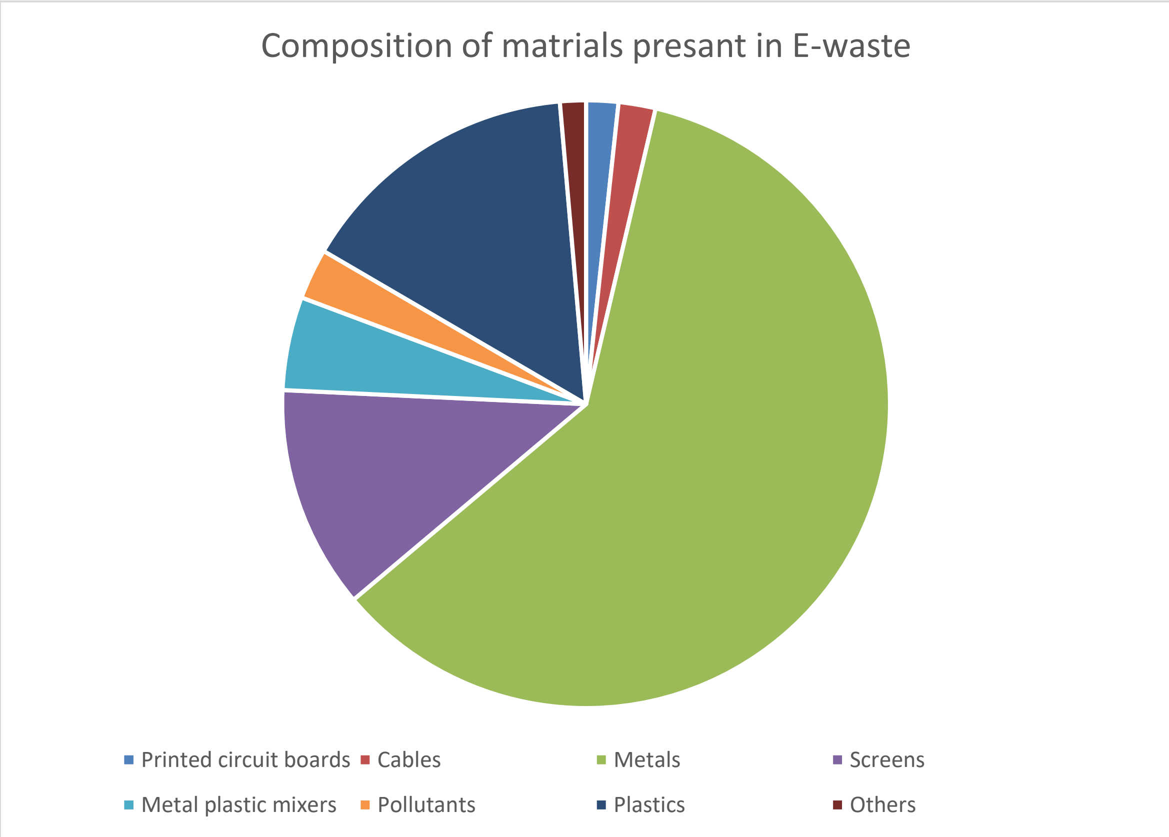
Since the 1980s, with the development of consumer-oriented electrical and electronic technologies, countless units of electronic equipment have been sold to consumers when electronic products become obsolete and are ready for disposal, they are known as e-waste. Information Technology and Electronic Industry are the world's largest and fastest growing manufacturing industries and as a consequences of this alarming growth, combined with rapid product obsolescence, discarded electronics is now the fastest growing solid waste stream in the industrialized world. Most of the governments have been forced to solve this serious problem Developed countries that use most of the world's electronic products and generate most of the e-waste, tried to solve the problem by exporting hazardous e-waste to the developing poor countries of Asia and Africa. Waste Electrical and Electronic Equipment (WEEE) directive classifies e-waste into 10 groups. E-waste recovery rate changes from 70% to 80% and reuse and recycling rate from 50% to 75% [6].

Waste electronic and electric equipment (WEEE) is now the world's fastest-growing solid waste stream, as a result of the explosive demand and shorter product cycles nearly 53.6 million tons (MT) of e-waste was generated globally, a 21% growth compared to 5 years ago Despite this growth, only 17.4 wt% of e-waste was collected and recycled, which means that the valuable metal and high-value recyclable materials in the e-waste were abandoned instead of being recycled.

Unlike conventional solid wastes such as household waste, e-waste has the dual attributes of hazardousness and resourcefulness. From the perspective of resource utilization, the metal and non-metal compositions contained in e-waste are highly recyclable, especially precious metals, of which the grade is dozens or even hundreds of times higher than that of crude ores. E-waste contains up to 60 different types of metals, such as copper, gold, silver, palladium, aluminum, and iron. It is estimated that as of 2017, the value and reserves of waste materials in e-waste are as follows: Iron/steel of 16,500 kt (9 billion Euros), copper of 1900 kt (10.6 billion Euros), aluminum of 220 kt (3.2 billion Euros), gold of 0.3 kt (10.4 billion Euros), silver of 1.0 kt (0.58 billion Euros), and plastics of 8600 kt (12.3 billion Euros). The recycling cost of metal from e-waste is far below the mining of crude ore, which means that e-waste recycling is an energy-saving and environmentally-friendly approach. The total economic value of the recyclable resources contained in e-waste is as high as 57 billion USD, which is higher than the gross domestic product of most countries in the world.

However, there are a variety of heavy metals such as lead, mercury, and cadmium, and persistent organics such as polychlorinated biphenyls and brominated flame retardants. If handled illegally, such hazardous substances will cause serious harm to the global eco-system and human health. The increasing pollution and damage to the environment are the price paid to the upgrade of electronic products. The e-waste from high-income countries, where disposal cost is high and eco-friendly regulations are strict, is often passed onto low- and middle-income countries illegally (such as China, India, Ghana, and Nigeria) for recycling. The industrial infrastructure and recycling technology, however, tend to be informal in those countries, with workers adopting crude methods to recover the valuables from the e-waste, resulting in negative and irreversible impact on local, regional, and even global ecological environment. Considering the huge volume and rapid growth rate of e-waste, there must be an understanding of the impact and potential hazard of e-waste recycling, and a discussion of sustainable e-waste management and recycling technology to form a comprehensive solution for e-waste.

This review provides a comprehensive overview of the status of e-waste globally. First, the characteristics of e-waste are introduced from the aspects of quantity, product type, composition, and global impact. Subsequently, the management measures, legislative policies, current disposal, and transboundary movement in different countries are examined from international, regional, and national levels to outline the situation of e-waste collection and disposal. For recycling, the application of techniques such as physical dismantling, component classification, metal extraction, and non-metal reutilization, and the potential hazards of e-waste to the environment and organism are concluded. Finally, targeted measures are proposed to sustainably promote the global recycling of e-waste.




## II. FACTS ABOUT E-WASTE IN THE WORLD

According to the US Environmental Protection Agency (EPA), yearly e-waste produced in the USA, is estimated 5 to 7 million tons. Only 10% of this e-waste is recycled. 30% or more stored typically for 3-5 years for future disposal and the rest is land filled [7]. E-waste already constitutes 2-5% of the US MSW stream and is growing rapidly [9]. In the EU, 6.5 million tons of e-waste are generated yearly [8]. In Europe, the volume of e-waste is raising 3-5% per year- almost three times faster than the MWS. Today's computer industry innovates very rapidly, bringing new technologies and "upgrades" to market on average of every 18 months. Conventional TV sets will be replaced by high-definition (HD) TVs soon, which will put millions of kilos of CRT Pb into the environment. Between 1980 and 2005, an estimated 410 to 460 million computer CRTs have been sold in the USA. Approximately 25 million TV sets are sold in the USA annually. Each year, some 50 million computers and 20 million TVs become obsolete. The use of TVs in USA may be double that of computer monitors. But the rate of sales growth (and obsolescence) is slower in TVs than in computers. Annually less than 20000 TV units are being recycled in the USA where 50-80% of the collected e-waste for recycling are not recycled domestically at all, but very quickly placed on container ships bound for destinations like China, India, and Nigeria etc. [8]. India exports 4.5 million PC every year from developed countries. Currently over 50% of US households own computers. Half of the turned-in computers are in good working conditions but they are replaced with the latest technology. In the USA, there are 315 to 680 million unused computers. There were nearly 500 million obsolete computers in USA between 1997 and

2007. In 1999, 11-15% discarded computer is recycled compared with 28% of overall MSW and 70% of the major appliances recycling in the USA. Americans own about 2 billion electronic devices or 25 per household. Consumers have on average 2 to 3 obsolete computers in their garages, closets, basements, storerooms, attics or storage spaces for later disposal. Americans have buying more computers, than any other nations. In California alone, over $1.2 billion will be spent for e-waste disposal over the next 5 years. Recycling price of a computer is about $10 to $30 per unit. The cost of properly disposal of TVs or PCs could easily be $25 to $50. [8]. According to the International Association of Electronics Recyclers (IAER), 7000 employees were working and $ 700 million annual revenue were obtained from electronic recycling in the USA in 2003. One hundred thirty million cell phones are retired each year in the USA.

According to EPA, approximately 78 to 80 million automotive batteries are consumed and replaced in the USA, not including those used for large tracks or non-automotive uses, such as lawn and garden machinery and emergency power and the nationwide recycling rate is about 90%. 80% of the consumed Pb is manufactured by the recycling of old Pb-acid batteries in the secondary smelters. Average battery contains about 9 kilos of Pb. Primary Pb industry is declining and national demands are filled by secondary smelters using recycled materials [10]. Household battery industry in the USA is estimated to be a $ 2.5 billion with annual sales of nearly 3 billion batteries. These batteries are used in over 900 million battery operated devices [11]. In 2000, over 75 million NiCd batteries, which are considered one of the most hazardous with respect to disposal, were sold. In Europe the battery consumption per person is about 10 and 5 billion units of batteries were produced in year 2000 [11]. Zn-C cells represent 39%, alkaline cells 51% and rechargeable batteries represent 8% of European portable household battery market. Among the rechargeable batteries NiCd represents 38%, NiMH 35% and Li-ion 18% of the European market [12].

## III. TYPES OF ELECTRONIC WASTE

E-waste can be categorised depending on the origin and purpose of electronic items. There are ten different types of e-waste. The average percentage of each category of e-waste can vary depending on many factors, including socio-economic conditions, consumer behaviours, populations, and the dependency of businesses and households on electronic and electrical equipment (EEE) [13]. Nonetheless, large household items are the leading contributor (42.1%) to e-waste, followed by IT and telecommunication (33.9%), consumer devices (13.7%), and small household equipment (4.7%) [14]. Other categories have lesser contributions (< 2% for medical, lighting, electrical, and electronic tools while < 1% for automatic dispensers, toys, sports, monitoring, and control devices) [14] for better readability. In developing countries, e-waste is mainly dominated by TVs, computers, and mobile phones [15,16,17].

## IV. RECYCLE AND RECOVERY OF E-WASTE

Recycling and recovering e-waste are critical aspects of e-waste management that involve economic, environmental, and health-related benefits. E-waste is a resource only if it is recycled and precious materials are recovered. The following sections describe the collection and treatment of e-waste.

As the first step of e-waste waste management, waste generated by households and businesses is collected [18]. The second stage of waste management is the pre-treatment before they are sent to treatment centres or dumping sites. The collection processes can be one of the four ways: (a) the official take back system, (b) mixed residual waste, (c) collection outside the official take-back system for countries with developed waste management, and (d) collection outside the official take-back system for countries without developed waste management [13, 16, 19, 20, 21, and 22].

After collecting e-waste, it goes through a pre-treatment process before the final processing in the treatment facilities [23]. The objective of the pre-treatment process is to separate different useable materials from the bulk of the e-waste mix so that they can be transferred to appropriate recovery treatment plants. The pre-treatment process can be three types: (a) manual dismantling, (b) mechanical dismantling and separation, and (c) a combination of both manual and mechanical processes [24]. Manual dismantling often separates hazardous and valuable materials such as PCBs, casing, monitors, and batteries, sometimes labour intensive and costly [25]. Mechanical pre-treatment comprises separating metals and non-metals, size reduction, shredding, and crushing [24]. It is worth noting that if the e-waste is a complex mix of various equipment and items, it is time and cost-effective to use the combined manual and mechanical pre-treatment processes. In developed countries, pre-treatment mostly comprises semi-automatic (manual and mechanical) separation followed by metal recovery in state of- the-art units [26].

Manual separation is the dominant method in developing countries, followed by metals recovery in small workshops. Low-intensity magnet drums are commonly used to separate ferrous metals from e-waste, while non-ferrous metals are separated from non-metals using electric conductivity base separation toos [24]. Other separation techniques, including the gravity method using airflow or water flow tables and sifting, are also commonly used. Once metals are separated from other materials, they are then transferred to the final recovery stage, where two recovering methods are widely used, namely pyro metallurgy and hydrometallurgy [27]. The pyro metallurgy technique uses high temperatures to purify and extract metals. Some examples of pyro metallurgy are refining, smelting, combustion and incineration [28]. On the other hand, hydrometallurgy is concerned with extracting metals from concentrated mixtures or a mixture of different materials using aqueous solutions. In a broader sense, pyro metallurgy is commonly used to extract ferrous metals from e-waste, whereas hydrometallurgy is used for recovering non-ferrous metals, e.g. copper, lead, and zinc [29].

## V. CONCLUSION

E-waste comprises metal (40%), plastic polymers (30%), and oxides of other materials (30%). The collection, washing, sorting, pre-treatment, and treatment are the key steps for recycling and recovering e-waste. E-waste consists of three major categories: large household items, IT and telecommunication, and consumer and small household equipment. Currently, Europe is the leading collector of e-waste (5.10 Mt, 42.3% of its total e-waste), followed by Asia (2.9 Mt, 11.7%), America (1.2 Mt, 9.4%), Oceania (0.06 Mt 8.8%), and Africa (0.03 Mt, 0.9%). E-waste contains precious materials, base materials, hazardous materials, and other halogens, plastics, glass, and ceramics. Asia is the highest e-waste generator among the continents. However, Asia generates far less waste per inhabitant (5.6 kg/inh) than Europe, Oceania, and America. Unfortunately, 83% of the e-waste generated globally is not documented, meaning the fate of that e-waste is open burning or illegal dumping, leading to a serious threat to the environment and human health. A collective approach from national and international bodies, including public awareness, is crucial to managing e-waste, which will play an important role in the circular economy.

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