

## Electronic Waste: Concerns & Hazardous Threats

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### Abstract

*The technological development, transmigration of Electronic products, unequal growth, impact of urbanization and lesser regulatory mechanism has lead to a situation where one is single mindedly thinking of automation and self growth. The manufacturers / producers and dealers are only thinking of making profit but no one is thinking of that this automation, urbanization growth, technological advancement is leading to disaster and we are ruining the atmosphere, environment in which we are finding our existence and will continue to remain in. The hazardness and toxicity of materials used in the popular electronic products are circulated, recycled and when they come to end of life stage, they have to be disposed off and this disposal which should have taken place in safe sophisticated manner in the most appropriate technological manner as per their constituents but find the most unfriendly and crude manner of disposal, dismantling and burning in uncontrolled and unsafe manner by unskilled workers. The workforces most of the time constitute children also. The employment or earning they get in return is very little compared to the exposer and harm they are subjected to. The certain substances and minerals are needed for the safer and healthy life but its excess exposer and intake leads to hazardous & toxic situation leading to many complex and dangerous situations which damages the life by development of inability and degradation of environment. The presence of metals, minerals and substances in and around the disposal sites show alarmingly high presence of these substances and are posing threats of imminence nature. The efforts and strict enactment for regulatorory agencies, extended producers responsibility (EPR) and take back system by the producers has to be developed and strictly adhered to. The local Government should come with strong legislations and coordinate their effort to tackle the situation with cooperation of each other. The technology for production of eco friendly manufacturing of electronic appliances and their proper disposal facilities are need of the hour. Any nation, irrespective of their level of development lack proper inventory of EEE produces, hence the real threat and level of participation cannot be fixed upon. The transmigration of obsolete products in name of technology transfer must be stopped and one has to realize that loss to environment will be loss to human kind as the air, ground water level of pollution, change of soils texture, erosion and seepage of waste product will not remain confined to the boundaries of the nations what mankind has fixed. The quarrel that who is the larger polluter and who should be fixed for such are very minor issues as day by day we are shrinking and the globe has to be treated as one entity and safeguard of all beings will generate world where all can live in humane manner.*

**Keywords:** Metals, EEE, Hazardous, Toxic, Regulations, Inventory, Development, Environment, Degradation

### 1. Introduction

The advancement of technology and desire of human kind for automation & luxury vis-a-vis expectations for an effortless life has lead to rapid growth Electrical & Electronic Equipment (EEE) and appliances. The world is becoming pool of various types of EEE and with advent of new products the transmigration of used and older EEE are evident in the socio economic differences in the world order. The globalization and development of Information Technology Communication and cohesion among different parts of world in various names has lead to unprecedented growth of such product which are nearer to end of life of

have virtually lost their credibility and life and are redundant and useless. These obsolete, redundant products which have met the end of life are popularly known as Electronic Waste or e-waste. As per UNEP survey and reports, annually 20 to 50 million tons of e-wastes are getting added to the stock every year (UNEP Vol II 2007). These e-wastes constitute many hazardous and toxic materials which are threat to environment and humans when they come in contact without proper knowhow and protection. The hazardous and toxic constituents are inclusive of heavy metals and organic compounds. Heavy metals and organic compounds mostly consist metals such as lead, cadmium chlorine bromine etc. These hazardous and organic compounds are serious threats to human health. The third world in general and Asian countries in particular where most of the EEE land in name of technology transfer, provision for socio economic status

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among fellows living here particularly meant for recycling and or dismantling or disposal in name of very cheaply available manpower for employment.

The situation was foreseen and realized by various sections in the developed and developing nations and many efforts have been taken and initiated to tackle these. In this area the European Union (EU) and individual countries have come up with regulations and legislations which as on date do not seem to be adequate. The regulatory and restriction measures for putting restriction and use of materials for EEE taken by the EU agency "Restriction of use of certain Hazardous Substances" (RoSH) and Waste of Electrical and Electronic Equipment Waste (WEEE) Directives are initial steps in this direction. The RoSH directive have laid down the upper limits for use of heavy metals and organic compounds like lead and Cadmium, Mercury, Hexavalent Chromium, Brominated Flame Retardants popularly known as BFRs etc. The WEEE directive emphasizes on setting up agencies and provisions for collection, finance and possible treatment of EEE by the producers / manufacturers or their agencies. Similar initiatives have been either initiated or are in practice in countries like India, China, Japan, Korea and likewise prominent EEE producers. The developed and developing countries have agreed to the provisions of various e-waste regulating agencies by becoming signatory of the different international summits by United Nations (UN).

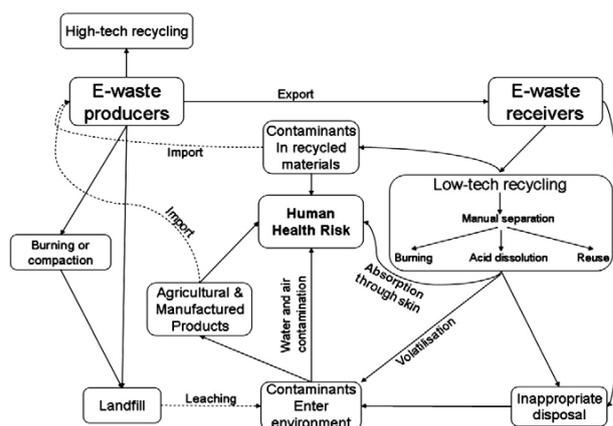
The e-waste being generated has many fold of operation. It is reported that even in EU only 25 % of generated e-waste is collected and treated. The figure for US is around 20 % , in India it is around 10 % observed i.e. 75 % in EU , 80% in US and 90 % in India it does not go to the Recycling / Disposal centre and get lost in the dusts creating serious hazardous environmental and health concerns. In case of EU and US the e-wastes to a greater extent illegally are transferred to developing and underdeveloped nations for recycle/disposal. In US some legitimacy has been provided in name of routine classification by US EPA.

The hazardous e-wastes, whether produce of national use or received through legal or illegal recycling / disposal activity, are done in informal unregulated small workshops which grossly lacks needed technology, knowhow and facilities for protection from ill effects. It is reported that only 10 % e-wastes are treated in the formal sector which has government / regulating agencies authority sanction / permission for such activities and are equipped with proper facilities. The major formal recycling / disposal units are located in major cities in India. The generation, collection and recycling / disposal efforts are constantly being observed in almost all parts of nation, irrespective of taking place in formal or informal ways. The major e-wastes maximum to a limit of 20 % are transported to the metros but the remaining 80 % e-wastes are dealt with the treatment in the slum areas, local waste collectors popularly known as "kabariwalas" who have their own ways and means of disposal and treatment. These kabariwalas often take out the valuable components or materials from the dismantled parts of e-wastes by extraction and dump the remains in the nearby areas

particularly in rivers, lakes, landfills or dumping areas in the slums. The worst ill effect of the degradation due to hazardous waste constituents from the e-wastes can be seen in the effected river or dumping areas .

The Ranchi, Dhanbad, Bokaro and Jamshedpur area have been identified for study the hazardous effects. The areas have been identified as state capital representing the situation of state capitals of the nation, old established and emerging Industrial area leading to urbanization where life is fast and turnovers of EEE are largest among the green areas. The unplanned and un-thoughtful developed has lead to highly underdeveloped areas near the big cities to grow as larger slum areas and represent population of varied cosmopolitan nature.

The figure 1 shows a typical out line of contaminants, sources, its flow and approach for possible intention of minimization with outline of the flow through all the stack holders and groups associated with it.



**Figure 1** Outline of contaminants associated with E-waste fluxes from producers to receivers and ultimately to humans.

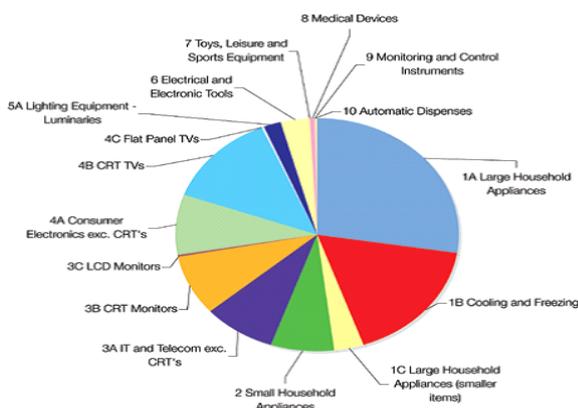
## 2. E-Waste Stock Recycling and Disposal Scenario

The Manufacturers Association of Information Technology (MAIT), Toxic link and GTZ various reports have reveals that the e-waste stock in 2005 was 146000 tons, it increased to 400000 tons by 2010, further advanced to 800000 tons by 2012 and is expected to further grow, when extrapolated, with similar growth rate to 500 % by 2020 in India (Amit naik et al 2013). The treatments of e wastes are carried out in both formal and informal sectors. The formal sector only constitutes 5 % of total e-wastes. The e-waste handling, redrassal and dealing is thus mostly taken up by informal i.e. unorganized sectors. Most of e-wastes (to the tune of 95 %) end up in the informal sector. The waste hawkers mostly known as kabariwalas or of radiiwalas & waste and scrap dealers who engage themselves for petty local earnings are handling the most deadly hazardous and sophisticated e wastes in most crud and unscientific manner. The non technical , having no knowhow of threat and skill manpower are engaged in most unprotected and unskilled manner for handling these e-wastes which may be responsible to ruin their own health and life in

particular and environment which is resulted by will result in grave concerns to the pollutions in general. The pollution may affect atmosphere which includes the air which we breathe, water by spilling of contaminations of heavy metals and soluble infactants penetrating up-to the underground water by unknowingly dumps in the open near the river sites / lakes in general

Study reveals that 20 to 50 million tons of e-waste are added / generated every year worldwide. As per an estimate of 2009, just a small percentage i.e. 13 % amounting to around 53 million tons of e-wastes were in the recycling process. By end of 2015 the use of Computers worldwide will touch to a high of 2 billion which will constitute a major stake among the growing information technology giants like India, China in Asian and Brazil and Russia outside Asian region. The increased use of Computers and EEE will result in increased e-waste and by 2020 it is estimated that there will be increase of 200 – 400 % in case of South Africa and China and will touch a high of 500 % in case of India (UNEP Vol I 2007). The contribution of states in India will grow as per development of states in area of information technology growth and application in India.

The metros are the main centers for recycling and recovery from e-wastes in India in quantitative volumes. The smaller and local centers in the cities are small actors in themselves but overall contribute sizable volumes in these areas. The states have their own recycling and recovery centers. The activities of these centers are mainly to dismantle and disassemble old obsolete EEE for retrieval of reusable components and materials. The reusable materials mainly constitute isolatable metals like copper and aluminum which can be directly taken out or can be separated from plastic by burning these in open. This is supposed to be an unskilled work, hence the workers of tender age i.e. children are mostly involved in it without protective equipments. The extraction is done with the rudimentary tools only. The copper is sold at Rs 80-120 per kg against steep price of copper in original market. Use of solder recovery, acid leaching and plastic shredding for copper recovery from printed circuit boards (PCB) is in practice in India is semi and formal recovery and recycling centers.



**Figure 2** General Composition of EEE & E-Waste

A brief outline of what constitutes the e-waste can be seen from the figure 2. The figure shows the possible

composition of EEE or e-waste. It is observed that processing of obsolete computers, monitors, television, mobile, washing machine, electric mixiees, electronic toys, electric motors, fans, regulators and similar EEE products find their way in local markets. These are manually worked upon needing sometimes winding done by semi automatic or automatic machines.

The dismantling of e-wastes takes place in small workshops/tiny industries/even at home of workers/ technicians. The remains of the e-wastes are transported to river sides or to lonely places in the periphery of markets and burnt. The e-wastes mainly consists of plastic coated cables, plastic embedded PCB, insulators of electrical windings, plastic casing and broken parts. The metals are extracted out from the remains after burning. The broken parts which significantly have no valuable materials to be extracted or have lesser value extractants than effort are disposed off or left as remains to be buried or kept aside or to be placed in stray fires after accumulation after certain time. For sustained fires for burning, mostly the waste insulating foam of the disposed refrigerators and polyurethane are used. Even today frequently Chlorofluorocarbons (CFCs) are used as blowing agents even though it has been internationally banned as it releases ozone depleting gases from the fumes. The use of CFCs and polyurethane can cause deadly hazards in long term contamination at the sites of burning of these e-wastes. The river sites and the abandoned areas suffer multiple type of problem in rainy seasons. The rivers on getting flooded carry the hazardous materials to the other areas and spread the contamination over larger areas. The rain water mixes and spreads the waste remains to other areas which may not be desirable as it may spread to dwelling areas and cause the air and water pollution. Thus one can conclude that the ill-treatment of e-wastes in the unskilled and non environmental friendly manner may cause threats of chemical intoxication in the area where it is being done and can spread to other areas also.

### 3. Hazardous Metals, Materials and Substances in the E-Wastes

The commonly obtainable metals, materials and substances in any disposable EEE i.e. e-wastes found in the samples and associated areas which have harmful effects and are responsible for contamination are as mentioned herein

- **Aluminum:** It is soft lightweight metal with dull silvery appearance having property of formation of thin oxide layer when exposed to air which makes it suitable for electronic products. It is nontoxic metal, nonmagnetic and non-sparking substance.

Exposer to high concentration is hazardous and causes health problems. The water-soluble form, known as ions causes harmful effects. Its excessive intake through food, breathing or by skin contact can cause damage to the central nervous system, dementia, loss of memory, listlessness or severe trembling. Increased exposer can increase problem of kidney patients when it get into during kidney dialyses. Inhalation of aluminum powder or powder of aluminum oxide can cause pulmonary fibrosis

and lung damage which is popularly known as Shaver's Disease. The disease gets complicated when silica and oxides of iron present in air for inhalation and may get implication in Alzheimer's disease.

The aluminum has very high acidifying effect. It gets accumulated in plants its consumption can cause health problems for animals. If the presence is in lakes it can be fatal for these. High aluminum concentrations can make the groundwater contaminated with acidified soils. Aluminum can damage the roots of trees when it penetrates to groundwater.

- **Antimony** is a semi-metallic element which can exist in metallic (metallic form is bright, silvery, hard and brittle) and non metallic (grey powder) forms. It is a poor conductor of heat and electricity.

Pure Antimony is used to for making semiconductor diodes and infrared detectors. Antimony alloys are used in batteries, low friction metals, cable sheathing and other similar products. Some times compounds are used for making flame-proofing materials, paints, ceramic enamels, glass and pottery.

Presence of antimony can cause irritation of the eyes, skin and lungs, lung diseases, heart problems, diarrhea, severe vomiting and stomach ulcers, sometimes cancer and reproductive failure. Antimony can be used as a medicine for parasitic infections, but people who have had too much of the medicine or were sensitive to it have experienced health effects in the past. These health effects have made us more aware of the dangers of exposure to antimony. Antimony can be found in soils, waters and air as pollutant. Through groundwater it can ship it to larger distances and can be deadly for small animals. It can damage lung, heart, liver and kidney. Long time inhalation may cause eye irritation and hair loss. Main uses of Antimony are in fire retardants for numerous commercial and domestic products. Antimony trichloride is used in the manufacturing flame proofing compounds as well as paints, ceramic enamels, glass and pottery. Other uses include ball bearings and mixing with alloys with percentages ranging from 1 to 20 greatly increasing the hardness and mechanical strength of the lead. The capability to strengthen already strong alloys is its largest and most widespread use.

- **Arsenic** : Arsenic are available in three allotropic forms: yellow, black and grey. The silver-gray form is stable one. It is brittle crystalline solid which tarnishes rapidly in air. It burns forming a white cloud of arsenic trioxide at high temperature. It is available in metallic and non metallic forms. The non metallic form is less reactive and dissolves in strong oxidizing acids and alkalis easily on heating.

These find extensive use in making special types of glass, wood preservative, in making semiconductor Gallium Arsenide which is capable of converting electric current to laser light. The  $AsH_3$  Arsine gas which is highly toxic is important dopant gas used in microchip industry It is a deadly poison, its intake of more than 0.01 mg/day intake adversely affects human and animals equally. Arsenic is one of the most toxic elements. The exposer to human can be through food, water and air or through skin contact with soil or water with arsenic. It can cause health

effects as irritation in the stomach and intestines, skin changes and lung irritation, can cause cancer of skin, lungs, liver or lymphatic. It can cause infertility and miscarriages with women, skin disturbances, declined resistance to infections, heart disruptions and brain damage in both men and women. It is capable of damaging DNA and nerve injury.

- **Barium** is a silvery-white metal. Barium reacts with almost all the non-metals and produces form which itself is poisoning compounds. Barium is commonly used in barium-nickel alloys for spark-plug electrodes in vacuum tubes, drying and oxygen-removing agent, fluorescent lamps etc. Barium finds extensive use in making paint, bricks, tiles, glass, and rubber. Barium infiltrates during mining processes, refining processes, and processing for production of barium compounds. People with the greatest risk to barium exposure with additional health effects are those that work in the barium industry. Most of the health risks that they can undergo are caused by breathing in air that contains barium sulphate or barium carbonate. The sites which contain barium inhale it and are exposed to harmful levels in way of drinking the contaminated water. The intake of heavily contaminated water can cause paralyses and even death. The moderate exposer can cause experience breathing difficulties, increase blood pressures, changes in heart rhythm, stomach irritation, muscle weakness, nerve reflexes changes, swelling in brains, liver, kidney.

- **Beryllium** is a toxic bivalent element, steel gray, strong, light-weight. It is used as hardening agent in forming alloys. Beryllium is nonmagnetic oxidation resistant material having good thermal conductivity. Beryllium is one of the most toxic metal. Its breathing causes damage to lungs which may cause pneumonia. The most common effect of beryllium is berylliosis a persistent and dangerous lung disorder which can damage other organs including heart. The mortality rate is as high as 20 in this disorder. Hypersensitive persons may develop allergic reactions and Chronic Beryllium Disease (CBD) . Beryllium can even cause cancer and change DNA. Beryllium oxide are fillers mostly for the thermal interface materials and are mostly used as heat transfer fins in vacuum tubes lasers, CPUs and power transistors, magnetrons, X ceramic windows etc .

- **Bismuth** is a white, crystalline, brittle pinkish tinge diamagnetic having high thermal conductivity high electrical resistivity showing highest Hall effect metal. Bismuth is dissolvable in concentrated nitric acid. Bismuth is used for manufacturing of low melting solders, fuse, synthetic fibers and rubbers. Bismuth on inhalation and ingestion can cause kidney damage, serious ulceration stomatitis, develops vague feeling of bodily discomfort, albumin or other protein substance in the urine, diarrhea, skin reactions, serious exodermatitis.

- **Cadmium** a lustrous, silver-white, ductile, very malleable metal has bluish tinge soft enough to be cut with a knife. It is not soluble in alkalis but soluble in acids. The major application is in Ni-Cd batteries and for preparation of pigments, coating and planting stabilizers for plastics. The intake of this through food which can be liver,

mushrooms, shellfish, mussels, cocoa powder and dried seaweed. Tobacco smoke is also a rich source and it straight goes to lungs and damages it. The higher level damages kidney by damaging its filtering mechanism. It can lead to Diarrhea, stomach pains, severe vomiting, Bone fracture, Reproductive failure including possibly of even infertility, Damage to the central nervous system, immune system, Psychological disorders, DNA damage or cancer development.

- **Chromium** is a silver gray coloured lustrous, brittle, hard metal which can be highly polished. It finds use in manufacturing alloys such as steel, metal ceramics, to provide corrosion resistance and Chromium (IV) oxide ( $\text{CrO}_2$ ) is used to manufacture magnetic tape.

Contaminated well water contain the dangerous chromium(IV), hexavalent chromium. Chromium(III) is an essential nutrient for humans and shortages may cause heart conditions, disruptions of metabolisms and diabetes. Chromium(VI) is a danger to human health. It can cause nose irritations and nosebleeds. Other health problems that are caused by chromium(VI) are Skin rashes, stomachs upset and ulcers, Respiratory problems, Weakened immune systems, Kidney and liver damage, Alteration of genetic material, Lung cancer, etc.

- **Cobalt** It is a hard ferromagnetic, silver-white, lustrous and brittle textured element. The radioactive isotopes, cobalt-60, is used in medical treatment and to irradiate food for preservation of food.

Cobalt is widely dispersed by breathing air, drinking water and eating food, Skin contact with soil or water which contains cobalt. As part of vitamin B it is beneficial for humans. It useful in treatment for anemia as it stimulates the production of red blood cells. However intake of high concentrations of cobalt may damage human health. The high content air breathing may result in asthma and pneumonia. Common health effects that result due to high intake of cobalt are Vomiting and nausea, Vision problems, Heart problems, Thyroid damage, hair loss, etc.

- **Copper** is a reddish malleable, ductile, an extremely good conductor of both heat and electricity metal. As on date this the most commonly used metal in EEE. Copper is used for electrical equipment (60%) construction, in roofing and plumbing (20%), industrial machinery, such as heat exchangers (15%) and alloys (5%). Copper is ideal for electrical wiring because it is easily worked, can be drawn into fine wire and has a high electrical conductivity. Copper can be present in many kinds of food, drinking water and air. The permissible amount of Copper is essential but intake of large amounts by different means can cause eminent health problems. copper contagion can lead to a flu-like condition known as metal fever. Long-term exposure to copper can cause irritation of the nose, mouth and eyes and it causes headaches, stomachaches, dizziness, vomiting and diarrhea. High intake can cause liver and kidney damage. Industrial exposure to copper fumes, dusts, or mists may result in metal fume fever with atrophic changes in nasal mucous membranes. Chronic copper poisoning results in Wilson's Disease, characterized by a hepatic cirrhosis, brain damage, demyelization, renal disease, and copper deposition in the cornea.

- **Gallium** Solid gallium is a blue-gray metal while very pure gallium has a stunning silvery color. Gallium is solid at normal room temperatures, but as mercury, cesium, and rubidium it becomes liquid when heated slightly. It is stable in air and water and is soluble and reactionable with acids and alkalis.

Gallium has semiconductor properties, especially as gallium arsenide (GaAs). Uses in forming electronic Analog integrated circuits are the most common application for gallium, with optoelectronic devices where mostly laser diodes and light-emitting diodes (LED) are fabricated with GaAs. Pure gallium is not a harmful substance for humans to touch. Acute exposure to Gallium (III) chloride can cause throat irritation, difficulty in breathing, chest pain, and its fumes can cause very serious conditions such as pulmonary edema and partial paralysis.

- **Germanium** Pure germanium is a hard, lustrous, gray-white, brittle metalloid used as elemental semiconductor. Similar to Silicon it has a diamond like crystalline structure. As an important semiconductor it is mainly used in fabrication of transistors and integrated circuits. Unlike other substances its high intake is supposed to improve the immune system, boost the body's oxygen supply, make a person feel more alive and destroy damaging free radicals.

The byproducts Germanium hydride and germanium tetra hydride are extremely flammable and explosive when mixed with air. Inhalation may cause abdominal cramps, burning sensation, cough, skin redness, pain, eyes redness & Pain. Effects of short-term exposure can cause irritation to eyes, skin and respiratory tract. It may cause effects on the blood, resulting in lesions of blood cells.

- **Indium** is a soft, ductile, malleable, lustrous metallic silvery white coloured metal. It is found in liquid form over a wide range of temperatures. Indium is stable in air and water but soluble in acids.

The small doses is said to stimulate the metabolism. All indium compounds should be treated as highly toxic. Indium compounds are capable to damage the heart, kidney, and liver, and may be teratogenic.

- **Lead** It is bluish-white lustrous soft, highly malleable, ductile, relatively poor conductor of electricity though very resistant to corrosion substance. As a major constituent lead is found in lead-acid battery extensively used of electrical source. It is used as electrodes in electrolysis. Among the chief uses it can be seen as in glass of computer and television screens, where it shields the viewer from radiation besides find use in sheeting, cables, solders, lead crystal glassware, ammunitions, bearings etc.

Lead is regarded as essential element for the human beings but its higher exposer or intake can cause several unwanted effects which can include as Disruption of the biosynthesis of hemoglobin and anemia, rise in blood pressure, Kidney damage, Miscarriages and subtle abortions, Disruption of nervous systems, Brain damage, Declined fertility of men through sperm damage, Diminished learning abilities of children, Behavioral disruptions of children, such as aggression, impulsive behavior and hyperactivity, Lead can enter a fetus through

the placenta of the mother and cause serious damage to the nervous system and the brains of unborn children.

- **Lithium** : the first of the alkalis in the periodic table. In nature it's found like a mixture of the isotopes  $Li_6$  and  $Li_7$ . It's the lightest solid metal, it's soft, silvery-white, with a low melting point and reactive. Many of its physical and chemical properties are more similar to those of the alkaline earth metals than to those of its own group.

The Inhalation can cause Burning sensation. Cough. Laboured breathing, Shortness of breath, Sore throat, Skin Redness, Skin burns, Pain, Blisters, Redness in Eyes, Severe deep burns, Ingestion, Abdominal cramps, Abdominal pain, Burning sensation, Nausea, Shock or collapse, Vomiting, Weakness.

- **Mercury** : The perfect liquid conductor often finds place in the fluorescent tubes, tilt switches, conducting electronic tubes, control solid state devices and flat screen monitors. The health hazards are dermatitis, sensory impairment, memory loss, weakness in muscle reduced fertility causing slowing of growth and development etc. The severe effect can be resulting in death of living beings when affected.

- **Molybdenum**: In powders form it is used in circuit inks for circuit boards. These find use in microwaves devices and heat sinks for solid-state devices. It is highly toxic and can cause liver dysfunction with hyperbilirubinemia. Signs of gout can be seen on the infected person. It can develop joint pains in the knees, hands, feet, auricular deformities, erythema, and edema in the joint areas.

- **Nickel**: Major use of nickel is in the preparation of alloys. It is easy to work on and can be drawn into wire. It resists corrosion even at high temperatures and for this reason it is used in gas turbines and rocket engines. It is commonly present in the NiCd batteries used in electronic equipments for power sources. These are extremely poisonous and harmful in long run. Humans may be exposed to nickel by breathing air, drinking water, eating food or smoking cigarettes. Skin contact with nickel-contaminated soil or water may also result in nickel exposure. The large quantity can cause Higher chances of development of lung cancer, nose cancer, larynx cancer and prostate cancer, Sickness and dizziness after exposure to nickel gas, Lung embolism, Respiratory failure, Birth defects, Asthma and chronic bronchitis, Allergic reactions such as skin rashes, mainly from jewelry, Heart disorders etc.

- **Selenium**: It has very good photovoltaic and photoconductive properties hence it finds extensive use in electronic devices in form of photocells, light meters and solar cells and in lead plates used for storage batteries and in rectifiers to convert AC current in DC current. The use is in photocopying, in the toning of photographs etc. Its artistic use is to intensify and extend the tonal range of black and white photographic images. People that live near hazardous waste-sites will experience a higher exposure through soil and air. Selenium from hazardous waste-sites and from farmland will end up in groundwater or surface water through irrigation. Overexposure of selenium fumes may produce accumulation of fluid in the lungs, garlic breath,

bronchitis, pneumonitis, bronchial asthma, nausea, chills, fever, headache, sore throat, shortness of breath, conjunctivitis, vomiting, abdominal pain, diarrhea and enlarged liver.

- **Silver**: It is an excellent conductor of heat and electricity. It has the highest electrical conductivity of all metals, but its greater cost has prevented it from being widely used for electrical purposes.

Repeated and prolonged contact of silver with skin may cause allergic dermatitis. Inhalation hazards. High concentrations vapor exposer may cause dizziness, breathing difficulty, headaches or respiratory irritation. Extremely high concentrations may cause drowsiness, staggering, confusion, unconsciousness, coma or death. It may lead to Kidney damage, Eye damage, Lung damage, Liver damage, Anemia, Brain damage, Cardiac abnormalities etc.

- **Sulphur**: Sulphur is a multivalent non-metal which is not toxic. The exposure can lead to Neurological effects and behavioral changes, Disturbance of blood circulation, Heart damage, Effects on eyes and eyesight, Reproductive failure, Damage to immune systems, Stomach and gastrointestinal disorder, Damage to liver and kidney functions, Hearing defects, Disturbance of the hormonal metabolism, Dermatological effects, Suffocation and lung embolism etc. In environment it can be source of formation of Sulphuric Acid in humid and wet conditions which can lead to loss of fertility of land etc.

- **Tin** is a substance which is not easily oxidized and resists corrosion. The niobium-tin alloy is used for superconducting magnets, tin oxide is used for ceramics and in gas sensors. It has good electrical conductivity. Tin is mainly applied in various organic substances. The organic tin bonds are the most dangerous forms of tin for humans. Higher exposer can cause Eye and skin irritations, Headaches, Stomachaches, Sickness and dizziness, Severe sweating, Breathlessness, Urination problems, Depressions, Liver damage, Malfunctioning of immune systems, Chromosomal damage, Shortage of red blood cells, Brain damage, sleeping disorders, forgetfulness etc.

- **Vanadium**: It is rare, soft, ductile gray-white a good resistant to corrosion element mainly used to produce certain alloys. The exposer can cause severe eye, nose and throat irritation. It can be responsible for Cardiac and vascular disease, Inflammation of stomach and intestines, Damage to the nervous system, Bleeding of livers and kidneys, Skin rashes, Severe trembling and paralyses, Nose bleeds and throat pains, Weakening, Sickness and headaches, Dizziness, Behavioral changes etc.

- **Yttrium**: It is used in making red phosphors for color television picture tubes. It is used in, fluorescent lamps, energy-saving lamps and glasses. Yttrium is one of the rare chemicals that can be found in houses in equipment such as colour televisions. All rare chemicals have comparable properties. It is dangerous and hazardous substance. It can cause lung embolisms, cancer with humans, as it enlarges the chances of lung cancer, threat to the liver when it accumulates in the human body.

- **Zinc**: It is used principally for galvanizing iron and used in batteries. It can be used as pigment zinc for use in

plastics, cosmetics, photocopier paper, wallpaper, printing inks etc. It is an essential component needed for human body development. The excess exposure can lead to stomach cramps, skin irritations, vomiting, nausea and anemia, can damage pancreas, disturb the protein metabolism, and cause arteriosclerosis.

- **Brominated flame retardants (BFR):** The BFR is frequently used as flame retardants in plastics for the electronics industry producing products. The BFR includes the banned product PBBs, PCB, Octa BDE, Penta BDE also. The hazardous hygienic and health effects ranges of this BFR ranges from thyroid problem, impaired development of the nervous system to other deadly health problems etc. (umesh et.al 2014)

#### 4. Selection of Samples

Jharkhand is a relatively backward state having varying demography. The urban and rural areas with varied industrialization are identity of the area. The old industrial hubs such as located in Dhanbad and Jamshedpur have well developed slums and give a good mix culture of metros. The use of technology and high purchasing power can be very well evident. The capital of state i.e. Ranchi cannot be ignored as it is supposed that any advancement will transfer to other areas through this region only. Bokaro is also an important area which has steel and other ancillary industries. The EEE use can be seen as at peak in the areas mentioned here. The inhabitants are of mixed culture and have access to varied technology by all means including the imports from developed countries to developed EEE products from the local manufacturers or assemblers.

The formal availability of recycling or disposal centers cannot be observed. Most of the e-wastes get transmigrated to nearby metro Kalkota which is a larger destination but still the recycling and disposal activities can be observed here locally in all the major cities identified. The recycling and disposal activities take place locally as explained earlier in the paper and degradation of environment and ill-effects can be well visualized in certain pockets and areas. The areas of disposal and burning centers are mostly located in the river / lake side and abandoned area of the cities near the slums where the unskilled laborers are living and have the best option of finding the products from all means and after they get irreparable are left with no option to throw or burn as it becomes liability. The visual degradation of the areas has been major for selection of the sites.

#### Sampling

Proper exposure for determination of extent of contamination as a result of e-wastes is the main aim for this study. The exploration of contamination of surrounding, soils, texture, sediments and possible evaluation of content of contaminations needs collection of samples in similar quantity from possibly similar conditions. The samples were collected from the river sides of Suwarnrekha and slum side of Harmu in Ranchi, Kharkai river and Mango slum of Jamshedpur, Bokaro

and Dhanbad. The sites are so selected that the samples obtained from the area represent maximum contaminations available in the area so that a worst effected data is available and the discussion will enable us to have scenario suited for proper representation. The level of contamination and its hazardous effects on the persons living nearby and working in the atmosphere are our target and motive.

The details can be put as mentioned in table 1 which shows the details of description of samples obtained and collected from e-waste dumping / disposal burning / disposal sites in the specified areas. The separate samples for identification of un-burnt parts of plastics and mixes of glasses which may cause harm to the persons working there in is also collected. The volumetric and weight-wise analysis will be done on it and the outcome will tell us that how physically it is difficult to work in these areas.

Table 1

Sample No	Type	Location
RNC01	Burning / destroying Place	Slum /Market side Ranchi
RNC02	Dumping site / Burning /disposal area	Ranchi Scrap dealers dumping area
DHN03	Dumping site / Burning/ disposal area	Dhanbad slum Market side
JSR04	Dumping site / Burning/disposal area	Jamshedpur slum Market side
JSR05	Soil Below broken CRT glass within disposal area	Slum market area Jamshedpur
BKO06	Sediment of lake adjacent to disposal and burning areas,	Bokaro area

#### Details of Sampling and data obtained

Samples collected were stored in properly pre cleaned and rinsed with nitric acid and analytical grade pentane glass bottles. The collected samples were taken to the technical laboratories for examination and evaluation of concentration of different types of constituents. Proper care for isolation of organic substances was done. The analytical data obtained from the examinations for metals are listed in table 2. The data obtained and the examinations reveals that the hazardous constituents are very much present and are alarmingly high for posing threat to health, hygiene to individuals and damaging to the environment. The degradation and level of toxicity and hazardous contents needs to develop technology to reduce the level of threats and keep the environment safe and under limit. The manufacturers and the agencies regulating the safety measures should take note of alarming situation and address the problem by making provisions for recycling and disposal in a environment friendly manner under strict vision of the welfare agencies. The fairer examination can lead to better results and will be more alarming and eye catching. Utmost care has been taken to collect the samples from the places which show that maximum level of contamination visually. The volumes for physical examinations were also collected. From the physical examinations the content wise un-burnt parts of plastic, glasses and soil texture was analyzed. The

evaluation showed that the un-burnt parts of plastic and glass pieces makes the environment and situation even worse so that one gets cuts and injuries when he / she moves naked or bare footed. The chances of intoxication and inhalation through these cuts and wounds are even more enhanced. Volume wise it was observed that un-burnt plastic and glasses constituted to around 9 to 12 % as per sample and sites.

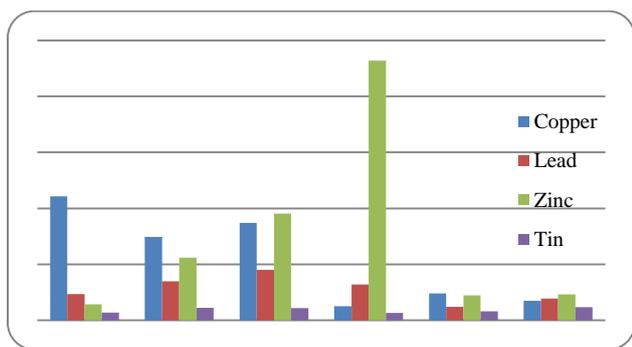
**5. Observations and analysis of findings**

Details of observations obtained from the samples collected from the various spots and positions.

**Table 2** Details of constituents obtained

Metal/ Substances	RCN01_mg/kg	RCN02_mg/kg	DHN03_mg/kg	JSR04_mg/kg	JSR05_mg/kg	BKO06_mg/kg
Antimony	145	210	413	10	6	214
Arsenic	12	14	18	7	8	18
Barium	217	873	892	67	72	280
Beryllium	0.14	0.54	0.17	0.23	0.34	0.53
Bismuth	15	17	17	11	12	10
Cadmium	2	6	8	0.7	1.2	0.6
Chromium	42	43	31	19	31	33
Cobalt	11	56	87	94	26	27
Copper	11065	7456	8713	1276	2397	1756
Gallium	13	17	18	12	16	16
Germanium	24	21	19	26	23	27
Indium	16	13	18	15	16	14
Lead	2354	3485	4512	3197	1211	1937
Manganese	231	312	217	132	157	193
Mercury	0.4	0.6	0.4	0.3	0.5	0.45
Molybdenum	3.4	3.2	3.7	3.91	2.6	4.2
Nickel	6	12	19	23	21	26
Selenium	26	26	21	29	25	27
Silver	1.1	5.1	4.6	3.8	1.8	1.7
Tin	696	1126	1093	665	821	1167
Vanadium	21	32	8	24	31	25
Yttrium	1.1	6.8	1.5	2.9	23.1	7.1
Zinc	1432	5612	9523	23185	2246	2315

The variation of substances which are abundantly found in the samples i.e. Copper, Lead, Zinc and Tin is represented in the figure 3 below.

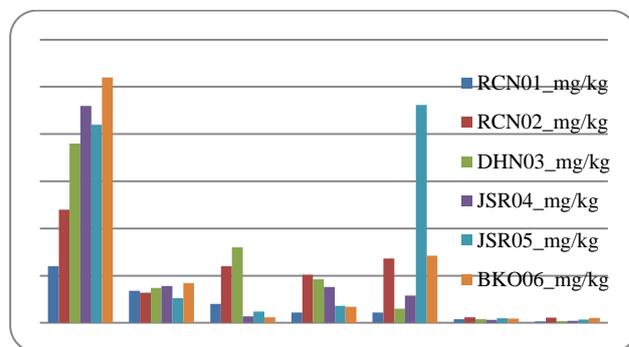


**Figure3.** For variation of Copper, Lead, Zinc and Tin

The copper content is maximum in Ranchi followed by Dhanbad sample and once again of Ranchi only. The

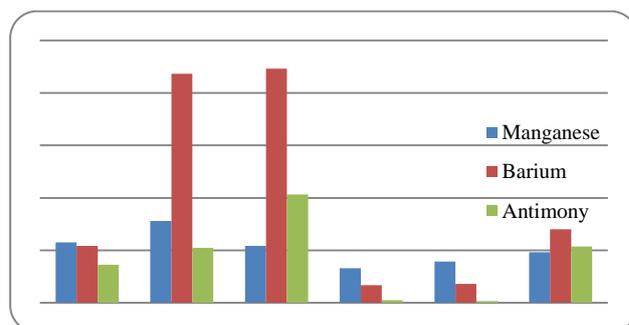
amount of copper is least for Jamshedpur. The recyclable e-waste of Jamshedpur is transported to nearby Kolkata. The demography of Bokaro is cosmopolitan as the residents come mostly from other states hence the wastes get transferred to other places. The scenario of lead and zinc is also almost same. The alarming level of zinc in Jamshedpur and Dhanbad is probably because of the fact that the industrial wastes which contains these are getting mixed in the soil/ash and are reflected in this case. The case of Tin is similar throughout.

The variation of nickel, Molybdenum, Cadmium, Silver, Yttrium, Mercury and Beryllium can be seen in the next graphical i.e. figure 4. The variation shows that the Nickel is one substance which is present in the entire sample in study reveals that the presence of Yttrium is excessive in Jamshedpur sample. The levels of constituents in the samples are more or less indicators of the industrialization and waste added by e-wastes. The mercury and Beryllium shows a uniform pattern in all the samples. The variation of cadmium is much. The Jamshedpur and Bokaro showed least levels. The silver content in Ranchi and Jamshedpur is higher for the reason that the disposal of mobiles etc is more. The presence of Molybdenum is almost uniform.



**Figure 4** Variation of Nickel, Molybdenum, Cadmium, Silver, Yttrium, Mercury & Beryllium

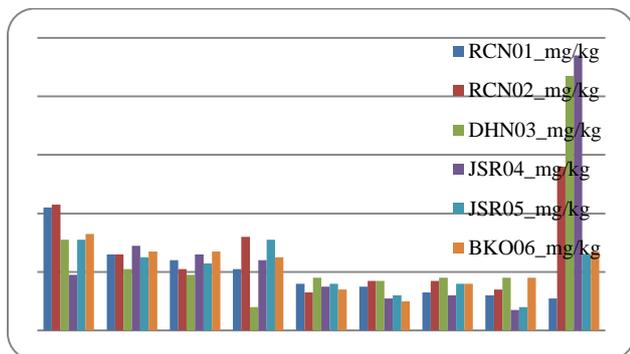
The next variation of Manganese, Barium and Antimony is shown in figure 5. The level of Barium is Ranchi and Dhanbad is eye catching. The presence of antimony is throughout with variation.



**Figure5.** Variation of Manganese, Barium and Antimony

In figure 6 the presence of cobalt is important in all the samples. This is followed by chromium. The remaining

materials are showing their increased presence. The e-wastes are showing marked increase in levels of hazardous substances. The informal and unorganized sectors which are disposing the e-waste in unskilled manner is the sole reason for the rise in level to alarming contents. This is going to affect environment and health in significant way.



**Figure 6** Variation of Chromium, selenium, Ge, Vanad, Indium, Bismuth, Gallium, Arsenic and Cobalt

The overall observation is that the constituents of the substances discussed above are sometimes 100 to 1000 times higher in limits which are desirable for the existence. The very high increased levels of metals and substances make the situation alarming and grave. All means and precautions are needed for bringing the level back to permissible limits and only then we can say the area will remain safe to live in. The bad aspects of localized urbanization and mad rush for automation and ease must come to an end. The environmental limits and stretching of limits internationally be fixed and re-fixed/re-administered so that sustained development of all individual, technology, and society takes place irrespective of region and parity we live in.

## Conclusion

The growth of EEE, rapid industrialization with technical advancements, copying of leading giants in name of civilization for ease of life and establishing technological foothold warrants some precautions also. The graveness of situation can only be judged if one looks at the stock of situation on what he or they are paying or causing to the nearby and situation where we are living in. The health, environment their degradation level highlights the need for skillful use of technology and development of technology in safe manner. The stock of situation need be done for such. The present position as it looks from the study presses that we need to change our mindset and keep breaks on madness for development. We need sustainable development for safe and purposeful development with proper match of health, hygiene and environment.

The resource recovery from the wastes or recyclable remains needs to be carried out in a technical and skilled manner. The present unplanned, unregulated pattern is resulting in environmental degradation and risking the workers for the serious consequences. The areas where such activities are taking place are highly contaminated by the pollutants of the e-wastes. The crude recovery

processes, particularly by burning the e-wastes in common places are main cause for degradation. The study results reveals that the contaminants in the EEE, e-wastes improper handling are threats to workers and local residents. The children are the worst effected individuals as they are more affected by the toxicity present in their blood compared to adults. The ill management and poor handling and lack of far sightedness of authorities are evident. The need to redesign new EEE products by minimizing use of hazardous contents and restriction on transboundary movements which add to such waste needs urgent attention. The legislation and regulations enacted by the agencies and government here are inadequate, necessary clauses and acts have to be enacted. The planed phasing out of the disposable EEE can lead to a situation where sustained e-wastes are generated. A global initiative is need of hour so that technology transfer, responsibility of exporters & importers are fixed and addressed so that overall e-waste is reduced. The divide between formal and informal handling is the actual cause of non availability of reliable data for the EEE products and unless one have reliable data, one cannot come out with proper strategy, strength and options for tackling this situation. The inventory of such EEE products needs to be regularly updated and maintained. The initiative of Extended Producers Responsibility needs a total submission for proper tackling & minimization of e-waste in proper and purposeful way. Making persons aware of the situation is the best way of creating general awareness, mentality and here the inclusion of such efforts need to be put in curricula of professional courses of environmental concerns. The self regulation, morale and motivation to fight any menace are the best tool to handle the situation. The satisfaction and restraint from running towards ease and automation will lead to a situation where in name of ease one will not press for discarded product and contribute towards lessening of e-waste production.

The combined efforts for proper enactment of proper regulation, public participation, general awareness, improvement in curricula, creating general awareness, restraint from having out of phase product will effectively reduce the e-waste and reduction of e-waste will lessen the need of recycling and disposal and ultimately reduce the contamination of environment, individual suffering and improve health and hygiene.

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