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Electronic waste: Problems & business opportunities

Dr. Sanjay Keshaorao Katait

Assistant Professor, Department of Commerce, Shri Shivaji Arts and Commerce College, Morshi Road, Amravati, Maharashtra, India

Abstract

This research paper titled "*Electronic Waste: Problems & Business Opportunities"* make an attempt to conceptualize problems of electronic waste in to business opportunities by investing in "greening" and it also aims to provide guidance how to mobilize such investment. It demonstrates how green investment in the electronic waste sector can create jobs, business opportunities and contribute to economic growth, while addressing environmental issues, in an equitable manner. The presence of toxic and hazardous substances in e-wasted attracted the attention of the waste managing agencies in the country because these substances endanger the human health, environment. In India 95 % of electronic waste is recycled by informal sector with hazardous practices. E-waste contains a good amount of valuable recyclable materials which has potential to become lucrative business opportunity in the country.

Keywords: Electronic waste, Environment, Hazardous, Informal, Problems, Recycling

Introduction

In recent decades, the use of electronic and electrical devices has increased significantly, leading to rapidly rising amounts of waste electrical and electronic equipment (WEEE), called e-waste. Currently, around 20-50 million tons of E-waste are generated worldwide. The rate increases by as much as 3-5% each year, making e-waste one of the fastest-growing hazardous waste streams on a global level. The factors behind this development are the rapid obsolescence and replacement of electronic products caused by technological innovation and aggressive marketing. These aspects will contribute considerably to the dimension of e-waste quantities in the future. These waste substances are in the long run hazardous in nature as they are ignitable, corrosive, reactive, toxic, explosive, poisonous or infectious. Hence, they pose substantial or potential threat to public health and the environment. The problem of electronic waste pollutant has become an immediate and long term concern as its unregulated accumulation and recycling can lead to major environmental problems endangering human health and environment.

Composition of electronic waste

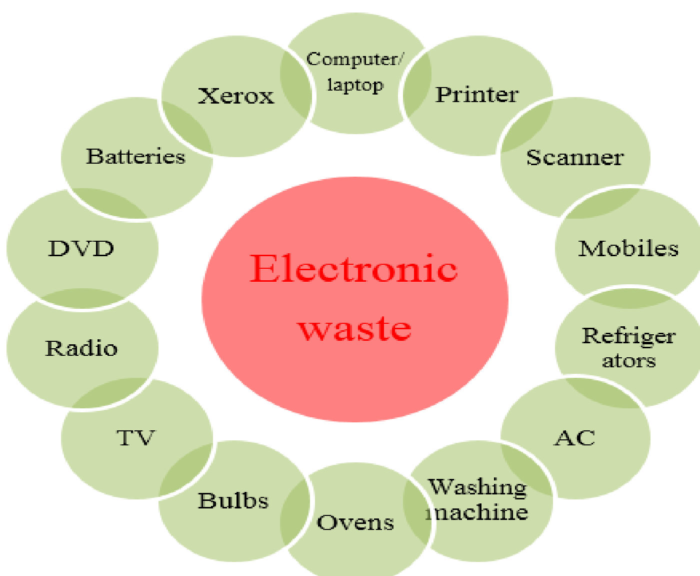

Fig 1

E-waste consists of all waste from electronic and electrical appliances which have reached their end of life period or are no longer fit for their original intended use and are destined for recovery, recycling or disposal. It includes computer and its accessories, monitors, printers, keyboards, central processing units; typewriters, mobile phones and chargers, remotes, compact discs, headphones, batteries, LCD/Plasma TVs, air conditioners, refrigerators and other household appliances. The composition of e-waste is diverse and falls under ‘hazardous’ and ‘non-hazardous’ categories. Broadly, it consists of ferrous and non-ferrous metals, plastics, glass, wood and plywood, printed circuit boards, concrete, ceramics, rubber and other items. Iron and steel constitute about 50% of the waste, followed by plastics (21%), non-ferrous metals (13%) and other constituents. Non-ferrous metals consist of metals like copper, aluminum and precious metals like silver, gold, platinum, palladium and so on. The presence of elements like lead, mercury, arsenic, cadmium, selenium, chromium, and flame retardants beyond threshold quantities make e-waste hazardous in nature. It contains over 1000 different substances, many of which are toxic, and creates serious pollution upon disposal. Obsolete computers pose the most significant environmental and health hazard among the e-wastes.

Review of related literature

Bina Rani, Upma Singh, Raaz Maheshwari, A. K. Chauhan in their research article titled “Perils of Electronic Waste: Issues And Management Strategies” in journal of Advanced Scientific Research 2012, 3(1) suggested that electronic waste or e-waste is one of the most popular growing issues of the world. The term e-waste is for the collection of old discarded computers, TVs, Refrigerators,, radios – basically any electrical or electronic appliance that has reached its end-of-life. While e-waste contains both valuable materials such as gold, palladium, silver and copper, it also contains harmful metals like lead, cadmium and mercury. In the absence of suitable techniques and protective measures, recycling e-waste can result in toxic emissions to the air, water and soil and pose a serious health and environmental hazard. In India, e-waste is mostly generated in large cities like Delhi, Mumbai and Bangalore. In these cities a complex e-waste handling infrastructure has developed mainly based on a long tradition of waste recycling. But the problem is that these recycling processes are extremely harmful and have negative impacts on the worker’s health and the environment. E-waste is assuming serious proportions in India and urgent steps need to be taken to mitigate this problem.

Jennifer Namias in her research titled The Future of Electronic Waste Recycling In The United States: Obstacles and Domestic Solutions submitted in partial fulfillment of the requirements for M.S. degree in Earth Resources Engineering Department of Earth and Environmental Engineering Columbia University July 2013 advocates that E-waste contains precious and special metals, including gold, silver, palladium and platinum, as well as potentially toxic substances such as lead, mercury, cadmium and beryllium. Therefore, responsible end-of-life management of e-waste is imperative in order to recover valuable components and properly manage hazardous and toxic components. End-of-life management of e-waste includes reuse of functional electronics, refurbishment and repair of electronics, recovery of electronic components, recycling e-waste, and disposal. Reuse, refurbishment or repair of electronic products is most desirable since this option increases the life span of the electronic product and higher resource efficiency. Recycling of electronics allows for precious and special metals to be recovered, reduces the environmental impact associated with electronic manufacturing from raw materials, and ensures that hazardous and toxic substances are handled properly.

Nirmala Menikpura and Janya Sang-Arun Institute for Global Environmental Strategies and Institute for Global Environmental Strategies in Research Gate in their article titled Assessment of environmental and economic performance of Waste-to-Energy facilities in Thai cities article in renewable energy august 2015 advocates that waste-to-Energy (WtE) technologies seem to be an option to tackle the growing waste management problems in developing Asia. She further suggested a quantitative assessment of the environmental and economic attributes of two major WtE technologies: landfill gas to energy (LFG-to-energy) and incineration in Thai cities. Net greenhouse gas (GHG) emissions, net fossil resource consumption and net lifecycle cost (LCC) were used as the basic indicators for measuring performance of these two technologies from a life cycle perspective.

Swati Kwatra Suneel Pandey Sumit Sharma, (2014), "Understanding public knowledge and awareness on e-waste in an urban setting in India ", Management of Environmental Quality: An International Journal, Vol.25 issue 6 pp. 752 – 765 expressed that E-waste contains more than 1,000 different substances, many of which are toxic, such as lead, mercury, arsenic, cadmium, selenium, hexavalent chromium and ruminated flame retardant. The recovery process in the informal set-up being rudimentary has limited efficiency in material recovery, resulting not only in loss of significant amount of precious metals and material but also disposal of residues of toxic materials into water bodies and soil, which creates serious issues of water and soil pollution. It also has immense ill-impacts on the health of the workers engaged in the informal recycling units.

Impact of hazardous electronic waste on health and environment

Fig 2

Fig 3

It is estimated that 50 to 80 percent of e-waste collected in developed nations is exported to developing countries such as China, India and Pakistan due to cheap labor and lenient environmental regulations (StEP, 2009). These developing nations lack the health and safety infrastructure to process and dispose of materials safely, and consequently workers handle toxic metals without proper equipment. While there are operators in China who are licensed to process e-waste, the market is dominated by small-scale entities that are not authorized, nor properly equipped to treat e-scrap. Common techniques for processing e-waste in developing nations include manual dismantling of hazardous materials and open-air burning, which generates significant accounts of dioxins and furans if performed without proper emission control systems. Cyanide leaching is also a prevalent technique for processing e-waste in developing countries, posing a significant concern to worker well-being if the spent leaching solution is not properly disposed.

The waste from electronic products include toxic substances such as cadmium and lead in the circuit boards; lead oxide and cadmium in monitor cathode ray tubes (CRTs); mercury in switches and flat screen monitors; cadmium in computer batteries; polychlorinated biphenyls in older capacitors and transformers; and brominates flame retardants on printed circuit boards, plastic casings, cables and PVC cable insulation that releases highly toxic dioxins and furans when burned to retrieve copper from the wires. Many of these substances are toxic and carcinogenic. The materials are complex and have been found to be difficult to recycle in an environmentally sustainable manner even in developed countries. Listed in the table below are the harmful elements in the compositions of electrical and electronic appliances that can be hazardous to health and environment.

Table 1

S. No.	Pollutant	Occurrence	Danger / Disease
01	Lead	Batteries, solar system, transistors, stabilizers, lasers, LEDs, thermoelectric elements, circuit Boards, TV screen	Affects the kidneys, reproductive system, mental development, and fumes causing respiratory problems.
02	Plastic	Circuit boards, cabinets and cables,	Brominated flames contain Dioxins harm reproductive and immune systems. Water pollutant.
03	Chromium	Used to protect metal housings and plates in a computer from corrosion.	Inhaling chromium can damage liver, kidneys and cause bronchial maladies including asthmatic bronchitis and lung cancer and DNA Damages.
04	Beryllium	Electron tubes, filler for plastic switch board and rubber, lubricant additives	It is carcinogenic and causes lung diseases. Causes damages to heart liver and spleen.
05	Cadmium	Batteries, pigments, solder, alloys, circuit boards, computer batteries, monitor cathode ray tubes	Causes severe pain in the joints and spine. It affects the kidneys, softens bones and neural damages. Cadmium is released into the environment as powder while crushing and milling of plastics, CRTs and circuit boards. Cadmium may be released with dust, entering surface water and groundwater.
06	Acid	Circuit boards	Sulphuric and hydrochloric acids are used to separate metals from circuit boards. Fumes contain chlorine and sulphur dioxide, which cause respiratory problems. They are corrosive to the eye and skin.
07	Arsenic	Semiconductors, diodes, microwaves, LEDs (Light-emitting diodes), solar cells	Causes lungs cancer.
08	Brominated flame-proofing agent	Casing, circuit boards (plastic), cables and PVC cables	Causes the problem of inhaling.
09	Cobalt	Insulators	Problems to eyes and skin
10	Copper	Conducted in cables, copper ribbons, coils, circuitry, pigments	Excessive use causes harm to immune system, stomach pain

11	Liquid crystal	Displays	Nausea irritant
12	Lithium	Mobile telephones, photographic equipment, video equipment (batteries)	Damage nervous cells and system
13	Nickel	Alloys, batteries, relays, semiconductors, pigments	Nausea, irritant and sensation of vomiting
14	PCBs (polychlorinated biphenyls)	Transformers, capacitors, softening agents for paint, glue, plastic	Causes respiratory problems
15	Selenium	Photoelectric cells, pigments, photocopiers, fax machines	Damage eyes and eyesight
16	Silver	Capacitors, switches (contacts), batteries, resistors	Causes burning sensation in body
17	Zinc	Steel, brass, alloys, disposable and rechargeable batteries, luminous substances	Respiratory and lungs disorder.

Problem to be investigated

Fig 4

E-waste is a highly complex waste stream, as it contains both very scarce and valuable as well as highly toxic components. Mobile phones, for instance, consist of up to 1000 different components, many of which contain toxic elements such as lead, cadmium or brominated flame retardants. When burned, these elements release toxic emissions. Many detrimental health effects are connected to the recycling and disposal of e-waste when performed without the necessary safety precautions. For instance, lead affects the nervous and blood system. Its effects on children are particularly negative, damaging their brain development. In addition, land filled seriously affects the environment, causing contamination problems such as the pollution of groundwater through the leakage of toxins (Puckett *et al.*, 2002). In spite of this, great quantities of e-waste are dismantled or recycled in developing countries and countries in transition, using "backyard" techniques which pose substantial dangers to both unprotected workers and the environment (StEP 2009). Present research focuses on the problematic health, environmental and economic issues that are connected with e-waste and on the currently existing measures to counter the problem on the policy level.

Reasons for urgent recycling of electronic waste in India

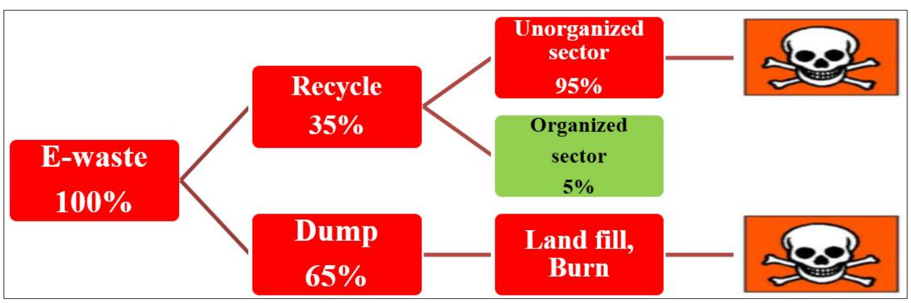

Fig 5

The informal recyclers are not serious about the guidelines issued by CPCB (Central Pollution Control Board) and using hazardous methods of e-waste disposal like open burning for the recovery of targeted metals like copper, aluminum, iron and steel from equipment peripherals and acid leaching for the recovery of copper and precious metals from PCB (Printed Circuit Boards), mother boards and leave all hazardous metals like Pb, Hg, Cd etc at the treating sites in open causing an explosion of pollutants in the environment. However, CPCB has registered 23 recyclers for treating e-waste by environmentally sound methods also, the CPCB has encouraged informal recyclers to be part of formal recycling which can be carried out with compliance under single umbrella of guidelines issued in 2008(MoEF, Guidelines, 2008).

Table 2: State wise distribution of electronic waste in India

S. No.	State	Waste (Mt Tons per year)	Percent (%)	Recycle
01	Andaman and Nicobar Islands	92.2	0.06	35 % (5% Organized sector 30% Unorganized sector) 65%? (Dump, Land fill, Burn)
02	Andhra Pradesh	12780.3	8.74	
03	Arunachal Pradesh	131.7	0.09	
04	Assam	2176.7	1.49	
05	Bihar	3055.6	2.09	
06	Chandigarh	359.7	0.25	
07	Chhattisgarh	2149.9	1.47	
08	Daman and Diu	40.8	0.03	
09	Delhi	9729.2	6.66	
10	Goa	427.4	0.29	
11	Gujarat	8994.3	6.15	
12	Haryana	4506.9	3.08	
13	Himachal Pradesh	1595.1	1.09	
14	Jammu and Kashmir	1521.5	1.04	
15	Karnataka	9118.7	6.24	
16	Kerala	6171.8	4.22	
17	Lakshadweep	7.4	0.005	
18	Madhya Pradesh	7800.6	5.34	
19	Maharashtra	20270.6	13.87	
20	Manipur	231.7	0.15	
21	Meghalaya	211.6	0.14	
22	Mizoram	79.3	0.05	
23	Nagaland	145.1	0.09	
24	Orissa	2937.8	2.00	
25	Pondicherry	284.2	0.19	
26	Punjab	6958.5	4.76	
27	Rajasthan	6326.9	4.33	
28	Sikkim	78.1	0.05	
29	Tamil Nadu	13486.2	9.23	
30	Tripura	378.3	0.26	
31	Uttar Pradesh	10381.1	7.10	
32	Uttarakhand	1641.1	1.12	
33	West Bengal	10059.4	6.88	
	Total	146180.7	100%	

(***Source:*** MOEF)

There are 10 States that contribute to 70 per cent of the total e-waste generated in the country, while 65 cities generate more than 60 per cent of the total e-waste in India. Among the 10 largest e-wastes generating States, Maharashtra ranks first followed by Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab. Among the top ten cities generating e-waste, Mumbai ranks first followed by Delhi, Bangalore, Chennai, Kolkata, Ahmadabad, Hyderabad, Pune, Surat and Nagpur.

Table 3: Number of registered recyclers in India.

S. No.	States	No. of Registered Recyclers	Total Quantity of E-waste Allotted for recycling by CPCB
01	Andhra Pradesh	02	11800 MTA
02	Karnataka	07	3140.6 MTA and 120000 nos. cartridges
03	Gujarat	01	12000 MTA (Shredded PCBs and mother boards
04	Maharashtra	03	8060 MTA
05	Haryana	01	1200 MTA
06	Rajasthan	01	450 MTA
07	Tamil Nadu	06	38927 MTA
08	Uttar Pradesh	01	1000 MTA
09	Uttarakhand	01	12000 MTA
Total		23	88,577.60 MTA

(***Source:*** MOEF)

Business opportunities associated with electronic waste
Economic factor

Fig 6

Electronic devices contain up to 60 different elements, many of which are valuable, such as precious and special metals, and some of which are hazardous. Precious metals are rare, naturally occurring metallic elements which traditionally have a higher melting point, and are more ductile than other metals. They have a high economic value, as demonstrated by the two most well-known precious metals; gold and silver. Special metals include nickel, nickel base alloys, cobalt base alloys, titanium and titanium base alloys. Electronic equipment is a primary consumer of precious and special metals and therefore it is imperative that a circular flow is established in order to recover these metals and valuable elements. Investments are being made to treat e-scrap and reclaim the valuable metals, especially as raw materials become more scarce and expensive.

Table 4: Concentration of heavy economical metals in electronic

S. No	Electronic Equipment	Copper	Silver(ppm)	Gold(ppm)	Palladium(ppm)
01	Television (TV)	10%	280	20	10
02	Computer	20%	1000	250	110
03	Mobile Phone	13%	3500	340	130
04	Portable Audio Scrap	21%	150	10	4
05	DVD Player	5%	115	15	4

(***Source:*** Department of information technology & Umicore Precious Metals Refining. Geneva)

Circuit boards contain the highest value of precious metals in a computer, as well as most of the heavy metals (United States Geological Survey (USGS), 2001). The components of a personal computer have the highest economic value, due to gold plated connectors, components, pins and transistors.

Concentration of other heavy economical metals in electronic waste

Fig 7

Presently, the e-waste is treated by both informal and formal recyclers sharing total e-waste quantity in 95 to 5 ratios in the country. From the total e-waste generated in the country 60% e-waste remains in warehouses/storages and only 40% is made available for recycling process. In recycling process 95% E-waste is being used for the refurbishment and only 5% need process of disposal [MAIT]. The enormous energy may be saved by adapting recycling of e-waste. In recycling of e- waste aluminum 95%, copper 85%, iron and steel 74%, lead 65%, Zinc 60%, plastics 80% energy can be saved and for extraction of virgin material emission takes place for each tone of metal. So, this environmental loading also can be avoided if recovery of metals is done from e-waste and put in the recycling of the metals for further use. The informal recyclers get the e-waste from local waste collectors at very cheap price and recover the targeted metals like copper, aluminum, iron and steel with rudimentary and primitive methods and put a heavy environmental loading of pollutants on atmosphere. They are using open burning, acid leaching for the recovery of metals, which are non-environment friendly methods. The informal recyclers treat 95% of the e-waste generated by all sources. These activities of e-waste treatment are cause of concern of the ambience and society as these are detrimental to the air quality, human health as the pollutants persist in the environment years together and harm it continuously. The dispersion of pollutants due to treatment in uncontrolled conditions and further transportation ahead, resulting various kinds of diseases to the human beings effecting kilometers distant human being and environment. The recovery of materials: metals etc. are a lucrative business and acts as feedstock for the manufacturing of the new equipment, which is going to meet the user equipment demand at very cheap rate [Rajya Sabha, 2010]. The state of the art is available to recover metals to the maximum from the e-wasted equipment easily. Umicore in Belgium and Attero in India are the appropriate examples recovering gold up to 99% efficiently.

Recycling to Employment

Recycling is likely to grow steadily and form a vital component of greener waste management systems, which will provide decent employment. Recycling creates more jobs than it replaces. Recycling in all its forms employs 12 million people in the three countries - Brazil, China and United States. Sorting and processing recyclables alone sustain ten times more jobs than land filling or incineration on a per tonne basis. Estimations made in the context of this Report suggest that if an average of US$ 143 billion were invested in waste management over the period 2011-2030, a total employment of 20-23 million could be created in the waste sector by 2030, which represents 2-2.4 million jobs, more than the 23 million projected under a business as usual scenario.

Employment opportunity from e-waste

Table 5

S. no.	E-waste processed in one year	Manpower Employed in numbers	Working Hours per day	Daily Wages Rate	Per Annum Employment Business	Working Place	Safety Measures
01	10,000 to 20,000 tonne	25000	8 to 10	Rs 350/-	3193750000 or Rs.319 crore	Basements, close units	Minimum

(Amitava, 2010)

The rapidly increasing e-waste may be utilized as an economic source of recyclable and recoverable materials and may generate enormous employment opportunities. It is evident that the demand of virgin material for the manufacturing of the new EEEs is increasing every day. The materials mined from natural resources consume ten times energy with respect to recovery of materials from e-waste. E-waste confirms the availability of these materials but natural resources confirm it partially. In view of that the recovery of recyclable materials from e-waste releases environmental pressure on all natural resources until unless it is carried out by environment friendly techniques and methods. The environment friendly recovery infrastructure adopted by Umicore in Belgium and Attero in India employed specialized, skilled, semiskilled and unskilled manpower in proportion to the e-waste treated. Even before treatment, presently e-waste engages enormous unskilled manpower for the collection, segregation, manual dismantling, packaging, transportation of e-waste. So, there is and would be a huge demand of all kind of manpower if e-waste profession is organized professionally in the country.

Manpower Required

Fig 8

The e-waste pre-processing is cheap in developing countries due to the availability of human resource at reasonable cost. The availability of update environment friendly recovery technology will strengthen and explores more employment opportunities in the country.

Job opportunities in e-waste

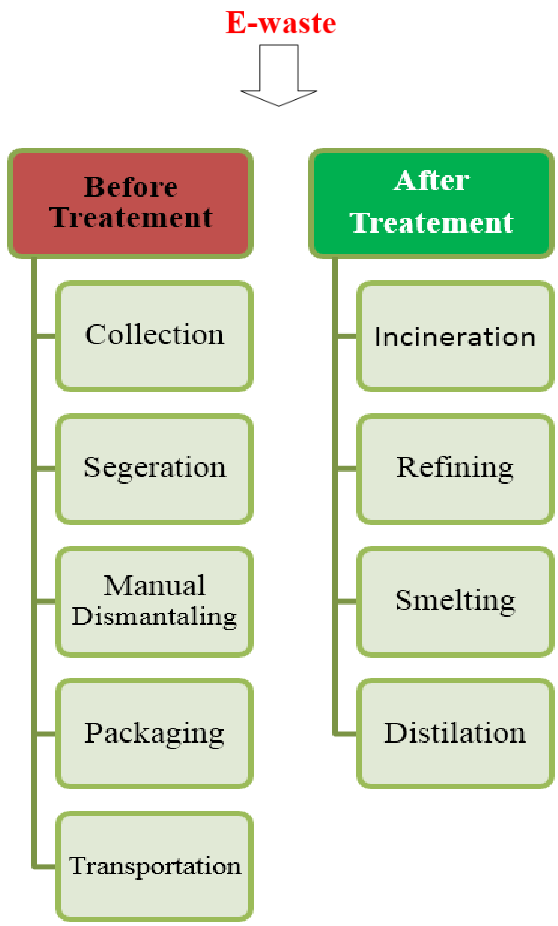

Fig 9

Improved Economy

Greening the waste sector includes, the minimization of waste. Where waste cannot be avoided, recovery of materials and energy from waste as well as remanufacturing and recycling waste into usable products should be the second option. The overall vision is to establish a global circular economy in which material use and waste generation is minimized, any unavoidable waste recycled or remanufactured, and any remaining waste treated in a manner least harmful to the environment and human health or even generating new value such as energy recovered from waste. Investing in greening the waste sector can generate multiple economic benefits. Recycling leads to substantial resource savings and helps in improving economy.

Greening Electronic Waste

Greening electronic waste refers to a shift from less-preferred waste treatment and disposal methods such as incineration and different forms of land filing towards the five "R" Reduce, Reuse, Repair, Recovery and Recycle. The strategy is to move upstream in the waste management hierarchy, based on the internationally recognized approach of Integrated Solid Waste Management or ISWM. This strategic approach to manages all sources of waste; prioritizing waste, avoidance and minimization, practicing segregation, promoting "5 R" for implementing safe waste transportation, treatment, and disposal in an integrated manner, with an emphasis on maximizing resource-use efficiency.

Improved labor condition and health

Improving labor conditions in the waste sector is imperative. The activities of collection, processing and redistribution of recyclables are usually done by workers with few possibilities outside the sector. Thus, despite the potentially significant contribution to employment creation, not all of the recycling and waste management related jobs can be considered green jobs. To be green jobs they also need to match the requirements of decent work, including the aspects of child labor, occupational health and safety, social protection and freedom of association.

Conclusion & Suggestions

The most common practices adopted for disposal of e-waste are acid baths, land filling and open air burning. When electronic equipments are burned, they release abundant fumes which are dangerous for environment way beyond our imagination and estimation. The principle of "6Rs" applies here. Report about the electronic waste to proper authorities. Recover the electronic waste in an appropriate and environmentally friendly manner. Reduce the generation of e-waste through smart procurement and good maintenance. Reuse still functioning electronic equipment by donating or selling it to someone who can still use it. Repair or reboot electronic equipment for next use if possible. Recycle those components that cannot be repaired. Public education and outreach may well be the most important component. That is because no matter what infrastructure is available and developed, what the laws are, and what the option are, no one will be aware of it without public education. Presently the informal recycling dominates over formal recycling in the country. The infrastructure for e-waste treatment is money intensive but a lucrative business these days as recovery of metals is possible up to 99% from the e-wasted EEEs. Umicore in Belgium and Attero in India are the appropriate examples of metal recovery. For the reduction of environmental loading 6Rs (Report, Recover, Reduce, Reuse, Repair, Recycle) principles should be followed in the country and a multi-crore lucrative business can be explored easily.

Fig 10

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