

E – waste Recycling Technology Patents filed in India - An Analysis

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The increasing use of electrical and electronic equipments has led to a significant rise in e-waste worldwide over the past two decades. E-waste is today the fastest growing component of the municipal solid waste stream and currently comprises more than 5% of its total flow, which is equivalent to 20-50 million tonnes a year worldwide. Electrical and electronic equipment contain different hazardous materials which are harmful to human health and the environment. There are several international and Indian initiatives to dispose and recycle e-waste. Even as India has been and continues to be a dumping ground of e-waste from western countries, no serious effort has been made to arrest the situation. To manage and dispose e-waste, technology often plays a vital role. The present study focuses on the e-waste patents filed in India. The study reveals a good number of technologies developed by Indian institutions like Council of Scientific and Industrial Research, individuals belonging to different institutions of India and other foreign companies. Despite its economic importance, research on e-waste recycling has never been seen as a priority and gets little respect within companies in India. This study suggests that electronic brand companies in India are laggard rather than leaders in adopting new technologies and innovation on e-waste recycling. This aversion to innovation has left consumers and workers associated with e-wastes exposed to dangers that have not been addressed. To reverse this, most of these companies will need to venture out of their comfort zone which in turn may be ensured by implementation of effective laws.

Keywords: E-waste patents, recycling, solid waste management

E-waste is a generic term comprising all electrical and electronic equipment (EEE) that have been disposed of by their original users, and includes everything from large household appliances, such as refrigerators, microwave ovens, television sets, and computers, to hand-held digital apparatuses, cell phones and toys. E-waste is today the fastest growing component of the municipal solid waste stream and currently comprises more than 5% of its total flow, which is equivalent to 20-50 million tonnes a year worldwide. Generation of e-waste is a result of constant desire for newer and more efficient technology, as well as the intense marketing by producers, that make consumers replace electronic devices more and more frequently. For example, cell phones have now an average life span of less than two years in the industrial world, and computers two to four years.¹ This paper analyses the current problem from both the legal and technical point of view.

Effect of E-waste on Environment and Human Health

Electrical and electronic equipment which are in abundance in the environment contain various hazardous materials that are harmful to human health and the environment. Such equipment also contain fractions of valuable materials most of which are found in printed circuit boards (PCBs) present in office, information and communication equipment as well as entertainment and consumer electronics. Besides, well known precious metals such as gold, silver, platinum palladium and also scarce materials like indium and gallium have important applications in new technologies like advanced flat screens and photo-voltaic cells. The recycling of EEES is thus a very challenging and profitable market, nonetheless fraught with risks and hazards. Table 1 gives a selection of the mostly found toxic substances in e-waste.

The extent of toxic elements and metals present in EEES and their lethal effect on the environment can be illustrated by the following examples. Polychlorinated biphenyls are a class of organic

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Table 1 – Percentage of harmful elements associated with e-waste

Material	Large household appliances	Small household appliances	ICT and consumer electronics	Lamps
Ferrous metal	43	29	36	-
Aluminum	14	9.3	5	14
Copper	12	17	4	0.22
Lead	1.6	0.57	0.29	-
Cadmium	0.0014	0.0068	0.018	-
Mercury	0.000038	0.000018	0.00007	0.02
Gold	0.00000067	0.00000061	0.00024	-
Silver	0.0000077	0.000007	0.0012	-
Palladium	0.0000003	0.00000024	0.00006	-
Indium	0	0	0.0005	0.0005
Brominated plastics	0.29	0.75	18	3.7
Plastics	19	37	12	0
Lead glass	0	0	19	0
Glass	0.017	0.16	0.3	77
Other	10	6.9	5.7	5
Total	100	100	100	100

Source: e Swiss Federal laboratories for Materials Testing and Research for industry (Empa)

compounds used in a variety of applications like condensers heat transfer fluids, dielectric fluids for capacitors and transformers, and as additives in adhesives and plastics. They are known to cause cancer in animals and also shown to cause a number of serious non-cancer health effects in animals, including effects on the immune system, reproductive system, nervous system, endocrine system, etc. Closely following polychlorinated biphenyls in the hazardous list are brominated flame retardants. Combustion of halogenated case material and printed wiring boards at lower temperatures releases toxic emissions including dioxins which can lead to severe hormonal disorders.

Among the heavy metals, the most prominent examples are arsenic, barium, cadmium, lead and mercury. Chronic exposure to arsenic can lead to various diseases of the skin and decrease nerve conduction velocity and lung cancer. Barium is used in sparkplugs, fluorescent lamps and getters in CRT (cathode ray tube). Being highly unstable in the pure form, barium forms poisonous oxides when in contact with air; short-term exposure to it could lead to brain swelling, muscle weakness, damage to the heart, liver and spleen. Cadmium is found in rechargeable nickel cadmium (NiCd) batteries, fluorescent layer (CRT) screens, printer inks and toners, photocopying-

machines (printer drums). Cadmium components may have serious impacts on the kidneys. The list of toxic content in EEEs is enormous and the object of this study is to find patented technologies for their disposal.

However since every action in a democratic, civilized and a conscious community requires a legislative sanction, many nations around the world have framed their own legislations on this issue of tackling e-waste while simultaneously coming together on an international platform to respect certain conventions to bring a common world order on this subject.

E-waste Regulation at the Global Level

The Basel Convention identifies wastes as substances or objects, which are disposed or intended to be disposed, or required to be disposed by the provisions of national laws.² The Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal came into being after it was ratified by 173 nations in the year 1989. It is the most comprehensive global environmental agreement regulating movements of hazardous wastes, including Waste Electrical and Electronic Equipments (WEEE), between nations, and specifically to prevent transfer of hazardous e-waste from developed to less developed countries. It puts the onus on the country exporting the waste to ensure that hazardous wastes are managed in a sound manner in the country of import. It has placed certain obligations on the countries that have ratified this convention. The crux of this convention directs there should be minimal generation of hazardous waste, enough facilities for disposal and sound management, a check on movement of hazardous waste, and stringent laws to act as a deterrent and to punish illegal traffic.

A few other international initiatives include the Mobile Phone Partnership Initiative (MPPI), The StEP initiative, Silicon Valley Toxic Coalition (hereafter SVTC) and computer take back campaign National Electronics Product Stewardship Initiative (NEPSI). For instance, for the MPPI partnership initiative, 12 mobile phone manufacturers and other stakeholders, came together to develop and promote the environmentally sound management of end-of-life mobile phones. E-waste recycling practices in many parts of the world are alarming with little or no regard to safety. The International Labour Organization reports that the flow of e-waste from developed economies such as Europe and the US to Asia, in particular to China and India, is a regular practice.³

Such exports become possible since the necessary environment and occupational regulations are non-existent, minimal, lax or not well-enforced, in many developing countries. The low cost of labour in India and China are an added advantage. Exporting e-waste is more lucrative for the exporter country than recycling or disposing it within the country. For instance, waste traders in Europe or USA have to pay \$US 20 to recycle a computer safely in their countries while they can sell it at half the cost to the informal traders in developing countries.⁴ Less than 10% of all this e-waste is collected and disposed in adequate recycling facilities in developed countries, despite the well known fact that it contains a wide variety of hazardous materials.⁵ Of the e-waste generated in the industrial world, between 50-80% of the electronic waste generated finds takers in China, India, Nigeria and Ghana. Within the European Union (EU), it is estimated that only 25% of the e-waste generated is collected and treated, while the remaining 75% is lost in a “hidden flow”.⁶ While it costs Rs 12,000 to recycle a ton of rubbish after segregation in the United Kingdom, shipping the rubbish to India costs just about Rs 2,800 (ref. 7). No wonder it is profitable to export the junk to developing countries. The ever increasing demand for metals in countries like India, China, and Brazil, coupled with their thriving economies makes it a profitable situation for both parties. As a result, the EU, Japan, South Korea, Taiwan, China and several states of the USA have introduced legislation making producers (financially) responsible for their end-of-life products.⁸ The Directive 2012/19/EU of the European Parliament and the Council repealing the old directive of Directive 2012/19/EU specifically aimed at tackling the WEEE problem. The policy is based on the precautionary principle and the principles that preventive action should be taken, that environmental damage should, as a priority, be rectified at source and that the polluter should pay. It calls for changes in recent pattern of development, production, consumption behaviour and encourages the reduction of wasteful consumption of natural resources and the prevention of pollution.

The Indian Scenario

The problem of handling and disposal of e-waste surfaced due to the boom in the electronic and the information technology industry. In the year 2005, a bill was introduced in the upper house (i.e. Rajya Sabha) of the Indian Parliament with intent to tackle the same. It however lapsed due to certain reasons and

India has still not got a legislation to tackle the menace. Although the Municipal Solid Wastes (Management & Handling) Rules, 2000 have provisions relating to e-waste management, its implementation remains dismal. The Hazardous Wastes (Management and Handling) Rules, 2003 were notified in 2002 contained e-waste within its purview and gave them a hazardous tag. According to rule 3(k), “e-waste means waste electrical and electronic equipment, whole or in part, or rejects from their manufacturing and repair process which are intended to be discarded.”

The Hazardous Wastes (Management, Handling and Transboundary Movement) Rules were amended twice in 2008 and 2011 following India’s need to conform to the Basel Convention. As per these rules, every person desirous of recycling or reprocessing hazardous waste including electronics and electrical waste is required to register with the Central Pollution Control Board. There are certain categories of waste the importing of which are prohibited. Yet, e-waste is being dumped in India by developed nations using loopholes in domestic rules which allow non-governmental organizations and educational institutions to import such gadgets freely on the pretext of donations.

Electronic Take Back Services in India - Company Responsibility

As per a Green Peace report approximately 20 brands carry business on electronic equipments in India.¹⁰ Out of the 20 companies, 9 have no take back service in India including Apple, Microsoft, Panasonic, PCS, Philips, Sharp, Sony, Sony Ericsson, and Toshiba. Samsung claims to have a take-back service but only for mobile phones with only one collection point for the whole of India. Other brands such as HCL, Wipro, Acer, Nokia, etc., do have take back facilities but they are either not user-friendly or grossly inadequate in terms of collection means or centres.

Of those brands that provide take-back services in India, many including Acer, Dell and LG Electronics do not have take-back information on their Indian websites making it difficult for Indian customers to access the information and avail themselves of the service. Only two brands, Acer and HCL, have come out publicly in support of the e-waste legislation in India. Positions of other brands are not clear and no brand has invested much in education and awareness of general customers on e-waste management. Few brands have taken any initiative to train their frontline staffs on take-back and recycling service.

In the management and disposal of e-waste, technology plays a vital role. About 80% of technologies first come to public domain in form of patents. Recently, to address the e-waste management problem, the World Intellectual Property Organization (WIPO) in collaboration with Basel Convention brought out a patent landscape report on e-waste recycling technologies.¹¹ The study revealed that most of the e-waste patents were filed by developed nations like Germany, USA and Japan with China leading among the developing countries. However no study has been done at a local level to estimate the extent of e-waste recycling technology patents filed in India. While the WIPO report covers the patenting activities of BRICS countries like China and Russia, there is no mention of patenting activities in India which is gap this study seeks to fill.

Methodology of the Study

The search was performed iteratively, with the results of each generation of search string reviewed and evaluated to tailor the search for better accuracy. As each search string was created, the results were sampled and reviewed for relevancy and keywords and classifications amended as appropriate. Further, the results of each string were data mined for further key terms of interest, synonyms and alphanumeric technology classification codes of relevance, which were then incorporated in revised search strings. This process was repeated until revisions caused only minor variations in results. The strategy was to find e-waste varieties, material components and constituents, devise precise keywords (given in Table 2), which would generate specific patents overcoming noise (unwanted hits leading to irrelevant patents). The

patent database was extensively searched to process key concepts from each patent document. These concepts then acted as additional facets to search relevant patents. Knowing the relationships between the concepts and class codes are helpful to create a landscape of the entire patent database.

The Indian patent database IPAIRS version 2.0 of the Indian Patent Office (IPO) and Derwent World Patents Index (DWPI), a product of Thomson and Reuters were used for the search initially. Foreign patent databases were also searched to retrieve patents so as to have an insight into global development in the field of e-waste management and disposal and compare it with the patents filed in India, both in a numerical and qualitative sense. Other than DWPI, the databases that were searched included USPTO, EPO, PatentScope of WIPO and Google Patents.

The keywords were narrowed down to very specific from very general. This included a transition of words from solid waste management to electronic wastes or e-wastes or WEEE. This further involved a great magnitude of classification, each branching out to new and important keywords, almost like an inverted tree. For instance, a search on metal recovery led to a huge number of patents which involved metal recovery from industrial scrap, effluents, and other industrial waste by-products. But the main objective of this study was to determine metal recovery from waste electrical and electronic equipments. So the search was refined, by applying the words e-waste or WEEE along with the primary keyword-metal recovery. This could be further broken down to precious metal recovery like gold, platinum, silver and other common but useful metals like copper, iron, nickel, cadmium and many more. The keyword metal

Table 2 —IPC codes used to search E-waste patents

IPC	Description
A 62D 3/00	Process for harmful chemical substances harmless by effecting a chemical change in the substances
B02C 18/00	Disintegrating by knives or other cutting and tearing members which chop material into fragments
B22F 8/00	Manufacture of articles from scrap or waste metal particles
B27B 33/20	Edge trimming saw blades or tools combined with means to disintegrate waste
B29B 17/00	Recovery of plastics or other constituents of waste materials containing plastic
B62D 67/00	Systematic disassembly of vehicles for recovery of salvageable components for recycling
C03C 1/00	Ingredients generally applicable to manufacture of glass, glazes or vitreous enamels
C08J 11/00	Recovery of waste materials for macromolecular substances
C09K 11/01	Recovery of luminescent materials
C10L 5/48	Solid fuels essentially based on industrial residues and waste materials
C22B 7/00	Working up raw materials other than ores, e.g. scrap, to produce non-ferrous metals and compounds thereof
C22B 25/06	Obtaining tin from scrap
H01B 15/00	Apparatus or processes for salvaging materials from electric cables
H01M 6/52	Reclaiming serviceable parts of waste cells or batteries
H01M 10/54	Reclaiming serviceable parts of waste accumulators

recovery is important because extensive metal (tin, lead and their alloys, mercury, nickel and cadmium) recovery is possible from PCBs. The other common waste was glass. Cathode ray tubes and used fluorescent bulbs contribute a lot to waste glass. A lot of valuable materials are recoverable from waste glass like lead and indium. Waste battery and waste plastics were also used as relevant keywords.

Along with the keywords, a finer search was done by clubbing the search along with the use of International Patent Classification (IPC) search codes. The IPC search codes specified during the search led to specific and successful hits, thereby reducing noise to a greater extent. For instance, B29B 17/00, using the IPC for recovery of plastics or other constituents of waste materials containing plastic. A few such IPCs used were C08J 11/00 for recovery of waste materials for macromolecular substances, H01M 6/52 for reclaiming serviceable parts of waste cells or batteries, C09K 11/01 for recovery of luminescent materials and B29B 17/02 for separating plastics from other materials. Table 2 lists the IPCs (in relation to electronic waste terminology) that were used. However it was difficult to keep away unrelated patents completely in the search which were then sorted out manually. This search strategy hypothesis was tested by carrying out a prior single patent analysis and the search conducted randomly initially.

Along with IPCs, the keywords that were used included metal recovery (in association with e-waste), metal recovery from PCBs, waste PCBs recycle, waste glass, metal recovery from CRT, LCD dismantling and disassembly, battery recycle, separation and segregation of electronic waste

(both methods and apparatus). For selecting and framing keywords and search strings, non-patent literature can be a good source. Further, text-mining techniques help in analysis and extraction of technological information. Patents were searched using abstract, title of invention, inventor’s name, type of document and patent citation.

Results and Discussion

Quantitative Analysis

The focus of this paper is to access the key technology patents available in India on e-waste. After a thorough search, analysis and filtrations, a total of 135 patents were retrieved from the Indian Patent Office website and analysed. Figure 1 represents patents filed by the foreign companies in the Indian jurisdiction and identifies the patent trend in novel technologies on e-waste management. Using patent analytics, important areas where maximum number of patents have been filed were distinguished. This kind of quantitative analysis normally uses bibliographical information contained in patent documents, document number, patent classification, nationality and name of the applicant and the name of an inventor (very helpful). The collected patent data was quantitatively analysed with respect to the top assignees and major players in the field, top inventors and widely recurring IPC search codes used.

A total of 41 (54 %) patents were filed from India, out of which 8 were from the Council of Scientific and Industrial Research (CSIR), 5 were from Peethambaram P (an individual) and the remaining 27 patents filed separately by other individuals. Among the foreign nations, the USA appeared most

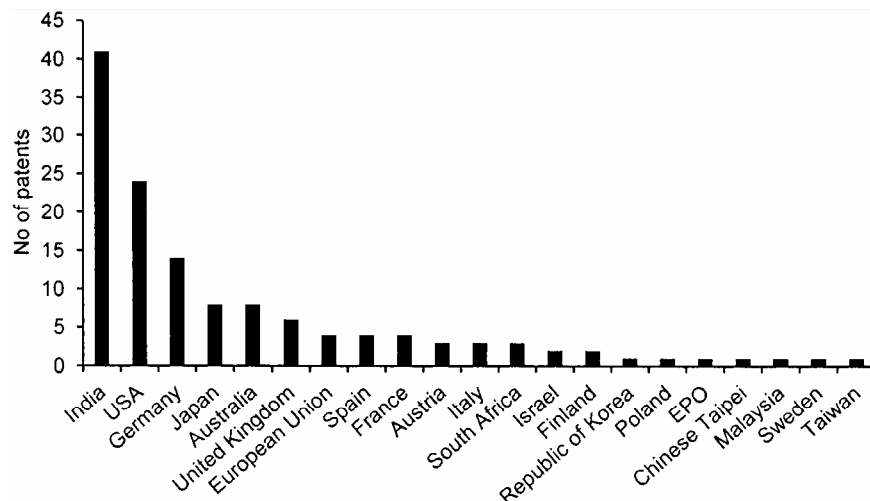


Fig. 1 - Country wise patenting trend: E-waste technology in India

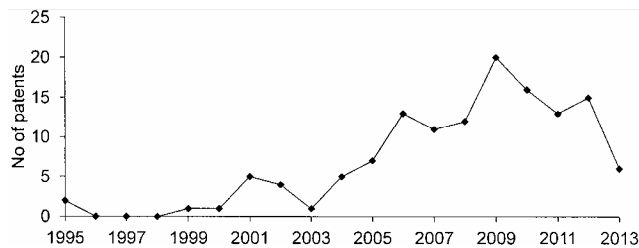


Fig. 2 - E-waste technology in India: Year wise patenting trend

interested in protecting their technologies in the Indian jurisdiction with 24 patents, followed by Germany and Japan with 13 and 8 patents respectively. These numbers could be indicative of the technological prowess the respective countries in the area of e-waste management and recycling.

Figure 2 shows the year wise filing of patent applications in India. From 1995 to 2013, the general trend was an increase in filing which may further rise to plug the technological gap considering the advancement in technology and inventions. The study shows that the year 2009 saw the highest number of patents filed whereas a sharp decline was observed in 2013. The decline can be attributed to incomplete data since a patent application is published only after 18 months in conformity with the Patent Cooperation Treaty.

At the international level as per the WIPO report¹¹ the filing trends have always shown a steady exponential increase from the 1980s. However, India was hardly technologically developed in the 1980s as compared to now. There was not much influx of electronic equipments and gadgets and hence no need to address any e-waste problem. Therefore in comparison to the global trend, few or no patents related to electronic waste may be found in India either by a domestic or foreign applicant. According to the WIPO report, there has been a significant increase in filings in the area of e-waste management from 2003 to 2013. But in India where awareness on e-waste and patent filings are still in the nascent stage, this may not be a comparable trend.

It is only recently that awareness regarding the hazardous effects of e-waste is spreading and legislative mechanisms are being implemented for regulation. In addition, there have been initiatives by a few private entities all over the country to tackle this problem. Sensing the potential market and business opportunities, e-waste plants have been set by government, government-sponsored and private groups. Though it is only the beginning, it is nonetheless a good sign compared to the pre-1990s

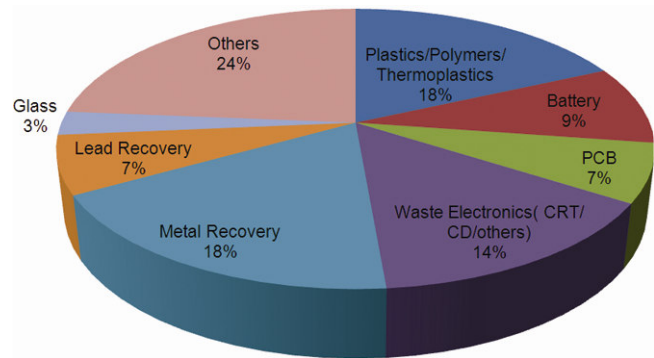


Fig. 3 - E-waste recycling technology: Material constituents

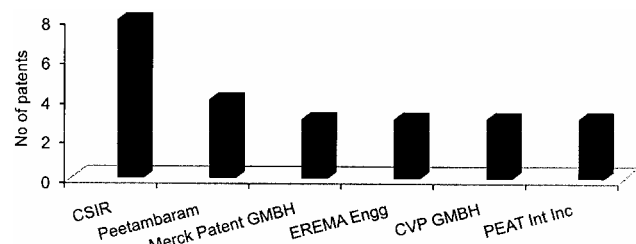


Fig. 4 - E-waste patents in India: Top assignees

when there was practically no awareness or even patents filed on this topic. Quantitative superiority may be attained only when entrepreneurs realize it is a good business opportunity coupled with subsidies from the government and stricter laws.

Figure 3 shows the various materials recovered using the patented technologies (recycle, reuse, treatment or disposal). The various constituents were plastics and polymers (18%), metal recovery (18%), printed circuit boards (7%), lead recovery (7%), waste electronics (14%) and others (24%).

Figure 4 highlights the top 5 companies and individual who have patent application in the field of e-waste management. The Council of Scientific and Industrial Research (CSIR) from India leads with 8 patents followed by Peetambaram P (individual), Merck Patent GMBH (Germany), EREMA Engineering (Austria) and CVP Clean Value Plastics GMBH (Germany).

Technology Analysis

The need of the hour is innovative technology and novel methods that deal with e-waste. From a technical point of view, e-waste patents can be divided into two components: (1) material recovery from sources of e-waste- materials such as plastics and metals, batteries, displays, cables, PCBs, logistics involved in e-waste treatment or recycling, such as magnetic sorting, IT related management of recycling

systems and similar items and (2) methods, apparatus and process involved in e-waste treatment.

Material Recovery from Sources of E-waste

The focus of this study being to tap the patent databases to gain an insight into e-waste management technologies, there has been no attempt to technically discuss each invention in detail as it goes beyond the scope of this study. However, a few of the technologies have been discussed in here in a concise manner just to have an idea of the content of these inventions. A majority of the patents filed are in the domain of plastic recycling, waste battery and cells, PCBs, chips and other waste electronics, waste glass (from CRT and LCD).

Plastic, Polymer Recycle and Recovery

Plastics and its derivatives like PVC (polyvinyl chloride) and other polymers find use in every electrical and electronic gadget. Therefore proper disposal after the gadgets have reached the end of their life is very important. The patent application, 01842/KOLNP/2004 (Indian patent application number), discloses an apparatus for processing thermoplastic synthetic plastic material using heating, segregation and treatment via various tools. 1137/MUMNP/2009 generally speaks of a method for the recycling of all types of waste plastic, in particular mixed plastic streams. 1540/MUMNP/2007 is an invention which relates to a method for comminuting and cleaning waste plastic, particularly mixed plastic, basically, compacted material produced from film scraps or film remnants. 1791/MUM/2011 is a domestic invention that relates to a process for recycling of plastic waste comprising: segregating plastic waste collected from various sources followed by cleaning of the segregated plastic waste to obtain segregated cleaned waste; grinding of the segregated cleaned waste to obtain ground waste. 204/KOL/2014, is a process for preparing recycled plastic materials from waste electrical and electronic equipment, like thin walled housing parts of electronic materials (for instance the outer casing of mobile phone charger). This is a very practical and useful technology available to dispose mobile phone plastics which is a gadget that is virtually inundating today's world. 772/CAL/2004 relates to an improved eco friendly /green recycling process of post-consumer waste plastics. 358/DELNP/2007 describes a method of recycling mixed streams of e-waste (WEEE) providing substantially zero landfill. The

invention describes methods of recycling ink, toner, and/or PU foam from imaging consumables, forming part of the WEEE. Recycling of plastic materials containing flame retardants, including the recycling of plastics materials, such as plastics materials containing brominated flame retardants generally based on styrenics and polyamides and other engineering plastics such as polyacetal, polycarbonate, PET, PBT (Polyethylene terephthalate) liquid crystal polymers are also described in the application.

Battery and Cells

Waste battery has very harmful chemical constituents like the battery acid and other elements like mercury, cadmium and lead that have a deleterious effect on the human body.

Related patents are as follows: 1687/DEL/2010 describes an improved extraction process for the selective recovery of cadmium from spent nickel cadmium battery. The process is particularly useful for the selective extraction to separate cadmium from aqueous solutions containing high total metal content and elevated nickel and cobalt concentrations, while avoiding the co-extraction of nickel and cobalt along with the cadmium. 996/MUM/2008 is an invention not directly related to the topic but was considered due to its potential to replace galvanic cells thus reducing e-waste. This invention differs from the well known and widely understood galvanic cell as it does not make use of any chemical (other than water) as a part of the electrolyte solution. This invention establishes that such water cells can be connected in series and parallel combinations to form a water cell battery to generate electricity at required potential and current to operate lighting and other electric loads. 682/CHENP/2011 deals with a method for recovering oxide-containing battery material from a waste battery material. 2216/KOLNP/2009 describes a method of recycling lead from lead containing waste, the method comprising the steps of mixing the battery paste with aqueous citric acid solution so as to generate lead citrate; isolating lead citrate from the aqueous solution; and converting the lead citrate to lead and/or lead oxide which may be then extracted. Similarly, 2997/CHE/2013 relates on recovery of cobalt from the spent lithium-ion battery through chemical extraction and precipitation.

Printed Circuit Boards

Electronic waste contains several different substances, of which some of are toxic and create

serious environmental and health problems when disposed or land filled in an unscientific manner. Printed circuit boards are one of the foremost contributors of waste in e-waste category, with chips and circuit boards finding use in every range of computing equipment. 3289/KOLNP/2012 discloses a process for recycling printed wire boards using environmentally-friendly compositions, wherein electronic components, precious metals and base metals may be collected for reuse and recycling. 1751/CHE/2006 is a process for recovery and recycling of valuable metals from PCBs obtained from electronic waste. The invention is largely confined to recycling of metals from PCBs using simple, non-incineration, cost effective technology with maximum resource recovery in an environmental friendly way, suitable for Indian conditions. The content of these inventions could form the basis for future recyclers, to get a better understanding of suitable methodologies or to extend and adapt for other waste management areas as well.

Glass

A few important patent applications relating to glass waste also came up during the search. 3004/KOLNP/2008 provides processes to immobilize radioactive and/or hazardous waste in a borosilicate glass, the waste containing one or more of radionuclides, hazardous elements, hazardous compounds, and/or other compounds. 1993/KOLNP/ 2009 describes an etching process to etch the layers/films of chips, PCBs. 1222/CHE/2004 describes a novel circuit for burnt fluorescent tubes re-use while 1755/CHE/2006 describes a florescent lamp crushing setup.

Optical Disk, Polycarbonate Material, Cathode Ray Tube

The patent application 5435/CHENP/2008 provides a method for producing a high-quality material (from used optical discs and/or waste optical discs) for an optical disc that can be reused as a resin for an optical disc substrate. 6239/CHENP/2008 relates to manufacture of a recycled polycarbonate raw material for a flame retardant resin composition from discarded and/or recovered optical discs using a polycarbonate resin as a substrate material. 1714/MUM/2012 shows a product for waste electrical and electronic equipment reutilization and process for preparation.

It is expected that within the next few years, the number of patents filed in this technology area may rise sharply. With new gadgets and technologies coming up

every day, there will be a need to dispose it efficiently as the volume of such waste keeps rising at alarming rates. There is no question of trend here as it is certain that use and production of such materials will only increase in future and so will the demand for their disposal.

Methods, Apparatuses, Waste Treatment System, Microwave and Infrared Assisted Process Burning

There are patent applications which specifically aim to extract one or more particular components. But there are also inventions on methods, designs and apparatuses which generally aim to treat, shred, dismantle, or decontaminate the e-waste. A few of the inventions are as follows; a simple integrated waste storage method and system is described in 415/CHENP/2011. This invention provides integrated bunker storage systems for waste streams based on the composition and characteristics of waste streams. 145/KOLNP/2009 is an application on a method and apparatus for reducing the volume of disposable containers, particularly metallic beverage containers. 2643/KOLNP/2013 describes an apparatus and method for conducting microbiological processes on a bulk of waste. 5337/DELNP/2006 is another such invention on a method and apparatus for treating waste with alternating current plasma torches with a variable flame mounted with the vessel. The flames generated by the torches can be adjusted depending on the characteristics of the waste being treated. Vitrification of the inorganic portion of the waste followed by gasification and dissociation of the organic portion of the waste, destroys the hazardous or toxic constituency of the waste. 696/DEL/2002 is a process and apparatus for pyrolysis of thin coatings of polymer mixtures on conducting webs

A waste treatment system that processes waste upon application of energy is described in 5598/DELNP/2010. The system includes a vessel that has an open space that receives waste feedstock, at least two plasma electrodes to facilitate a pyrolysis process.

A few of the patents employ the process of etching to remove substances from silicon layers and conductive films. 554/KOLNP/2005 presents an invention related to novel etching media in the form of etching pastes for selective etching of silicon surfaces and layers. 1885/KOLNP/2013 is based on printable etchant compositions for etching silver nanowire-based transparent, conductive films. The etched films are suitable as a transparent electrode in visual display devices such as touch screens, liquid crystal displays, plasma display panels and the like. 1993/KOLNP/2009

is an invention which relates to etching media containing particles in the form of etching pastes suitable for the full surface, or selective etching of finest lines or structures on silicon surfaces and layers, and glass-like surfaces being formed of suitable silicon compounds. 2/KOLNP/2012 describes two component etching in a process for the etching of surfaces semiconductor devices or surfaces of solar cell devices.

A microwave treatment of bulk particulate material is described in 1234/DELNP/2010, for disposing electrical and electronic equipment comprising plastic and metal components, the method comprising: melt processing the equipment and/or comminuted parts thereof to form a melt processed product; transferring the melt processed product into a vessel and heating the product using far infrared radiation such that it liberates volatile hydrocarbons and leaves behind non-volatile residue comprising metal; both of which could be subsequently used. 1452/KOLNP/2006 involves the use of a microwave transceiver unit for detecting the level of waste in a furnace. 2316/MUMNP/2010 describes ultrasound assisted heavy metal recovery. The method utilizes ultrasonic treatment assisted acid leaching process to separate and recover different heavy metals from metals containing sludge.

4286/CHE/2012 describes a portable electronic incinerator for burning waste material and includes a heater unit that burns the waste material by providing 360° surround heating to the waste material. 7208/CHENP/2009 shows a method and system for wavelength specific thermal irradiation and treatment using an infrared radiation system for direct injection of selected, narrow bandwidth thermal infrared radiation or energy into articles for a wide range of processing purposes. Wavelengths are selected according to the specific absorption band characteristics of the target entity to create the desired efficiency of thermal transfer.

Conclusion

E-waste management seems to be an inevitable task with new electronic products coming up almost every day. The only solution seems to be the utilization of new technology, for only a technology can replace a technology. India definitely needs a strong legislation on e-waste management which can levy penalties and ensure e-waste is managed properly.

Despite its economic importance, research on e-waste recycling has never gained priority and gets little respect within companies in India. The present study only confirms that electronic manufacturing

companies in India are laggard rather than leaders in adopting new technologies and innovation on e-waste recycling.

To solve the e-waste problem, new technologies are required and the study reveals a good number of technologies developed by Indian organizations like Council of Scientific and Industrial Research and other individuals belonging to educational institutions. Though the WIPO study suggests the major applicants have invested heavily in protecting their patents across all jurisdictions, little is known about their interest in India. This may be a boon in disguise to use such technology and also to build on it.

The main focus in this research is to encourage entrepreneurs, R&D units and the government to take this challenge of management e-wastes head on and arrest the situation spiraling out of control. Needless to say the India is also a major contributor to e-wastes and not only produces a huge amount of electronic and electrical equipments but also legally and illegally imports much larger quantities. A solution to the problem of managing and disposing e-waste is urgently required in the interest of society.

The analysis also indicates that the bigger players who have invested heavily in patent protection of their e-waste technologies over the world seem to have left out India. The big companies like Panasonic which is the most active applicant, followed by German specialist materials company HC Starck, Japanese metals corporation JX Nippon Mining & Metals, Sumitomo and others like Hitachi, Mitsui Mining and Smelting, Kobe Steel and many more have not filed their patents in India due to lack of proper legislation and hence the need to dispose of these wastes in a regulated manner. India is but at a nascent stage of e-waste disposal and management. When patent filings started to rise from the 1980s across the world, India was nowhere in the picture because of lack of awareness. It is only after 1995 that patent applications in relation to e-wastes have been filed in India. Since there is no market available here with hardly any technologies and uninterested companies, it is practically and economically not feasible for foreign companies to file their patents here. In other words there are no takers for their patents which involve a complex technical understanding. But with active participation of both the governmental and non-governmental research units, the e-waste

menace can be tackled better. With the European and the American traders trying to direct the flow of e-waste into India it is time the country awakened to the reality and magnitude of the problem.

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