NOVEL AND LEGACY BROMINATED FLAME RETARDANTS IN THE URBAN SOILS OF MELBOURNE, AUSTRALIA

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Introduction

A range of brominated flame retardants (BFRs) have been incorporated into polymeric materials like plastics, electronic equipment, foams and textiles to prevent fires. The most common of these, polybrominated diphenyl ethers (PBDEs), have been subject to legislated bans and voluntary withdrawal by manufacturers in North America, Europe and Australia over the past decade due to long-range atmospheric transport, persistence in the environment, and toxicity.[1-3] Evidence has shown that replacement novel brominated flame retardants (NBFRs) are released to the environment by the same mechanisms as PBDEs and share similar hazardous properties. BFRs are released atmospherically from a range of sources[4] and undergo net deposition to land by wet and dry processes.[5,6] Contamination of soils by PBDEs and NBFRs has been indicated in a wealth of studies from around the world.[7-11] In May 2013, Australia's National Environment Protection Measure (NEPM) of 1999 was amended to include a Health Investigation Level (HIL) for all mono- through nona-BDE homologues in soil.[12] The current study aims to characterize soil contamination by PBDEs and NBFRs in the urban soils of Melbourne, Australia. A variety of industrial and non-industrial land-uses were investigated with the secondary objective of determining likely point-sources of pollution.

Materials and methods

A total of 30 soil samples were collected from an area spanning approximately 40 km x 120 km across the Greater Melbourne region, Australia, between March and June, 2014. Sample sites were categorized by land-use as manufacturing industries (n=18), waste disposal facilities (n=6) or non-industrial sites (n=6). Manufacturing sites includes principal production of polymeric materials as well as industries involved in consequent manipulation of plastics and foams through processes such as molding, extrusion or cutting. Waste disposal sites comprise waste incineration (n=2), electronic waste recycling (n=2) and domestic dumpsites (n=2), while non-industrial samples were collected from residential (n=2), urban parkland (n=2) and background (n=2) locations. Eight PBDEs (-28, -47, -99, -100, -153, -154, -183 and -209) and six NBFRs (PBT, PBEB, HBB, EH-TBB BTBPE and DBDPE) were analysed in soil samples by selective pressurized liquid extraction (S-PLE) and gas chromatography – triple quadrupole mass spectrometry (GC-MS/MS).

Results and discussion

PBDEs were detected in 29/30 samples with Σ_8PBDE soil concentrations ranging nd-13,200 ng/g dw and Σ_7PBDEs (excluding BDE-209) levels of nd-70.5 ng/g dw. Soils from waste disposal sites (n=6) contained the highest median Σ_7PBDE and Σ_8PBDE concentrations, followed by manufacturing sites (n=18) and then non-industrial sites (n=6). Electronics recycling facilities contained the greatest levels of Σ_8PBDEs by a significant margin ($p<0.05$) to indicate that these industries are a potential source of contamination. BDE-209 was the dominant congener, contributing an average of 75.5% to Σ_8PBDEs soil concentrations, followed by BDE-47, BDE-99 and BDE-183 at 7.90, 5.64 and 4.31%, respectively. Congener profiles reflected global estimates of Deca-BDE, Octa-BDE and Penta-BDE commercial production, with the most significant congener correlation existing between BDE-47 and BDE-99 ($p<0.001$, $r=0.943$).

NBFRs were detected in 24/30 soil samples with Σ_5NBFR concentrations ranging from nd-385 ng/g dw. HBB was the most frequently detected compound (14/30), while the highest concentrations were observed for DBDPE, followed by BTBPE. Electronic waste recycling and polymer manufacturing also appear to be key contributors to NBFR soil contamination in the city of Melbourne. A significant positive correlation between Σ_8PBDEs and Σ_5NBFR soil concentrations was observed at waste disposal sites to suggest that both BFR classes are present in Melbourne's waste streams, while no association was determined among manufacturing sites.

This research provides the first wide-ranging account of PBDEs in Australian soils and indicates that NBFRs possess a similar potential to contaminate soils as PBDEs in the City of Melbourne.

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