SUPPLEMENTAL FILE 3:
RESIDENTIAL MONITORING DATA

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The summaries below are taken from primary data sources with reliability ratings of 1, 2 or 4 (OECD 2003).[1]

1 TBBPA

1.1 Measured Concentrations in Indoor Dust

Measured concentrations of TBBPA in indoor dust, extracted from ten sources, are summarized below and tabulated in Table S3-1.

North America

Indoor dust samples from 16 homes in the San Francisco Bay area of California were measured in 2006 and again in 2011 for 62 flame retardants and organohalogens, including TBBPA (Dodson et al., 2012). The samples were collected from surfaces in the living rooms using a vacuum cleaner and sieved to <150 µm. TBBPA was detected in the majority of the samples collected in 2006 at levels from <LOQ (<10) to 3,400 µg/kg (median 260 µg/kg) and in all samples collected in 2011 at 22 to 2,000 µg/kg (200 µg/kg median). Residents were also surveyed about the presence of furniture, carpets, and electronics in the home. The study authors found a significant association between the reduction of TBBPA concentrations between 2006 and 2011 and the presence of new electronics, suggesting that new electronics contain less TBBPA (rho = −0.69; p = 0.003).

Batterman et al. (2010) measured TBBPA and other brominated flame retardants in floor dust samples and other indoor media samples (ventilation filter dust, air, and/or carpets) that were collected in 2006 and 2007 from ten commercial and institutional buildings in southwest Michigan. Using a vacuum with a pre-cleaned and pre-weighed filter attached, floor dust was collected from office and public areas of the following types of sites: equipment sales and service, medical equipment manufacturing, art museum, university, tire and auto service, and computer server building. TBBPA concentrations in settled floor dust from nine of the buildings (1-3 samples per building) ranged from 20 to 938 µg/kg (223 µg/kg mean; 134 µg/kg median). The highest concentration was found in an office of a medical equipment manufacturing facility, at 938 µg/kg (n = 1). TBBPA was also detected in HVAC dust from exposed panel filters (n = 2 composite) and bag filters (n = 2 composite) of a university building at ~10 to 20 µg/kg (values estimated from figure).

Europe

Kopp et al. (2012) conducted a method development study in which a small number of house dust samples from Bavaria, Germany were analyzed by liquid chromatography–mass spectrometry (LC–MS/MS) following ultrasonic assisted solvent extraction and on-line sample preparation via column switching. House dust was collected from household vacuum bags and sieved to obtain the <63 µm

[1]For a rating of 1, the study should have a valid analytical method, data should be representative, statistical analysis could be conducted, and sampling (location, time period, matrix) should be adequate. For a rating of 2, three criteria from the rating of 1 should be met, excluding the requirement for conducting statistical analyses. A rating of 4 indicates that measurements are available but data are limited and reliability cannot be judged (OECD, 2003).

particle fraction for analysis. TBBPA concentrations in five house dust samples ranged from 2.9 to 232.8 µg/kg (59.1 µg/kg mean). Accuracy, precision and recovery were reported to be comparable to common LC–MS/MS methods in different matrices.

D'Hollander et al. (2010) measured TBBPA, as well as other brominated flame retardants and perfluorinated compounds, in indoor dust samples collected in 2008 from randomly selected homes and offices in Flanders, Belgium. Samples were collected in nylon socks mounted in the furniture attachment tube of vacuum cleaners. In office spaces, sampling was conducted by vacuuming a 10 m^2-area of floor surface. In homes, a 20 or 24 m^2-area of floor surface was sampled. The results showed TBBPA concentrations ranging from <LOQ (<3) to 419 µg/kg (11.7 µg/kg median) in homes, and a median concentration of 70.4 µg/kg in offices (range was not reported).

Geens et al. (2009) also determined the concentration of TBBPA and other phenolic organic contaminants in indoor dust samples from houses (n=18) and offices (n=2) in Flanders, Belgium. The samples were collected in the spring of 2008 using a vacuum cleaner. A nylon sock placed inside the tube of the vacuum cleaner was used to collect the dust. The main living room (8 m^2), bedroom (4 m^2) and kitchen (4 m^2) in each house were sampled. The results showed TBBPA concentrations ranging from 0.85 to 1,481 µg/kg (146 µg/kg mean; 10 µg/kg median) in house dust samples and from 45 to 100 µg/kg (75 µg/kg median) in offices.

In the West Midlands region of the United Kingdom, Harrad et al. (2010) sampled floor dust from 43 classrooms in daycare centers and primary schools during winter 2007 through spring 2008. The samples were collected in 25 µm mesh size socks attached to a portable vacuum cleaner. For this study, the entire floor surface of each classroom was vacuumed. Sampled floor surface areas ranged from 6 to 12 m^2. The results showed TBBPA concentrations ranging from 17 to 1,400 µg/kg (200 µg/kg mean; 110 µg/kg median).

Between September 2006 and June 2007, Abdallah et al. (2008) collected indoor dust samples in homes, offices, cars and public microenvironments (3 pubs and 1 restaurant) located in West Midlands and Basingstoke, Hampshire in the United Kingdom. The authors also collected indoor air samples (refer to Table C-2). Dust sampling was conducted by vacuuming 1 m^2 of carpet for 2 minutes in offices and homes. The vacuumed bare floors (4 m^2) for 4 minutes. In cars, the surface of the seats in direct contact with passengers was sampled for 2 minutes. Samples were collected using nylon sample socks (25 µm pore size) mounted in the furniture attachment tube of the vacuum cleaner. TBBPA concentrations ranged from <MQL to 382 µg/kg (87 ± 71 µg/kg mean; 62 µg/kg median) in homes; from <MQL to 140 µg/kg (49 ± 46 µg/kg mean; 36 µg/kg median) in offices; from <MQL to 25 µg/kg (6 ± 8 µg/kg mean; 2 µg/kg median) in cars; and from 52 to 350 µg/kg (220 ± 140 µg/kg mean; 230 µg/kg median) in the public microenvironments sampled. The reported MQL was 0.05 µg/kg. The measured TBBPA concentrations in car dust were significantly lower ($p < 0.05$) than those in homes and offices. No significant difference was observed between concentrations in homes and offices. In the sampled public microenvironments, TBBPA concentrations were higher than those in cars, homes or offices.

Asia

Ni and Zeng (2013) measured TBBPA in air conditioning filter dust samples from 56 offices in Shenzhen, China in 2009, presumably from a single building. The dust samples were collected by brushing the air

conditioner fiberglass filters, which trapped particles over 0.3 µm. TBBPA concentrations in the 56 dust samples ranged from 30 to 59,140 µg/kg (3,382 µg/kg mean; 975 µg/kg median). The study authors noted that since smaller particles may be more likely to blow through the filter or to remain on the filter after brushing, the TBBPA concentrations observed in the study may be underestimated.

Wang et al. (2013) sampled house dust from vacuum cleaner bags from one home in Changsha, China and one home in Guangzhou, China in 2012. Participants in the study were asked to avoid vacuum cleaning their homes for at least one week prior to collection of the samples. TBBPA was detected in the two samples at concentrations of 97 and 95 µg/kg.

Takigami et al. (2008) measured TBBPA in dust collected in 2005 from inside five television sets from a store in Japan. All five of the televisions (cathode-ray tube type; manufactured in Japan between 1989 and 1998) were previously used and had been traded in for purchase of new products. Dust was collected by vacuuming the inside of each television to obtain a minimum sample size of 200 mg. The results showed TBBPA concentrations ranging from 5,500 to 680,000 µg/kg (240,000 µg/kg mean) in TV interior dust samples. Pulverized sections of the television cabinet and circuit board were also analyzed in the study.

Table S3-1. Measured Concentrations of TBBPA in Indoor Dust

Location	Site	Year	N (# of ND)[a]	TBBPA Concentration (µg/kg)		Comments	Reference (Reliability Rating[d])
				Range[b]	Central Tendency[c]		
North America							
United States; San Francisco Bay Area, CA	Homes	2006 2011	16 (6%) 16 (0)	<10–3,400 22–2,000	260 median 200 median	Collected from surfaces in living room using a vacuum.	Dodson et al. (2012) (2)
United States; MI	Commercial and institutional buildings	2006-2007	9[e] (0)	20–938	223 mean; 134 median	Collected from floor of office/reception areas using a vacuum.	Batterman et al. (2010) (1)
Europe							
Germany; Bavaria	Homes	NR	5 (0)	2.9-232.8	59.1 mean	Collected from vacuum cleaner bags.	Kopp et al. (2012) (4)
Belgium; Flanders	Homes	2008	45 (NR)	<3-419	11.7 median	Collected from floor of living room, bedroom, kitchen, and working area (20 to 24 m^2 total) using a vacuum.	D'Hollander et al. (2010) (2)
	Offices		10 (NR)	NR	70.4 median	Collected from floor (10 m^2) using a vacuum.	
Belgium; Flanders	Homes	2008	18 (0)	0.85-1,481	146 mean; 10 median	Collected from main living room (8 m^2), bedroom (4 m^2) and kitchen (4 m^2) using a vacuum.	Geens et al. (2009) (1)
	Offices		2 (0)	45-100	75 median	Collected using vacuum.	
United Kingdom; West Midlands County	Daycare center and primary school classrooms	2007-2008	43 (0)	17-1,400	200 mean; 110 median	Collected from entire classroom floor using a vacuum.	Harrad et al. (2010) (4)
United Kingdom; West Midlands and Basingstoke, Hampshire	Homes	2006-2007	35 (1)	<0.05-382	87±71 mean; 62 median	Collected from floor of home, office, or pubic environment and from seat of car using a vacuum.	Abdallah et al. (2008) (1)
	Offices		28 (4)	<0.05-140	49±46 mean; 36 median		
	Cars		20 (10)	<0.05-25	6±8 mean; 2 median		
	Public microenvironments (3 pubs and 1 restaurant)		4 (0)	52-350	220±140 mean; 230 median		

Table S3-1. Measured Concentrations of TBBPA in Indoor Dust

Location	Site	Year	N (# of ND)[a]	TBBPA Concentration (µg/kg)		Comments	Reference (Reliability Rating[d])
				Range[b]	Central Tendency[c]		
Asia							
China; Shenzhen	Office buildings (56 offices total)	2009	56 (0)	30-59,140	3,382 mean; 975 median	Air conditioning filter dust	Ni and Zeng (2013) (1)
China; Changsha and Guangzhou	Homes	2012	2	95-97	NR	House dust samples collected from vacuum cleaner bags	Wang et al. (2013) (4)
Japan	Interior of used televisions	2005	5 (0)	5,500-680,000	240,000 mean	Cathode-ray tube type; manufactured in Japan between 1989 and 1998.	Takigami et al. (2008) (2)

NR = Not reported

[a] N refers to the number of samples, unless otherwise noted. The number of non-detect values is reported in parenthesis. Values reported as < "X" value are assumed to be non-detect.

[b] The range is the minimum and maximum values reported. Non-detect values are shown as less than the detection limit.

[c] The central tendency values shown are as reported in the reference.

[d] Reliability rating: 1 = valid without restrictions; 2 = valid with restrictions; 4 = not assignable.

[e] N represents the number of buildings, however, 18 samples were collected overall (1-3 samples per building).

1.2 Measured Concentrations in Indoor Air

Measured concentrations of TBBPA in indoor air, extracted from four sources, are summarized below and tabulated in Table S3-2.

North America

Indoor air samples collected from 10 commercial and institutional buildings in Michigan over a one week sampling period in 2006 and 2007 (Batterman et al., 2010) showed TBBPA concentrations ranging from ND to 86 pg/m^3 in the vapor phase and from ND to 12 pg/m^3 in the particulate phase. Mean concentrations were ND. Concentrations above the detection limit were only present in the vapor phase of 3 buildings (university and computer server offices) and in the particulate phase of 3 buildings (medical equipment manufacturer, university, and tire store offices).

Europe

As part of a screening investigation on brominated flame retardants in environmental samples from Nordic countries, Schlabach et al. (2011) collected three indoor air samples from the Norwegian Climate and Pollution Agency (KLIF) building in Oslo, Norway. Indoor air samples were collected 1.5 m above the floor level. The sampling time for indoor air was one week. All three indoor air samples collected were below the detection limit of 100 pg/m^3 in the particulate phase. The vapor phase was not collected. Outdoor air samples were also collected during the same sampling period (refer to Appendix E).

In addition to indoor dust, Abdallah et al. (2008) collected indoor air samples in homes, offices, and public microenvironments (3 pubs and 1 restaurant) in Birmingham, West Midlands within the United Kingdom. The authors collected samples between February and December 2007. During method development it was observed that airborne TBBPA was present mainly in the particulate phase; therefore, active air samplers were used to collect samples for TBPPA analysis. TBBPA concentrations ranged from 9 to 22 pg/m^3 (16 ± 5 pg/m^3 mean; 15 pg/m^3 median) in home indoor air, 4 to 33 pg/m^3 (16 ± 12 pg/m^3 mean; 11 pg/m^3 median) in office indoor air, and 17 to 33 pg/m^3 (26 ± 7 mean; 27 pg/m^3 median) in the public microenvironments sampled. The small number of samples collected precluded statistical analysis of differences in TBPPA concentrations between the various microenvironment categories. However, the study authors noted that there were no substantial differences between concentrations in public microenvironments and those in homes and offices.

Asia

Using measured TBBPA concentrations in air conditioning filter dust samples collected from an office building in Shenzhen, China (refer to Table S3-1), Ni and Zeng (2013) calculated TBBPA concentrations in the particular phase of indoor office air, using an equation described in Ni and Zeng (2011). TBBPA concentrations were estimated to range from 12.7 to 1,057 pg/m^3 (465 pg/m^3 mean; 507 pg/m^3 median) in $PM_{2.5}$ (representing dust with particle diameter of 0.4–2.2 μm) and from 6.26 to 511 pg/m^3

(235 pg/m^3 mean; 240 pg/m^3 median) in PM_{10} (representing dust with particle diameter of 2.5–8.9 µm).

Table S3-2. Measured Concentrations of TBBPA in Indoor Air

Location	Site	Year	N (# ND)	Phase	TBBPA Concentration (pg/m³)		Comments	Reference (Reliability Rating)
					Range	Central Tendency		
North America								
United States; MI	Commercial and institutional buildings	2006-2007	10[e] (7)	Vapor	ND-86	ND mean	Detection limit not provided.	Batterman et al. (2010) (1)
			10[e] (7)	Particulate	ND-12	ND mean	One week sampling period.	
Europe								
Norway; Oslo	KLIF building	2009	3 (3)	Particulate	All <100	--	One week sampling period. Inlet 1.5 m above the floor level.	Schlabach et al. (2011) (4)
United Kingdom; West Midlands	Homes	2007	5 (0)	Particulate	9-22	16±5 mean; 15 median		Abdallah et al. (2008) (1)
	Office		5 (0)	Particulate	4-33	16±12 mean; 11 median		
	Public microenvironments (3 pubs and 1 restaurant)		4 (0)	Particulate	17-33	26±7 mean; 27 median		
China								
China; Shenzhen	Office Building (56 offices total)	2009	56 (0)	Particulate ($PM_{2.5}$)	12.7-1,057	465 mean; 507 median	Values calculated from measured TBBPA concentrations in air conditioning filter dust samples (refer to Table C-1).	Ni and Zeng (2013) (1)
			56 (0)	Particulate (PM_{10})	6.26-511	235 mean; 240 median		

NR = Not reported

[a] N refers to the number of samples, unless otherwise noted. The number of non-detect values is reported in parenthesis. Values reported as < "X" value are assumed to be non-detect.

[b] The range is the minimum and maximum values reported. Non-detect values are shown as less than the detection limit.

[c] The central tendency values shown are as reported in the reference.

[d] Reliability rating: 1 = valid without restrictions; 2 = valid with restrictions; 4 = not assignable.

[e] N represents the number of buildings, however, 12 samples were collected overall (1-2 samples per building).

1.3 Measured Concentrations in Food

Measured concentrations of TBBPA in food, extracted from five sources, are summarized below and tabulated in Table S3-3. Note that this section only includes data for food samples obtained from markets. However, some wildlife biota samples may also be categorized as food (refer to Supplemental File 2: TBBPA Environmental Monitoring Data, Table S2-8).

Europe

Driffield et al. (2008) analyzed food samples from the United Kingdom for brominated flame retardants, including TBBPA, using a LC-MS/MS method developed and validated in-house, and calculated estimated adult dietary intakes. The food samples analyzed were purchased from randomly-selected locations across the United Kingdom as part of the 2004 UK Total Diet Study (TDS). Food samples were prepared and cooked according to normal consumer practices before being pooled into composite samples representing 19 food groups for analysis. The food groups included: bread, miscellaneous cereals, carcass meat, offal, meat products, poultry, fish, oils and fats, eggs, sugars and preserves, green vegetables, potatoes, other vegetables, canned vegetables, fresh fruit, fruit products, milk, dairy products and nuts. TBBPA was not detected in any of the composite food samples; LODs ranged from <0.017 to <0.19 µg/kg whole wt. The authors also present results for shellfish samples collected in Scotland (see Table S2-8). In the 2001 UK TDS (UKFSA, 2004), TBBPA was also not detected above the LOD in any of the food groups; LODs ranged from <0.78 to <30 µg/kg fat wt.

Grumping et al. (2007) collected cow's milk samples from Ireland in 2006. Pooled samples were tested for the presence of various brominated flame retardants, including TBBPA. TBBPA was not detected in any of the samples above the LOQ (200 ng/kg fresh wt).

Asia

Pooled food samples collected during China's fourth TDS in 2007 were investigated for levels of TBBPA and HBCD (Shi et al., 2009). Investigators collected food samples from markets in 12 provinces in China. The authors prepared and cooked the samples according to consumer practices prior to being blended into composite samples representing four food groups: meat, eggs, aquatic food, and milk. Concentrations of TBBPA ranged from <LOD to 2.044 µg/kg lipid wt, and TBBPA was detected in 26 of 48 composite samples. LODs ranged from 0.05 to 0.10 µg/kg wet wt.

Ashizuka et al. (2008) investigated the concentrations of TBBPA and other brominated flame retardants in fish purchased at markets in three regions of Japan between October 2004 and February 2005. The samples represented a commercialized and industrialized area (N region), an industrialized area (S region), and a less industrialized area (K region). The experimenters purchased various species and numbers of fish at markets in these three regions. Edible portions were blended to obtain 15 pooled samples per region. The authors reported the approximate size, weight, and type of fish sampled. The detection limit for TBBPA was 0.01 µg/kg wet wt. Across all regions, concentrations of TBBPA ranged from <LOD to 0.11 µg/kg wet wt, with a mean of 0.02 µg/kg wet wt. Sixteen of the 45 pooled samples were reported as non-detects. Fish from N region had TBBPA levels that ranged from <LOD to 0.04 µg/kg wet wt, with a mean of 0.01 µg/kg wet wt. Fish from S region had TBBPA concentrations ranging

from <LOD to 0.10 µg/kg wet wt, with a mean of 0.01 µg/kg wet wt. Finally, in fish from K region, TBBPA ranged from <LOD to 0.11 µg/kg wet wt, with a mean of 0.02 µg/kg wet wt. The results reported in Ashizuka et al. (2008) appear to be the same as presented in Nakagawa et al. (2006).

Table S3-3. Measured Concentrations of TBBPA in Food.

Media (Sub-Type)	Location	Year	N (# ND) [a]	TBBPA Concentration (µg/kg)		Comments	Reference (Reliability Rating [d])
				Range [b]	Central Tendency [c]		
Europe							
19 Food Groups	United Kingdom	2004	19	All <LOD (<0.017 - <0.19 whole wt)	--	Samples were purchased from randomly-selected locations across the UK as part of the 2004 UK Total Dietary Study, prepared and cooked according to normal consumer practices, and combined to represent 19 food groups. Concentrations were corrected for recovery.	Driffield et al. (2008) (2)
19 Food Groups	United Kingdom	2001	19	All <LOD (<0.78 - <30 fat wt)	--	Samples were purchased from randomly-selected locations across the UK as part of the 2001 Total Dietary Study. The samples were prepared and cooked according to normal consumer practices before being pooled into composite samples representing 19 food groups for analysis.	UKFSA (2004) (4)
Cow's Milk	Ireland	2006	5 (5)	All <0.2 fresh wt	--	5 pooled samples consisted of 3 individual samples each.	Grumping et al. (2007) (4)
Asia							
4 Food Groups	China	2007	48 (22)	<LOD - 2.044 lipid wt	NR	Samples were collected from markets in 12 Chinese provinces, prepared and cooked to a "table ready" state, and blended to form composite/pooled samples. LOD ranged from 0.05 to 0.10 wet wt; LOD not provided for lipid weight.	Shi et al. (2009) (2)
Fish	Japan (N region: Commercial and Industrial)	2004-2005	15 (7)	<0.01-0.04 wet wt	0.01 wet wt mean	15 pooled fish samples purchased at market. Fish fat contents are available in study.	Ashizuka et al. (2008) (4); Nakagawa et al. (2006) (4)
	Japan (S region: Industrial)		15 (7)	<0.01-0.10 wet wt	0.01 wet wt mean	15 pooled fish samples purchased at market. Fish fat contents are available in study.	
	Japan (K region: Less Industrial)		15 (2)	<0.01-0.11 wet wt	0.02 wet wt mean	15 pooled fish samples purchased at market. Fish fat contents are available in study.	
	Japan (Overall)		45 (16)	<0.01-0.11 wet wt	0.02 wet wt mean	45 pooled fish samples purchased at market. Fish fat contents are available in study. Authors note that TBBPA didn't correlate with fish size or fat content.	

[a] N refers to the number of samples, unless otherwise noted. The number of non-detect values is reported in parenthesis. Values reported as "<X" are assumed to be non-detect.

[b] The range is the minimum and maximum values reported. Non-detect values are shown as less than the detection limit.

[c] The central tendency values shown are as reported in the reference.

[d] Reliability rating: 1 = valid without restrictions; 2 = valid with restrictions; 4 = not assignable.

2 TBBPA-bis(dibromopropyl ether)

Monitoring information on TBBPA-bis(dibromopropyl ether) is included below. Note, that individual summaries of each study are not provided as they were for TBBPA. However, there is significant overlap in the studies that measured TBBPA and those that measured this cluster member.

Table S3-3. Measured Concentrations of TBBPA-bis(dibromopropyl ether) in Dust

Env. Medium	Country	Location Details	Date	Single Est.@	Range (% non-detects)	Wt. type	Detect. limit**	N	Units*	Reference
Dust from living rooms	United States	Inside homes	2006	22 (median)	< 10 – 180 (25%)	-	10 (LOQ)	16	µg/kg	Dodson et al. (2012)
Dust from living rooms	United States	Inside homes	2011	7 (median)	< 10 – 560 (50%)	-	10 (LOQ)	16	µg/kg	Dodson et al. (2012)
Dust outdoors in e-waste area	China	Qingyuan suburb	2006	n.d.	n.d.	dry	1.5	5	µg/kg	Shi, T. et al. (2009)

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