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Mercury in e-waste: Environmental and human health hazards

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ABSTRACT

The generation and accumulation of electric and electronic wastes (e-waste) is increasing worldwide due to the high demand of information technology in every aspect of life. However, the recycling industries are very active in their business; still, there also exists an informal recycling industry which are collecting the e-wastes in an eco-unfriendly manner. As a result, causing environmental and health hazards simultaneously. The present study is focused towards the mercury present in the e-waste and hazards to the environment and human related to this heavy metal. E-waste like spent batteries, mercury vapor and fluorescent lamps, switches, dental amalgams, measuring devices, control instruments, and laboratory and electrolytic refining wastes contains mercury or mercury compounds. This mercury is released into the environment because of the improper processing methods of the informal sectors. In addition, the recyclers themselves face the maximum possibility of mercury exposure. According to a recent report, establishment of these informal recycling complexes are prominent in the slum areas, such as such as Dharavi in Mumbai where hygiene and living conditions of the dwellers and workers are poor. Obsolete electrical and electronic equipment's containing mercury, such as fluorescent lamps, computers and TV sets are the primary focus of the informal collectors in developing countries in terms of earnings. Mercury containing appliances are collected by local collectors throughout a country and ultimately, sent to such recyclers for further processing in compilation with other wastes. Fluorescent lamps, for example, are processed for reuse in a very crude manner because of the lack of awareness and the lack of a separation collection system. Such e-waste ends up at landfill sites or is treated by incinerators (open burning). As a consequence, the mercury in the waste is released in the environment and mercury pollution is suspected around those sites because of mercury emission from the electrical and electronic equipment. Mercury emission can cause air as well as water pollution. The mercury vapour inhaled by an individual will develop an asthma and lung cancer to its extreme. On the other hand, when the mercury is contaminating the ground water followed by ponds and rivers, it gets converted to methyl mercury (an organic form of mercury). The methyl mercury is a very toxic compound and it enters the food chain through the fish and gradually to birds and human beings. The mercury contamination in the environment can be curbed by different strategies. Firstly, the informal and illegal e-waste collection and recycling should be stopped through the development of a public-private partnership under a legal framework and investment in environmentally sound technologies. Secondly, awareness development programs should be launched. Finally, development and investment in research projects that are working on de-mercurization of soil or water through chemical and microbial route.

Key Words :- Mercury; e-waste; health hazards

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INTRODUCTION

Electronic waste or e-waste is generated when electronic and electrical equipment (EEE) becomes outdated or unfit for their intended use (Clifton, 2007). The primary examples of e-waste are Computers, servers, mainframes, monitors, compact discs (CDs), printers, scanners, copiers, calculators, fax machines, battery cells, cellular phones, transceivers, TVs, iPods, medical apparatus, washing machines, refrigerators, and air conditioners. Due to the rapid technology progress and production of newer models, the electronic equipment gets fast replacement. This has led to a giant leap in e-waste generation (Davidson *et al.,* 2004).

E-waste is mainly the metals, plastics, cathode ray tubes (CRTs), printed circuit boards, cables, etc., the integral operational components of the EEE. Several valuable metals such as copper, silver, gold, and platinum could be recovered from e-wastes, if they are scientifically processed. On the other hand, the e-waste also contains toxic substances like liquid crystal, lithium, mercury, nickel, polychlorinated biphenyls (PCBs), selenium, arsenic, barium, brominated flame retardants, cadmium, chrome, cobalt, copper, and lead that makes it life threating. But these types of elements only cause hazards if they are improperly dismantled and processed with rudimentary techniques. E-waste poses a huge risk to the biotic as well as the abiotic world.

Consumers are the key to better management of e-waste. Initiatives such as Extended Producer Responsibility (EPR), Design for Environment (DfE); Reduce, Reuse & Recycle (3Rs), technology platform that are linked with the market for facilitating a circular economy thus can aim to encourage consumers to correctly dispose their e-waste, with increased reuse and recycling rates, and adopt sustainable consumer habits.

In developed countries, e-waste management is given high priority. Whereas, in the developing and the under developed countries the same is exacerbated by completely adopting or replicating the e-waste management of developed countries. Moreover, several peeping issues viz. lack of investment and technically skilled man power are always there. In addition, there is a lack of infrastructure, appropriate legislations specifically dealing with e-waste and inadequate description of the roles and responsibilities of stakeholders and institutions involved in e-waste management. The Ministry of Environment, Forest and Climate Change (MoEFCC) had released the updated E-waste (Management) Rules in 2016 which came in supersession of the E-waste in India (GOI, 2016).

E-waste and mercury

Mercury in the EEE is contained in LCD backlights, lamp components, display panels etc. Although the amount of mercury contained in each unit of EEE is at minute amount (approximately 2- 10 mg per equipment). It is estimated that all the mercury annually used in EEE accounts for about 22 % of the world mercury consumption because of the extensive use of the EEE (Goldman & Shannon, 2004). In the developed countries, mercury usage in EEE is tending to be phased out due to the current environmental awareness against hazardous chemicals used in EEE. In the present situation, the producers of EEE technically reduce the amount of mercury in EEE as low as possible, or they use some alternatives instead of mercury to manufacture EEE.

In developing countries, unlike the developed countries, the producers of EEE containing mercury are least bothered to reduce the amount of mercury in the EEE, or to phase out the mercury used in the EEE, because there is less opportunity for them to know that mercury has the potential to cause adverse effects to human health and the environment. Some EEE containing mercury, viz. the fluorescent lamps, has no mercury-free alternatives. Some countries, mainly developed countries, set the maximum level that mercury can be used in EEE and allow some EEE to contain as little mercury as possible. Nevertheless, the amount of e-waste containing mercury tends to increase in both developed and developing countries as a consequence of the current EEE containing mercury. The mercury contained in EEE in terms of its chemical properties holds the potential to cause adverse effects on human health and the environment if the EEE is dealt with in an environmentally unsound manner. According to different reports, (Harada *et al.*, 1999) several workshops in the informal recycling industry deal with used parts, such as LCD backlight and lighting products, dissembled from used EEE and similar products, including fluorescent lamps, and the working conditions in the workshops are environmentally unsound. For example, a workshop dealing with used fluorescent lamps is not equipped with a ventilation system, including windows, despite the fact that broken fluorescent lamps are scattered on the floor. It can be concluded that mercury contained in the used EEE in the informal recycling industry escapes to the environment. The present review depicts the current situation and the environmental and health concerns of e-waste containing mercury in the informal recycling sector. It also discusses an ESM of e-waste in the informal recycling industry.

Issue of e-waste with mercury

Obsolete EEE containing mercury, such as fluorescent lamps, is one type of e-waste which informal collectors in developing countries target, despite the fact that earnings are less than for obsolete EEE such as used computers and TV sets. EEE containing mercury is collected by local collectors who collect various kinds of wastes throughout a country and sent to such recyclers, together with other wastes for further processing. Fluorescent lamps, for example, are processed for reuse as follows: The end-caps of fluorescent lamps are removed; The glass tubes are washed with water and then dried; The removed end-caps are repaired if possible; New fluorescent lamps are remodeled by using washed glass tubes and the repaired or new end-caps; and A gas containing low pressure mercury vapour is filled in the fluorescent lamps. Although their recycling processes are the same as those of recyclers who operate in an environmentally sound manner under a regulation, they rely only on their skills to dismantle and remodel.

Obsolete EEE containing mercury which can no longer be reused or recycled is disposed of as any other municipal solid waste and mixed with other wastes in most developing countries, (Wada *et al.* 2009) because of the lack of awareness and the lack of a separation collection system, or the lack of facilities for EEE containing mercury. Such EEE ends up at landfill sites or open dumping sites, or is treated by incinerators or open burning. As a result, the mercury in the EEE is released into the environment. Mercury pollution is suspected around those sites because of mercury emission from EEE and other mercury wastes (Hybenova *et al.,* 2010).

Environment and health concerns

When EEE is disposed in the environment an environmentally unsound manner, because of its chemical properties the mercury contained in it is released into the environment. A gas containing low pressure mercury vapour in fluorescent lamps, for instance, escapes into the environment when fluorescent lamps are broken. The other occasions on which mercury leak is when obsolete EEE is disposed of into landfills, or incinerated, or openly dumped into illegal dumping sites in an environmentally unsound manner. Once mercury is released into the environment, it remains there permanently, changing its chemical forms depending on the environment. Mercury cannot be converted to a non-mercury compound. Thus, it can be hypothesized that mercury released from informal recycling sectors in an environmentally unsound manner is diffused throughout the environment. If people inhale mercury vapour, approximately 80 per cent of it crosses the alveolar membrane and is rapidly absorbed into the blood (Landrigan, 2010). Due to the high lipophilicity, elemental mercury vapour passes the blood-brain barrier and the placenta. The WHO air quality guideline for mercury is 0.001 mg × Hg/m^3 (annual average). The threshold limit value (TLV) for mercury vapour is 0.025 mg × Hg/m^3 for longterm exposure as the time weighted average (TWA), which means the time weighted average concentration for a normal 8 hour-day and 40 hour-work week (Ceccatelli *et al.*, 2010). The acute exposure limit for mercury vapour is 0.1 mg×Hg/m3. Kazantzis (2002) estimated that mercury emissions from a fluorescent lamp after breakage were about 6.8 % of the total mercury content of each fluorescent lamp (Wu *et al.*, 1985).

When two fluorescent lamps are dealt with simultaneously and the mercury vapour in the lamps escapes into the air, the concentration of mercury vapour is 0.027 mg × Hg/m^3, that exceeds the TLV. According to a research article, one-third of the mercury contained in a fluorescent lamp would be released during the first 8 hours after breakage (Solt & Bornstein 2010). Therefore, if ventilation is poor in a workshop dealing with used fluorescent lamps, recyclers and their family members inside the workshop would inhale mercury vapour and face possible occupational exposure to mercury vapour.

Remediation of mercury

According to the present investigation the following measures should be adopted to prevent mercury pollution in the environment:

1. Establishment of proper recycling system for the spent fluorescent lamps.
2. Improvement of the disposal capacity and technology of mercury
3. A systemic management of mercury disposal
4. Development of the LED industries

On the other hand, several researches are nowadays focused towards the phyto-remediation and microbial remediation of mercury from air and water. Terrestrial plants like garden pea (*Pisum sativum* L.), sugar beet (*Beta vulgaris* L.) and the willow roots are significant accumulator of methyl mercury (Bhardwaj *et al.*, 2009). Bacteria viz. Bacillus subtilis, Bacillus cereus are excellent eliminator of mercury because of the presence of the mer-operon in their extra chromosomal DNA (Bhattacharya *et al.,* 2016).

CONCLUSION

The foregoing review thus concludes that in terms of energy conservation and eliminating mercury pollution from the environment, the use of fluorescent lamps and spent fluorescent lamps should be discouraged. Rather, the light industry should focus towards the production of LED lamps. As far the other EEE are concerned, the use of alternatives has become inevitable for a cleaner and greener tomorrow.

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