Institutional Mechanism in E-Waste Management and Recycling

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Abstract: *Waste electrical and electronic equipment (WEEE) is one of the extensivelygrowing waste streams universally. Hence, for a sustainable environment and the economic retrieval of treasured and valuable material for recycle, the efficient recycling of electronic scuffleand scrap has been rendered badly essential, and must still be regarded as a big challenge for today's society. In contrast to the well-established recycling of metallic waste, it is much more complicated to recycle electronics products which have reached the end of their life as they contain many different types of material types integrated into each other. As epitomisedpredominantly for the recycling of mobile phones, laptops, and other technological hardwires, the efficient recycling of WEEE is not only a threaten for the recycling industry; it is also often a question of as-yet inadequateassortmentand collection of infrastructures and poor collection efficiencies, and a considerable lack of the consumer's awareness for the potential of recycling electronics for the benefit of the environment, as well as for savings in energy and raw materials.Institutional arrangements for e-waste management play a crucial role in the society which cover organizational structures and roles and responsibilities of agencies involved in various aspects of WEEE management, including interagency coordination, procedures and methods, capacity, and private sector involvement.1Institutional arrangements also cover the laws, regulations, and policies implemented by concerned organizations to plan and manage their activities to fulfil their mandates on the management of WEEE.*

Key Words: *e-waste management and recycling, institutional mechanism, waste electrical and electronic equipment, sustainable environment*

1. INTRODUCTION:

E-Waste (Electronic Waste) or WEEE (Waste Electrical and Electronic Equipment) is one of the fastest growing waste streams in the world. E-waste problems are now becoming wide spread and defused, because computerization and use of electronic equipment are expanding at an unprecedented rate. The technical innovations and rapid changes in the model of some entities like personal computer, mobile phone, refrigerator, television, washing machines etc.., have generated huge quantum of waste.When developing country constitutes 0.01% to 1% of total solid waste, developed country accounts more than 1% for the same. Trade associated with WEEE /E-wastes have been responsible for the evolution of concept and definition of E-waste from the global environmental perspective.

2. THE CONCEPT OF E-WASTE:

E-waste is a complex mixture of hazardous and non-hazardous waste, which has much economic value. Electronic waste, popularly known as 'E-waste', can be defined as electronic equipment / products connects with power plug, batteries etc.., which have become obsolete due to advancement in technology changes in fashion, style and status nearing the end of their useful life.

Composition of WEEE/ E-waste vary diverse and differs in products across different categories. E-waste contains more than 1000 different substances, which fall under hazardous and non-hazardous categories. Broadly it consists of ferrous and nonferrous metals, plastic, glass, wood and plywood, printed circuit boards, concrete and ceramics, rubber, and other items. Iron and steel constitutes about 50% of the WEEE, and other constituents. On ferrous metals consist of metals like aluminium and precious metals like silver, gold, platinum, palladium and so on. The pressure of elements like lead, mercury, arsenic, cadmium, selenium, hexavalent chromium, and flame setardants beyond threshold quantities in WEEE/ E- waste makes it hazardous in nature.

E-waste the Global View

Globally there is no standard definition of WEEE/ E-waste. Many countries are postulated their own definition, interpretation and usage of the term E- waste/ WEEE. The most widely accepted definition given by European Union Directive includes that there are three major drivers determine WEEE/e waste definition. These drivers are definition of 'EEE or electrical and electronic equipment', description of its `loss of utility' and `way of disposal'.

Waste Electrical and Electronic Equipment (WEEE) includes the classification into 10 categories, and it extents as per voltage rating 1000 volts for AC and 1500 volts for DC. The WEEE has been further classified into `components, sub-assemblies and consumables. Loss of utility includes variation in the consumer behaviour. Way of disposal broadly reflects different national policies and regulations for considering waste as a `pollutant' or a `resource'. There is no definition of WEEE in Indian environmental regulations.

3. GLOBAL E-WASTE GROWTH:

Globally about 20-50 million tons of e-wastes are disposedoff each year which accounts for 50% of all municipal solid waste. Higher percentage of WEEE/ E-waste in municipal solid waste is expected to be a phenomenon of developing countries. The EU and USA would account for maximum WEEE/ E-waste generation during these decades. A recent study estimates that total WEEE generated in the EU ranges from 7 million tons to 10 million tons per annum or about 14-15 kg per Capita and is expected to grow at a 3%-5% per year. In the EU, WEEE increases by 16%-28% every 5 years which is 3 time faster than average annual municipal solid waste generation. In USA, E-wastes account for 1%-5% of total municipal waste generation. This growth rate will accelerate global WEEE/ E-waste reclining method.

4. E-WASTE GROWTH IN INDIA:

As far as India is concerned, the electric industry has emerged as fastest growing segment of Indian industry both in terms of production and exports. A review of industrial statistics shows that the software services contribute more than hardware in IT revenue. The shift in the IT industry is a result of liberalization and the opening up of Indian market together with change in India's import policy viz., hardware, leading to substitution of domestically produced hardware by imports. As per Manufacture's Association for Information Technology (MAIT) estimates, in Indian PCs are growing at 25% compounded annual growth rate.

The growth has significant economic and social impacts. The increase of electronic products, consumption rates, and obsolescence rate leads to generations of E-waste. The increasing obsolescence rates of electric products added to the huge import of junk electronics from abroad, creating complex scenario for solid waste management in India. This problem was highlighted in 2004 as a result of pilot E-waste assessment study for New Delhi. As a follow up of the pilot study, it carried out a national-level desk study under the guidance of CPCB/ASEM (advisory services in environmental management) program of GTZ (German technical institution) to assess the quantum of E-waste being generated at national level and identify states and cities requiring rapid assessment in India. The desk study covered market size and growth for ICT, brown goods, and white goods segments. The report indicates that computers (ICT), TVs, (brown goods), refrigerators and washing machines (white goods) will drive the future growth of electronics hardware industry in India. The study shows that growth rate of computer has been estimated to be 25%, and for all other items, it ranges 15%-20% annually. It was established that obsolesce rate for computers is seven years and that for TVs, washing machines and refrigerators is 15 years. The study also reveals that 10 states generate 70% of the total E-waste generated in India, ranking Maharashtra first followed by Tamil Nadu, Andhra Pradesh. 65 cities in India generate more than 60% of the total E-waste generated in India ranking Mumbai first followed by Delhi and Bangalore. And also, there is no large-scale organized E-waste recycling facility in India, and entire recycling is carried out in unorganized sector.

5. MANAGEMENT OF E-WASTES:

It is estimated that 75% of electronic items are stored due to uncertainty of how to manage it. The best option for dealing with E-wastes is to reduce the volume. Designers should initiate the process, since designers should produce the Electronic and Electrical Equipment (EEE) in such a manner that the product can re-use, repair or upgrade. Stress should be laid on use of less toxic, easily recoverable and recyclable materials which can be taken back for refurbishment, remanufacturing, disassembly and reuse. Recycling and reuse of material are the next level of potential options to reduce e-waste. Recovery of metals, plastic, glass and other materials reduces the magnitude of e-waste. These options have a potential to conserve the energy and keep the environment free of toxic material that would otherwise have been released.

There should have proper vision for E-waste management and recycling. 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: (1) Inventory management, (2) Production-process modification, (3) Volume reduction, (4) Recovery and reuse.

Inventory management

Quantity of E-waste can be reduced by controlling the quantity of hazardous material used in the process and the amount of excess raw material in stock. Establishing material-purchase review and control procedures are two methods in this regard.

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.

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.

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.

6. E-WASTE RECYCLING:

Recycling can be defined as the assembling, developing promoting or buying of new products, which are prepared from waste materials. This exercise also reduces litter and the costs of solid waste disposal. In the past, when pots were broken, they are not thrown away. The broken pots were then crushed into fine clay powder. That improved clay was used to make striking and fine-looking new pots. Today, we use many materials once, and then consider them as waste. Our task now is to develop the age-ole art of recycling exercises by our forefathers.

Today the electronic waste recycling business is in all areas of the developed world a large and rapidly consolidating business. Part of this evolution has involved greater diversion of electronic waste from energy-intensive down cycling processes (e.g., conventional recycling), where equipment is reverted to a raw material form. This diversion is achieved through reuse and refurbishing. The environmental and social benefits of reuse include diminished demand for new products and virgin raw materials (with their own environmental issues); larger quantities of pure water and electricity for associated manufacturing; less packaging per unit; availability of technology to wider swaths of society due to greater affordability of products; and diminished use of landfills. Audio-visual components, televisions, VCRs, stereo equipment, mobile phones, other handheld devices, and computer components contain valuable elements and substances suitable for reclamation, including lead, copper, and gold.

One of the major challenges is recycling the printed circuit boards from the electronic wastes. The circuit boards contain such precious metals as gold, silver, platinum, etc. and such base metals as copper, iron, aluminium, etc. Conventional method employed is mechanical shredding and separation but the recycling efficiency is low. Alternative methods such as cryogenic decomposition have been studied for printed circuit board recycling, and some other methods are still under investigation. The process adopted by one recycling unit named Trishyiraya Recycling India Private Limited is as follows;

a) Collection of e-waste material from premises and safe transportation to our factory premises within the high security.
b) Segregation of the waste into various categories like PCBs, Ferrous and Non-Ferrous Metals, Plastic etc...
c) Weight Ascertainment and Destruction of Waste into Non-Recoverable pieces (5-10mm bits) by our custom–built Crushers.
d) Packaging the segregate material for global export.

7. E-WASTE MANAGEMENT IN NON-FORMAL SECTOR IN INDIA:

Non-formal sector units in India include *kawaries*(ragpickers), scrap dealers, whole sellers, recyclers etc. The E-waste management in non-formal sector has following major operations:

Collection

Kawaries, small scrap dealers collect the E-wastes from consumer with suitable compensatory price. The consumers are also encouraged in putting the E-waste in recycling chain instead of storing the E-waste or throwing away in municipality garbage. *Kawaries*are one of the most efficient collectors of E-waste and also reduce the load of civil agencies responsible for waste collection.

Segregation

Collected E-waste from diversified sources is segregated in various categories such as components, modules, metals, glass and plastics depending on the saleability for highest economic returns.

Disassembly

The disassembly methods would be of two types, non–destructive and destructive. Non–destructive recovers the certain disassembled parts for reuse while the destructive disassembly separates each material type for recycling processes. Non–destructive method is not feasible as designs of the products are changing very fast, new functionalities are being added.

Re-use of recovered materials

The *Kawaries*and the scrape dealers sell all the dismantled and segregated parts of metal, glass and plastics to metal/glass smelters and plastic re-processor who specialize in converting these scrap of coppers, aluminium, iron, glass and plastics. Non-formal units have lack of knowledge of the processes of smelting/reprocessing and, therefore, prefer to sell such scrap.

8. E-WASTE MANAGEMENT IN FORMAL SECTOR:

Disassembly/Segregation

Units in formal sector use all types of methods to disassemble and segregate the E-waste materials. These methods are varied from manual or semi-automated techniques. These methods are environmental friendly and take care of the safety of the health of the operators. Disassembly involves the removal of hazardous components such as batteries and other high and low grade including component, part, and group of parts or a sub-assembly from a product (partial disassembly) or the separation of a product into all of its component parts complete disassembly). The recovery of valuable materials such as printed circuit boards, cables and engineering plastics is simplified by such approach.

Recycling of printed circuit boards (PCBs)

The segregated populated PCBs are processed for the recovery of copper, gold, and other precious metals. The PCBs are grounded to powder of desired size through various mechanical processes including physical impaction, shredding/fragmentation and granulation, etc.… Shredding breaks down the PCBs into pieces via ripping or tearing which may then be sorted into material streams having dissimilar subsequent processing demands. The mechanical process, granulation is used to make PCBs scrap into fine particles.

9. INSTITUTIONAL MECHANISM IN E-WASTE MANAGEMENT:

We can see that electronic junks lay unattended in offices, warehouses etc. and normally mixed with household wastes, which are finally disposed of at landfills. Institutions have significant role in E-waste management and recycling. As the institutions are the main cause for E-waste, it should be taken relevant steps to control E-waste.

Let us explain institutional mechanism first, it mainly includes, (1) Education institutions, (2) Medical institutes/Hospitals, (3) Social Organizations, Trust Offices including NGO's, (4) Private institutions, (5) Government institutions.

The present study mainly concentrates on the role of educational institutions in the above said institutions and institutional mechanisms.

10. EDUCATIONAL INSTITUTIONS:

The educational institutions which develop the future generation have an important role in E-waste management and recycling programs. Unless they took part in the E-waste management, the coming generation will suffer its consequences the most adverse manner. The educational institutions should have to concentrate in E-waste management because of the following reasons. It includes EEE aspects and awareness program.

- In current modernized scenario, nursery to primary level student's studying equipment and playing tools are further dumped as E-wastes. The modern play schools are front runners in this category.
- It is essential to model the recycling depletion or dumping of the used and damaged electronic gadgets which using in the educational institutions.
- 'Pilot E–assessment study' conducted in Delhi on 2004, had observed that computer products are dominant among e-waste. Students and professionals are the main contributors of E-waste as they work with computer equipment mostly.
- The electronic equipment in the science laboratory of educational institutions further converted in to E-waste.
- Only the educated can contribute for e-waste management especially in a highly populated and developing country like India where proper planning to control e-waste is still far away.
- Research students and teachers including scholarly professors are part and parcel of educated citizens, and they can be front leaders and gates of our society for the course.
- Business graduates and engineering professional students too contributing a lot to E-waste.

Role of educational institution in E-waste management

Not more used electronic gadgets like computer, lab equipment and other electronic devices of the institutions have increased the level of E-wastes rapidly. The Institutions of the country who have to formulate a model for recycling and disposal of the E-wastes are not so satisfactory in the subject concerned. Now-a-days these E-wastes are improperly managed by these institutions and regarding this subject unscientifically. Now these are disposed serious less just as scraped.

As far as educational institutions are concerned, they should adopt well planned E-waste management programs. We are suggesting a model applicable in the current Indian scenario.

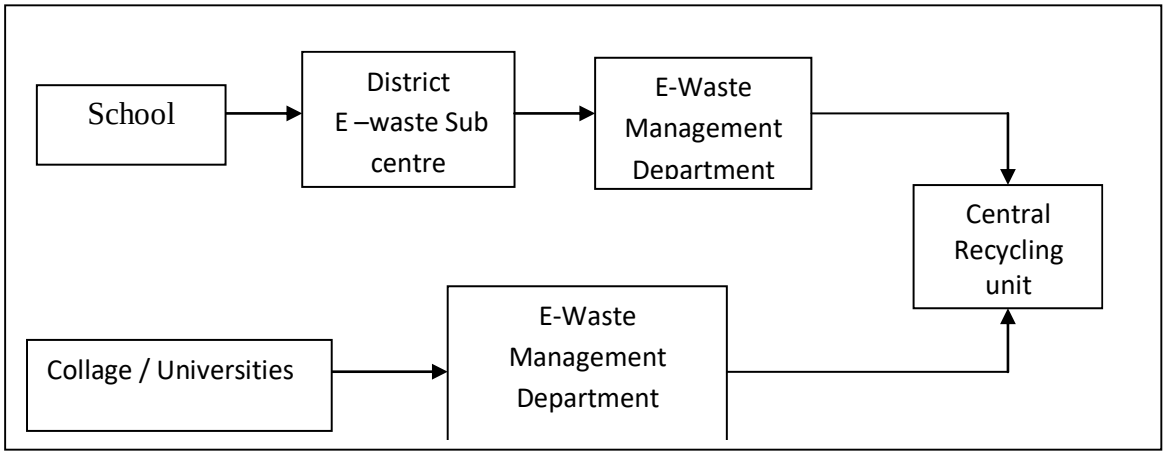

Figure 1: EDUCATIONAL INSTITUTIONAL MECHANISM ON E-WASTE MANAGEMENT-A MODEL RECOMMENTED IN INDIAN CONTEXT

The model explains;

1. The board/ Universities under which the schools/colleges are affiliated can establish an E-waste management department.
2. In case of Board, they can use district level E-waste sub-centres for the convenience. They can assess, monitor and can take proper remedial measures of e-wastes of the schools and institutions. These sub-centres will also collect the E-wastes from the schools.
3. These sub-centres connect with E-waste management department of the Board.
4. Colleges/universities directly connect with the E-waste management department of the university and they also collect respectively.
5. Each institution should allocate respective in budget for e-waste management. Governmental funds can also be used on this perspective.
6. Then the E-waste management departments will send the bulk hazardous and non-hazardous E-wastes to recycling units through tenders.
7. The departments should look after its income and expenses. They can toll respective fund from the schools/colleges.

The education institutions have to do their own part by conducting public awareness programs. By these programs, it can make aware about the impacts of e-waste on the environment especially on health and life hazardous. As a part of management institutions and engineering institutions are unavoidable in this category. The management students should have to be aware about the consequences of E-wastes and they should have to conduct public awareness programs in this regard. The respective board and universities should include the E-waste management as a topic in their syllabus. The technical and engineering students should also aware about e-waste that their consumption itself can produce.

The scientific and research community should put special efforts on e-waste. The degradation of E-waste, the application of nanotechnology on electronic products. The law graduates also should concern with the legal aspects of E-waste. They should work with legal implications of e-waste management if further needed. These all efforts should have to combine and make united and finally manipulate the all issues in front of the respective authority (may be government, executive and boards)

11. MEDICAL INSTITUTES/ HOSPITAL:

E-Waste management and handling rule 2010 clearly mentions the involvement of medical institute by defining the medical devices. According to the rule Medical devices (except implanted and infected products) includes Radiotherapy Equipment Cardiology Dialysis Pulmonary ventilators Nuclear medicine Laboratory equipment for in-vitro diagnosisAnalyzers Freezers.

Source of e-wastes	Constituent	Health effects
Solder in printed circuit boards, glass panels and gasket 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 hardener 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 equipment 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.

Table 1: Sources of E-Waste and its Effects on Health
Source: Rajesh Johri

Fertilization tests other appliances for detecting, preventing, monitoring, treating, alleviating illness, injury or disability. This reveals the important role of medical institutes and hospital in controlling and managing the E-waste. Necessary steps should be taken by institute authorities in reducing and controlling the E-waste. Since the dangerous consequences of E- waste effects in the health sector. Following table shows the effects in human health.

Medical institutes and hospitals have to function a significant role in E-waste management. It includes both EEE aspects and also awareness programs, are following.

- The medical institutes should try to purchase the electronic and electrical items which have the following characteristics. the devices
  - 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.
- Proper emphasis should be given for the management of the E-waste by keeping them in single places and dispose through proper channel.
- Advertise the consequences, health hazards of E-waste and their controlling measures in hospital premises
- Conduct effective seminars, debates, workshops…etc. which is mainly focused on the consequences of e-waste in health sector.

12. GOVERNMENT, PRIVATE AND PUBLIC ENTREPRISES:

As far government institutions are concerned, it should be a role model on E-waste management. It can be only possible when the government of India amend certain rules and regulations.The rules of government like municipal solid waste (management and handling) rules 2000, hazardous waste rule 2003 and at the last (e-waste management and handling)rule 2010, are not satisfactory in controlling the E-waste management. The rules are only remains in the papers, not in practical.

The private and public enterprises should involve and come forward for all activities of government to control recycle E-waste. The management can only be possible when the government and public enterprises takes necessary steps in involving the e-waste management activities.

13. NGO's AND WELFARE INSTITUTIONS:

European countries succeeded in E-waste management and they converted it as revenue mode rather than expenditure by involving the NGO's as an effective part of E-waste management and recycling administration. As far as India is concerned NGOs can help government by conducting in E-waste management process by conducting surveys, proposing proper projects etc.… it is also possible to implement the government programs by the slogan of 'model city on E-waste management' etc... The above said awareness program can also properly implemented with the help of NGOs. It is only through government-NGO co-partnership make it success of these big problem.

14. CONCLUSION:

As far as India is concerned following are the main problems in dealt with E-Waste management and recycling

- The improper government master plans, rule, regulations and constitutional support and ineffective implementation of existing rules and laws. In other words, laws and rules remained kept in papers.
- Limited number of recycling units and these recycling units would not have proper infrastructural capacity for disposal.
- Recycling through informal unit will create horrible problems to the environment and life.

These whole problems also related with management of E-waste in institutional mechanism. In case of educational institutes E-wastes can be managed with the help of suggested model. Students should also take a part in E-waste controlling project especially management, technical and law student. For medical institutes/hospitals EEE should be managed by concerned authority. And also, participate in E-waste management program by communicating the public about the health-related consequences of E-wastes. All institutions can conduct awareness program by conducting conference, seminar, workshops etc.… Governmental institutions should discharge their obligation on the subject by acting as a role model for other institutes. NGO-government co-partnership project will lead to success in E-waste management and recycling. With the above recommendations, we strongly believe that institutional mechanism has a significant function in the E- waste management and recycling process that play vital role in the development of the country.

REFERENCES

1. Rajesh Johri.(2008) *E waste -implications, regulations, and management in India and current global best practices* pp 1-356
2. Joseph. K, "Electronic Waste Management in India – Issues and Strategies", Eleventh International Waste Management and Landfill Symposium, Cagliari, Italy; 1 - 5 October, 2007
3. Raghupathy. L, Chaturvedi. A, Arora. R, Mehta. V, "E-waste Recycling in India- Bridging the formal-informal gap", 2010, Available online at [http://tutzingwaste.org/pub/Tutzing/WebHome/Krueger_e-waste_recycling_in_india.pdf]
4. Alastair I. (2004) Mapping Environmental Justice in Technology Flows: Computer Waste Impacts in Asia Global Environmental Politics 4:4, Massachusetts Institute of Technology
5. CII (2006). "E-waste management", Green Business Opportunities, Vol.12, Issue 1, Confederation of Indian Industry, Delhi
6. Chatterjee. S and Krishna Kumar (2009). Effective electronic waste management and recycling process involving formal and non-formal sectors, International Journal of Physical Sciences Vol. 4 (13)
7. Shobana Ramesh and Kurian Joseph (2006). Electronic waste generation and management in an Indian city, Journal of Indian Association for Environmental Management, Vol. 33, No.2, pp 100-105
8. Widmer R, Heidi Oswald-Krapf , Deepali Sinha-Khetriwal, Max Schnellmann, Heinz Bo¨ni (2005), Global perspectives on e-waste, Environmental Impact Assessment Review 25 436– 458

Web references:

- www.toxics link.org
- www.ewasteguide.info
- www.iimm.org
- www.moef.nic.in
- www.ewsate.in
- www.usepa.gov