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Aquatic Toxicity of Leachates Generated from Electronic Devices

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Abstract. Heavy metal leaching of electronic waste has been documented in recent literature. Heavy metal aquatic toxicity in the toxicity characteristic (TC) leachates produced from 56 electronic devices were tested using the aquatic toxicity assays such as *Ceriodaphnia dubia* 48-hr acute toxicity assay, the *Selenatastrum capricornutum* chronic algal growth inhibition assay (test used only for circuit-board leachates), and the MetPLATE acute heavy metal toxicity tests. The electronic devices tested, include 9 circuit boards (printed wire boards), 2 videocassette recorders, 4 remote controls, 1 cathode ray tube, 15 cellular phones, 1 calculator, 5 smoke detectors and their PC board components, 3 printers, 4 laptop computers, and 7 personal computer central processing units (CPUs). The toxicity tests showed toxicity in 51 of the 56 Toxicity Characteristic Leaching Procedure leachates of electronic devices assayed.

Key words: E-waste leachates—Metal toxicity—MetPLATE—Toxicity testing

Discarded electronic devices are known to contain a variety of potentially toxic chemicals that might cause harm to human health and the environment if improperly managed. Recent research has focused on whether these devices merit classification as hazardous waste when disposed of into the environment (DEH 1999; Musson *et al*. 2000; Yang, 1993) and what the true environmental impacts of discarded electronic wastes (i.e., e-wastes) are (Jang and Townsend 2003; Yang, 1993). In industrialized countries, this waste stream is mainly disposed in controlled landfill systems or they might be salvaged for ultimate recycling. Recent reports have described the fate of recycled electronic devices shipped from industrialized to nonindustrialized countries, as they are often disposed of in an uncontrolled manner (BAN 2002). In Switzerland, the Basel Convention has identified e-wastes as hazardous materials and would ban the export of e-wastes from developed to industrializing countries (Widmer *et al*. 2005).

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The risk of chemical leaching from discarded electronic devices has traditionally been evaluated using chemical tests (Vann *et al*. 2006b; Yang 1993). The complex nature of toxicants in e-wastes suggests that toxicity assays may be a useful tool for assessing potential environmental risks, especially for indiscriminate dumping along water bodies, which has been described (BAN 2002).

This article presents the results of a study in which leachates, collected using batch leaching tests on e-waste components, were tested for toxicity using various assays such as *Ceriodaphnia dubia* 48-h acute toxicity assay, the *Selenatastrum capricornutum* chronic algal growth inhibition assay, and the MetPLATE acute heavy metal toxicity assay. The objective of the study was to assess the bioavailable fraction of heavy metals in the leachates to best assess the potential environmental problems due to these wastes. A similar approach has been taken in previous studies (Stook *et al*. 2004; 2005) to help understand the heavy metal contamination of leachates from preserved wood. Several species of heavy metals present in the leachates are predominantly in complexes with several organic and inorganic ligands and might not be bioavailable, and thus not toxic to the test organisms in toxicity testing.

Materials and Methods

Sample Collection

Electronic devices were collected from household hazardous waste collection facilities or donated by local electronic repair shops. Samples were transported back to the University of Florida laboratories in large High Density Polyethylene (HDPE) bins that had been washed with Liquinox™, acid rinsed (20% conc. HNO_3), and rinsed with deionized water prior to use.

Electronic Devices

Fifty-six electronic devices were tested, including 9 circuit boards (printed wire boards), 2 videocassette recorders (VCRs), 4 remote controls, 1 cathode ray tube (CRT), 15 cellular phones, 1 calculator, 5 smoke detectors and their PC board components, 3 printers, 4 laptop computers, and 7 personal computer central processing units (CPUs).