

First report of flame retardant exposure in indoor dust from Canadian e-waste recycling facility

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Introduction

Managing electronic waste (e-waste) is a growing challenge for communities and countries. In 2013, over 75,000 tonnes of electronic waste were collected and processed in the Canadian Province of Ontario, a roughly 500 % increase over the amount processed in 2009 (Ontario Electronics Stewardship, 2013). Flame retardants (FRs) such as PBDEs, novel brominated flame retardants (NBFRs), and organophosphorus flame retardants (OPFRs), are chemicals added to a wide variety of electrical and electronic products to meet flammability standards. Little is known about FR exposures to workers in e-waste facilities in high-income countries. Two studies from Europe reported that FRs exposure levels were at least an order of magnitude higher in an electronics recycling facility as compared to different occupational groups (Sjödin *et al.*, 2001; Rosenberg *et al.*, 2011). Here we report on a study conducted in an e-waste recycling facility in Ontario, Canada. This facility dismantled a diversity of waste electrical and electronic products such as computers, televisions, toasters and hair dryers. Here the concentrations of FR collected in dust from this facility (14 PBDE congeners, 4 NBFRs, 6 OPFRs and 2 DPs) are reported.

Materials and methods

Nine dust samples were collected from floor (n=3), bench tops where dismantling takes place (n=4), and inside bins used to separate e-waste (n=2). Samples were taken one day during each of the months of May, June and September 2016. Dust was collected using a vacuum cleaner fitted with pre-cleaned polyester socks inserted at the end of the vacuum cleaner hose attachment (Venier *et al.*, 2016). Dust samples were transferred to pre-cleaned vials and stored in -20 °C until chemical analysis. Socks with dust were weighed, the dust was sieved to <500 µm, approximately 100 mg were weighed. The sock was rinsed with solvent (30 mL hexane in acetone, 1:1; v/v), and the solvent was combined with weighed dust. Dust was sonicated for 5 mins in 30 mL of acetone/hexane 1:1 (v/v) and vortexed for 1 min; left to settle for 30 min, and the supernatant was decanted. The procedure was repeated 2 additional times with 10 mL of solvent, and the extracts were combined (50 mL total). The extract was then rotary evaporated to 2 mL and fractionated on a silica column (3.5 % water deactivated) using 25 mL of hexane, 25 mL hexane/dichloromethane 1:1 (v/v), and 25 mL of dichloromethane in acetone 3:7

(v/v) as eluting solvents. Extracts were analysed by gas chromatography with mass spectrometry (GC-MS) using predefined methods (Ma *et al.*, 2013).

Results and discussion

The most abundant FRs in the floor dust samples from the e-waste recycling facility were PBDEs (BDE-209 accounted for ~90 % in floor dust and ~70 % in bench dust) and OPFRs. Among NBRs, 2-ethylhexyl-2,3,4,5-tetrabromobenzoate (EHTBB) and hexabromobenzene (HBB) were measured at the highest levels. As seen in Figure 1, the total median concentrations of PBDEs, OPFRs, DP and NFRs in floor dust were around 143,000, 41,400, 6,100 and 410 ng/g, respectively. Similar to the floor dust results, PBDEs and OPFRs were detected at the highest levels in dust from the top of working benches, with the median concentrations ranging from 7 to 20,500 ng/g and from <LOD to 6,900 ng/g, respectively. Compared to a study conducted in Chinese e-waste facilities (Zheng *et al.* 2015), the total PBDE and OPFR levels in this e-waste site was one order of magnitude higher. Concentrations differed between dust in the sorting bins containing monitors and computer cases. Total PBDE concentrations in the “monitor bin” were 200 % greater than was found in the “computer bin”. Conversely, total OPFR concentrations in the “computer bin” were twice as high as in the “monitor bin”. In both bins, BDE-209, tris(1-chloro-2-propyl) phosphate (TCIPP) and tris(1,3-dichloro-2-propyl) phosphate (TDCIPP) were found at the highest levels. This results show the movement of PBDEs, and especially BDE-209, through end-of-life processes where the plastic from dismantled casings could be recycled into new products. The results also show the abundance of organophosphate esters in newer discarded products that also require appropriate re-use or disposal.

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