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Management of electrical and electronic waste: A comparative evaluation of China and India

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ABSTRACT

Globally, electrical and electronic equipment (EEE) is now a part of daily life. When this equipment becomes waste electrical and electronic equipment (WEEE or E-waste), however, it needs to be properly processed, for use as a source of materials for future production and renewable energy, and to minimize both the exploitation of raw materials and the deleterious effects on both the environment and human health. A large quantity of e-waste is generated in both India and China, and both countries still suffer from an entrenched informal e-waste processing sector. Consequently, valuable materials in e-waste are disposed in open land, rather than being properly extracted for reuse and recycling. In this article we note that the major portion of e-waste in China and India is collected by the informal sector and treated with primitive methods. Additionally, illegal shifting agents also play a role by mislabeling e-waste and exporting them to developing countries. This article proposes that: the implementation of e-waste management laws and policies for proper e-waste collection, treatment and recycling, better educate consumers on the dangers of e-waste contamination, restrict the illegal movement of e-waste across borders, and support the development of a formal, regulated e-waste processing industry by funding incentive programs constructing recycling infrastructure. These measures should increase the recycling capacity and decrease the amount of WEEE contaminating the environment and endangering human health.

1. Introduction

Rapid advancements in science and technology revolutionized the fields of information and communication in the late 20th century, triggering dramatic changes in the industrial and socioeconomic landscape, that have continued into the early 21st century [1]. Consequently, new Information Communication and Technology (ICT) products and other e-products are continually being introduced into the market, and older products rapidly become obsolete [2]. The volume of e-waste is growing fast [3,4]. A recent United Nations University (UNU) report estimated that 41.8 MT of e-waste is generated globally every year [5]. A major portion of this e-waste is illegally transferred from developed countries to developing Asian countries like India and China. However, both India and China have ratified the Basel convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, which restricted the illegal movement of hazardous waste substances.

The UNEP [6] has predicted that by 2020— the quantity of discarded computers will increase 5 times over current levels, and that of discarded mobile phones, 18 times over year 2007 levels, in India. The ISRI [7] has reported that, India generates approximately 2.7 million tons of e-waste annually, and that 70 per cent of the total e-waste comes from 10 Indian states [8]. And, while the global compound annual growth rate (CAGR) of e-waste is anticipated to be 23.5% over these thirteen years, the rates for India for the period of 2015–2019, and of China for the period of 2013–2018, are predicted to be 26% and 19.4%, respectively [9]. The e-waste mismanagement poses a great threat to both the environment and human health [10–13]. Informal recycling of WEEE in India and China has already caused severe impacts on the natural environment and the health of unprotected workers in the waste management sector, as well as in areas immediately surrounding e-waste processing sector. Clearly, there is a critical need for sustainable e-waste recycling [14–16], and both the Indian and the Chinese governments have issued and enforced laws and regulations banning the illegal importation and informal recycling of WEEEs, and established collection, handling and treatment systems for environmentally sound recycling.

Although several studies on e-waste estimation, prediction and

Abbreviations: step, Solving the E-waste Problem; WEEE, Waste Electrical and Electronic Equipment; E-waste, Electronic Waste; EPR, Extended Producer Responsibility; MoEFCC, Ministry of Environment, Forestry and Climate Change; CPCB, Central Pollution Control Board; BAN, Basel Action Network; UNEP, United Nations Environment Programme; ISRI, Institute of Scrap Recycling Industries MTA, Metric Ton per Annum

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management have been carried out in China in the past few years, there have been comparatively limited studies on WEEE in India. Therefore, in this article, we preliminary evaluated the management of waste electronic and electrical equipment's (WEEEs) in China and India.

2. WEEE generation, composition and distribution

In India, there is no very clear/updated information on WEEE generation: how much is collected, treated and disposed of annually. Although some non-governmental organizations (NGOs) have conducted studies, these have been limited to a few selected cities. For instance, an Associated Chambers of Commerce of India [30] report suggested that currently Indian e-waste is being generated at an annual growth rate of 25% and is expected to be about 1,500,000 metric tonnes (MT) for 2015. Similarly, governmental bodies, such as State Pollution Control Boards (SPCBs) and the Central Pollution Control Board (CPCB) are also inventorying the e-waste programs. But these projects are still going on among the different cities. A report revealed that China, and India are expected to double their quantity of e-waste in the upcoming few years [31,32]. Sthiannopkao and Wong [33] predicted that the quantity of obsolete computers will be 400–700 million in developing countries by 2030.

2.1. Domestic WEEE

Indian and Chinese domestic e-waste contains a variety of electronic and electrical appliances, such as computers and their accessories (monitors, printers, keyboards, central processing units); mobile phones and chargers, remote-control units, compact discs, headphones, batteries, LCD/Plasma TVs, air conditioners and refrigerators [35,36]. While in case of China, the main e-waste includes—television, refrigerator, washing machine, air conditioner, personal computer, range hood, electric water-heater, mobile phone, fax-machine, gas water-heater, single-machine telephone, printer, copier and monitor.

Dangerous quantities of lead, mercury, arsenic, cadmium, selenium, and hexavalent chromium are present in e-waste, which cause serious environmental deterioration. Another category, consisting of ferrous and non-ferrous metals, glass, wood and plywood, concrete, ceramics, rubber and other items, are categorized as non-hazardous. Iron and steel constitute about 50% of the waste, followed by plastics (21%), non-ferrous metals (13%) and other constituents. Non-ferrous metals include copper, aluminum and precious metals like silver, gold, platinum, and palladium [37]. According to Balde et al. [5], the e-waste generation in absolute amount are in China (6.0 Mt) and India (1.7 Mt).

China accounts for approximately 20% of global volume of WEEE and is expected to produce 15.5 Mt per year by 2020. In the past, four types of WEEE (by weight)—air conditioners, monitors, desktop personal computers, and TVs—accounted for 71% of this WEEE. Zhang et al. [38] estimated that the total discarded quantity of five types of household appliances came to 130 million units in 2010, and predicted that this figure will increase to between 216 and 221 million units by 2020. The quantity of e-waste generation was 70 million units in 2014. Earlier study revealed that, about 440,000 people are engaged in collection for informal e-waste. In case of China, these areas are such as, Guiyu, Dalion the Pearl River Delta; Taizhou on the Ynagtze River Delta, Longtang, Hunan Province, Hebei Province; and Jianxi Province. Particularly, Guiyu, is the major informal e-waste processing site in China, and has a population about 150,000 people, approximately 100,000 of rural peoples are migrant labors involved in recycling sectors [162,163] In other hand, the main location in India, for informal recycling are such as New Delhi, Bangalore Chennai, Kolkata [164].

2.2. Import of e-waste

Both, China and India are not only the largest consumer of EEE and generator WEEE, but also both the country's heavily suffered from illegal WEEE shifting and informal practices. The United States has not yet ratified the Basel Convention, regarding e-waste. Nevertheless, the U.S. Resource Conservation and Recovery Act (RCRA) covers CRTs and contains regulations for e-waste generation, disposal and export [39,160]. The e-waste exportation is cheaper than recycling in the United States [40,41]. China have banned the import of WEEE since 2000, and also ratified the Basel Convention in 1991 as well as Ban Amendment in 2001. Although, unauthorized Scrap dealers and smugglers are use indirect way to illegally import e-waste into China even also other developing countries. In other hand, the unauthorized traders in high-income countries such as Korea and Japan, frequently mixing WEEE components with metal scrap shifted into China. In the same time, because of “One Country, Two Systems” policy, legislation of mainland China is not applicable in Hong Kong, which is moved to massive amounts of WEEE to China. In addition, the Hong Kong also acts as a transit point for re-exportation of WEEE to other countries [150,151]. According to a UNEP study on e-waste trafficking in 2013, most of the e-waste originating from the developed countries (European Union, the U. S., Japan, and Korea) was destined illegally to developing countries, especially India and China (Fig. 1(A) & (B)); but including others such as Indonesia, Pakistan, Malaysia [42–45]. This illegal dumping is profitable, and much of it is attributable to white-collar criminals and international smuggling enterprises [46]. Incidents such as these triggered the creation of the Global E-waste Crime Group in 2009, to try to stop such criminal activity at its source [47].

Since India and China, both countries have ratified the Basel convention prohibiting the importation of e-waste, tighter regulations and the growing cost of importation reduced the quantity of WEEE from 1500 kt in 2001 to 600 kt in 2014 (In case of China) [48]. However, the developed countries are also shipping out their used EEEs by incorrectly labeling them as electronic goods or as direct donations to institutions in developing countries [49,33]. When secondhand e-products land in these counties and are purchased by consumers, they quickly reach their end of life and become e-waste [50–52]. Annual domestic e-waste generation is earlier reported about 3,50,000 t, and illegal imports account for another 50,000 t. While it was reported by Zeng et al. [48], the import of e-waste decreased in China, and also expected to be decline more in near future. While, as per best of our knowledge, no clear recent information available about illegal e-waste import in India. However, several researchers have already found that—both India and China are playing the role of a disposal site for e-waste, as shown in Fig. 1 [51,52].

3. E-waste recycling practices in India and China

Many published literatures specify that, when EEE reaches its end of life—, almost all of it is collected & processed in the informal sector (small level family workshops) using primitive methods such as, manual dismantling, open burning and acid leaching [33,93,96]. The main goal of these small workshops is to extract and recover most of the valuable and reusable components from the e-waste [166]. In this informal sector scavenging is a major issue in e-waste processing, in developing countries [53].

3.1. Informal recycling

Empirical studies have shown that because discarded electronics contain precious materials such as copper, gold, and silver—many informal recycling yards have sprung up in developing countries [54]. And the flow of e-waste into the informal sector is faster in countries like, India and China, because of easy to set up and operate at a small