the purified extracts were concentrated under the stream of nitrogen gas to about 100 µL, toped up with 150 µL of toluene and further reduced to about 160 µL. Prior to analysis, the reduced extracts were spiked with 10 µL of 2.0 ng µL-1 of internal standard (BDE-118). One microlitre of the extract was injected into the GC-MS under optimized instrumental conditions. Analyses of PBDEs and NBFRs were performed using Shimadzu model 2010 plus gas chromatography coupled with a model QP 2010 ultra-mass spectrometer (Shimadzu, Japan) using electron ionization and injected automatically by Shimadzu AOC-20i auto sampler. Operation mode was in the selected ion-monitoring (SIM). A 15 m column; DB5 (0.25mm ID, 0.1 µm df) was used for separation. The oven temperature program set at 90oC (1min), 30 oC min-1 to 300 oC min-1(5min) and 10 oC min-1 to 310 oC min-1 (10min). Helium (purity 99,999%) was used carrier gas and set at a constant flow of 1.5mL min-1.The injector, transfer line, and ion source temperature were set at 290, 300 and 250 oC, respectively.

All laboratory glassware were washed with soap water, rinsed and soaked overnight in 10% (v/v) nitric acid aqueous solution and finally rinsed with de-ionized water. Silica, glass wool and sodium sulphate were baked at 450oC for 12 h to remove impurities. To avoid absorption of moisture, glass wool was wrapped with aluminium foil and kept in the desiccator. Silica gel and sodium sulphate were stored in separate glass jars, which were pre-cleaned and rinsed with a mixture of hexane: acetone (2:1, v/v), then sealed to protect them from moisture absorption and contamination. Samples were collected and wrapped with aluminium foil, to protect them from light. Extraction was performed in the absence of light (electricity). Retention times of the unknowns were matched with those of individual standards and quantification was done by monitoring the molecular ions using external methods.

Results and discussion

Bromine was detected in majority of the screened electronic products. Of these, keyboards had the highest concentrations which ranged from 174-4019 µg g-1, while the lowest concentrations were found in cell phones, which ranged from ND-158 µg g-1 with a mean of 33.5 µg g-1. For the gas chromatography-mass spectrometry analysis, eight brominated diphenyl ether (BDE) congeners namely (BDE-28, -47, -99, -100, -154, -153, -128, and -183) and three novel brominated flame retardants (NBFRs) TBB, TBPH and TBPE were identified in the collected dust samples. The ∑PBDEs ranged from 1814.7 - 5970.6 ng g-1 with a mean of 3456.3 ng g-1, while that of NBFRs ranged from <dl - 3376 ng g-1 with a mean of 1237.2 ng g-1 dry weight. The highest concentrations in electronic dust were observed for BDE-47 ranging from 1525.0 -3797 ng g-1 with a mean of 1442.6 ng g-1. This is about 9 times greater than the mean of BDE-153 (154.0 ng g-1) and six times more than the mean of BDE-28 (238.6 ng g-1) and BDE-128 (219.8 ng g-1). Penta-BDE represented the major congeners, in which BDE-47, BDE-99 and BDE-100 were detected in all dust samples analyzed. In the case of NBFRs, a contribution of approximately13 % to 38 % was observed. Of the sixteen dust samples analyzed, three were found to contain 2-ethylhexyl-2,3,4,5-Tetrabromobenzoate (TBB), bis (2-ethylhexyl) tetrabromophthalate (TBPH) and 1,2-bis(2,4,6-tribromophenoxy)ethane (TBPE). While keyboards were found to contain these compounds (NBFRs) below detection limits. Printer (a) and (V) monitor contained only TBB and TBPE giving the total of NBFs 1237.2 ng g-1 for printer (a) and 665.1 ng g-1 for (V) monitor, respectively. The detection of NBFRs in electronic dust may be due to their use as replacements for penta-, octa and deca-BDE. The presence of TBB and TBPH may have migrated through dust from the treated furniture which was stored at the same location with the screened electronics. With respect to keyboard, printers and monitors, the concentrations of Br determined using XRF exhibited the following trend: keyboard>printer>monitors. This trend was repeated in the GC-MS analysis of dust samples. With the novel BFRs, the concentration trend was: monitor>printer>keyboard. The observed trends suggest that the XRF can be used as a reliable screening tool for indirect measurement of PBDEs in dust samples.

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