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Electronic Waste impacting Health and Environment, It's Management -Global & Indian Perspective

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Abstract:

Use of electronics equipment and their disposal is increasing exponentially with time. The disposal of equipment is in proportion to obsolescence which in turn is linked with adoption of new technology. It has attributed around 10 % growth in e-Waste in India. Recycling of e-Waste through environment friendly means is utmost need of the day. Still in India, instead of using standardised technology based methods in recycling, it is carried out by using primitive means which are extremely hazardous and spoiling the environment. Development of an ecosystem comprising adequate legislation, restrictions on hazardous substance (RoHS) , cost-effective technology based recycling solution, awareness to all stakeholders & general public on electronic waste is to be ensured and full proof management practices warrantying environment protection and eco-friendly manufacturing and recycling are to be adopted.

Keywords **—e-Waste, WEEE, RoHS, Recycling, Extraction**

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I. INTRODUCTION

Discarded electronics and electrical equipment appliances are considered widely Electronic Waste (E-Waste). It is generally utilised for refurbishment, recycling for material recovery for reuse. It potentially contains toxic , hazardous, carcinogenic substances such as mercury, lead and cadmium etc and essentially is to be handled & disposed with scientific & eco-friendly manner.

Annually , approx. 50 million tonnes of electronic and electrical waste is generated globally which is more than six kilograms per person per year. If it keeps on increasing with current pace, it will be doubled by 2050. Only 20 % e-Waste is recycled through formal sector recyclers. Rest 80 % , majorly imported as well as locally generated in developing countries, is largely ending up in landfill contaminating soil and groundwater, putting food supply systems and water sources at risk or it is being informally recycled through primitive methods exposing labours to hazardous and carcinogenic substances leading to adverse human health effects .

The substances found in e-waste which are toxic and hazardous to human & environment include : Lead and Cadmium in Cathode Ray Tubes (CRT), Computers Batteries , Plating Metal Enclosures/ Metal Parts in sub-assemblies, Printed Circuit Boards (PCBs), ; mercury in Switches, Flat Screen, CFL etc ; Poly Chlorinated Biphenyls in Capacitors, Transformers , retardant on Printed

Circuit Boards, plastic casings, cables ; Poly Vinyl Chloride (PVC) in cable sheathing ; PBD/PBDE in plastic parts of electronics ; and various other substances [6]

E-Waste contains around 7% of world's gold. As compared to gold ore, e-Waste have 100 times more gold. Poor management of e-waste is ensuing in a significant loss of rare, scarce and valuable raw materials viz gold, platinum, cobalt, apart from polluting the planet and effecting health adversely.

In India, ill effects of improper e-waste processing - leaching of hazardous contents from landfills to soil, contamination of rivers & underground water sources, emission of gases to air, impacted human through inhalation of gases emitted during recycling and through contact with hazardous substances used in recovery processes – is substantially visible. With the support of legislation which has been updated time to time, Ministry of Environment and Forests, Government of India along with agencies like Central Pollution Control Board, State Pollution Control Board and others are handling, managing, controlling the e-Waste related affairs including Restriction of Hazardous Substance (RoHS) directives in India. Despite it, no formal data from Government is readily available. However, by efforts of some Non Government Organisations (NGOs) , the assimilated data is eye opener and informs that still e-Waste collection, segregation, recycling is majorly dealt by informal sector and labour health & environment issues are grossly ignored.

II. Size of Electronics Waste

E-waste today often consists of products from the past. In year 2016, 44.7 Million Tonnes (MT) of e-Waste was generated globally by adding in 16.8 MT small equipment, 9.1 MT large equipment, 7.6 MT temperature exchange equipment, 6.6 MT screens, 3.9 MT small IT equipment, 0.7 MT lamps [1].

Though forecasting the volumes of e-waste generation is difficult, yet considering the current pace and in the absence of some effective controlling & managing mechanism, it is expected that by 2021 the annual total volume may surpass 52 million tonnes.

Some other indicators - EE devices connected to the internet at between 25-50 billion by 2020 i.e. three times the world population; By 2040, carbon emissions from production and use of electronics including devices like PCs, laptops, monitors, smartphones and tablets reaching 14% of total emissions; By 2060, the world's consumption of raw materials is set to double - give insight that by 2050, the volume of e-waste, in the worst-case scenario, could top 120 million tonnes annually.

India generates around two million tonnes of e-waste per annum and is at fifth rank among e-waste producing countries, after the US, China, Japan and Germany. However, there is no government data on e-waste generation in the country [(ii)].

However important indicators -rapid growth of Mobile subscriber in India from 310 million in 2001 to 1.1 billion in 2016 which is nearly 4 times that of United States and ranking second only to China in the world, which has 1.3 billion subscribers ; 57 million computers in use and plethora of other gadgets and consumer electronics- predict growth in domestic e-Waste generation in India. 10 year ago, around 70 % of e-Waste processed or disposed of in India was originated from abroad. Afterward efforts to control the inflow have been effective , but surge in domestic consumption have overshoot it, leading to an over all growth in e-Waste generation.

Computer equipment and mobile telephones as the principal e-waste generators in India contributing around 70 per cent of the total e-waste generated in

India, while telecommunication equipment attribution is about 12 per cent. Mumbai is first among cities generating around 1,20,000 tonnes of e-waste per annum, followed by Delhi and Bengaluru with generation of 98,000 and 92,000 tonnes of e-waste per annum [4]. About 70 per cent of heavy metals in landfills is sourced from E-waste.

III. ELEMENTS AND ECONOMIC VALUE:

There are so many elements which are scarcely available in nature but available in e-Waste with good recycling rates. Extraction of these scarce elements from e-Waste is more economical than their extraction from ore. Also extraction from ore mines is also causing enormous pollution. Availability in nature, pollution caused by mining and recycling rates of some important elements [1]are which are available in e-Waste is depicted in Tables 1:

TABLE1 :

CLASSIFICATION OF ELEMENTS PRESENT IN E-WASTE BASED UPON PARAMETERS-THEIR AVAILABILITY IN NATURE, POLLUTION CAUSED DURING MINING , AND RECYCLING RATES :

Availability in Nature:			
Low < Scarcity in Nature > High			
Available in Nature	Limited Availability, Future Risk of Supply	Rising Threats from increased use	Serious Threat in Next 100 years
Na, K, Rb, Cs, Be, Ca, Ba, LA, Ti, Ta, Te, Fe, Al, Si, Ce, Pr, Sm, Eu, Gd, Tb, Ho, Er, Yb	Li, Mg, Sr, Sc, Y, Zr, Nb, Cr, Mo, W, Mn, Co, Ni, Pd, Cu, Au, Cd, Hg, Ti, Sn, Pb, Sb, Bi, Se, Nd	Pt	Ag, Zn, Ga, In, Ge, As, Te
Pollution Caused by Mining of elements:			
Low < Pollution Caused by Mining > High			

Ca	Li, Mg, Sr, Ba, Y, Ti, Zr, Nb, Mn, Fe, Co, Cd, Al, Sn, Pb	Be, Ni, Bi	Sc, Hf, Ta, Cr, Mo, W, Cu, Ag, Zn, Ga, In, Tl, Ge, As, Sb, Se, Te	Pd	Re, Pt, Hg	Na, K, Rb, Cs, La, Si, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Ho, Er, Yb	Au
Recycling Rates of elements from e-Waste:							
Low < Recycling Rate > High							
<1%		1-10%	>10-25%	> 25-50%		>50 %	
Li, Be, Sr, Ba, Sc, Y, La, Zr, Hf, Ta, Ga, In, Tl, Ge, As, Bi, Se, Te, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Ho, Er, Yb		Hg, Sb	W, Cd	Mg, Mo		Ti, Nb, Cr, Mn, Re, Fe, Co, Ni, Pd, Pt, Cu, Ag, Au, Zn, Al, Sn, Pb	

By seeing the elements in above table and analysing pollution in their mining, scarcity in nature vis a vis recycling rates gives an enormous clue that scarce elements like Gold (Au) having high recycling rate and polluting environment heavily during their mining must be recycled as it adds enormous value to e-Waste Economy Chain and in environment protection.

Elements such as Iron, Aluminium, Copper amounts around 40-50 % of weight of e-Waste whereas valuable elements are found in lesser amounts but are still of high importance.

TABLE 2: METAL COMPOSITION OF SOME COMMON ELECTRONIC APPLIANCES [3]

e-Waste Items	Weight (%)					Weight (ppm)		
	Fe	Cu	Al	Pb	Ni	Ag	Au	Pd
TV Board	28	10	10	1	0.3	280	20	10
PC Board	7	20	5	1.5	1	1000	250	110
Mobile Phone	5	13	1	0.3	0.1	1380	350	210
Portable Audio System	23	21	1	0.14	0.03	150	10	44

DVD Player	62	5	2	0.1	0.05	115	15	4
Calculator	4	3	5	0.1	0.5	260	50	5
Printed Circuit Board	5.3	26.8	1.9	NR	0.14	3300	80	NR
E-waste Mixture	36	4.1	4.9	0.29	1.0	NR	NR	NR

Some precious metals like gold are contained in E-Waste as large as around 7% of world's gold and 100 times more available in as compared to gold ore. 24 kg Gold is present in 148.4 tons (1 million units) of Mobile phones and to extract the same weight of Gold from gold ore, 23763.4 tons of gold ore is to be processed.

IV. HEALTH & ENVIRONMENTAL IMPACT:

EEEs are manufactured with various components , some containing high value substances. Recycling of these substances may be toxic and have an adverse impact on human health and the environment ,if not handled properly. It may affect seriously human involved in recycling process and/or living in proximity to places where e-waste is recycled or burnt [5]. A computer contains highly toxic chemicals like Lead, Cadmium, Mercury, Beryllium, BFR, Poly Vinyl Chloride and Phosphor compounds.

TABLE 3 : HAZARDOUS OF PROCESSING OF WASTE COMPUTER ON HUMAN LIFE AND ENVIRONMENT

e-Waste Component	Process	Potential Occupational Hazards	Potential Environmental Hazards
Cathode Ray Tubes	Breaking to extract copper and dumping	Silicosis, Cuts from glass, Inhalation or contact with toxic phosphor containing cadmium or other metals	Lead, Barium and other heavy metals leaching into ground water and release of toxic phosphor in air.
Printer Circuit Boards	De-soldering to removing computer chips and	Tin and Lead inhalation, Possible Brominated Dioxin, Beryllium, Cadmium	Air emission of the same substances
	open burning	and Mercury inhalation	
Chips and other Gold-plated items	Chemical stripping using nitric and hydrochloric acid along riverbanks	Acid contact with eyes, skin may result in permanent injury; Inhalation of acids fumes, chlorine and sulfur dioxide gases can cause respiratory difficulty ,pulmonary allergy, respiratory failure and death	Hydrocarbons, heavy metals, brominated substances etc. discharged directly into river ;Acidifies the river destroying fish and flora
Plastics from the computer and peripherals	Shredding and low-temperature melting	Probable hydrocarbon, brominated dioxin and PAH exposure to workers and people living in the nearby area	Emission of brominated dioxins and heavy metals and hydrocarbons
Steel, Copper & metal smelting	Furnace recovers steel or copper from waste	Exposure to dioxins and heavy metals	Emission of dioxins and heavy metals
Wires	Open burning to recover copper	Brominated and Chlorinated Dioxin and PAH exposure to workers and people living in nearby area	Hydrocarbon and ashes including PAHs discharged into air, water and soil

V. REGULATION AND ECOSYSTEM DEVELOPMENT

With the new E-Waste Management Rules 2016, responsibility of recycling now lies with equipment manufacturers too to take up the task of recycling the products they produce. Though anticipated outcome is not feasible until & unless , society at large is sensitised about its necessity to manage e-Waste.

Taking measures by Government to turn the informal sector into a well-managed system will not be adequate. In most proposed sustainable e-waste models , informal e-waste value chains are offered no alternate livelihood options and ultimately they will lose their livelihoods. Safe, low-cost or intermediate e-waste recycling technology, enabling appropriate finance mechanism, are the

need of the day , so that some alternative livelihood options are emerged for existing e-waste markets by re-shaping value chain for the better instead only imposing regulations.

It requires better cooperation and trust between national and local governments, manufacturers and retailers, and small informal businesses. An ecosystem- where informal sector functions alongside and with the formal, new innovative &equitable models of functioning, with key economic and non-economic incentives for informal and formal, large and small-scale stakeholders , with greater understanding of the diversity, inequalities and vulnerabilities that exist within the informal e-waste sector - is to be developed in India for settling a balance among all stakeholder to manage e-Waste better.

Improved scientific understanding of the different environmental and health risks along the chain, and the technologies that could mitigate risks, will also serve to inform better targeted interventions.

VI. CONCLUSIONS

In India, significant size of manpower in informal sector is involved recycling of e-Waste to extract elements by using primitive means resulting in health and environment hazards. Despite regulations, the concerns of livelihood, & lack of awareness are important constraints for managing e-Waste in appropriate ways. A suitable model is to be evolved including all stakeholders. One approach could be to create an ecosystem having all stakeholders in one value chain - unorganized sector to concentrate on collection, dismantling, segregation etc; whereas the metal extraction, recycling and disposal could be done by the organized sector ; setting responsibilities with manufacturers to recycle their obsolete produce; and awareness of masses - so that e-Waste can be managed in a better way.

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