A literature review is a critical and in-depth evaluation of previous research. It is a summary and synopsis of a particular area of research, allowing anybody reading the paper to establish why one is pursuing a particular research program. A good literature review expands upon the reasons behind selecting a specific research question.
CHAPTER-2

REVIEW OF LITERATURE

The first report regarding the recycling of computers and electronic waste has appeared on the front page of the *New York Times* on April 14, 1993, written by Steve Lohr*. The starting point of E-waste recycling including EOL-PCs is the extensive use of precious metals in electronic industries especially in electrical contacts for high reliability applications such as computer mainframes. The article highlights the life of computers as “this is where mainframes come to die” also mentions that “if the rate of discarding of computers continues, some 150 million computer carcasses will reside in the nation’s landfills by the year 2005” according to Carnegie-Mellon University Study.

Niederkorn and Huzar (1984) are the pioneers who have worked on gold recovery from used electrical contactors. According to their estimate about 700 tonnes of gold must have been consumed in the manufacture of low voltage electrical contactors, which have become redundant over a period. Thus, gold becomes a candidate for recovery. Further, they have also demonstrated an average gold recovery rate of 95% from contactors by mechanical and chemical processing. Dunning B. W. Jr. (1986) and Gloe et al (1990) have discussed the recovery of Precious Metals from Electronic Scrap and Solder used in Electronics Manufacture. Subsequently, Hoffmann (1992) has worked on precious metals recovery from electronic scrap. Mellon and Matthews (1991) are the first to make organised attempts to estimate the computer waste disposal and recycling options.

The first published work on E-waste recycling is by Boswell (1995), who emphasises the concept of de-manufacturing design for disassembly in close loop for end of life cycle equipment. In Rio de Janeiro (3rd-14th June 1992) “Earth Summit” mention also has been made about the precautionary principles and sustainability of resources. Basel Convention, which came in
to force in 1992, forbids industrialised nations from exporting their hazardous waste to developing countries without obtaining the permission in writing from the importing country and with the guarantee of treating the toxic substances in an environmental and eco-friendly manner. Canada, India and 168 other countries have ratified this treaty.

Ching et al (1996) in their article ‘Plastic Recycling issues for computer industry’ have suggested the close loop and open loop recycling alternatives to landfill or incineration for PVC, PET and HDPE. In 1997, Matthews et al have described the implications of land filling of PCs.


Dwelling (1999) study on house equipment statistics reveals, the average life (amount of PC time useful to its original owner) is 2-4 years and by the year 2005, a PC’s first life is expected to decrease by another year, considering reuse and shortage options, the total lifespan (the period from manufacture to disposal) is estimated to at 3-4 years. He also states that the
computer equipment includes desktop personal computers, notebooks, keyboards, printers and speakers.

According to Nokia’s Environmental Report (2000), only 22% of the waste produced during 1997-98 was recycled. Esko Nurmi (2000), who was responsible for waste management and recycling in Oulu facility of Nokia, says the volume of landfill waste could be significantly reduced during 1999 it is 58% during 2000, and by 2001 the figure should rise to 60%. Kopek et al (1999) have published articles on disassembly of e-waste using semi-automatic machines. Greenpeace (2001) were the first to investigate environmental contamination from the crude recycling of E-waste and Hesselbach et al (1999 & 2001) have studied on combined strategy for recycling, based on Product and Process Oriented Quantitative Bench Marking and for close loop economy and economical efficiency. Smith et al (2001) have presented an article on recycling through free enterprise, a motive force behind development. Bailey (2001) introduces material cycling with ecological input output mathematics to evaluate the recycling content and recovery rate. In the year 2001, Silicon Valley Toxics Coalition’s (SVTC), highlighted the greatest threat to the Environment in their article entitled “Poison PCs and Toxic TVs”. The article deals with the toxic components of end of life electronic products especially CRT leaded glass and other hazardous waste. USGS Facts sheet (2001) indicates the quantities of resources that can be recovered from personal computers. One metric ton of E-waste from personal computers contains more gold than gold ore.

National Defence Centre has prepared series of reports for Environmental Excellence USA during 2002, which includes Demanufacturing of Electronic Equipment for Reuse and Recycling (DEER2). USEPA (2002) has proposed rules to include Cathode Ray Tube and Mercury containing equipments under hazardous waste program. Franz (2002) has presented an article based on his pilot study about numerical survey to
measure recycling process, validation and capability, and developed procedure to evaluate recyclers. Puckett and Roman (2002), founders of Basel Action Network (BAN), have stated that export market is critical for bringing new life to viable equipment that becomes obsolete by the US standards”.

BAN and Silicon Valley Toxics Coalition (SVTC) have made a publication jointly with the contribution from Toxics Link India, SCOPE Pakistan and China, on backyard practices entitled “Exporting Harm” (2010). It is the first publication dealing with shocking illustrations of E-waste dismantling by unorganized sector in China. Huisaman et al (2002) have discussed on Heavy Metal Leakages during dismantling, mechanical separation, incineration and landfill. The article of Ploog et al, (2002), is on cost effective recovery concepts with choice of scrap, disassembly operation and programming optimization model. In the same year, Zhang et al (2002) have described Circuit Board recycling process with automated disassembly part removal followed by incineration, crushing and hydrometallurgical process. The report of Goosey et al (2002) deals with Scoping Study, End-of-Life Printed Circuit Board and various treatment options. Drohmann et al. (2002) have highlighted integrated waste management concept and have suggested that bromine recovery from the plastics is technically, economically and ecologically feasible. Organization for Economic Co-operation and Development (OECD’s), a working group on Waste Prevention and Recycling has published an article (2002) on Waste Streams with Specific Guidelines for the Environmentally Sound and Management of Used and Scrap Personal Computers (PC’s).

Article entitled “Scrapping the Hi-Myth Computer Waste in India” by Toxics Link (2003) is the first ever report in India highlighting the E-waste and its hazards especially in the informal sector backyard operations. This report is also the beginning for several investigations in India especially backyard recycling in and around Delhi. European Union (2003) published
Review of Literature


During 2005, Eco-Efficiency Centre of Dalhousie University, Canada has produced a fact sheet: Eco-Efficiency and Electronics Management, highlighting good house keeping practices and benefits of electronics recycling. Sunil Herat (2005) has studied on High-Tech Trash from Modern Society. Wolfram et al (2005) writes on ‘end of life treatment of second-generation electronic gadgets. Major greenhouse gas (GHG) emissions related to plastic waste recycling were evaluated with respect to three management alternatives: recycling of clean, single-type plastic, recycling of mixed/contaminated plastic, and use of plastic waste as fuel in industrial
Review of Literature

processes. It is an excellent report for complete treatment options for various waste plastic recycling. Greenpeace International (2005) has brought out a report on Recycling of Electronic Waste in China and India with details on work place and environmental contamination at various E-waste recycling sites of India and China. In the same year it has published another report “Pulling the Plug on Dirty Electronics”. UNEP’s (2005) paper deals with E-waste, the hidden side of IT equipment’s manufacturing and use.

Industrial Council for Electronic Equipment Recycling (ICER, UK) in the 2005 brought out an updated report, stating that 90% of UK’s domestic E-waste comes from 3 categories - large household appliances, a small household appliances and followed by IT and Telecom appliances. Rolf Widmer et al. (2005) paper deals with global perspective on E-waste.


Ph.D thesis: Recovery of Metals from EOL-PC
Mathias Schluep, et al. (2009) have discussed for the first time the social issues in the reuse of computers in developing countries like China, India, and Peru. Fraunhofer Institute, Germany (2008) reports CO₂ reduction by recycling of various materials. Dodibba et al. (2008) who have worked on recycling of E-waste Plastics concluded that mechanical recycling is more effective and has lower environmental impact and global warming. In the year 2008, the Energy and Resources Institute (TERI) and Central Pollution Control Board (CPCB), India, have brought out guidelines for environmentally sound management of E-waste, and Mercury Management in Fluorescent Lamp Sector. Noemi Mercier (2008) in “Our Computers are poisoning the Planet” has revealed how computers exported to India for their supposedly Ecofriendly recycling are dismantled under poorest conditions poisoning the people and the planet, and now the life span of the people involved shortened.


UNEP in its report recycling from E-waste to resources (2010) indicates that electronic products in countries like China and India are set to
rise sharply in the next 10 years. Further, global E-waste generation is growing by 40 million tons by 2020. In India, over 56,300 tons of obsolete PCs and 47,000 tons of printers are estimated to be generated by 2020. Ruediger Kuehr (2010) paper on E-waste: “not your normal trash” has emphasised the need for toxic free solder by non toxic substances, besides how the E-waste generation remains unaccounted. He further discusses on resource efficiency, partially burnt cables, circuit boards are deserted where cattle and people are moving. In order to extract precious materials or recycle parts for further use, this waste is finally processed in the majority of cases by crude backyard techniques such as applying acid baths to obtain gold or burning wires to remove insulation and get the copper. This emits dioxins and other pollutants and poses a danger to protect and their local environment.

Subramanian et al (2010) have published a paper on “Pollution Trends in India- Evidence for the Need of an Environmental Specimen Bank”. Euguchi et al (2010) have worked on “Organohalogen and Metabolite contaminants in Human serum samples from Indian E-waste Recycling workers” highlights on the accumulation of Polychlorinated biphenyls (PCBs) and Polybrominated diphenylethers (PBDEs) in human serum samples from Indian E-waste Recycling Workers. Samples have been collected during the field work for the present research work. Accumulations of PCBs in human serum of Backyard practitioners have been found to be relatively higher than permitted doses.

Since 2010, E-Parisarra, India’s First Approved E-waste Recycler Bangalore, in collaboration with C-MET Hyderabad has been studying on the “Recovery of Precious metals form circuit boards by Pyrolysis.” The major research project is approved and funded by the Dept. of Information and Technology, (DIT), Govt. of India, New Delhi. The author of this thesis, is one of the member of the monitoring committee of this prestigious project nominated by the Dept. of Information and Technology, (DIT), Govt. of India,
New Delhi. The findings of the research project have been quite encouraging and may soon open new avenues in the recovery of precious metals from circuit boards in India.

Literature review reveals that since 1996, there is no updated study on the characterisation of EOL-PC of Pentium III, which are obsolete and enters the recycling facility. However, most of the recent publications are using the same outdated data though, there has been technological advancement and many new materials have been used in the production of assemblies and subassemblies of a personal computer. Moreover, there is no sufficient data available to correlate between the recovery of metals from EOL-PC and conservation of natural resources and mineral substitution. Besides, there are no studies on impact of resource recovery and environment, while the backyard practitioners retrieve metals unscientific methods from E-waste in general and EOL-PC in particular. Therefore, in the present study an attempt has been made to address these issues.