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SITE RECLAMATION & UTILIZATION OF E-WASTE BLACK POWDER IN MAKING CONCRETE BLOCKS FOR PAVEMENTS

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Abstract: In the present context, electronic waste is one of the emerging global issues and must required proper attention at global as well as local level. Moradabad is now biggest hub of e-waste recycling in India and handling almost 50% PCBs waste of the country with involvement of almost 2 Lakh people. A field visit was undertaken at Moradabad E-waste dumping site; sampling & preliminary characterization of e-waste black powder done at Lab scale. The condition of Moradabad ecosystem is really need urgent attention and hence there is an immediate need of an eco-friendly technology for environmental protection. People are openly dumping ash of PCBs after executing recycling activities. This black powder ash is creating problem to terrestrial and aquatic ecosystem of the vicinity. Thus, there is a need to make an integrated strategy to combat against e-waste pollution as well as site reclamation/ restoration in association with suitable local authorities or community.

Keywords: Black powder; Environmental Pollution; E-waste; Informal recycling.

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INTRODUCTION

Electronic waste or e-waste is described the discarded electrical or electronic devices. Electronic waste contains harmful components such as lead, cadmium, beryllium, or brominated flame retardants. Crude and unscientific recycling of e-waste involves risk to health of workers and also leads to emissions of toxic materials such as heavy metals. Informal processing of e-waste in developing countries can lead to emission of pollutants, which can have adverse effects on human health and environment. Electronic waste or E-Waste includes computers, office electronic equipment, entertainment device electronics, mobile phones, television sets, and refrigerators. This includes used electronics which are destined for reuse, resale, salvage, recycling, or disposal (Wikipedia, 2018). Others are re-usable and secondary scrap (copper, steel, plastic, etc.) to be commodities, and reserve the term waste for residue or material which is dumped by the buyer rather than recycled, including residue from reuse and recycling operations, because loads of surplus electronics are frequently commingled (good, recyclable, and non-recyclable), several public policy advocates apply the term e-waste broadly to all surplus electronics. Cathode Ray Tubes (CRTs) are considered one of the hardest types to recycle.

Current Disposal

The problem of e-waste disposal and safe recycling is escalating rapidly through increased production of electronics in developing countries because of the beneficial economic incentives that it provides. The total amount of e-waste produced has reached approximately 41 million ton (Perkins and Nxele, 2014) and is increasing at a rate of 3-5% every year (Balde *et al*., 2017; Kumar *et al.,* 2017).

i. Global Scenario

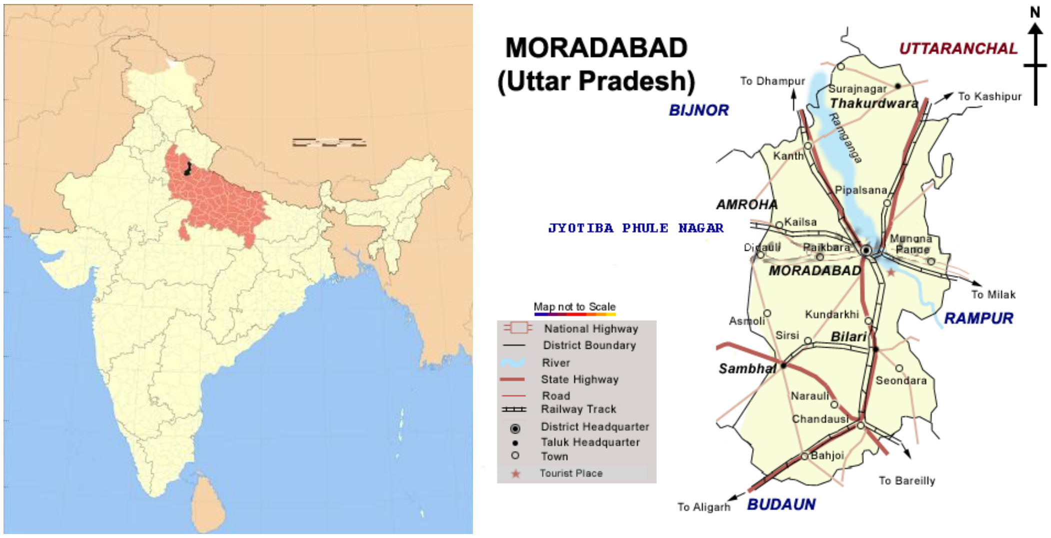
In the world, about 50 million metric tonnes (Mt) of e-waste is generated annually in 2016. This is close to 4,500 Eiffel Towers each year. The amount of e-waste is expected to increase to 55 million metric tonnes by 2021 (Balde *et al*., 2017). Of those 44.7 Mt, approx. 1.7 Mt are discarded into the residual waste in developed countries, and are also incinerated or land-filled. Around 10 Mt of e-waste are to be collected and recycled, which corresponds to 20% of all the e-waste generated (Garlapati, 2016). The USA is ranked first in e-waste generation, generating 11.7 million tonnes of e-waste annually. China is ranked second with 6.1 million tonnes of e-waste every year (Balde *et al*., 2017).

ii. Indian Scenario

India is ranked as the fifth largest generator of electronic waste in the world, with an estimated 1.85 million tonnes generated annually as on 2016. Globally, the number is an astounding 40 to 50 million tonnes annually. India accounts for roughly 4 % of e-waste generated annually (Balde *et al*., 2017). The 70% e-waste is being generated by ten states in India. 50% of PCBs are being dismantle in Moradabad only, where approx. 2 Lakh peoples are involve in e-waste recycling. Informal e-waste recyclers are recovering 70% of precious metals and materials using crude technology (Burning/washing), while dumping remaining 30% in the form of black carbon (CSE, 2015).

iii. Scenario at Moradabad

The UP district of Moradabad has for last one decade in recycling of e-waste in India in unscientific ways. It generates around 9 tonnes of hazardous waste daily, and around 50,000 people are involved in it. Most of the recycling is illegal. Location map of Moradabad district is given as Figure 1 (A-B). As per the Centre for Science and Environment (CSE) report on Moradabad's e-waste recycling industry in city the situation is alarming. The e-waste workers may face serious health hazards, and the industry poses a serious threat to the environment. The country does not even have soil contamination norms or standards. There is a need to develop them to measure and lower the level of pollution in cities like Moradabad. There is also a need to monitor e-waste related activities in Moradabad. It is found that zinc levels were 15 times more than that the prescribed limits. Copper levels, were five times higher in the soil samples collected near river Ramganga. Chromium level was twice the standard, while cadmium was 1.3 times (CSE, 2015). According to the study, the results were similar for water samples taken from Ramganga where mercury levels were found to be eight times higher. Traces of arsenic were found too. CSE collected samples from Nawabpura, Karula, Daswaghat and Rehmat Nagar localities, where a vast majority of the population is involved in handling e-waste, and Bhojpur, a neighboring village which is also a major e-waste handling centre. Open dumping site for e-waste black powder and collected black powder samples are shown in Figure 2 (A-B). With huge amounts of e-waste being dismantled and recycled in the city, black powder is generated during recycling of e-waste are needed to deal with the problem. The study said that the soil and water of Moradabad contain heavy metals, which are dangerous to the environment and can cause serious ailments, including cancer. High levels of mercury and arsenic can lead to chronic poisoning. Tests to detect such poisoning are usually expensive and nobody gets them done. Mercury enters the food chain through bio-accumulation in fish and other aquatic life forms. It is a known neurotoxin and interferes with the proper functioning of the brain and the nervous system. However, ailments caused by heavy metal pollution go unreported or undetected. High levels of zinc, cobalt and nickel do not have any reported clinical problems, but they may lead to sub-clinical problems which cannot be detected on the basis of symptoms, but persist.



A B

Figure 1. (A-B): Map of Moradabad district

A B

Figure 2. (A-B): Dumping site and black powder sample (Taken by PKB on 8-02-2018)

The health hazard was also highlighted in a report the district pollution control board had shared with the central government last year. In fact, then UP chief secretary had ordered a complete ban on e-waste recycling in Moradabad, Ghaziabad and Hapur last year, but nothing much came of it. There have been several incidents in the city where residents have had to rush out of their houses choking on toxic fumes. In many cases, such incidents have led to hospitalization of people and police raids on illegal e-waste recycling dens. In 2014, more than 50 cases of illegal e-waste recycling were registered under Mughalpura and Nagfani police stations and more than a hundred offenders were put in jail.

iv. Recycling of E-waste

Only 6% e-waste is recycled in India, out of which 95% is recycled through informal sector. In an environmental friendly manner, all e-waste should be recycled in formal recycling facilities with high technology. The formal e-waste facilities are costly to operate, especially in India, informal recycling are prevalent (Terazono *et al.,* 2016). The informal e-waste sector extracts the valuable materials of the e-waste using crude recycling and disposal methods usually without any safety equipment or the assistance of technology (An *et al.,* 2015). The workers in these communities depend on the extraction of the valuable metals from e-waste for their livelihood. The valuable materials are removed and the remaining parts of the e-waste are burned, buried or discharged into water for easy disposal (Sthiannopkao and Wong, 2013). These crude processes used in the informal sectors lead to environmental contamination because the processes emit toxic chemicals from the e-waste into the surrounding (Song and Li, 2014). The most common operation is open burning to remove valuable metals from PCBs and other e-waste. During the process, it releases toxic chemicals such as PAHs into the air and water environment. The improper incineration and the burning of e-waste to recover metals is also carried out and lead to emission of dioxins which are extremely toxic compounds (Zhang *et al.,* 2012). The open acid leaching is also used to recover metals from the electrical components (Zhao *et al.,* 2009). The spent acid from treatment process is dumped into the surroundings, which creates environmental hazard. The pollutants can be exposed to the environment from e-waste being physically dismantled, buried or dumped into the environment (Sthiannopkao and Wong, 2013). E-waste informal processing sites can be located near agricultural fields and other cropland where heavy metals and other pollutants can penetrate into the soil where food is grown (Song and Li, 2014; Park *et al*., 2017).

Environmental Impacts

The processes of dismantling and disposing of electronic waste in developing countries led to a number of environmental impacts as illustrated in the graphic. Liquid and atmospheric releases end up in bodies of water, groundwater, soil and air and therefore in land and sea animals both domesticated and wild, in crops eaten by both animals and human, and in drinking water. These may be as follows:

- Airborne dioxins – one type found at 100 times levels previously measured.
- Levels of carcinogens in duck ponds and rice paddies exceeded international standards for agricultural areas and cadmium, copper, nickel, and lead levels in rice paddies were above international standards.
- Heavy metals found in road dust – lead over 300 times that of a control village's road dust and copper over 100 times.

The major impacts of the processing of different e-waste components on environment are given in table 1.

Table 1. The environmental impact of the processing of different e-waste components

#	E-Waste	Process Used	Potential Environmental Hazard
1.	Cathode Ray Tubes	Dismantling and dumping	Lead, barium and other heavy metals leaching into the water and release of toxicants
2.	Printed Circuit Board (PCBs)	De-soldering; open burning and acid baths.	Air emissions and emissions of glass dust, tin, lead, dioxin, beryllium cadmium and mercury
3.	Chips and other gold plated components	Chemical treatment and burning of chips	PAHs, heavy metals, brominated flame retardants into water. Tin and lead contamination of water. Air emissions of dioxins, heavy metals and PAHs
4.	Printers, keyboards, monitors, etc.	Shredding	Emissions of dioxins, heavy metals and hydrocarbons
5.	Wires & Cables	Open burning to remove copper	PAHs released into air, water and soil.

Table 2. Hazardous and Non-hazardous substances in e-waste

S.No.	Category	Elements/compound
1.	Hazardous substances	Americium, Lead, Mercury, Cadmium, Hexavalent chromium, Sulphur, Brominated Flame Retardants (BFRs), Perfluorooctanoic acid (PFOA), Beryllium oxide
2.	Non-hazardous substances	Aluminium, Copper, Germanium, Gold, Lithium, Nickel, Silicon, Tin, Zinc,

Issues and challenges

One of the major challenges is itself recycling of the electronic wastes. The e-waste contains precious metals as gold, silver, platinum, etc. and also metals such as copper, iron, aluminum, etc. Presently, e-waste is processed by burning and acid leaching to recover copper and metals. The conventional method employed is shredding and separation but the recycling efficiency is low. Alternative methods such as cryogenic decomposition have been studied for printed circuit board recycling, and some other methods are still under investigation. Properly disposing of or reusing electronics can help prevent health problems, reduce greenhouse-gas emissions, and create jobs. Reuse and refurbishing offer a more environmentally friendly and socially conscious alternative to down-cycling processes (Bharti *et al.,* 2018a; Bharti *et al.,* 2018b). Hazardous and Non-hazardous substances present in e-waste are given in table 2.

Solutions

The existing policies that developing countries have created so far have not been effective in reducing the amount of informal recycling because there is an overall lack of governance and enforcement resources in these areas. Formal facilities have not been able to compete with the informal recycling. An incentive system will most likely be needed to have the informal recyclers be more willing to bring their collected e-waste to the formal facilities where it will be recycled without resulting in negative impacts to the environment and human health. Additionally, investment in the resources necessary to provide enforcement and supervision for the existing and potential new policies that will be put in place should be implemented. For example, the restriction of e-waste importation needs to be controlled better in order to decrease the amount of e-waste being transported to these informal recycling areas. Considering future mitigation methods, one primary option is for manufacturers and producers to become more involved in implementing take-back systems to recycle their electronic items properly (Park *et al*., 2017; Bharti *et al,* 2018a; Bharti *et al*, 2018b).

For the existing problems in the informal sector of India, a few issues must be resolved in an integrated manner. Proper training should be provided to e-waste dealers, dismantlers, recyclers and appropriate awareness program must be organized for them. It will help out to make the recycling method better and technology oriented. Utilization of e-waste slag/ black powder must be carried out in some useful applications for the betterment of society. The applications may be material development, concrete blocks for pavements, etc. to make sure the leaching of hazardous metals out of it. The task can be jointly carried out by Nagar Palika, SDM, UPSPCB, local community and other research body.

A flow chart of integrated strategy to combat e-waste pollution is given in Figure 3. One another big issue is the reclamation of infected site due to the e-waste ash contamination. Soil modification is the prime concern in this regard. Top soil modification is required for soil affected by black carbon slag of burnt e-waste. Either top soil removal or replacement by new healthy soil or soil amendment using sand, lime and compost/green manure is the possible solutions. Biotechnological approaches (using Bacteria/Super Bug, Macrophytes, Grass or woody plants) may be a good option for soil reclamation of contaminated sites. The approach must be designed in such a way, so that the solution of the problem is resolved to a great extent.

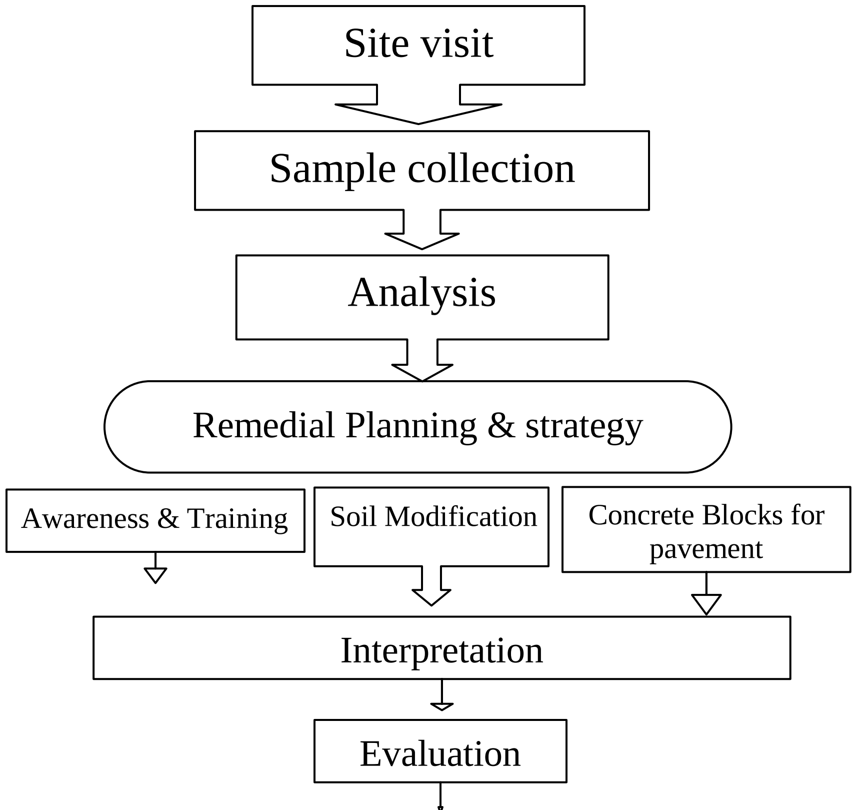


Figure 3. Flow chart of Integrated Strategy to combat e-waste pollution

CONCLUSION

E-waste is generated at a rapid rate in almost all developing countries including India. This e-waste disposal & recycling issue needs to be addressed scientifically to reduce the harmful effects of the toxic chemicals in e-waste that have an environmental and human health impact. The e-waste recycling should be carried out in a sustainable manner. It is advised to adopt the above given integrated strategy to combat e-waste pollution as well as site reclamation/ restoration in association with suitable local authorities or community.

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