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What is e-waste?

Electronic and electrical waste includes ICT equipment, Consumer electronics, Small household appliances and large household appliances.

Why should we recover e-waste?

Electronic and electrical waste contains both valuable and potentially hazardous material that can be recovered through proper recycling, while hazardous fractions can be treated prior to safe disposal.

Possible Health effects if e-waste is mismanaged

E-waste recycling has direct and indirect effects on human health conditions.

Direct impacts on human health may be caused by:

- Dust in indoor air generated in manual and mechanical dismantling processes (e.g. when processing plastics or Cathode Ray Tubes (CRTs) found in old TVs and Computer screens);
- Filter dust generated in the mechanical dismantling process;
- Noise emissions during the manual and mechanical dismantling process (conveyor belts, hammering, shredders etc.);
- Deviations from occupational safety standards;

Indirect impacts on human health may be caused by:

- Air pollution related to (HT) incineration (however the situation has been very much improved since waste gas purification systems are a common standard);
- Emissions due to transportation of materials;
- Contamination of water systems and soil near landfills.

The indirect impacts on human health are difficult to quantify, among others because of synergistic effects and the time-lag between exposure and reaction.

What could be hazardous?

Substance	Occurrence in e-waste	Health effects
Halogenated compounds:		
- PCBs (polychlorinated biphenyls)	Condensers, Transformers	PCBs are a class of organic compounds use in a variety of applications, including dielectric fluids for capacitors and transformers, heat transfer fluids and as additives in adhesives and plastics. PCBs have been shown to cause cancer in animals. PCBs have also been 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 and other health effects. PCBs are persistent contaminants in the environment. Due to the high lipid solubility and slow metabolism rate of these chemicals, PCBs accumulate in the fat-rich tissues of almost all organisms (bioaccumulation). The use of PCBs is prohibited in OECD countries, however, due to its wide use in the past, it still can be found in waste electrical and electronic equipment as well as in some other wastes.
- TBBA (tetrabromo-bisphenol-A) **- http://www.atsdr.cdc.gov/tfacts68.html ">PBB (polybrominated biphenyls)** **- PBDE (polybrominated diphenyl ethers)**	Fire retardants for plastics (thermoplastic components, cable insulation) TBBA is presently the most widely used flame retardant in printed wiring boards and casings.	The three main types of BFRS used in electronic and electrical appliances are Polybrominated biphenyl (PBB), Polybrominated diphenyl ether (PBDE) and Tetrabromobisphenol - A (TBBPA). Flame retardants make materials, especially plastics and textiles, more flame resistant. They have been found in indoor dust and air through migration and evaporation from plastics. Combustion of halogenated case material and printed wiring boards at lower temperatures releases toxic emissions including dioxins which can lead to severe hormonal disorders. Major electronic manufacturers have begun to phase out brominated flame retardants because of their toxicity.
- Chlorofluorocarbon (CFC)	Cooling unit, Insulation foam	Chlorofluorocarbons are compounds composed of carbon, fluorine, chlorine, and sometimes hydrogen. Used mainly in cooling units and insulation foam, they have been phased out because when released into the atmosphere, they accumulate in the stratosphere and have a deleterious effect on the ozone layer. This results in increased incidence of skin cancer in humans and in genetic damage in many organisms. For more information go to http://www.c-f-c.com/supportdocs/cfcs.htm
- PVC (polyvinyl chloride)	Cable insulation	Polyvinyl chloride (PVC) is the most widely-used plastic, used in everyday electronics and appliances, household items, pipes, upholstrery etc. PVC is hazardous because contains up to 56 percent chlorine which when burned produces large quantities of hydrogen chloride gas, which combines with water to form hydrochloric acid

		and is dangerous because when inhaled, leads to respiratory problems.
Heavy metals and other metals:		
- Arsenic	Small quantities in the form of gallium arsenide within light emitting diodes	Arsenic is a poisonous metallic element which is present in dust and soluble substances. Chronic exposure to arsenic can lead to various diseases of the skin and decrease nerve conduction velocity. Chronic exposure to arsenic can also cause lung cancer and can often be fatal.
- Barium	Getters in CRTs	Barium is a metallic element that is used in sparkplugs, fluorescent lamps and "getters" in vacuum tubes. Being highly unstable in the pure form, it forms poisonous oxides when in contact with air. Short-term exposure to barium could lead to brain swelling, muscle weakness, damage to the heart, liver and spleen. Animal studies reveal increased blood pressure and changes in the heart from ingesting barium over a long period of time. The long-term effects of chronic barium exposure to human beings are still not known due to lack of data on the effects.
- Beryllium	Power supply boxes which contain silicon controlled rectifiers and x-ray lenses	Beryllium has recently been classified as a human carcinogen because exposure to it can cause lung cancer. The primary health concern is inhalation of beryllium dust, fume or mist. Workers who are constantly exposed to beryllium, even in small amounts, and who become sensitised to it can develop what is known as Chronic Beryllium Disease (beryllicosis), a disease which primarily affects the lungs. Exposure to beryllium also causes a form of skin disease that is characterised by poor wound healing and wart-like bumps. Studies have shown that people can still develop beryllium diseases even many years following the last exposure.
- Cadmium	Rechargeable NiCd-batteries, fluorescent layer (CRT screens), printer inks and toners, photocopying-machines (printer drums)	Cadmium components may have serious impacts on the kidneys. Cadmium is adsorbed through respiration but is also taken up with food. Due to the long half-life in the body, cadmium can easily be accumulated in amounts that cause symptoms of poisoning. Cadmium shows a danger of cumulative effects in the environment due to its acute and chronic toxicity. Acute exposure to cadmium fumes causes flu-like symptoms of weakness, fever, headache, chills, sweating and muscular pain. The primary health risks of long term exposure are lung cancer and kidney damage. Cadmium also is believed to cause pulmonary emphysema and bone disease (osteomalacia and osteoporosis). For more information on go to: http://www.intox.org/databank/documents/chemical/cadmium/ehc135.htm
- Chromium VI	Data tapes, floppy-disks	Chromium and its oxides are widely used

		because of their high condctivity and anti corrosive properties. While some forms of chromium are non toxic, Chromium (VI) is easily absorbed in the human body and can produce various toxic effects within cells. Most chromium (VI) compounds are irritating to eyes, skin and mucous membranes. Chronic exposure to chromium (VI) compounds can cause permanent eye injury, unless properly treated. Chromium VI may also cause DNA damage. For more information, go to http://www.intox.org/databank/documents/chemical/chromium/ehc61.htm
- Lead	CRT screens, batteries, printed wiring boards	Lead is the fifth most widely used metal after iron, aluminium, copper and zinc. It is commonly used in the electrical and electronics industry in solder, lead-acid batteries, electronic components, cable sheathing, in the glass of CRTs etc. Short-term exposure to high levels of lead can cause vomiting, diarrhea, convulsions, coma or even death. Other symptoms are appetite loss, abdominal pain, constipation, fatigue, sleeplessness, irritability and headache. Continued excessive exposure, as in an industrial setting, can affect the kidneys. It is particularly dangerous for young children because it can damage nervous connections and cause blood and brain disorders. For more information go to http://www.hc-sc.gc.ca/english/iyh/environment/lead.html and http://www.intox.org/databank/documents/chemical/lead/ukpid25.htm.
- Lithium	Li-batteries	*Chemical dangers:* Heating may cause violent combustion or explosion. The substance may spontaneously ignite on contact with air when finely dispersed. Upon heating, toxic fumes are formed. Reacts violently with strong oxidants, acids and many compounds (hydrocarbons, halogens, halons, concrete, sand and asbestos) causing fire and explosion hazard. Reacts violently with water, forming highly flammable hydrogen gas and corrosive fumes of lithium hydroxide. Read more: http://www.lenntech.com/Periodic-chart-elements/li-en.htm#ixzz0LnNiT4YC *Effects of short-term exposure*: The substance is corrosive to the eyes, the skin and the respiratory tract. Corrosive on ingestion. Inhalation of the substance may cause lung oedema. The symptoms of lung oedema often do not become manifest until a few hours have passed and they are aggravated by physical effort. Rest and medical observation is therefore essential. Immediate administration of an appropriate spray, by a doctor or a person

		authorized by him/her, should be considered. Read more: http://www.lenntech.com/Periodic-chart-elements/li-en.htm#ixzz0LnNlsXV6
- Mercury	Fluorescent lamps that provide backlighting in LCDs, in some alkaline batteries and mercury wetted switches, Compact Florescent Lamps (CFLs) and Florescent tubes	Mercury is one of the most toxic yet widely used metals in the production of electrical and electronic applications. It is a toxic heavy metal that bioaccumulates causing brain and liver damage if ingested or inhaled. In electronics and electrical appliances, mercury is highly concentrated in batteries, some switches and thermostats, and fluorescent lamps. For more information go to http://www.intox.org/databank/documents/chemical/mercury/cie322.htm
- Nickel	Rechargeable NiCd-batteries or NiMH-batteries, electron gun in CRT	An uptake of too large quantities of nickel has the following consequences: - 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 jewellery - Heart disorders Nickel fumes are respiratory irritants and may cause pneumonitis. Exposure to nickel and its compounds may result in the development of a dermatitis known as “nickel itch” in sensitized individuals. The first symptom is usually itching, which occurs up to 7 days before skin eruption occurs. The primary skin eruption is erythematous, or follicular, which may be followed by skin ulceration. Nickel sensitivity, once acquired, appears to persist indefinitely. Read more: http://www.lenntech.com/Periodic-chart-elements/Ni-en.htm#ixzz0LnO7z0QT
- Rare Earth elements (Yttrium, Europium)	Fluorescent layer (CRT-screen)	The toxicity of europium compounds has not been fully investigated, but there are no clear indications that europium is highly toxic compared to other heavy metals. The metal dust presents a fire and explosion hazard. Water soluble compounds of yttrium are considered mildly toxic, while its insoluble compounds are non-toxic.[40] In experiments on animals, yttrium and its compounds caused lung and liver damage, though toxicity varies with different yttrium compounds. In rats, inhalation of yttrium citrate caused pulmonary edema and dyspnea, while inhalation of yttrium chloride caused liver edema, pleural effusions, and

		pulmonary hyperemia.[6] Exposure to yttrium compounds in humans may cause lung disease.[6] Workers exposed to airborne yttrium europium vanadate dust experienced mild eye, skin, and upper respiratory tract irritation—though this may have been caused by the vanadium content rather than the yttrium.[6] Acute exposure to yttrium compounds can cause shortness of breath, coughing, chest pain, and cyanosis.[6] NIOSH recommends a time-weighted average limit of 1 mg/m^3 and an IDLH of 500 mg/m^3.[65] Yttrium dust is flammable.[6]
- Selenium	Older photocopying-machines (photo drums)	Exposure to high concentrations of selenium compounds cause selenosis. The major signs of selenosis are hair loss, nail brittleness, and neurological abnormalities (such as numbness and other odd sensations in the extremities). Source: Information collated from http://www.atsdr.cdc.gov/toxfaq.html
- Zinc sulphide	Interior of CRT screens, mixed with rare earth metals	
Others:		
- Toner Dust	Toner cartridges for laser printers / copiers	
Radio-active substances **- Americium**	Medical equipment, fire detectors, active sensing element in smoke detectors	The radiation from exposure to americium is the primary cause of health effects from absorbed americium. Americium moves rapidly through the body after uptake and is concentrated within the bones for a long period of time. During this storage americium will slowly decay and release radioactive particles and rays. These rays can cause alteration of genetic materials and bone cancers. Read more: http://www.lenntech.com/periodic-chart-elements/Am-en.htm#ixzz0LnRNkSVm

Dioxins

Dioxins and furans are a family of chemicals comprising 75 different types of dioxin compounds and 135 related compounds known as furans. Dioxins is taken to mean the family of compounds comprising polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). Dioxins have never been intentionally manufactured, but form as unwanted by-products in the manufacture of substances like some pesticides as well as during combustion. Dioxins are known to be highly toxic to animals and humans because they bio-accumulate in the body and can lead to malformations of the foetus, decreased reproduction and growth rates and cause impairment of the immune system among other things. The best-known and most toxic dioxin is 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). For further information go to http://www.deh.gov.au/industry/chemicals/dioxins/pubs/incinfinal.pdf

Valuable Materials

The following table presents the composition of a desktop computer plus a CRT screen in 1996. More than 80% of the weight consists of silica (glass), plastics, iron and aluminium. Precious and scarce materials account for only a small percentage of the total weight. Nevertheless, the concentration of such metals, e.g. gold, is higher in a desktop computer than found in naturally occurring mineral ore.

Composition of a Desktop Personal Computer Based on a typical desktop computer, weighing ~27 kg

Material name	Content (% of total weight)	Weight of material in computer (kg)	Use	Location
Plastics	22.9907	6.26	Insulation	Cable, Housing
Lead	6.2988	1.72	Metal joining	Funnel glass in CRTs, http://www.pwbrc.org/faq10.cfm ">PWB
Aluminum	14.1723	3.86	Structural, Conductivity	Housing, CRT, PWB, connectors
Germanium	0.0016	< 0.1	Semiconductor	PWBs
Gallium	0.0013	< 0.1	Semiconductor	PWBs
Iron	20.4712	5.58	Structural, Magnetivity	Housing,CRTs, PWBs
Tin	1.0078	0.27	Metal joining	PWBs, CRTs
Copper	6.9287	1.91	Conductivity	CRTs, PWBs, connectors
Barium	0.0315	< 0.1	Â	Panel glass in CRTs
Nickel	0.8503	0.23	Structural, Magnetivity	Housing, CRT, PWB
Zinc	2.2046	0.6	Battery, Phosphor emitter	PWB, CRT
Tantalum	0.0157	< 0.1	Capacitor	Capacitors/PWB, power supply
Indium	0.0016	< 0.1	Transistor, rectifier	PWB
Vanadium	0.0002	< 0.1	Red Phosphor emitter	CRT
Terbium	0	0	Green phosphor activator, dopant	CRT, PWB
Beryllium	0.0157	< 0.1	Thermal Conductivity	PWB, connectors
Gold	0.0016	< 0.1	Connectivity, Conductivity	Connectivity, conductivity/PWB, connectors
Europium	0.0002	< 0.1	Phosphor activator	PWB
Titanium	0.0157	< 0.1	Pigment, alloying agent	Housing
Ruthenium	0.0016	< 0.1	Resistive circuit	PWB
Cobalt	0.0157	< 0.1	Structural, Magnetivity	Housing, CRT, PWB
Palladium	0.0003	< 0.1	Connectivity, Conductivity	PWB, connectors
Manganese	0.0315	< 0.1	Structural, Magnetivity	Housing, CRT, PWB
Silver	0.0189	< 0.1	Conductivity	Conductivity/PWB, connectors
Antinomy	0.0094	< 0.1	Diodes	Housing, PWB, CRT
Bismuth	0.0063	< 0.1	Wetting agent in thick film	PWB
Chromium	0.0063	< 0.1	Decorative, Hardner	Housing
Cadmium	0.0094	< 0.1	Battery, blue-green	Housing, PWB, CRT

			Phosphor emitter	
Selenium	0.0016	0.00044	Rectifiers	rectifiers/PWB
Niobium	0.0002	< 0.1	Welding	Housing
Yttrium	0.0002	< 0.1	Red Phosphor emitter	CRT
Rhodium	0	Â	Thick film conductor	PWB
Platinum	0	Â	Thick film conductor	PWB
Mercury	0.0022	< 0.1	Batteries, switches	Housing, PWB
Arsenic	0.0013	< 0.1	Doping agent in transistors	PWB
Silica	24.8803	6.8	Glass, solid state devices	CRT,PWB

Source: Microelectronics and Computer Technology Corporation (MCC). 1996. Electronics Industry Environmental Roadmap. Austin, TX: MCC.