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Assessment of legislation and practices for the sustainable management of waste electrical and electronic equipment in India

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ABSTRACT

The waste electrical and electronic equipment (WEEE or e-waste) are the globally recognized hazardous material, though containing a full spectrum of valuable and critical metals. India, being the fifth largest generator of WEEE, is facing a great challenge in the sustainable management of such waste. Therefore since the past few years, Government of India has been trying to establish a proper institutional and legislative framework to implement the sustainable management of WEEE in the country. Accordingly, the global issues related to WEEE and how it is being tackled by other countries/regions with implemented regulations has been reviewed in this paper. Furthermore, the status-quo of WEEE generation, management policies and recycling practices in India has been systematically assessed while emphasizing the key issues of future initiatives, environmental and health hazards. The mathematical model of WEEE generation in India along with identifying the influences of recycling in sustainable management of WEEE has also been established.

1. Introduction

Technological advancement and extreme marketing approach engender a fast turnover of the electrical and electronic equipment (EEE). A broad range of commodity/gadgets, which can generate, measure and transfer the electric power or electromagnetic current, and/or function by supplying the electrical current are coming under the definition of EEE, as stated by the European Commission [1–4]. EEE usefulness is primarily based on their life cycle and/or availability of a newer version which is technologically superior from the existing one [5,6]. Once the EEE reaches to their end-of-life (EoL) and/or replaced with the advanced version, the disposed items are synonymously termed as: "WEEE" or "e-waste" [7–10]. E-waste can be a subset of WEEE; where the discarded electronic goods (e.g. personal computers, hand/telephones etc.) belongs to e-waste, however WEEE additionally refers to the EoL electrical appliances (e.g. air conditioners, refrigerators, washing machines etc.) [11–13]. The Association of Plastics Manufactures in Europe (APME) has defined e-waste as the multifarious combination of ferrous, non-ferrous, ceramic and plastic materials [14]. As adopted in the Indian legislation, both WEEE and e-waste are being accounted for the same in this article which broadly deals with the discarded/broken/surplus/obsolete electrical and electronic devices [15,16].

WEEE is the fastest growing waste stream globally (an annual growth rate of 4%) with an estimation of ~72 million metric tonnes in the year 2017 [17–19]. But the magnitude of WEEE growth has not been corresponded to their collection, recycling, refurbishing and reuse. Consequently, the life-cycle of WEEE is a linear progression with manufacturing, use, storage and waste disposal. The complex mixture of hazardous heavy metals (lead, chromium, mercury, cadmium and tin), large amount of base metals (copper, nickel and zinc) along with the toxic organic pollutants (viz., polybrominateddibenzo-p-dioxins and difurans, PBDD/Fs) as flame retardants and polyvinyl chloride (PVC) constituents in WEEE cause significant challenges to the living organism and environment [20–25]. Nevertheless primitive recycling practices of informal sector generally impose a serious threat to the environment and human health due to the severe pollutants release into air, soil and ground water [26]. The situation is worst for developing countries (with a higher economic growth rate) like, China and India [26–30]. Along with the unauthorized imports of WEEE and used EEE (UEEE), the electronics, electricals and telecommunications market has expanded many folds in India due to recently implemented technological development programs in the country (under the umbrella of Digital India Mission by the Ministry of Electronics &

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Information Technology, Government of India; MeitY, GOI) [31,32]. The large volume of waste generated after completing the life span of EEE can be catastrophic and demands entire cleanliness. In view of that, there is need to design novel systems and approaches for WEEE management in India [33–35]. Ideally, such approaches will minimize environmental impacts by increasing reuse and recycling of waste materials, and developing a sustainable society that learns to make balance between the technological evolution and their effective management with responsibility.

Accordingly, this paper explores issues related to planning future regulations for WEEE management systems in India. It first highlights the worldwide issues of WEEE management and how it tackled by other countries/regions (e.g., the European Union, Japan, South Korea, and Taiwan etc.). Then, it accounts the status-quo of WEEE generation and handling situation in India with their impact on public health and environment. In addition, the development of legislative framework in India has also been reviewed to reach at the newly introduced e-waste legislation 2016 in the country along with the effectiveness and future prospects of WEEE management in Indian scenario.

2. Global issues with WEEE and their management

WEEE is one of the global rising problems due to the associated health and environmental hazards with an expanding volume of it. WEEE is mainly generated by the Organization for Economic Cooperation and Development (OECD) countries, however the studies suggest a sharp increase and double amount of WEEE production by developing countries than the developed countries in next 6–8 years [36,37]. As estimated, an average 550 million metric tonnes of WEEE will be discarded by the developing and developed countries by 2030 [20]. The saturated market of WEEE in the OECD/developed countries has organized WEEE management system. Though, they also export their waste in developing countries (usually China, India and African countries), causes serious threats to the ecosystem. WEEE disposal with household waste lead to toxic emission; landfilling contaminates the ground water with hazardous leachates; incineration generating harmful fumes causes severe air pollution.

Such disposal of WEEE, without any obligation on their importer and unauthorized recycler with improper technology has stimulated the further trans-boundary flow. In response to this, the trans-boundary movement of hazardous waste and their disposal, under the Basal Convention, was enacted to prohibit the international trade of WEEE [38]. However, the movement of WEEE (in other form than waste or illegal movement) was unable to fulfill the purpose of Basal Convention. The next big step was taken by the European countries as WEEE directive and the Restriction of Hazardous Substances (RoHS Directive, 2002/95/EC) [4,39,40]. Aiming to the improvement of environment, the European countries have made significant efforts to achieve the zero/minimum material waste in product's life-cycle. Such efforts driven by environmental considerations and have broader impacts to produce better product on global demand. Later, the responsibilities of producers have emphasized under an extended producer responsibility (EPR) system whereby WEEE manufacturer have assigned the obligation for environmental impacts throughout the life-cycle of products, including recycling, reuse and final disposal of waste materials [3]. The worldwide initiatives related to WEEE management and increasing awareness on environmental issues have been listed in Table 1.

Based on the “polluter-pay-principle”, EPR shifts either financial or physical upstream responsibility to the producers. Presently, EPR is the foremost policy focusing on product systems instead of the production facilities. It intends to provide incentives to manufacturer for incorporating the environmental considerations during product design [11,52]. The policy considered by European Union and OECD countries largely shifts away the responsibilities from municipals to manufacturers by inclusion of treatment and disposal costs with the selling price of products [11]. The policy tools lie under EPR umbrella include various kind of product fees and taxes, viz., advance recycling fees (ARF), take-back system, virgin material taxes, pay-as-you-throw, waste collection charges, landfill bans and their combinations.

The development of global WEEE management tools as a whole can be understood from Fig. 1. Parallel to the global initiatives on WEEE management and development of various tools for it, time-to-time individual country or, region also attempted to overcome the rising increasing problem either by developing their own way of WEEE management or adopting the initiatives of others. Further, Table 2 presents such legislation/regulation developed for the sound management of WEEE through individuals. By looking on Tables 1, 2, it is clear that the awareness of global community for the sustainable handling of WEEE was increasing with time; however, not any specific guideline or, legislation was developed or, adopted to tackle it in India. In resultant to this, India along with China and African countries became the hub for global WEEE/UEEE dumping. The policy paralysis for import and efficient management of WEEE/UEEE, expansion of UEEE market with a rise in lower-middle class economy, growing upper-middle class economy with rapid industrialization, and growth of the unauthorized recycling sector have remained the main factors to proliferate UEEE/WEEE in India and raised the problem many folds with time-span.

3. Accounting the problems of WEEE in India

India is the fifth largest WEEE generator country worldwide and the volume is growing with an estimated rate of ~21% annually [20,61]. A large amount of waste coming through illegal trading routes, mainly handled by the informal/unauthorized sector, are a serious threat to the sustainability (Fig. 2). Although the Basel Action Network (BAN) and Hazardous Waste Rules (2008) restrict the trans-boundary movement of WEEE, the permissible import of UEEE (of spent life < 10 years) as donation to non-profit organization in India has kept the backdoor open [62–64]. Therefore, the catastrophic problems created by WEEE cannot be visualized clearly without a proper identification of items belonging to e-waste category, accounting their volume and adverse impact on the environment and human health.

3.1. WEEE generation in India

The OECD countries contribute approximately 50–60% of the total WEEE in India, and it makes difficult for a precise evaluation of WEEE generation and inventory data [65]. In Indian scenario, mainly three types of WEEE have been designated: the households, IT & communication equipments and consumer electronics. A description of all types of WEEE with their annual generation amount in India is given in Table 3. The Associated Chambers of Commerce of India (ASSOCHEM) has estimated a 25% compound annual growth rate of WEEE; generating a total 1.85 MT in the year 2016 [66–68]. Mumbai (1.2 MT) tops in the list followed by Delhi-NCR and Bangalore generating 98,000 and 92,000 t WEEE, respectively [63]. The other metro cities Chennai (67,000 t), Kolkata (50,000 t), Ahmedabad (36,000 t), Hyderabad (32,000 t) and Pune (25,000 t) have also placed in the list.

A rapid growth of Indian economy, fast urbanization and enhanced purchasing capacity of the expanded middle class society in contrast to cheaper and easily available advanced EEE (Fig. 3) would keep rising the volume of WEEE reserves [69]. The reserves is likely to increase exponentially up to 2025 due to improper treatment facilities in India [70,71]. Nevertheless such estimation cannot put an actual scenario of the threat produced by WEEE to the sustainable society. Therefore, a predictive mathematical modeling [72] has been adopted to quantify the two most sellable EEE in Indian market: computers and mobile phones. At first, the computers and mobile phones have been inventoried by considering the real time available data on their number of units produced and weight [61,73]. Subsequently the total weight of gadgets was determined by considering the factors of: (i) constant increasing