Electronic Wastelands: Decomposing Computers and Communities Around the World

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WHAT IS ELECTRONIC WASTE?

In the 1980s, the dawn of the computer revolution was brewing. At the time, few were interested; but merely 25 years later, approximately 88% of Canadians own a personal computer.[1] Unfortunately, with the ever-growing plethora of new programs and hardware, there is also an increase of electronic waste (e-waste): the disposal of electronic equipment, including computers, television screens, and cellular phones. In their original state, these products, which consumers rely on daily, are harmless. However, when improperly discarded, these products release lethal toxins into atmosphere, water, and soil. It is estimated that 20 to 25 million tonnes of e-waste are created worldwide annually, producing high levels of toxins and exposing workers and nearby residents of e-waste recycling plants to extremely toxic health consequences.[2]

WHO CREATES VERSUS WHO SUFFERS FROM THE WASTE?

Even though environmental toxins affect all citizens, the majority of e-waste is created in and collected by North American and European companies and processed in developing nations such as India, Malaysia, China, and Ghana.[3] These countries are experiencing increasing rates of local and illegally imported e-waste primarily due to lack of national regulation and/or lax law enforcement.[3] Normally, these laws would protect against the growth of this semi-formal or informal economy in industrializing countries.

As a result these impoverished populations have built a new industry around e-waste which they increasingly rely on for economic sustainability. Their dependence on e-waste for income propagates within the communities as home-based waste workshops which employ low-cost migrant workers. These in-house processing facilities, which include a dismantling shop, are typically in multi-level homes.[4] Workers often use old and simple tools without protection, such as goggles, masks, or gloves, to strip wires, melt metals, and separate computer parts.[5] By improperly assembling cheap recycled computers for resale, and creating "at home" facilities, these communities have advanced but at a dangerous cost: their health.

Figure 1. Recycling computer components at Free Geek in Vancouver. *Photo Credit*: Jordan Eunson.

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E-WASTE DIRECTLY AFFECTS HUMAN HEALTH

Populations encountering the toxins from electronic devices could suffer from several health effects.

There have been many studies conducted to confirm that these health risks are indeed a result of toxins from nearby e-waste facilities as well as to assess health consequences in these populations. Since the kidney secretes many of these compounds, nephrotoxicity is a major concern with certain metal toxins – even low levels of cadmium cause glucosuria, aminoaciduria, and low molecular weight proteinuria, leading to hypercalciuria and renal stones.[7]

In a study by Wong *et al.*,[8] mercury-discarded electronics were identified as the main contributor of rising mercury emission into the atmosphere in China. Mercury filtered by the glomerulus and reabsorbed in the proximal convoluted tubules causes both tubular and glomerular damage leading to nephrotic syndrome, either because of membranous nephropathy or minimal change disease.[7]

In 2007, Huo *et al.*[4] found much higher serum lead levels in 165 children in the small Chinese town of Guiyu when compared to 61 children from a nearby town that did not participate in e–waste recycling or dumping. Acute exposure to lead can cause direct proximal tubular injury, including glucosuria, aminoaciduria, and phosphate wasting, all of which are potentially caused by mitochondrial dysfunction.[7] Lead toxicity also can result in chronic nephrotoxicity due to decreased clearance of uric acid, decreased estimated glomerular filtration rate (eGFR), or proteinuria.[7] Further studies by Soderland *et al.*[7] showed that chronic metal exposure leads to many serious conditions such as disruptions on calcium–mediated cell signaling and effects on the renin-angiotensin-aldosterone system, both of which can lead to hypertension. Most metal compounds, including nickel, chromium, beryllium, cadmium, arsenic, and gallium, are also known carcinogens.[9] In particular, hexavalent chromium (Cr VI), commonly found in metals, causes cancer by eliciting DNA damage in otherwise healthy cells.[5]

Like chromium, many small and lipid soluble toxins have the ability to enter cells and cause DNA damage. Unfortunately, in the large e-waste city of Tianjin, China, Lui *et al.*[10] used single cell gel electrophoresis to demonstrate a significantly greater degree of DNA damage in women than in men. This will lead to problems in forthcoming generations as many of these toxins cross the placenta and cause adverse affects on the resulting newborn. For example, children born to mothers who ingested large quantities of local fish contaminated with polychlorinated biphenyls (PCBs) were found to exhibit deficits in childhood intellectual function.[11]

Even though PBDEs are banned in some parts of the world, Ma *et al.*[12] found high levels of PBDEs on workshop floors, in electronic shredder waste, and in the dust and soil near e-waste facilities in eastern China. PBDEs might play an important role on thyroid hormone homeostasis and liver metabolism. Marsh *et al.*[13] suggested that two hydroxylated PBDE congeners induce both phase I and II metabolic enzymes in the liver as well as bind to human thyroid hormone receptor-α1 (TR-α1) and TR-β.

Incinerated waste releases toxins, such as furans, polycyclic aromatic hydrocarbons (PAHs), hydrogen chloride, and dioxin (otherwise known as polychlorinated dibenzodioxins (PCDD)), into our biosphere.[14] These chemicals are very dangerous because they are very stable, highly lipophilic, poorly metabolized, and very resistant to environmental degradation.[11] Chan *et al.*[15] found that the estimated daily intake of PCDD from an e-waste processing site in Taizhou, China ranked among the highest in the world. The World Health Organization classified dioxins as

Table 1. Common e-waste toxins and human health consequences. Adapted from Martin and Griswold.[6]

Toxic Chemical	Electronic Source	Health Consequence
Aluminum	Sheathing of computer wires and circuit boards	Disfiguring rashes, respiration problems (i.e. sarcoidosis), severe pulmonary damage, kidney disease, bone fragility
Barium	Front panel of the CRT monitor to protect users from radiation	Vomiting, diarrhea, high blood pressure, arrhythmias, paralysis
Beryllium	Motherboards and connectors	Severe lung damage, skin rashes, ulcers
Cadmium	Batteries, SMD chip resistors, infrared detectors, semiconductors, older types of cathode ray tubes, and some plastics	Kidney damage, lung damage, fragile bones
Chromium	Corrosion protection of untreated and galvanized steel plates. Hardener for steel housing	Asthmatic bronchitis, ulcers, liver damage, kidney failure, circulatory and nerve problems
Dioxin, or polychlorinated dibenzodioxins (PCDD)	Plastic casings. Released when electronics are incinerated or thrown in a landfill	Impairs immune system, developing nervous system, endocrine system and reproductive system
Lead	Found in liquid crystal display (LCD) screens in TV and Computer monitors. Soldering on the circuit boards	Acute exposure can cause vomiting, diarrhea, convulsions, coma, or death
Mercury	Light bulbs in flat panel displays, LCD screens, switches, & printed wiring boards all contain mercury	Ingestion or inhalation can cause central nervous system and kidney damage as well as tremors and memory lapses
Polybrominated diphenyl ethers (PBDEs)	Used as flame retardants plastic casings and components (print circuit boards). Released when electronics are incinerated	Disrupt hormones, (reduce levels of the hormone thyroxin which potentially harms the developing fetus in pregnant women), erythema, dryness, rash, hyperkeratosis, hyperpigmentation, some hepatic involvement, and elevated plasma triglycerides

a carcinogen in 1997.[16] Dioxins have also had adverse effects on laboratory animals, including wasting syndrome, thymic atrophy, epidermal changes, hepatotoxicity, immunotoxicity, and teratogenic effects on reproduction and development.[11]

TECHNOLOGICAL RESPONSIBILITY

With technological growth, there has been a desire for the newest products. As 'new' models for old hardware are created, consumers upgrade. Likewise, the incompatibility of new software with previous versions or competitors leaves consumers eager to buy a newer and faster version of products they may already own and use. Unfortunately with these upgrades, new electronic devices are being created as single whole units without removable and replaceable parts such as batteries or screens. This discourages the modularized system of the past, which allowed replacement of individual parts to prolong the device's life, a process not unlike an organ transplant. More and more, however, an entire device is replaced instead of only its dead battery. This leads to high turnover of products, and the piles of e-waste continue to grow.

POLITICAL RESPONSIBILITY

With the buildup of e-waste, it is crucial that we have safe and reliable disposal services. The "Basel Action Network" (BAN) is a global non-governmental organization which includes members from North America, the European Union, and developing nations. BAN is dedicated to forging the way for toxin–free methods of disposal as well as outlawing the hazards of toxic e-waste dumping.[17] Nationally, recycling groups require proper certifications for e-waste management. Canada, as part of the Basel Convention, has adopted the recycling certification regime, known as "e-Stewardship" to ensure the highest standards of environmental and social responsibility are used for e-waste recycling.[18] Locally, there are a number of Canadian organizations that have received such certification.[19]

CONSUMER RESPONSIBILITY

E-waste is not unlike other forms of environmental hazards. Much like other environmental initiatives, such as reducing carbon footprints by choosing fuel-efficient or hybrid vehicles, the choices consumers make regarding e-waste have the potential to reduce its impact on developing countries. To protect victims of e-waste via disposability policies, consumer and disposers, particularly in developed countries, should focus on minimizing the amount of e-waste created. Consumers should look to purchase durable hardware with replaceable parts as this lowers the amount of e-waste created. Consumers should also challenge technology companies to create more sustainable products. For disposers of electronic goods, including computers, cell phones, down to AA batteries, verification of recycler integrity is critical. Thorough awareness and understanding of e-waste and its hazardous health effects requires only very small changes in our daily lives but could result in saving many children, families, and communities around the world from the dangers of e-waste.

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