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Comparative Examining and Analysis of E-waste Recycling in Typical Developing and Developed Countries

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Abstract

The aim of this study is to comparative examining and analysis of electronic and electric waste (e-waste) between developing and developed countries. In fact, most of the developing countries are suffering from informal recycling, because of enormous number of unemployed people engaged in the collection and recycling at family workshop. They are working in different level of community for collection of refused electronic products directly from consumer, followed by sell it to refurbishers and recyclers. These are completely recycled through “backyard recycling” or primitive or crude methods includes open burning to extract metals, acid leaching for precious metals at family level workshop. These activities are running due to lacking of legislation, treatment standards, environmental protection measures, recycling infrastructure and awareness. Due to absence of updated data of WEEE generation in India with respect of other two countries China, USA and Europe, it cannot possible to make effective control system. The study is based on literature survey by using different database science direct, google scholar with several keywords such as key words e-waste or electronic waste or WEEE recycling or management in India, China, USA and Europe etc. The obtained output from this comprehensive work will make a strong contribution to scientific knowledge and valuable for scientists and policy-makers to solve the e-waste problems towards best available techniques and best environmental practices in future.

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1. Introduction

Electrical and electronic equipment is becoming e-waste when they are deemed at the end of their useful life

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leads to an emerging and most critical as well as fast-growing waste issues (Zeng et al., 2015a; Zeng et al. 2015b; Zeng et al., 2015c; Li et al., 2015; Jiang et al., 2012). It mainly included computers, printers, cell phones, photocopiers, TVs, fax machines, home appliances, and lighting equipment (Zeng et al., 2013). Recently, it was reported that 41.8 million metric tonnes (Mt) of e-waste generated at global scale and expected to lead up to around 50 million tons in 2018 (Balde et al., 2015). This huge portion of e-waste is covered about 12.8 Mt of small equipment (such as toasters, electric shavers, vacuum cleaners, video cameras, microwaves, etc.), 11.8 Mt of large equipment (such as dishwashers, clothes dryers, electric stoves, washing machines, photovoltaic panels, etc.) 7.0 Mt of cooling and freezing equipment (temperature exchange equipment), 6.3 Mt of screens type materials, 3.0 Mt of small IT (such as mobile phones, pocket calculators, personal computers, printers, etc.), and 1.0 Mt of lamps. However, rapid e-waste generation is a serious and significant issue for sustainable development that covers the technical, ecological, socioeconomic, and legal components (Chang et al., 2011). The presences of highly valuable materials such as metals and plastics in e-product have encouraged the recovery of these materials from e-waste (Reck et al., 2012; Xanthos, 2012). But it should be much concerned because e-waste can be regarded as hazardous waste. A number of environmental pollution problems arose with crude dismantling and informal recycling in some developing countries (Duan et al., 2011; Shingkuma et al., 2010). Consequently, a large amount of money and effort has been gone into e-waste treatment research in the past many years (Li et al., 2015). Although recycling is a better way to reuse the raw/resource materials from any product, because hazardous materials of e-waste can harm workers who associated with in the recycling yards, along with near communities and local environment. In order to develop an ecofriendly process for efficient recovery of precious metals from WEEE, in both terms economic feasibility and environmental impact. In this regard, it is notice that biotechnology approach has been become most promising technologies (Bas et al., 2013). However, limited research was carried out on this aspect electronic waste processing.

In developed countries, electronics recycling considers in purpose-built recycling plants under controlled manner. For example, many EU states, they avoid brominated furans and dioxins released into the atmosphere by do not recycled plastics from e-waste. In another hand in developing countries, there are no such controls facility and almost recycling is carrying by hand scraping in small family yards by children (Greenpeace, 2009). In this regard, such facility also affected their recycling capacity. Therefore, in this study we examine e-waste issue in developed and developing countries.

2. E-waste Generation of in these countries

2.1. India

Most of the e-waste was generated in Asia: 16 Mt in 2014. This was 3.7 kg for each inhabitant (Balde et al., 2015). According to National WEEE task force, reported that total E-waste or WEEE generation was about 146,000 tonnes/year in India in 2005 (Wath et al., 2010). Another hand, Central Pollution Control Board (CPCB) estimated that 1.347 lakh MT of E-waste was generated in the country in the year 2005, which can be expected to reach 8.0 lakh MT by 2012. In addition, GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit)-MAIT (2007)¹ had estimated and suggested that huge amount (3,30,0000 tonnes) of WEEE generated in 2007 in India. However, other researcher also estimated as 420,000 tonnes/year (Wath 2010), and 382,979 tonnes/year generated in India (Skinner 2010). Although, E-waste flows complexity in India along with inadequate record-keeping pushing its estimation more difficult (Streiche-Porte et al., 2007).

2.2. China

The total amount of e-waste was estimated as 3.6 million tonnes in 2010 and nest to 5.5 million tonnes in 2013, and is expected to reach 11.7 million tonnes by 2020 and 20 million tonnes by 2040. This e-waste, mainly includes air conditioners (26%), televisions (24%), computers (14%), refrigerators (12%), washing machines (7%), printers (9%) and fluorescent lamps (7%) are produces respectively (Li et al., 2015). On January 1, 2015, a new Catalog of

WEEE Recycling (Batch 2) was issued, extended by covering of more nine type of categories of WEEE. These 'new' WEEE categories will increase the amount of governmental oversight of the recycling industry (Zeng et al., 2015 (Under review paper)).² Although, formal as well as informal activities involved in the collection system. In the meantime, the informal collection is reported from urban areas due to its most chances in highly populated places as well as availability of discarded or obsolete EEE. Another hand its availability is very low because slow penetration rate of home appliances with introduction/replacement of new technologies (Wang et al., 2013).

2.3. United State of America (USA)

According to UNEP (2007) e-waste is rapid growing component of municipal waste, including e-waste accounted about 70% of the heavy metals, by covering 40% of the lead, found in landfills with total 40 million metric tons annually at global. However, citizens have no idea what to do with their old computers and 75% of which are still sitting in closets of homes. The fate of most of the e-waste produced in the US remains a mystery, with experts assuming the majority is placed into landfill, incinerated, exported, or just abandoned in storage. In this regard, presently, USA generated 11.7 Mt of e-waste (7.9 Mt for North America, 1.1 Mt for Central America, and 2.7 Mt for South America), which represented 12.2 kg/inh. According to Balde et al. (2015) report the United States (7.1 Mt) is at top position in e-waste generation as absolute quantities followed by Brazil (1.4 Mt) and Mexico (1.0 Mt). In another hand, America generated highest e-waste quantity United States (22.1 kg/inh.), Canada (20.4 kg/inh.) and the Bahamas (19.1 kg/inh.).

2.4. European Union

Current European waste policy does not mainly aim to treat waste streams but rather place in the foreground of interest the complete supply chain of a product. Recycling only takes the third place whereas recovery and disposal represent the least favorable options (Bartl, 2014). The highest per inhabitant e-waste quantity (15.6 kg/inh.) was generated in Europe. However, the per inhabitant amount was nearly as high as Europe's (15.2 kg/inh.). Basically, waste generation is a huge business and numerous stakeholders are not interested to reduce waste. More sophisticated incentives are required to decouple economic growth from waste generation (Cucchiella et al., 2015).

3. Analysis and Discussion

Apart from resource materials used and emerging recycling technologies, legislation is also of necessity to sustainable management. The international community has established many standards, directives, or regulations concerned with WEEE, in order to improve its eco-friendly during the life cycle. The International Organization for Standardization set up ISO/TR 14062 (2002) and ISO 14001 (2004) with assistance from the United Nations and The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal; these state that the specific requirements for an environmentally sound management system, to enable organizations to develop and implement policies and objectives. These requirements apply not only to large enterprises, but also to small- and medium-sized ones (Li et al., 2015). Apart from, global environmental agreement, regional and national directives or regulations have been set up as well since 2002, which mostly are based on extended producer responsibility (EPR), to solve the e-waste problem (Stevens et al., 2013). In this regards, The European Union or the European Communities have established the Directive on Waste Electrical and Electronic Equipment, Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment, Directive on Packaging and Packaging Waste, Directive on Energy-related Products, and the Integrated Pollution Prevention and Control Directive. Another hand, China, since 2003, has set up the Cleaner Production Promotion Law, Ordinance on Management of Prevention and Control of Pollution from Electronic and Information Products, Circular Economy

² The study carried out by GTZ-MAIT in 2007 further estimates the total quantities of generated, recyclable and recycled E-waste to be 3,32,979, 000, 1,44,43 000 and 19,000,000 kg, respectively. Further, the study conducted by GTZ-MAIT (2007) states that about 14 million mobile handsets had been replaced in 2007.

Promotion Law, and Administrative Regulation for the Collection and Treatment of Waste Electric and Electronic Products. In United States, 25 states have e-waste laws and about 65% population is covered by a state e-waste recycling law, although some do not provide sufficient infrastructure or dedicated revenue streams to enforce compliance or to promote public participation (ETBC, 2012). Although legislation varies from country wise, the life cycle of electronics has been covered completely, from raw materials selection to e-waste recycling and disposal. In addition, global, regional, and national legislations have improved eco-design of CE in term of reducing emissions, saving resources, and eliminating the toxicity.

4. Role of microbes in recycling

It is believed that biotechnology has been one of the most promising technologies in metallurgical processing. Bioleaching has been used for recovery of precious and toxic metals from e-waste scrap. However, limited research was carried out on the bioleaching of metals from electronic waste (Hocheng et al., 2014; Hong et al., 2014; Hong and Valix, 2014). Mainly autotrophic bacteria, heterotrophic bacteria, and fungi are commonly used for the bioleaching (Ruan et al., 2014; Wang et al., 2014; Zhu et al., 2014). In this process microbial cells derive their energy needed for metabolism of itself through aerobic oxidation of reduced sulfur compounds (Ilyas et al., 2014; Ilyas et al., 2013; Ilyas et al., 2010; Vargas et al., 2014; Wang et al., 2014; Yang et al., 2014). Several researchers reported that fungi such as *Aspergillus* sp. and *Penicillium* sp. are extremely reported as promising fungal strains could be used as bioleaching (Bas et al., 2013; Coto et al., 2008).

5. Conclusion and Prospective

The key success parameters for the WEEE are based include environmental, social, and ethical benefits. However, there still exist several forthcoming challenges and opportunities for their management. First, the huge amount of generation has brought alarming indication for limited natural resources, which could have a directly/indirectly effect on recycling sector in upcoming future. Although, the existing rules and regulation will mitigate the pollution level but not able to solve complete problem of the environmental impacts of informal recycling, e-waste regulations should be continually concerned and the alliance of e-waste recycling can be established at special regional level. Similarly, in developed countries, e-waste is subjected to recover some materials of value and to be safely rid of the contain metals. Whereas, in developing countries, e-waste recovery is principally focused on few metals of value with primitive process. In addition, bioleaching potential systems is warranted for further detail research to establish systematic mechanisms.

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