

E-waste recycling as a source of PBDEs in environmental samples

Iryna Labunská¹, Stuart Harrad², David Santillo¹, Paul Johnston¹, and Kevin Brigden¹

¹*Greenpeace Research Laboratories, University of Exeter, United Kingdom*

²*School of Geography, Earth and Environmental Sciences, University of Birmingham, United Kingdom*

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Current study objectives

- Develop method for determination of 14 PBDEs in moderately and highly contaminated solid samples using ASE extraction technique and GC/MS analysis in ECNI mode
- Verify overall procedure with certified material SRM 2585
- Conduct quantitative analysis for PBDEs for samples from e-wastes reprocessing sites in Guiyu, China including:
 - 16 samples from acid processing sites
 - 5 samples from open burning sites
 - 2 samples from dismantling sites
 - 3 samples from separation/solder recovery sites
 - 5 samples from shredding sites



Methodology for sample extraction

Samples and SRM

0.05 g

10 ng
10 ng
40 ng

TBA
Florisil

25 ng/ml

200 μ l

Sample dried, ground and sieved
(63 μ m)

Internal standards
F-BDE-69
F-BDE-160
¹³C-BDE-209

ASE 350 extraction (pentane)

Concentration (TurboVap)

Clean-up

Concentration (TurboVap)

Recovery determination standard
PCB-209

5 most polluted samples

0.05 g

50 -100 ng
100-200 ng
250 - 500 ng

TBA
Florisil

25 ng/ml

500 - 1000 μ l

Final extract (toluene)

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Results of SRM2585 analysis (n=5), accuracy and precision, instrument and sample detection limits (IDL and SDL)

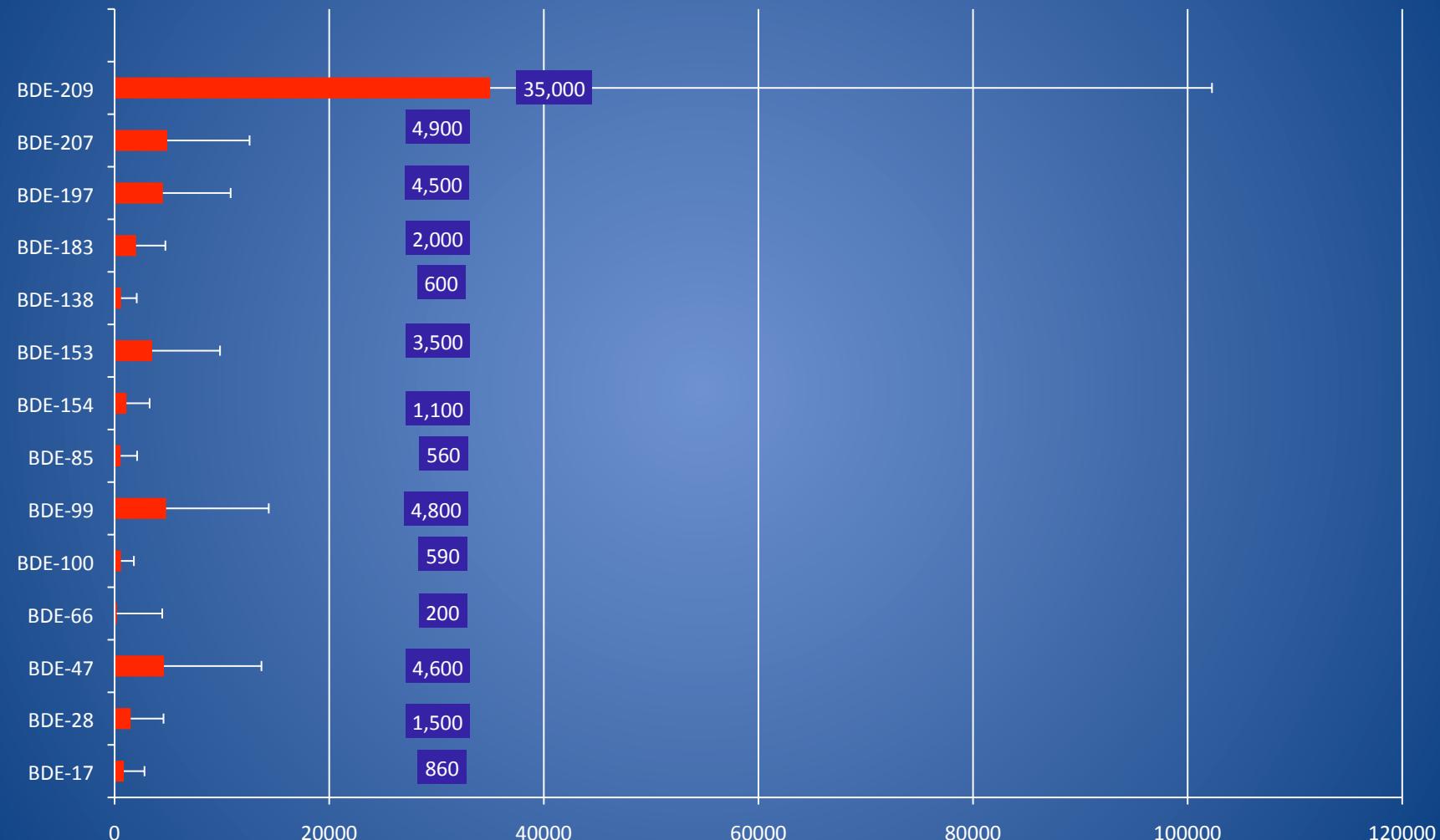
	Certified BDEs conc. in SRM2585, ng/g	Current study conc., ng/g	SD	RSD	IDL, pg/injection	SDL, ng/g
BDE-17	11.5 ± 1.2	18.0	0.8	4	0.02	0.1
BDE-28	46.9 ± 4.4	50.6	1.3	3	0.04	3.8
BDE-47	497 ± 46	547	34	6	0.02	16.3
BDE-85	43.8 ± 1.6	43.9	3.3	8	0.10	0.6
BDE-99	892 ± 53	958	86	9	0.06	8.9
BDE-100	145 ± 11	199	15	8	0.01	29.4
BDE-138	15.2 ± 2	16.9	3.6	22	0.17	1.1
BDE-153	119 ± 1	145	30	20	0.10	13.0
BDE-154	83.5 ± 2	112.4	23	21	0.06	0.4
BDE-183	43 ± 3.5	67	20	28	0.07	6.8
BDE-209	2510 ± 190	2555	390	15	0.09	10.3

Internal standards recoveries

ISs	% IS recovery
F-BDE-69	70 ± 10
F-BDE-160	63 ± 19
¹³ C-BDE-209	44 ± 24

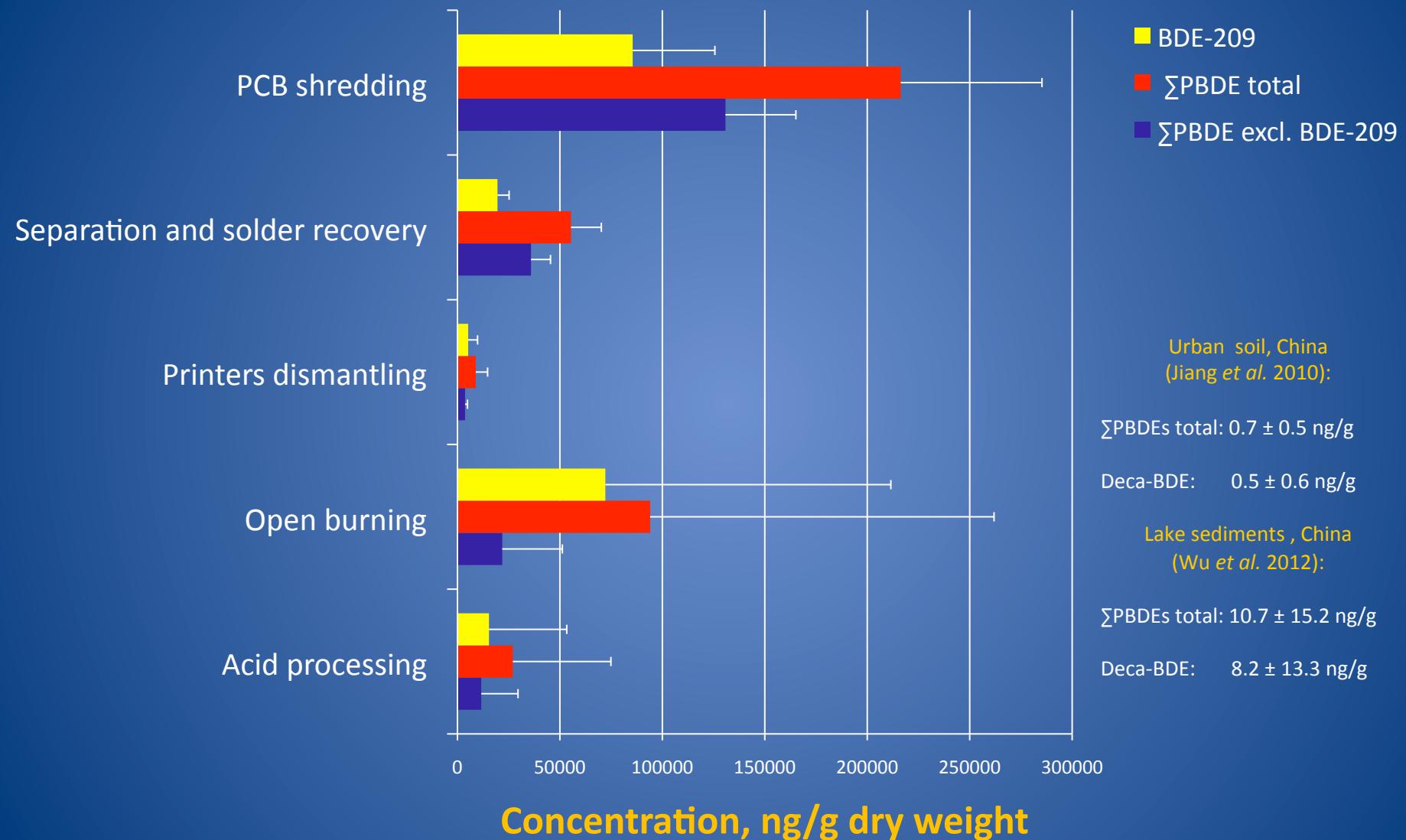
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Mean concentrations of PBDEs (ng/g d/w) in samples (n=29) from e-waste recycling sites at Guiyu, China.

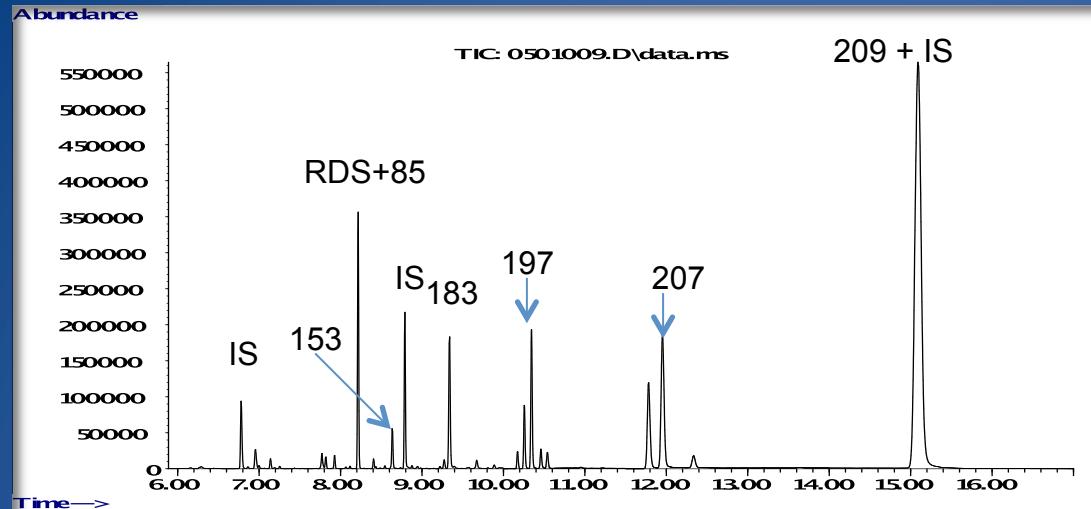


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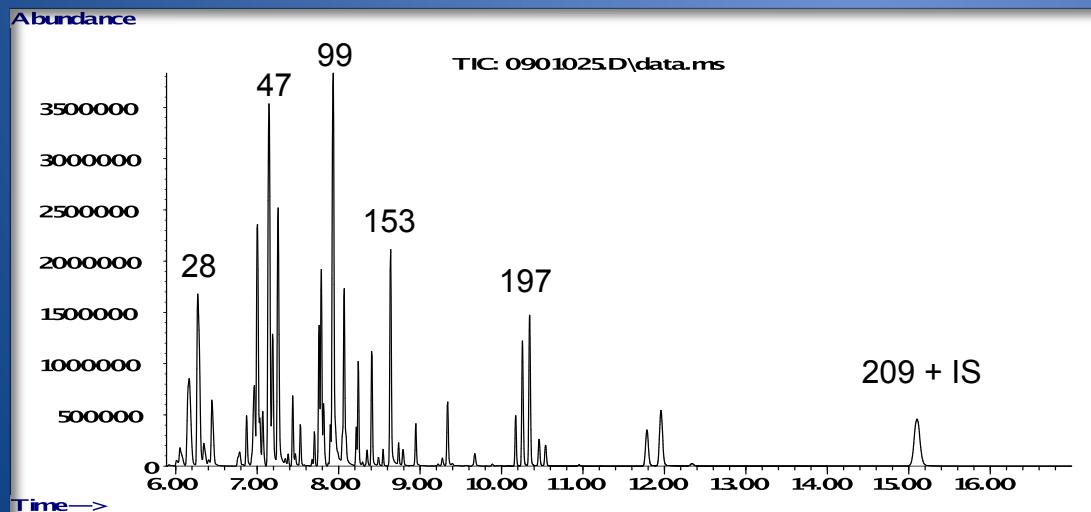
Mean PBDE concentrations in samples (n=29) collected from areas involved in various recycling activities at Guiyu, China



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Chromatogram of street dust/
soil sample SH1 around plastic
shredding workshop,
Longgang



Chromatogram of sediment
sample SH3 from Liangjiang
River receiving wastes from
PCB shredding workshop

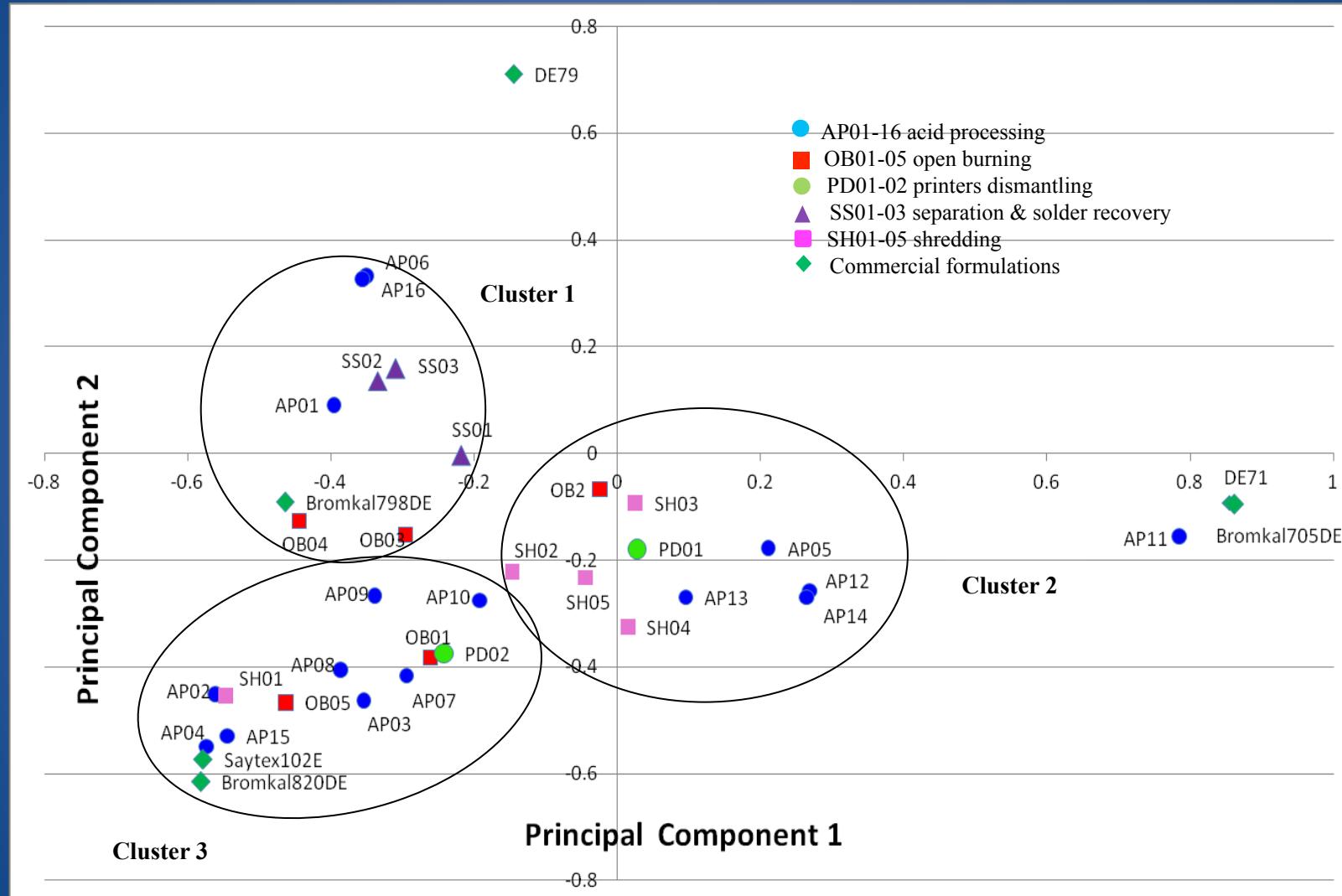
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Concentrations of PBDEs (in ng/g, dry weight) in current study and previously reported in samples collected from e-waste related sites in China and Thailand

Location	Matrix analysed	BDE-209 (range)	ΣPBDEs (range)	Average ^(av) or median ^(md) ΣPBDEs	Number of congeners	Source
Guiyu, Guangdong, China	soil, sediment, dust, ash, burnt e-wastes	96 – 320,000	140 – 390,000	66,000 ^{av} 15,000 ^{md} (n=29)*	tri-deca (14)	<i>Current study</i>
Four sites in Thailand	indoor dust, e-wastes storage	250 - 250,000	320 - 290,000	43,000 ^{av} 28,000 ^{md} (n=25)	tri-deca (21)	Muenhor <i>et al.</i> 2010
Guiyu, Guangdong, China	indoor dust, private houses	105 - 140,000	150 - 160,000	7,300 ^{av} 1,400 ^{md} (n=23)	di-deca (28)	Wang <i>et al.</i> 2010
Fengjiang, Taizhou, China	shredded residues of PCB and other plastics	977 - 6,390	997 - 163,000	45,500 ^{av} (n=5)	tri-deca (10)	Ma <i>et al.</i> 2009
Guiyu, Guangdong, China	soil, open burning site	328 - 48,600	398 – 63,300	21,200 ^{av} (n=3)	mono-deca (24)	Leung <i>et al.</i> 2007
Qingyuan, Guangdong, China	road soil, near e-wastes dismantling site	69 - 6,320	191 - 9,156	2,700 ^{av} (n=29)	mono-deca (22)	Luo <i>et al.</i> 2009
Fengjiang, Taizhou, China	indoor dust, e-wastes workshops floor	5,560 - 80,600	6,300 - 82,200	30,700 ^{av} (n=5)	tri-deca (10)	Ma <i>et al.</i> 2009



PCA of the samples associated with various e-waste recycling techniques employed at Guiyu, China.



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Conclusions

- A method was validated for quantitative determination of 14 PBDEs (tri- to deca-BDE) using an ASE technique with pentane as a solvent and ECNI GC/MS analysis in solid samples with moderate to high content of PBDEs
- The method was applied to analysis of samples (soil, sediment, dust, ash, and burnt e-wastes) collected at Guiyu, China
- The levels of PBDEs in samples around workshops at Guiyu detected in this study far exceeded those reported previously in background urban soils and sediments in China and were consistent with or exceeded those reported in previous studies around e-waste processing facilities
- The highest levels of contamination by PBDEs was associated with PCBs shredding and e-wastes open burning
- Strong evidence was provided that e-waste processing is a significant source of PBDEs to the environment
- PCA reveals a complex PBDE congener distribution suggesting contamination by two or even three commercial formulations which reflected the diverse range of wastes processed



Next steps

- Continue method development for PBDEs analysis in biological samples
- Conduct quantitative analysis for PBDEs in biological samples (eggs) collected from areas involved in e-wastes processing in China
- Assess human exposure to PBDEs via consumption of eggs sourced from areas influenced by e-waste processing



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Thank you for your attention !



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