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Environmental Impact of Uncontrolled Disposal of E-Wastes

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Abstract: E-wastes consist of discard of electronic appliances such as computers, mobiles and telephones. Major producers of e-wastes are USA, China, Europe and Australia and the total estimate of these products is about 25 million tonnes per year. These countries are forced to adopt the “reuse” procedure to save environment and money flow. However certain e-wastes are having their self-life, which cannot be reuse. Hence, it is essential to recycle or disposal of these with suitable precautions. Uncontrolled disposal and recycling activities generate and release high toxic metals such as Hg, Pb, Cd, Cr, Cr(IV), Co, Cu, Ni, and Zn. These also release high concentrations of different types of flame retardants such as PolyBrominated Diphenyl Ethers (PBDEs), Poly-Chlorinated Biphenyls (PCBs) and OrganoChlorine Pesticides (OCPs). In this current research paper, potential environmental health consequences of these toxic metals and organo compounds are described.The selection of this topic is to evaluate electronic waste (e-waste) pollution and the toxicsubstances present in the e-waste and their threats to human health. Due to technologyadvancement and development makes new innovative electronic products which areaffordable rather repair outdated equipment. It is evident that disposal of electronicproducts is due to production of new ones. This article mainly focuses on overview ofIndia’s current e-waste scenario and their problems in recycling and disposal of e-waste.The tools for e-waste management like life cycle assessment (LCA), material flowanalysis (MFA) have been developed to manage e-wastes especially in developedcountries. By developing eco-design devices and collecting e-waste and safe handlingthe disposal brings clean environment. There is no exact tool to solve this issue.
Keywords: Toxic metals; flame retardants; pesticides, E-waste; environmental hazard; Occupational hazard.

1. INTRODUCTION

"E-waste" is a popular, informal name for electronic products nearing the end of their "useful life."E-wastes are considered dangerous, as certain components of some electronic products contain materials that are hazardous, depending on their condition and density. The hazardous content of these materials pose a threat to human health and environment. Discarded computers, televisions, VCRs, stereos, copiers, fax machines, electric lamps, cell phones, audio equipment and batteries if improperly disposed can leach lead and other substances into soil and groundwater. Many of these products can be reused, refurbished, or recycled in an environmentally sound manner so that they are less harmful to the ecosystem. This paper highlights the hazards of e-wastes, the need for its appropriate management and options that can be implemented [1, 2].

Industrial revolution followed by the advances in information technology during the last century has radically changed people's lifestyle. Although this development has helped the human race, mismanagement has led to new problems of contamination and pollution. The technical prowess acquired during the last century has posed a new challenge in the management of wastes. For example, personal computers (PCs) contain certain components, which are highly toxic, such as chlorinated and brominated substances, toxic gases, toxic metals, biologically active materials, acids, plastics and plastic additives. The hazardous content of these materials pose an environmental and health threat [3]. Thus proper management is necessary while disposing or recycling e-wastes.

These days computer has become most common and widely used gadget in all kinds of activities ranging from schools, residences, offices to manufacturing industries. E-toxic components in computers could be summarized as circuit boards containing heavy metals like lead & cadmium; batteries containing cadmium; cathode ray tubes with lead oxide & barium; brominated flameretardants used on printed circuit boards, cables and plastic casing; poly vinyl chloride (PVC) coated copper cables and plastic computer casings that release highly toxic dioxins & furans when burnt to recover valuable metals; mercury switches; mercury in flat screens; poly chlorinated biphenyl's (PCB's) present in older capacitors; transformers; etc. Basel Action Network (BAN) estimates that the 500 million computers in the world contain 2.87 billion kgs of plastics, 716.7 million kgs of lead and 286,700 kgs of mercury. The average 14-inch monitor uses a tube that contains an estimated 2.5 to 4 kgs of lead. The lead can seep into the ground water from landfills thereby contaminating it. If the tube is crushed and burned, it emits toxic fumes into the air [5, 6, 7].

2. EFFECTS ON ENVIRONMENT AND HUMAN HEALTH

Disposal of e-wastes is a particular problem faced in many regions across the globe. Computer wastes that are landfilled produces contaminated leachates which eventually pollute the groundwater. Acids and sludge obtained from melting computer chips, if disposed on the ground causes acidification of soil. For example, Guiyu, Hong Kong a thriving area of illegal e-waste recycling is facing acute water shortages due to the contamination of water resources.

This is due to disposal of recycling wastes such as acids, sludges etc. in rivers. Now water is being transported from faraway towns to cater to the demands of the population. Incineration of e-wastes can emit toxic fumes and gases, thereby polluting the surrounding air. Improperly monitored landfills can cause environmental hazards. Mercury will leach when certain electronic devices, such as circuit breakers are destroyed. The same is true for polychlorinated biphenyls (PCBs) from condensers [7]. When brominates flame retardant plastic or cadmium containing plastics are land filled, both polybrominateddiphenyl ethers (PBDE) and cadmium may leach into the soil and groundwater. It has been found that significant amounts of lead ion are dissolved from broken lead containing glass, such as the cone glass of cathode ray tubes, gets mixed with acid waters and are a common occurrence in landfills. The toxic fall-out from open air burning affects both the local environment and broader global air currents, depositing highly toxic byproducts in many places throughout the world [8, 9].

The health effects of certain constituents in e-wastes were summarized in Table-1. If these electronic items are discarded with other household garbage, the toxics pose a threat to both health and vital components of the ecosystem. In view of the ill-effects of hazardous wastes to both environment and health, several countries exhorted the need for a global agreement to address the problems and challenges posed by hazardous waste. Also, in the late 1980s, a tightening of environmental regulations in industrialized countries led to a dramatic rise in the cost of hazardous waste disposal. Searching for cheaper ways to get rid of the wastes, "toxic traders" began shipping hazardous waste to developing countries. International outrage following these irresponsible activities led to the drafting and adoption of strategic plans and regulations at the Basel Convention. The Convention secretariat, in Geneva, Switzerland, facilitates and implementation of the Convention and related agreements. It also provides assistance and guidelines on legal and technical issues, gathers statistical data, and conducts training on the proper management of hazardous waste [10, 11].

Table I: Effects of E-Waste constituent on health

Source of e-wastes	Constituent	Health effects
Solder in printed circuit boards, glass panels and gaskets in computer monitors	Lead (PB)	• Damage to central and peripheral nervous systems, blood systems and kidney damage. • Affects brain development of children.
Chip resistors and semiconductors	Cadmium (CD)	• Toxic irreversible effects on human health. • Accumulates in kidney and liver. • Causes neural damage. • Teratogenic.
Relays and switches, printed circuit boards	Mercury (Hg)	• Chronic damage to the brain. • Respiratory and skin disorders due to bioaccumulation in fishes.
Corrosion protection of untreated and galvanized steel plates, decorator or hardner for steel housings	Hexavalent chromium (Cr) VI	• Asthmatic bronchitis. • DNA damage.
Cabling and computer housing	Plastics including PVC	Burning produces dioxin. It causes • Reproductive and developmental problems; • Immune system damage; • Interfere with regulatory hormones
Plastic housing of electronic equipments and circuit boards.	Brominated flame retardants (BFR)	• Disrupts endocrine system functions
Front panel of CRTs	Barium (Ba)	Short term exposure causes: • Muscle weakness; • Damage to heart, liver and spleen.
Motherboard	Beryllium (Be)	• Carcinogenic (lung cancer) • Inhalation of fumes and dust. Causes chronic beryllium disease or beryllicosis. • Skin diseases such as warts.

3. MANAGEMENT OF E-WASTES

It is estimated that 75% of electronic items are stored due to uncertainty of how to manage it. These electronic junks lie unattended in houses, offices, warehouses etc. and normally mixed with household wastes, which are finally disposed off at landfills. This necessitates implementable management measures.

3.1 E-waste management tips

1. Don't throw the waste cell phones, dumped systems into the landfills. Properly, deliver them to the organizations where recycling is carried out.
2. Get the electronic goods from the vendors who can take back for recycling.
3. Take care of the lifetime of your hardware equipments and so that e waste can be efficiently decreased
4. Big Industries may buy recyclers that can be used for long time.
5. Citizens should turn their interests to use the recycled products
6. Support green engineering.

In industries management of e-waste should begin at the point of generation. This can be done by waste minimization techniques and by sustainable product design. Waste minimization in industries involves adopting:

- ✓ inventory management,
- ✓ production-process modification,
- ✓ volume reduction,
- ✓ recovery and reuse.

Inventory management

Proper control over the materials used in the manufacturing process is an important way to reduce waste generation. By reducing both the quantity of hazardous materials used in the process and the amount of excess raw materials in stock, the quantity of waste generated can be reduced. This can be done in two ways i.e. establishing material-purchase review and control procedures and inventory tracking system. Developing review procedures for all material purchased is the first step in establishing an inventory management program. Procedures should require that all materials be approved prior to purchase. In the approval process all production materials are evaluated to examine if they contain hazardous constituents and whether alternative non-hazardous materials are available [12].

Production-process modification

Changes can be made in the production process, which will reduce waste generation. This reduction can be accomplished by changing the materials used to make the product or by the more efficient use of input materials in the production process or both. Potential waste minimization techniques can be broken down into three categories:

i) Improved operating and maintenance procedures,

ii) Material change and

iii)Process-equipment modification.

Improvements in the operation and maintenance of process equipment can result in significant waste reduction. This can be accomplished by reviewing current operational procedures or lack of procedures and examination of the production process for ways to improve its efficiency. Instituting standard operation procedures can optimize the use of raw materials in the production process and reduce the potential for materials to be lost through leaks and spills. A strict maintenance program, which stresses corrective maintenance, can reduce waste generation caused by equipment failure. An employee-training program is a key element of any waste reduction program [18-20]. Training should include correct operating and handling procedures, proper equipment use, recommended maintenance and inspection schedules, correct process control specifications and proper management of waste materials.

Hazardous materials used in either a product formulation or a production process may be replaced with a less hazardous or non-hazardous material. This is a very widely used technique and is applicable to most manufacturing processes. Implementation of this waste reduction technique may require only some minor process adjustments or it may require extensive new process equipment. For example, a circuit board manufacturer can replace solvent-based product with water-based flux and simultaneously replace solvent vapor degreaser with detergent parts washer.

Volume reduction

Volume reduction includes those techniques that remove the hazardous portion of a waste from a non-hazardous portion. These techniques are usually to reduce the volume, and thus the cost of disposing of a waste material. The techniques that can be used to reduce waste-stream volume can be divided into 2 general categories: source segregation and waste concentration. Segregation of wastes is in many cases a simple and economical technique for waste reduction. Wastes containing different types of metals can be treated separately so that the metal value in the sludge can be recovered. Concentration of a waste stream may increase the likelihood that the material can be recycled or reused. Methods include gravity and vacuum filtration, ultra filtration, reverse osmosis, freeze vaporization etc. For example, an electronic component manufacturer can use compaction equipments to reduce volume of waste cathode ray-tube [21-22].

Recovery and reuse

This technique could eliminate waste disposal costs, reduce raw material costs and provide income from a salable waste. Waste can be recovered on-site, or at an off-site recovery facility, or through inter industry exchange [23]. A number of physical and chemical techniques are available to reclaim a waste material such as reverse osmosis, electrolysis, condensation, electrolytic recovery, filtration, centrifugation etc. For example, a printed-circuit board manufacturer can use electrolytic recovery to reclaim metals from copper and tin-lead plating bath. However recycling of hazardous products has little environmental benefit if it simply moves the hazards into secondary products that eventually have to be disposed of. Unless the goal is to redesign the product to use nonhazardous materials, such recycling is a false solution.

Sustainable product design

Minimization of hazardous wastes should be at product design stage itself keeping in mind the following factors*

- **Rethink the product design:** Efforts should be made to design a product with fewer amounts of hazardous materials. For example, the efforts to reduce material use are reflected in some new computer designs that are flatter, lighter and more integrated. Other companies propose centralized networks similar to the telephone system.

- **Use of renewable materials and energy:** Bio-based plastics are plastics made with plant-based chemicals or plant-produced polymers rather than from petrochemicals. Bio-based toners, glues and inks are used more frequently. Solar computers also exist but they are currently very expensive.

- **Use of non-renewable materials that are safer:** Because many of the materials used are non-renewable, designers could ensure the product is built for re-use, repair and/or upgradeability. Some computer manufacturers such as Dell and Gateway lease out their products thereby ensuring they get them back to further upgrade and lease out again.

4.0 E-WASTE IN INDIA

As there is no separate collection of e-waste in India, there is no clear data on the quantity generated and disposed of each year and the resulting extent of environmental risk. Thepreferred practice to get rid ofobsolete electronic items in India is toget them in exchange from retailers when purchasing a new item. The business sector is estimated to account for 78% of all installed computers in India [23]. Obsolete computers from the business sector are sold by auctions. Sometimes educational institutes or charitable institutions receive old computers for reuse. It is estimated that the total number of obsolete personal computers emanating each year from business and individual households in India will be around 1.38 million.According to a report of

Confederation of Indian Industries, the total waste generated by obsolete or broken down electronic and electrical equipment in India has been estimated to be 1,46,000 tons per year.

The results of a field survey conducted in metro-plolitancity of India to assess the average usage and life of the personal computers (PCs), television (TV) and mobile phone showed that the average household usage of the PCranges from 0.39 to 1.70 depending on the income class . In the case of TV it varied from 1.07 to 1.78 and for mobile phones it varied from 0.88 to 1.70. The low-income households usethe PC for 5.94 years, TV for 8.16 years and the mobile phonesfor 2.34 years while, the upper income class uses the PC for 3.21 years, TV for 5.13years and mobile phones for 1.63 years. Although the per-capita waste production in India is still relatively small, the total absolute volume of wastes generated will be huge. Further, it is growing at a faster rate. The growth rate of the mobile phones (80%) is very high compared to that of PC (20%) and TV (18%). The public awareness on e-wastes and the willingness of the public to pay for e-waste management as assessed during the study based on an organized questionnaire revealed that about 50% of the public are aware of environmental and health impacts of the electronic items. The willingness of public to pay for e-waste management ranges from 3.57% to 5.92% of the productcost for PC, 3.94 % to 5.95 % for TV and 3.4 % to 5 % for the mobile phones.

However, noconfirmed figures available on how substantial are these trans boundary e-waste streams, as most of such trade in e-waste is camouflaged and conducted under the pretext of obtaining ‘reusable’ equipment or ‘donations’ from developed nations.

4.1 Present E-waste Status in India

In India most of activities like collection, transportation, segregation, dismantling, etc., is done by unorganized sectors manually. Being a rich source of reusable and precious material, E waste is also a good source of revenue generation for many people in India. The big portion (rag pickers) of the Indian population earned their livelihood by collecting and selling the inorganic waste-like plastics, polythene bags, glass bottles, cardboardspaper, other ferrous metals, etc. In India, most ofthe operations related to E-waste such acollections, segregation, dismantling, recycling, and disposals are performed manually. Inabsence of the adequate technologies and equipment, most of the techniques used for the recycling/treatments of E-waste are very raw and dangerous. Figure 1 reveals the trend in growth of E-waste in India that is continuously rising over the years. In 2007 E-waste generation is 332979, but in2009 it is 69926 MT. more than previous record. In 2011 the production of E-waste is 487515, and it is84610 more than 2009. So we conclude that the E-waste rising over the year with a healthy pace and it is an alarming signal for Indian environmentalist, planners and administrates.

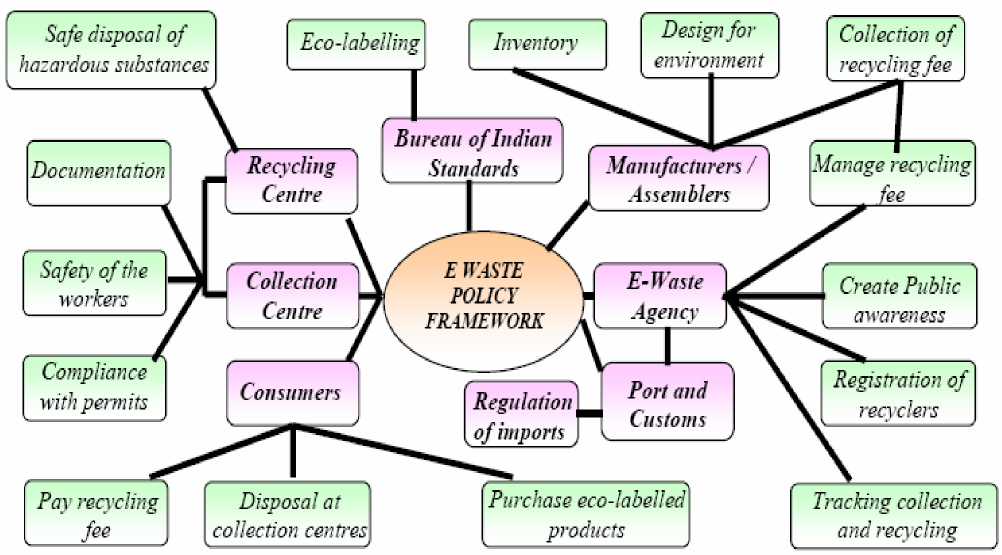

Figure 1. Elements of e-waste management system for India

Various Categories of Waste Electrical and Electronic Equipment

Sr. No	Category	Label	% of contribution
1.	Large household appliances	Large HH	42.1
2.	Small household appliances	Small HH	4.7
3.	Consumer equipment	ICT	33.9
4.	Lighting equipment	CE	13.7
5.	Electrical and electronic tools	Lighting	1.4
6.	Toys, and leisure and sports equipment	E&E tools	1.4
7.	Medical devices (with the exception of all implemented and infected products)	Toys	0.2
8.	Monitoring and control instruments	Medical equipment	1.9
9.	Automatic dispensers	M&C	0.1
10.	Automatic dispensers	Dispensers	0.7

Note: Cited from Basu, (2009)

Forecasted Scrapping Volume of Five Major Electronic Equipments Types (X1000 Units)

Year	Refrigerator	Air Conditioner	Washing machine	Television	Computer	Total	Growth rate %
2001	6,708	630	10,942	14,358	246	32,884	
2002	4,631	1,580	9,484	16,892	836	33,422	16
2003	4,699	3,464	10,747	20,577	1,388	40,876	223
2004	4,858	3,934	12,545	25,376	2,066	48,778	193
2005	5,967	6,826	12,073	27,113	2,914	54,893	125
2006	7,681	7,862	13,422	34,970	4,050	67,985	239
2007	9,185	9,740	14,430	42,620	6,720	82,695	216
2008	9,797	11,569	13,416	39,360	8,777	82,918	3
2009	10,444	13,376	15,958	40,937	14,635	95,350	150
2010	10,600	18,267	19,645	51,550	32,167	132,228	387
2011	12,100	23,336	25,334	65,414	59,749	185,934	406
2012	12,790	31,351	30,355	74,318	80,849	229,664	235
Average							

Source: China's plastic statistics yearbook 2006.
Note: Cited From Shivakumar et. al (2011)

Global WEEE production, disposal, recycling and import/export estimates (2005)

Country/Region	Annual household production in million Tons.	Land filling storage and incineration in million Tons.	Domestic recycling million Tons.	Annual exports in million tons	Annual import in million Tons.
U.S.A	6.6	5.2	0.13	1.3	-
EU-25	7	1.6	3.53	1.9	-
Japan	3.1	0.6	1.94	0.62	-
China	3.1	3.6	1.5	-	2.0
India	0.36	0.85	0.36	-	0.85
West Africa	0.05	0.45	0.17	-	0.57
Total	20.21	12.3	7.56	3.85	3.42

E-Waste Generation in India

Item	Weight (MT.)
Imports	332979
Domestic Generation	50000
Total	382979
WEEE available for recycling	144143
WEEE actual recycled	19000
Projected quantity of WEEE 2012 (without including the imports)	467098

Source: MAIT, GTZ, 2007

5.0 E-WASTE CONCERNS AND CHALLENGES

a) Accurate figures not available for rapidly increasing e-waste volumes— generated domestically and by imports.
b) Low level of awareness among manufacturers and consumers of the hazards of incorrect e- waste disposal.
c) No accurate estimates of the quantity of e-waste generated and recycled available in India.
d) Major portion of e-waste is processed by the informal (unorganized)sector using rudimentary techniques such as acid leaching and open-air burning, whichresults in severe environmental damage.
e) E-waste workers have little or no knowledge of toxins in e-waste and are exposed to health hazards.
f) Cherry-picking by recyclers who recover precious metals (gold, platinum, silver, copper, etc) and improperly dispose of the rest, posing environmental hazards.
g) No specific legislation for dealing.
h) High-risk backyard recycling operations impact vulnerable social groups like women, children and immigrant labourers.
i) Inefficient recycling processes result in substantial losses of material value and resources.

6.0 MANAGEMENT OPTIONS TO SEVERITY OF THE PROBLEM:

Considering the severity of the problem, it is imperative that certain management options be adopted to handle the bulk e-wastes. Following are some of the management options suggested for the government, industries and the public.

6.1 Responsibilities of the Government

- Governments should set up regulatory agencies in each district, which are vested with the responsibility of co-ordinations and consolidating the regulatory functions of the various government authorities regarding hazardous substances.
- Governments should be responsible for providing an adequate system of laws, controls and administrative procedures for hazardous waste management. Existing laws concerning e-waste disposal be reviewed and revamped.
- A comprehensive law that provides e-waste regulation and management and proper disposal of hazardous wastes is required. Such a law should empower the agency to control, supervise and regulate the relevant activities of government departments.

Under this law, the agency concerned should

- Collect basic information on the materials from manufacturers, processors and importers and to maintain an inventory of these materials. The information should include toxicity and potential harmful effects.
- Identify potentially harmful substances and require the industry to test them for adverse health and environmental effects.
- Control risks from manufacture, processing, distribution, use and disposal of electronic wastes.
- Encourage beneficial reuse of "e-waste" and encouraging business activities that use waste". Set up programs so as to promote recycling among citizens and businesses.
- Educate e-waste generators on reuse/recycling options.

- Governments must encourage research into the development and standard of hazardous waste management, environmental monitoring and the regulation of hazardous waste-disposal.
- Governments should enforce strict regulations against dumping e-waste in the country by outsiders. Where the laws are flouted, stringent penalties must be imposed. In particular, custodial sentences should be preferred to paltry fines, which these outsiders / foreign nationals can pay.
- Governments should enforce strict regulations and heavy fines levied on industries, which do not practice waste prevention and recovery in the production facilities.
- Polluter pays principle and extended producer responsibility should be adopted.
- Governments should encourage and support NGOs and other organizations to involve actively in solving the nation's e-waste problems.
- Governments should explore opportunities to partner with manufacturers and retailers to provide recycling services.

6.2 Responsibility and Role of industries

Generators of wastes should take responsibility to determine the output characteristics of wastes and if hazardous, should provide management options. All personnel involved in handling e-waste in industries including those at the policy, management, control and operational levels, should be properly qualified and trained. Companies can adopt their own policies while handling e-wastes. Some are given below:

- ❖ Use label materials to assist in recycling (particularly plastics).
- ❖ Standardize components for easy disassembly.
- ❖ Re-evaluate 'cheap products' use, make product cycle 'cheap' and so that it has no inherent value that would encourage a recycling infrastructure.
- ❖ Create computer components and peripherals of biodegradable materials.
- ❖ Utilize technology sharing particularly for manufacturing and de manufacturing.
- ❖ Encourage / promote / require green procurement for corporate buyers.
- ❖ Look at green packaging options.

Companies can and should adopt waste minimization techniques, which will make a significant reduction in the quantity of e-waste generated and thereby lessening the impact on the environment. It is a "reverse production" system that designs infrastructure to recover and reuse every material contained within e-wastes metals such as lead, copper, aluminum and gold, and various plastics, glass and wire. Such a "closed loop" manufacturing and recovery system offers a win-win situation for everyone, less of the Earth will be mined for raw materials, and groundwater will be protected. At minimum, all computer monitors, television sets and other electronic devices containing hazardous materials must be clearly labeled to identify environmental hazards and proper materials management.

6.3 Responsibilities of the Citizen

Waste prevention is perhaps more preferred to any other waste management option including recycling. Donating electronics for reuse extends the lives of valuable products and keeps them out of the waste management system for a longer time. But care should be taken while donating such items i.e. the items should be in working condition. Reuse, in addition to being an environmentally preferable alternative, also benefits society. By donating used electronics, schools, non-profit organizations, and lower-income families can afford to use equipment that they otherwise could not afford. E-wastes should never be disposed with garbage and other household wastes. This should be segregated at the site and sold or donated to various organizations. While buying electronic products opt for those that:

- ❖ are made with fewer toxic constituents
- ❖ use recycled content
- ❖ are energy efficient

- are designed for easy upgrading or disassembly
- utilize minimal packaging
- offer leasing or take back options
- have been certified by regulatory authorities. Customers should opt for upgrading their computers or other electronic items to the latest versions rather than buying new equipments.

7.0 CONCLUSIONS

Solid waste management in India, which is already a very problematic task, is becoming more difficult by the attack of e-waste. The complaint is alarming as India generates about 1.5 lakh tones of e-waste annually and almost all of it finds its way into the informal sector as there is no organized alternative available at present. E-waste generated in few cities across the nation show an alarming picture. In India Mumbai is on the top in terms of E-waste generation followed by Delhi with 9730.5 metric tonnes e-waste. Institutional infrastructures, including e-waste collection, transportation, treatment, storage, recovery and disposal, need to be established, at national and/or regional levels for the environmentally sound management of e-wastes. Establishment of e-waste collection, exchange and recycling centers should be encouraged in partnership with private entrepreneurs and manufacturers. An effective take-back program providing incentives for producers to design products that are less wasteful, contain fewer toxic components, and are easier to disassemble, reuse, and recycle may help in reducing the wastes. Hence creating awareness among the e-waste generating sectors is the important task now.

8.0 REFERENCES

1. Devi B.S, Shobha S. V, Kamble R. K., 2004, E-Waste: The Hidden harm of Technological Revolution, Journal IAEM, Vol.31, 196-205.
2. Ramesh, S. and Joseph, K. 2006, Electronic Waste Generation and Management in an Indian City, Journal of Indian Association for Environmental Management, Vol.33, 100-105.
3. Jain, A., 2009, “Development and Evaluation of Existing Policies and Regulations for E-waste in India”, IEEE, International Symposium on Sustainable Systems and Technology, 18-20 May, 1-4.
4. Implementation of the Waste Electrical and Electronic Equipment Directive in the EU, 2006,European Commission, Directorate General, Joint Research Centre, IPTS.
5. Jain, A. ,2009, Development and Evaluation of Existing Policies and Regulations for E-waste in India, IEEE, International Symposium on Sustainable Systems and Technology, 18-20 May,2009, 1-4.
6. Ministry of Environment & Forests and Central Pollution Control Board, 2008, Guidelines for environmentally Sound Management of e-waste.
7. UNEP, 2010, ‘E-waste Volume-I (Inventory Assessment Manual)’,Vol.1,145-162.
8. Sivakumar.T, 2011,“Global Challenges in E-waste Management: Indian Scenario”, International Journal of Advanced Engineering Technology, Vol.2, 10-15.
9. RamachandraT.V,Saira V. K.,2004, “Environmentally sound options for waste management”, Envis. Journal of Human Settlements.
10. Freeman M. H., 1989, Standard Handbook of Hazardous Waste Treatment and Disposal, McGraw-Hill Company, USA.
11. L. M. Hilty, 2005 “Electronic waste—an emerging risk?” Environmental Impact Assessment Review, Vol. 25, 431–435.
12. L. M. Hilty, C. Som, and A. Kohler, 2004 “Assessing the human, social, and environmental risks of pervasive computing,” Human and Ecological Risk Assessment, Vol. 10, 853–874.
13. W. He, G. Li, X. Ma, et al., 2006,“WEEE recovery strategies and the WEEE treatment status in China,” Journal of Hazardous Materials, Vol. 136, 502–512.
14. D. Woodell, 2008, Ministry of Environment & Forests and Central Pollution Control Board Guidelines for environmentally Sound Management of e-waste, 72–73.
15. W. J. Denga, et.al 2006,“Atmospheric levels and cytotoxicity of PAHs and heavy metals in TSP and PM 2.5 at an electronic waste recycling site in southeast China,” Atmospheric Environment, Vol. 40, 6945–6955.

16. M. Macauley, K. Palmer, and J. S. Shih, 2003 “Dealing with electronic waste: modeling the costs and environmental benefits of computer monitor disposal,” Journal of Environmental Management, Vol. 68, 13–22.
17. J. Puckett, L. Byster, S. Westervelt, et al., 2002, Exporting Harm: The High-Tech Trashing of Asia, The Basel Action Network (BAN) and Silicon Valley Toxics Coalition (SVTC).
18. D. Sinha-Khetriwal, 2002, The management of electronic waste: a comparative study on India and Switzerland, Switzerland.
19. R. Widmer, et al., 2005, “Global perspectives on e-waste,” Environmental Impact Assessment Review, Vol. 25, 436–458.
20. D. Sinha-Khetriwal, P. Kraeuchi, and R. Widmer, 2009, “Producer responsibility for e-waste management: key issues for consideration—learning from the Swiss experience,” Journal of Environmental Management, Vol. 90,153–165.
21. A. Sepúlveda, M. Schluep, F. G. Renaud, et al., 2010 “A review of the environmental fate and effects of hazardous substances released from electrical and electronic equipments during recycling: examples from China and India,” Environmental Impact Assessment Review, Vol. 30, 28–41.
22. Environmental Health Perspectives, 2004, Vol. 112, 1085–1091.
23. J. Kristina et.al. 2002 “Exposure to polybrominateddiphenyl ethers and tetrabromobisphenol A among computer technicians,” Chemosphere, Vol. 46,709–716.

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