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3R's of E-Waste in India: A Primary Survey

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Abstract

UNEP (2010) report forecasts that in India by 2020, Electronic waste from disposed-off mobile phones shall be approximately 18 times more; from old computers will rise to 500%; from disposed-off refrigerators shall double or triple; from televisions shall be 1.5-2 times higher; than its corresponding 2007 levels. Currently, in India the growth in e-waste is around 30% annually and is approximated to grow to 52 lakh MT by 2020, according to Assocham, as there is a dearth of agencies which could collect e-waste and dispose it. In this paper, using primary data collection and its analysis authors emphasizes 3R's of e-waste management (Reduce, Reuse, and Recycle). They have made an attempt to understand various e-waste related challenges both to the environment as well as to the human being; analysed preferences of people for the e-waste collection mechanism; studied numerous measure in place that can be taken to collect e-waste through various places: schools, apartments, non-apartment areas in the country; to encourage disposal of e-waste from homes and transport them to the recycling bins. The authors suggest that to incentivize people to part with their e-waste, mass awareness regarding health hazard issues related to various e-waste must be created (at the city level, village level across rural, urban areas). Startups, venture capitalists must be encouraged to come forward and take up investment plan in this aspect in the country. Revenue generated from the sale of e-waste as per the recovery of metals, plastic and other recyclable component of the item, will create an entire market for e-waste, which will eventually contribute to the GDP of the country. Overtime, a successful mechanism in place to collect e-waste from each and every household, can reduce the health risk posed to the people on a daily basis, which shall enrich the life expectancy of the people and possibly may reduce the unnecessary health expenditure. The objective of the policy makers must be to establish a mechanism that reduces e-waste, which would lead to sustainable and a pareto-optimal outcome, since all the stakeholders, namely-households, recycling companies will be benefitted by it; and finally, it would help our environment, to get rid of all the hazardous outcomes, which the inefficient decomposition of e-waste, generally leads to.

Keywords: Recycle, Re-Use, Reduce, E-Waste, E-Scrap.

Introduction

Electronic Waste/ E-scrap/ E-waste describes disposed-off electronic or electrical devices. Electronic waste means covered electronic equipment which has been disposed off or is not needed by its owner anymore, or that moves to the waste collection, treatment, processing, recovery. They mostly end up in informal sector; illegal or unrelated recycling and dumping centres that can do notable harm to the nature and to the human health. For example: e-waste may include: (i) Office devices, mobile phones, computers and telephones, (ii) Entertainment/consumer electronics (eg. tuners, DVD players and television), (iii) Lighting devices (such as desk lamps), (v) Household appliances (such as microwaves, fridges and washing machines), (iv) Power tools (like power drills) excluding stationary industrial devices, (vi) Devices used for leisure and sport including toys (eg. remote control cars and fitness machines). The e-waste is composed of non-ferrous and ferrous metals, printed circuit boards, plastics, plywood, glass, ceramics, rubber, wood, concrete, and other items. Of the e-waste, Iron and steel comprise of about 50%, non-ferrous metals (13%), plastics (21%) and other constituents. Non-ferrous metals is composed of metals like aluminum, copper and precious metals like palladium, platinum, silver, gold, and so on.

The Environmental Protection Agency states that only approximate 15-20% of the e-waste is recycled, remaining goes directly into incinerators and landfills. An Indian Market Research Bureau survey in 2009 on 'E-waste generation at Source', established that out of total e-waste in India, desktops and televisions including servers comprised 27 percent and 68 percent respectively. The main e-waste sources in India include the private (industrial) sectors and public, government, that account for approximately 70 percent of entire e-waste generation, whereas the individual households contribution is small at around 15 per cent; the remaining being contributed by the manufacturers.

Review of Literature

Uddin, M. J. (2012) in their study suggest that through usage of various substitutes (environmentally friendly in nature) of dangerous substances, negative impact of e-waste can be mitigated. Sivakumaran Sivaramanan (2013) confirmed that the mass awareness and manufactures cooperation is essential for an e-waste advancement management system; it is also the responsibility of the government to allot enough funds and to protect the internationally agreed legislations related to environment. According to Kiddee, P. et al. (2013), e-waste can be managed by developing eco friendly design devices, appropriately collecting e-waste, recycling and recovering material safely, disposal of e-waste with suitable techniques, prohibiting the used electronic device transfer to the developing countries, and raising awareness of the e-waste impact. Jadhav, S. (2013) observed that proper e-waste management shall help in efficient sourcing and collecting, right upto the disposal and extraction of material, making sure that e-waste will turn into the profitable business opportunity and products.

Allesch Astrid and Brunner Paul (2014) recommends the following considerations while assessing the waste management: (i) an approach of mass balance, based upon a rigid analysis of input–output of the whole system, (ii) an objective oriented assessment of the mass stability results, which accounts for the waste management objectives. Sikdar&Vaniya (2014) in their research stated that the government should introduce certain topics related to e-waste disposal materials and its recycling and unfavourable impact of e-waste on health of humans in Environmental Education as a mandatory subject. According to Othman, N. et al. (2015), the electronic wastes quantity can be controlled if there is a sustainable technique in managing the electronic waste; for which, electronic wastes management from the production till its disposal point should be considered. Prof. Arnav Chowdhury and Prof. Jitendra Patel (2017) concludes that there is a need to develop a legal framework for the e-waste management and is one of the challenge for the policy makers across developing nations. As per the UN environment report (2019, January), the world generates around 50 million tonnes of e-waste a year and only 20% of it is formally recycled with 80% either landing up being informally recycled or in landfills- majority of it is done manually in the developing countries, revealing workers to dangerous and carcinogenic substances like cadmium, lead and mercury, e-waste in landfill adulterates groundwater and soil, putting water resources and food supply system at risk.

Objectives of the Study

1. To understand the importance, various problems that arise due to e-waste.
2. To analyse the household responses to e-waste collection drive at mass level.
3. To understand the benefits of re-use of e-waste; various precautions that need to be taken.
4. To recommend suitable solutions for the e-waste collection mechanism at mass level in the country.

Data and Research Methodology:

The analysis in the study is based on primary data collected through survey/ information sources. Newspapers, books, relevant websites and Journals have been referred. The survey conducted was through google forms made online and circulated via social media. The sample size collected was majorly from Delhi across different age groups, gender, occupation and education qualification, summing upto 100 responders. Given the people's preferences as per the survey information, suitable recommendations for e-waste collection for our country is being made.

Why a Concern?

With the rising level of consumerism and increasing demand of electronic products and fast changing economy the replacement rate of electronic items is very high due to which each year the e-waste growth in India is approximated at around 30%; and is forecasted to grow to 52 lakh MT by 2020, according to Assocham. only 1.5% of the whole e-waste generated in India gets recycled, due to scarce proper legislation, infrastructure and framework in place; leading to wastage of natural resources, damage to nature and human health working in the industry; and more than 95 percent of the electronic-waste which gets generated, is organized by the scrap traders and unorganised sector who disassemble the disposed goods rather than recycling it. Further, approximately 4.5 lakh child labourers are found to be occupied in different e-waste activities, deprived of sufficient safeguards and protection in recycling workshops. The concern is, that heaps of e-waste is that could have been reused, renewed or recycled, is either not disposed off at all or if at all disposed off to the scrap dealer, not the entire e-waste is reused, renewed or recycled. Also the health cost to people exposed to varied chemicals released from e-waste is extremely high in monetary as well as real terms. The e-waste which is not disposed off properly is causing pollution of air, water and land as well along with harming human body by releasing toxic chemicals.

Problems created due to E-waste Hazards

Causing health hazards; Loopholes in legislation and enforcement create an incentive for illegal exports; Lack of national regulation and/or lax law enforcement. The biggest environmental and health hazards come from the metals recovery such as silver, copper, gold, etc. The residues which contain heavy metals and toxic organic traces are dumped in the open. This metal recovery takes place

almost exclusively in the informal sector, without any ecological and environmental. The environmental impact with the manufacturing of electronic products ("ecological baggage") surpasses by far the biggest environmental and health hazards that come from the recovery of metals like silver, copper, gold, etc. Tossing an equipment to an open flame, or to burn the non-valuable metals or to melt plastics, creates air pollution. This releases CARCINOGENS and NEUROTOXINS into the air, leading to an acrid SMOG. The toxins released in the process of separating these metals can damage kidneys, brain and lungs of those exposed to it. Skin diseases, hormonal imbalances, asthma and even cancer are caused by these toxins. These chemicals are now a part of their soil and water as well due to landfilling of e-waste.

The table below mentions the type of chemical released from different e-waste material.

Table 1

E-Waste Material	ProcessUsed	Chemicals Released, Type of Pollution
Cathode Ray Tubes (usage in computer monitors, TVs, video cameras, ATM, and more)	Removal and breaking of yoke, dumping thereafter	Barium, lead, other heavy metals filtering into the ground water; toxic phosphor release
Chips and various other gold plated items	Chemical stripping using hydrochloric and nitric acid; burning of chips	Heavy metals, hydrocarbons, brominated substances, discharged directly into rives acidifying flora and fish. Lead and tin contamination of groundwater and surface. Air emissions of heavy metals, hydrocarbons and brominated dioxins
Printed circuit board- a thin plate over which various electronic items and chips are placed.	Removal and de-soldering of computer chips; acid baths and open burning to discard final metals after removal of chips.	Air emissions; emit into the rivers of tin, glass dust, lead, brominated dioxin, mercury and beryllium cadmium
Computer wires	Stripping to remove copper; Open burning	Hydrocarbon ashes liberated into water, air and soil.

Table below discusses harmful chemicals found in various e-waste material and their health impact on the society.

Table 2

Harmful Chemical	Found in	Health Impacts
Mercury	Tilt switches (thermostats, mechanical doorbells), fluorescent tubes- numerous applications, flat screen monitors	memory loss, sensory impairment, muscle weakness and dermatitis. Exposure in-utero creates fetal deficits in attention, motor function and verbal domains. Impact in animals include slower growth, death etc.
Sulphur	lead-acid batteries	Kidney damage, liver damage, heart damage, throat and eye irritation, can create sulphuric acid in the environment.
BFRs- Brominated Flame Retardants	Used as flame retardants in most electronics, specifically in plastics.	Impaired nervous system development, liver problems thyroid problems, in both animals as well as humans.
Cadmium	corrosion-resistant alloys for aviation and marine environments; light-sensitive resistors, and nickel-cadmium batteries	When recycling is not done properly, it may leach in the soil, affect the soil ecosystem and harming microorganisms; lungs and kidney damage; deficits in learning, behavior, cognition
Lead	lead-acid batteries, solder, CRT monitor glass, some formulations of PVC.	Impaired behavioral disturbances, cognitive function, hyperactivity attention deficits, and lower IQ.

Analysis of Survey Responses

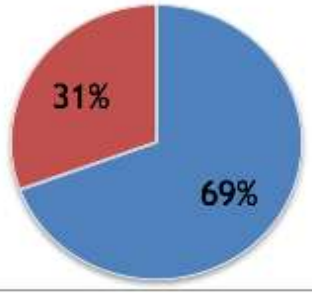
The objective of the survey done online of the households in Delhi, was to understand the awareness among the people regarding e-waste, their disposal behaviour etc. The questionaries for the same is mentioned below. A primary survey done of 100 households of Delhi depicted that on average households have 10 electronic waste items (at any given point of time) at their place. Since the sample size of 100 responders collected via google forms, was across different age groups, gender, occupation and education qualification; there was sufficient diversity in the primary data collected, to ensure that results are unbiased. In terms of age group that were surveyed, 67% of the responders were in the age group 20-30, 27% of them were in age group 10-20; and less than 5% were in age group above 30; whereas in terms of occupation, 82% of the responders were students, 15% belonged to the working class and the rest 2% were homemaker. The education qualification of the responders varies as 62% of them were graduate, 25% were post graduate, 11% did schooling, the rest Post Doctorate. Out of 62 Graduates, 37 of them rated themself above 5, in the scale of 1 to 10 in the knowledge of e-waste material components whereas 25 rated themselves 5 and below.

Among the working population of the sample, everyone except 2 rated themselves above 5, in the scale of 1 to 10 in the knowledge of e-waste material components; 70% of them had more than 5 e-waste items in their home; majority of them preferred disposing off e-waste in their locality as the first preference; however, in terms of its disposal, half of them dispose it off to the scrap dealers, 20% of them do not dispose off, rest either leaves it to the barren land, or exchange it if possible, or throws it to dustbin. Whereas among the student population of the sample, 83% of them rated themselves above 5, in the scale of 1 to 10 in the knowledge of e-waste material components; 46% mentioned that had more than 5 e-waste items in their home; 10% of them were not aware of it, and the rest had more than 5 e-waste items; 50% disposing it off to the scrap dealers, 32% of them mentioned they don't dispose it off; rest either leaves it to the barren land, or exchange it if possible, or throws it to dustbin or to the Nokia centre e-bin. Almost half of them prefer to self dispose at where-ever the e-bin is; and half prefer self-dispose at the e-bin in their locality as their first preference.

Majority of the e-waste comprised of old mobile phones, CFL, cells and other e-waste comprised of old computers, television, radio, ear phones, wires etc. In terms of outcome 57% of our surveyed population wants e-bin to come at their doorstep and take away their e-waste, 28% wish to self dispose in their locality at any e-bin, and 12% says they would dispose off in their college; around 95% of surveyed responses says they wish to dispose off their e-waste. When asked about their preference on disposing off their e-wastes, 57% population had quoted "dispose off when e-bin comes to society" as their first preference, whereas "self dispose at nearby e-bin" was the first preference of only 28% of the sample. The pie charts below gives further insight of people's preferences.

Figure 1

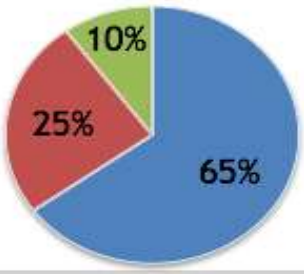
Do you think you have electronic appliances like machines, mobile phones, cells, wires, CFL etc. at your place which is completely useless and not disposed off?



31% says No; 69% says Yes

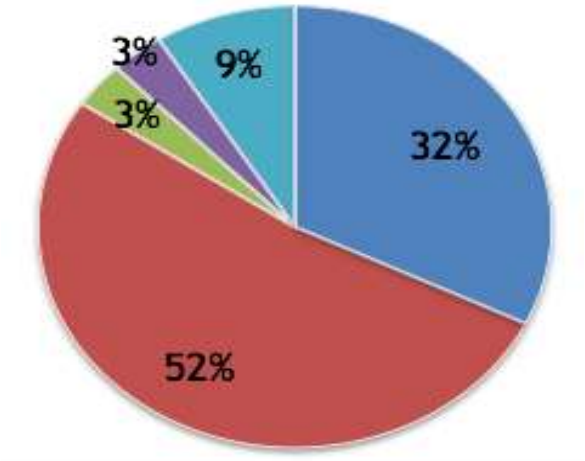
Figure 2

How many such useless electronic appliances might be lying at your place?



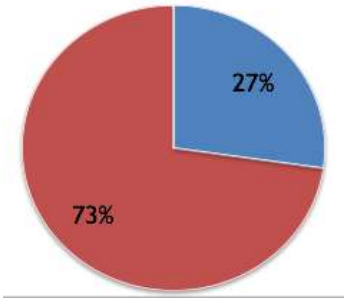
65% of people survey mentioned that no of e-waste items exceed more than 5, 25% mentioned its is less than 5; while 10% of the responder were not aware.

Figure 3: Where do you dispose off your e-waste?



52% responders says do not dispose off, 32% says scrap dealer, 9% says barren land, 3% says dustbin and the rest 3% says NOKIA centre,

Figure 4: Do you know that e-waste can be hazardous to health, land, air, water if not disposed off appropriately?



73% says Yes, rest responded No

Existing Measures/ Efforts to Reduce E-Waste

(i) To provide for large-scale e-waste recycling facility in an organised way, the Attero Recycling factory in Roorkee was started in January 2010. (ii) E-Cycle, LLC: is the first recycling and mobile buyback company globally to be ISO 14001, R2 and e-Stewards certified. (iii) Staples: Staples accepts e-waste material for recycling without any further cost; they also accept printer toner cartridges and ink. (iv) The Consumer Electronics Association in the US encourages consumers to dispose-off e-waste with its recycling locator through www.GreenerGadgets.org. This list includes retailer and manufacturer programs that use strict grade, third-party certified place recycling; to give assurance to the people that their products shall be recycled responsibly and safely.

Monetary Value of E-Waste

Precious metals in cell phones "A ton of used mobile phones or approximately 6,000 handsets (a tiny fraction of today's 1 billion annual production) contains around 340 gram of gold, 3.5 kg of silver, 130 kg of copper, and 140 grams of palladium according to STEP. The mobile phone battery on average consist of 3.5 grams of copper. Total value: exceeding $15,000 prices."

Benefits of Re-Use

The Social and Environmental Benefits

(i) Diminishes the volume of greenhouse gas emissions caused due to the manufacturing of new products. (ii) Larger quantities of electricity and pure water for associated manufacturing. (iv) Less packaging per unit. (v) Availability of technology (due to larger products affordability) (vi) Reduced use of landfills. (vii) Lead glass from CRTs are reused in ammunition, car batteries.

Precaution on E-waste Disposal

Ensure that containers are not damaged during on and off loading and that waste containers are secure during transport. Transporters storing e-waste for over 10 days should also follow recommended consolidation and storage practices. Transport e-waste to a licensed, approved, or other appropriate facility, such as a legitimate recycling facility, a licensed dangerous waste facility or a universal waste handler. The following recommended management practices apply to storage of e-waste before de manufacturing and to the storage of individual components after the e- waste has been broken down. In general, no DNR licenses or approvals are necessary if the management practices listed below are complied with. Recommended practices: (i) Ensure containers are closed, adaptable with the contents and structurally sound. (ii) Label waste to clearly identify the kind of waste. (iii) Containers of broken/ processed CRT glass shall be labeled as: *old cathode ray tubes containing leaded glass / waste cathode ray tubes containing leaded glass/ should not mixed with other glass materials.* (iv) Batteries, mercury and lamps containing devices must be labeled as "used", or "waste" batteries, lamps, mercury, etc., to clearly identify the waste type. (v) Document the time length the waste has been gathered onsite. Persons may store waste for up to one year for the motive of accumulating quantities necessary to facilitate proper recovery, treatment or disposal. (vi) Train employees on emergency procedures and proper handling. (vii) Records demonstrating proper recycling are recommended. Arrangements should be made before shipping the waste to other waste management facility. (viii) Store broken or processed CRTs in buildings having floors, roof and walls, or in a container that is constructed and handled to minimize dust.

Guideline on how to Decompose E-Waste

In India, there are no specific environmental laws or guidelines for e-waste disposal and it is governed only by the "The Hazardous Waste Management Rules, 2003". Waste management hierarchy includes: (i) *Reduce:*Eliminating or minimizing dangerous waste before it gets generated; is generally the most environmentally-protective and cost-effective way. (ii) *Reuse:* Reuse can help reduce liability and input costs; individuals, businesses can reuse an e-waste for its originally considered purpose instead of reclaiming it, or disposing it. (iii) *Recycle:* Recycling includes using e-waste for another purpose or reclamation than originally intended; although it is often more environmentally risky and costly than reuse or reduction, recycling still might be more environmentally protective and cheaper than waste disposal.

Other Solutions

(i) A pre-emptive action which major electronics firms must take is to eliminate the poor chemicals in their goods to ensure they are easier to recycle and safer. It is necessary that all firms take complete authority for their goods; and as they complete their productive life, take their products back for re-usage or recycle them safely. (ii) Purchase efficient electronics that don't contain hazardous materials such as mercury and lead. (iii) If the cell phone or computer is no longer useful, donating them to organizations or people who might use them for some productive work. The gadgets can be donated to children's home or charitable institution where they can use the e-waste for education or various other worthwhile purposes; as there are certain electronic and computer exchange companies whereby equipments can be donated from where they are usually passed on to special organizations. (iv) The producer shall be made accountable for "setting up

collection centres or take-back (electronic) systems either collectively or individually". And such details must be mentioned while getting an authorisation from the state pollution control boards.

Conclusion and Suggestions

Though the Ministry of Environment and Forest, Government of India mandates the e-waste collection developed from products 'end of life' in harmony with the 'Extended Producer Responsibility' principle, and that such e-wastes be channelized to dismantler or recycler, there has been no initiative on collecting such waste from non commercial or unregistered sector. Despite of the Delhi Governments' guidelines for "the installation of e-waste bins at varied schools and notable locations identified by NDMC and MCD ", they can be found nowhere in any locality, posing a major challenge in the e-waste management. In India, the individual households account for the 15% of the whole e-waste generation and are potential creator of waste. The race of technological advancements across the globe has made the average life of electronic products shorter, resulting into massive e-waste. To overcome the diverse and complex problem of e-waste management, a multi-disciplinary approach is required to implement the mechanisms for collection, sorting, reusing, repairing, remanufacturing to reduce emissions and save energy. Awareness is needed regarding proper collection of e-waste, Sorting, Maintenance and delivery to Recycling Plants.

The market for e-waste collection can be mobilised at a large scale, just like paper-collection mechanism is prevailing in various parts of the country.To carry on the e-waste collection venture successfully, an important requirement is of the investment needed to establish a warehouse to store all the e-waste that shall be collected from across the households. For collection of e-waste in schools, colleges, societies; e-bins shall be placed after creating awareness among students, across campuses as well as those societies which deploy guard (who can take charge of the bins) and has a society hall/storage room. Finally equally important is to ensure that the collected e-waste is sold off to the recycling companies. Start ups, venture capitalists must be encouraged to come forward and take up investment plan in this aspect in the country.

To create awareness about collection of non portable e-waste items such as refrigerators, computers, etc., mass awareness through pamphlets, media etc. can be promoted. Further investments involve setting up of e-bins, maintenance equipments, renting out trucks for collection mechanism at regular intervals, etc. The e-waste from these e-bins can be collected on a frequent basis (depending upon the numbers of items collected). The guard should be properly trained; surprise visits shall be done before the e-waste is collected from the e-bins.Similarly people will have to enter details when non portable items are collected on fixed dates by trucks. To avoid any sort of malpractice, various incentives can be given to such personnel and guards ensuring that they stick to their duties and don't indulge in any wrong practice. To incentivise people to part with their e-waste, mass awareness regarding health hazard issues related to various e-waste must be created (at the city level, village level across rural, urban areas) ; further ensuring that goodies/money is provided to the people in lieu of their e-waste; basis the quantity of e-waste collected, points can be given for redeeming at any e-waste related stores or a stock of goodies can be placed (in advance) with the personnel and the apartment guards; the points collected by people on giving us their e-waste can be redeemed. Revenue generated from the sale of e-waste as per the recovery of metals, plastic and other recyclable component of the item, will create an entire market for e-waste, which will eventually contribute to the GDP of the country. Further, awareness need to be created at schools and colleges to mobilise society regarding disposal of the e-waste. Though there are challenges regarding the possibility of different recycling agencies quoting different prices for e-waste. In such a scenario, a cost benefit analysis can be undertaken (for instance the distance of the agency quoting a higher price can be very large and so the cost may outweigh the benefit); whichever agency is found feasible, the agency quoting the highest price can be approached. Overtime, a successful mechanism in place to collect e-waste from each and every household, can reduce the health risk posed to the people on a daily basis, which shall enrich the life expectancy of the people and possibly may reduce the unnecessary health expenditure.

The focus should not just be on recyclable e-waste, but also on repairing and reusing the e-waste. The objective of the policy makers must be to establish a mechanism that reduces e-waste, which would lead to sustainable and a pareto-optimal outcome, since all the stakeholders, namely-households, recycling companies will be benefitted by it; and finally, it would help our environment, to get rid of all the hazardous outcomes, which the inefficient decomposition of e-waste, generally leads to.

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