SUPPLEMENTAL FILE 2:
ENVIRONMENTAL AND WILDLIFE MONITORING DATA

Prepared by

Versar Incorporated
6850 Versar Center
Springfield, VA 22151

Under
EPA contract EP-W-10-005

Also Prepared by

U.S. Environmental Protection Agency
1600 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Table of Contents

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 Surface Water (Dissolved and Particulate Phases)

Measured concentrations of TBBPA in surface water, extracted from eight sources, are summarized below and tabulated in Table S2-1.

North America

As part of a Masters of Science thesis presented to the University of Guelph, Quade (2003) developed an analytical method for the determination of TBBPA in sediment (suspended and bottom) and sewage sludge using accelerated solvent extraction and micro-column clean-up prior to analysis by isotope dilution gas chromatography high resolution mass spectrometry (GC/HRMS). Because the chemical analysis did not include partitioning or fractionating steps that would separate TBBPA from any methylated TBBPA (MeTBBPA) that may be present in the sediment originally, and the samples were methylated during analysis, the reported TBBPA concentrations are the sum of both TBBPA and MeTBBPA. Quade (2003) tested the method on suspended sediment samples (i.e. particulate phase of surface water) collected from the Detroit River in 2000. There were no known point sources of TBBPA in the Detroit River system. However, the area is heavily industrialized and densely populated. TBBPA was detected in all eight samples at concentrations of 0.6 to 1.84 µg/kg dw. The highest concentration was from a sample collected downstream from a Detroit River sewage treatment plant.

Pellizzari et al. (1978) conducted a study in southern Arkansas to investigate the presence of brominated organic compounds in the environment from a geographical area associated with the bromine industry. Various environmental media samples (water, sediment, soil and ambient air) were collected on and off plant property for analysis of TBBPA and other brominated chemicals. TBBPA was not detected (< 50 µg/L) in two surface water samples collected near one facility in El Dorado, AR in April 1977. The type of water body sampled was not reported.

Europe

Harrad et al. (2009) assessed the seasonal and spatial variability of TBBPA and HBCD in surface water collected from nine English lakes with no known major point source inputs. Sediment and fish were collected in the study as well. Average TBBPA concentrations in three water samples collected from

[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).

each lake in the summer, fall and winter of 2008-2009 ranged from 0.000076 to 0.002083 µg/L in the dissolved phase, 0.000061 to 0.001273 µg/L in the suspended sediment phase, and 0.000140 to 0.003200 in the combined phase (sum of dissolved and suspended sediment phase). Seasonal variation of TBBPA in water was reported as minimal. However, the intersite spatial variability was relatively high. The site with the highest TBBPA concentration had an average value that was 23 times higher than the site with the lowest average concentration.

As part of an analytical method development study for the simultaneous determination of select brominated flame retardants in river water and in river bed sediment, (Labadie et al., 2010) measured TBBPA concentrations in water and sediment samples collected in 2008 from five sampling stations on a suburban river (Predecelle River) in Paris, France. Acceptable recoveries were achieved. As analyzed by gas chromatography coupled to negative chemical ionisation mass spectrometry (GC-NCI-MS), TBBPA concentrations were <MDL (<0.000035 µg/L) in the particulate phase (n=5), and ranged from <MDL (<0.000035) to 0.000064 µg/L in the dissolved phase (n=5).

Asia

Two recent studies have investigated the presence of TBBPA in lakes located near highly developed regions in eastern China. In 2010, Xu et al. (2013) investigated the occurrence and distribution characteristics of TBBPA in water and sediments from a severely eutrophic lake, Taihu Lake. In the dissolved phase of water samples, TBBPA concentrations ranged from <LOD (<0.00013) to 0.00112 µg/L. TBBPA was detected in 3 of 12 samples.

Yang et al. (2012) conducted a study in 2008 to investigate the tissue distribution of TBBPA in four fish species and the seasonal variation of TBBPA in the lake water and sediment of Lake Chaohu. This lake is located near several brominated flame retardant manufacturers. TBBPA concentrations in water samples collected from seven sampling stations in July, September, and November ranged from <MQL (<0.04) to 4.87 µg/L. TBBPA concentrations in water followed a temporal pattern with levels highest in July followed by September and then November (P>0.05).

He et al. (2013) determined TBBPA and HBCD concentrations in water, sediments, sediment cores, and three fish species in the Dongjiang River, which runs through a highly industrialized area of southern China. TBBPA was detected in the dissolved phase of all five water samples collected in 2010 at concentrations ranging from 0.001110 to 0.002830 µg/L (0.001750 µg/L mean). TBBPA ranged from ND to 1.6 µg/kg dw (1.3 µg/kg dw mean) in the particulate phase.

The Environment Agency of Japan has been investigating levels of chemical substances in the environment since fiscal year 1974. In the environmental survey, TBBPA was most recently evaluated in 2007, where it was detected at one of 48 sites (one sample) at a value of 0.0051 µg/L. The detection limit was 0.0021 µg/L (MOE, 2014).

Table S2-1. Measured Concentrations of TBBPA in Surface Water (Dissolved and Particulate Phases)

Location	Water Body	Year	Phase	N (# ND) [a]	TBBPA Concentration (µg/L, unless noted otherwise)		Comments	Reference (Reliability Rating [d])
					Range [b]	Central Tendency [c]		
North America								
United States; Detroit, MI	Detroit River	2000	Particulate	8 (0)	0.6-1.84 (µg/kg dw)[e]	NR	Heavily industrialized and densely populated; the highest concentration was collected downstream from a sewage treatment plant	Quade (2003) (4)
United States; El Dorado, AR	Not Reported	1977	NR	2 (2)	All <50	--	In vicinity of an organo-bromide production facility	Pellizzari et al. (1978) (2)
Europe								
England	9 Lakes	2008-2009; summer, fall, winter	Dissolved Particulate Combined	27 (0) 27 (0) 27 (0)	0.000076-0.002083[f] 0.000061-0.001273[f] 0.000140-0.003200[f]	NR NR NR	No known major point source inputs	Harrad et al. (2009) (2)
France; Paris	Predecelle River	2008	Dissolved Particulate	5 (2) 5 (5)	<0.000035-0.000064 <0.000035	NR NR	Suburban; up and downstream WWTP and towns	Labadie et al. (2010) (2)
Germany			-	Upstream: 15 (11) Downstream: 15 (12)	Upstream: 0.0081-0.0204 Downstream: 0.0011-0.0188	NR	Near sewage treatment plants	Kuch et al. (2001) (4)
Asia								
China, eastern	Taihu Lake	2010	Dissolved	12 (9)	<0.00013-0.00112	NR	Adjacent to highly developed cities and towns; severe eutrophication	Xu et al. (2013) (2)
China, eastern	Lake Chaohu	2008; Jul, Sep, and Dec	NR	7 sites (NR)	<0.04-4.87	NR	Adjacent to most developed regions in China	Yang et al. (2012) (2)
China, southern	Dongjiang River	2010	Dissolved Particulate	5 (0) 5 (NR)	0.001110-0.002830 ND-1.6 (µg/kg dw)	0.00175 mean 1.3 (µg/kg dw) mean	Highly industrialized	He et al. (2013) (2)
Japan; 48 sites	NR	2007	NR	48 (47)	< 0.0021 - 0.0051	NR		MOE (2014) ENREF 19(4)

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] Sum of both TBBPA and MeTBBPA.

[f] Mean values of 3 samples per lake.

1.2 Measured Concentrations in Sediment

Measured concentrations of TBBPA in sediment, extracted from twenty-two sources, are summarized below and tabulated in Table S2-2.

North America

In addition to suspended sediment from the Detroit River (refer to Table S2-1), Quade (2003) analyzed bottom sediment collected from eight stations on Lake Ontario in 2002. TBBPA (determined as the sum of both TBBPA and MeTBBPA) was quantified in three of the eight samples (0.029 to 0.063 µg/kg dw) and was below the detection limit in the other five samples. Quade (2003) noted that laboratory recoveries were small in some samples (34-38%), possibly due to organic content of the samples. The reported concentrations, however, accounted for the losses during preparation and clean-up because calculations were based on the response to the labeled internal standard.

TBBPA concentrations in sediment samples collected in the Pellizzari et al. (1978) study from the vicinity of multiple organo-bromide production facilities in southern Arkansas in 1976 and 1977 ranged from ND to 330,000 µg/kg (wet or dry weight not reported). TBBPA was detected in six of the eight samples. The highest concentration was from a sample collected in water backed up in a reclamation area. Other samples were collected from ponds and running water.

South America

Baron et al. (2013) investigated the presence of brominated flame retardants in coastal, estuarine and river sediments from highly urbanized and industrialized areas of Colombia (n=13) and Chile (n=19). According to the authors, TBBPA was only detected in two Columbian samples (Bocas de Ceniza and Mallorquin Swamp) at a maximum concentration of 0.58 µg/kg dw. However, it should be noted that this value is <LOD (<2.7 µg/kg dw).

Europe

In the Harrad et al. (2009) study, surficial sediment samples collected in 2008-2009 from nine English lakes with no known major point source inputs showed detectable levels of TBBPA in all samples. Concentrations ranged from 0.33 to 3.8 µg/kg dw (n=9).

Mean concentrations of TBBPA in river bed sediment samples collected in 2008 from five sampling stations on the Predecelle River, a suburban river in Paris, France, ranged from 0.065 to 0.280 µg/kg dw (Labadie et al., 2010).

In Spain, sewage sludge and sediment samples from the Ebro River and Cinca River were analyzed as part of an analytical method development study for the simultaneous determination and quantification of TBBPA and related compounds and HBCD using liquid chromatography–quadrupole linear ion trap mass spectrometry (LC-QqLIT-MS) (Guerra et al., 2010). In three sediment samples collected in 2008 from the Ebro River near three different WWTPs, TBBPA concentrations ranged from <LOD (<2.7) to 3.1 µg/kg dw. In four sediment samples collected in 2006 from the Cinco River, up- and

down-stream of a heavily industrialized town with a chemical industry, TBBPA concentrations ranged from <LOD (<2.7) to 15 µg/kg dw. The maximum concentration was detected in the sample collected at the station near the industrial town.

The Nordic Council of Ministers conducted a preliminary investigation of the presence of emerging brominated flame retardants in the Nordic environment through the collection of a few samples from a variety of media (air, sediment sludge, and biota) at several sites (Schlabach et al., 2011). Environmental samples were collected between 2005 and 2010, with the majority collected in 2009. Sediment samples were collected in urban areas of Denmark (n=2; marine), Faroe Islands (n=3; marine), Finland (n=3; bays and lake), Sweden (n=1) and Norway (n=1; marine). Most samples were collected near WWTPs, sludge treatment plants or presumed hotspots. TBBPA was detected in only one sample from the Faroe Islands (presumed urban hotspot) at 16 µg/kg dw. TBBPA was below the detection limit, which ranged from <0.1 to <0.4 µg/kg dw, in all remaining samples

A study was also conducted by the Norwegian Institute for Water Research in 2003 to investigate contamination with brominated flame retardants and chlorinated paraffins in sediment and fish of the Drammens River and the Drammensfjordd, located in an industrialized area in the southeast of Norway (Schlabach et al., 2004). TBBPA was detected in all sediment samples at concentrations of 0.02 to 10 µg/kg dw in the Drammens River (n=7) and at 0.3 to 39.2 µg/kg dw in the Drammensfjordd. The highest concentrations in the Drammens River and the Drammensfjordd were closest to the industrial area.

The Netherlands Institute for Fisheries Research (de Boer et al., 2002) conducted a multi-part study in which TBBPA and HBCD were measured in sediment, sewage sludge, landfill leachate and aquatic biota from rivers and estuaries surrounding the North Sea. Select results, as well as a summary of the data, were also presented in Morris et al. (2004). In river and estuarine sediment collected between 2000 and 2002 from the United Kingdom, Belgium, the Netherlands and Ireland, TBBPA concentrations ranged from ND (<0.1-<2.4) to 9,753 µg/kg dw (n=73). The highest concentration measured was found in a freshwater sediment sample from the River Skerne in northeast England, near the vicinity of a BFR manufacturer. The River Skerne is a tributary of the Tees River, which showed the next highest TBBPA concentrations in England (ND to 57.7 µg/kg dw). TBBPA was not present, however, in the sediment sampled offshore of the Tees estuary.

In a Swedish study (Sellstrom and Jansson, 1995) that analyzed a limited number of sediment and sewage sludge samples, TBBPA was detected in surficial sediment samples (n=2) collected upstream and downstream of a plastics industry where TBBPA is used. TBPPA concentrations were 34 and 270 µg/kg dw, respectively.

Asia

Recently, numerous studies have been conducted in China to investigate levels of TBBPA and other brominated flame retardants in the environment. As part of an analytical method development study using enzyme-linked immunosorbent assay (ELISA), Xu et al. (2012) determined TBBPA levels in soils from farmlands, soils from an e-waste recycling site, and in sediments of a canal, all collected in 2011 from the Beijing area. The results agreed well with those of a LC-MS/MS method. In thirteen surface sediment samples collected along the Qinghe canal, TBBPA was detected at concentrations ranging

from 0.3 to 22 µg/kg dw (7.7 µg/kg dw mean). The canal receives widespread runoff, discharge from sewage treatment plants, and direct dumping of household and yard wastes. Samples with elevated TBBPA levels were collected from the vicinity of downtown and an upstream e-waste site.

Qu et al. (2013) analyzed samples of soil, sediment, rice hull and earthworms collected near a brominated flame retardant manufacturing plant in Liuyang, Hunan, China for TBBPA and/or TBBPA derivatives. Additionally, mollusks from nine cities on the Bohai Sea were analyzed. TBBPA concentrations in sediment collected from six sites in the Liuyang River in 2010 ranged from <LOD (<0.03) to 132 µg/kg dw. TBBPA levels were highest in sediment samples collected near the outlet of the BFR plant and decreased downstream. The lowest levels were detected in sediment found upstream of the BFR plant. As such, the authors state that the brominated flame retardant plant is most likely the release source of TBBPA and derivatives.

In addition to surface water, Xu et al. (2013) and Yang et al. (2012) investigated TBBPA levels in sediment samples collected from two eastern Chinese lakes located near highly developed regions. In Xu et al. (2013), TBBPA concentrations in surface sediment samples collected in 2009 from Taihu Lake (n=12) ranged from 0.056 to 2.15 µg/kg dw (0.7 ± 0.54 µg/kg dw mean). Higher concentrations were noted in areas more influenced by human activities.

In samples from Lake Chaohu collected in 2008, Yang et al. (2012) measured mean TBBPA concentrations of 105.8 to 230.5 µg/kg dw in surface sediments (maximum individual concentration of 518 µg/kg dw) and 88 to 155 µg/kg dw in sediment cores (0-12 cm). The highest levels were observed at the entrance of the most polluted inflow rivers and nearest an industrial city. TBBPA concentrations in surface sediment followed a temporal pattern. The levels were highest in spring, lower in autumn, even lower in summer and the lowest in winter ($P<0.05$). The concentrations of TBBPA in the sediment cores decreased from surface to bottom layers.

In the He et al. (2013) study of the sediment, water and fish of the Dongjiang River, which runs through a highly industrialized area of southern China, TBBPA was detected in the majority of the surface sediment samples collected in 2010 (39 of 42 samples). TBBPA concentrations ranged from ND to 82.3 µg/kg dw (15.2 µg/kg dw mean). Two sediment cores (0-76 cm) were also collected. TBBPA concentrations ranged from 7.9 to 450 µg/kg dw (n=13; 91.6 µg/kg dw mean) in the core from the outlet of the largest tributary of the catchment (Core 1) and from 0.2 to 14 µg/kg dw (n=15; 2.9 µg/kg dw mean) in the core situated in the middle of one small tributary of the catchment (Core 2). In both cores, TBBPA levels were significantly higher in the upper section than the lower section.

Surface sediment from six rivers, including the Dongjiang River, and an estuary in the Pearl River Delta of southern China, were also investigated by Feng et al. (2012) for the presence of TBBPA in samples collected between 2009 and 2010. Overall, TBBPA was detected in the majority of the samples at concentrations ranging from <MDL (<0.025) to 304 µg/kg dw (n=121). Mean concentrations ranged from 0.471 µg/kg dw in the Pearl River Estuary to 64.7 µg/kg dw in the Dayanhe River. Both rural and urban rivers were sampled, with the majority of the rivers impacted by industry. The highest concentrations were in the Dayanhe River, which runs through an agricultural area where e-waste is also processed.

TBBPA levels in surface sediment and sediment cores from the Dongjiang River were also previously measured in 2006 by Zhang et al. (2009). No TBBPA manufacturing plants were located in the study region. TBBPA was present in all surface sediment samples (n=15), at 3.8 to 230 µg/kg dw. In cores (0-60 cm), TBBPA was highest in the upper sections at maximum levels of 9.4 to 18 µg/kg dw.

Several studies have investigated the occurrence of TBBPA in the Japanese environment. Ohta et al. (2004) investigated the levels of TBBPA and other brominated flame retardants in stock fish of the Osaka Bay and in sediment collected from the coastal area of the Setouchi Sea in 2003. TBBPA was detected in 17 sediment samples from the Setouchi Sea at 0.08 to 5 µg/kg dw. The highest levels were from samples collected from an area containing many chemical factories.

Watanabe et al. (1983a) analyzed sediment from samples in estuaries in the Osaka Bay and rivers in Osaka, as well as in estuaries outside of Osaka. All samples were collected between 1981 and 1983. TBBPA levels were lowest in sediment from estuaries outside of Osaka, at ND (<0.5) to 1.8 µg/kg dw (n=7). In the estuaries of the Osaka Bay, TBBPA levels ranged from 0.5 to 4.5 µg/kg dw (n=6). Levels were highest in sediment from rivers in Osaka, at 22 to 140 µg/kg dw (n=6). The sampling sites in the rivers were near the city center of Osaka and receive large amounts of effluents from sewage treatment plants, municipal incinerators and factories.

The environmental surveys conducted across Japan by the Environment Agency of Japan show that TBBPA was detected (<0.57 – 6.2 µg/kg dw) in 26 sediment samples collected from 64 sampling areas in 2007 (n=192) (MOE, 2014).

Table S2-2. Measured Concentrations of TBBPA in Sediment

Location	Water Body	Year	N (# ND)[a]	TBBPA Concentration (µg/kg dw)		Comments	Reference (Reliability Rating [d])
				Range [b]	Central Tendency [c]		
North America							
United States and Canada	Lake Ontario; 8 stations	2002	8 (5)	ND – 0.063[e]	NR		Quade (2003) (4)
United States; El Dorado, AR	Ponds, clear running water, reclamation areas	1976-1977	8 (2)	ND – 330,000 (weight type not reported)	NR	In vicinity of organo-bromide production facilities	Pellizzari et al. (1978) (2)
South America							
Columbia	Magdalena River area (coastal, estuarine, and river); 5 sites	2009-2010	13 (13[f])	All <2.7[f]	--	Highly urbanized and industrialized areas	Baron et al. (2013) (2)
Chile	Biobio region (coastal and estuarine); 3 sites	2009-2010	19 (19)	All <2.7	--	Highly urbanized and industrialized areas	
Europe							
England	9 lakes	2008-2009	9 (0)	0.33-3.8	NR	No known major point source inputs	Harrad et al. (2009) (2)
France; Paris	Predecelle River; 5 stations	2008	15 (0)	0.065-0.28[g]	NR	Suburban river; Up and downstream up WWTP and towns	Labadie et al. (2010) (2)
Spain	Ebro River Cinca River	2008 2006	3 (1) 4 (2)	<2.7-3.1 <2.7-15	NR NR	-Near WWTP -Up and downstream of town with chemical industry	Guerra et al. (2010) (2)
Denmark	Two marine sites	2009	2 (2)	All <0.2	--	-One sample collected close to sludge treatment outlet, urban	Schlabach et al. (2011) (4)
Faroe Islands	Three marine/harbor sites	2007-2009	3 (2)	<0.1-16	NR	-Presumed hotspots, urban	
Finland	Two coastal/estuary bays; one lake	2009	3 (3)	All <0.1	--	-Major multi-affected rivers; lake downstream of a city	
Sweden	NR	2009	3 (3)	All <0.4	--	-Near effluent points of WWTPs, urban	
Norway	One marine site	2009	1 (1)	All <0.1	--	-Receiving water of WWTP, urban	
Norway	Drammens River Drammensfjord	2003 2003	7 (0) 4 (0)	0.02-10 0.3-39.2	NR NR	Highest levels were close to industrial areas	Schlabach et al. (2004) (4)
Belgium	Scheldt Basin (11 rivers)	2001	19 (4)	<0.1-67	5.4±16 mean		de Boer et al. (2002) (4) and Morris et al. (2004) (2)
The Netherlands	Western Scheldt (estuarine)	2000	19 (6)	<0.1-3.2	1±1 mean		
The Netherlands	8 rivers (estuarine and riverine)	2000	9 (1)	<0.1-6.9	2.2±2.2 mean		
United Kingdom	6 rivers (estuarine and riverine)	2000-2002	22 (12)	<2.4-9,753	451±2077 mean	Maximum value from River Skerne near the vicinity of a BFR manufacturer	

Table S2-2. Measured Concentrations of TBBPA in Sediment

Location	Water Body	Year	N (# ND)[a]	TBBPA Concentration (µg/kg dw)		Comments	Reference (Reliability Rating [d])
				Range [b]	Central Tendency [c]		
Ireland	Two rivers	NR	4 (1)	<2.4-3.7	NR		de Boer et al. (2002) (4)
Sweden	NR	NR	Up: 1 (0) Down: 1 (0)	Up: 34 Down: 270	-- --	Up and downstream of plastics industry were TBBPA is used	Sellstrom and Jansson (1995) (2)
Asia							
China, northern; Beijing	Qinghe Canal	2011	13 (0)	0.3-22	7.7 mean	Urban	Xu et al. (2012) (2)
China, eastern; Liuyang, Hunan	Liuyang River	2010	6 sites (NR)	<0.03-132	NR	Up- and downstream of the effluent outlet of a BFR factory	Qu et al. (2013) (1)
China, eastern	Taihu Lake	2010	12 (0)	0.056-2.15	0.7±0.54 mean	Adjacent to highly developed cities and towns; severe eutrophication	Xu et al. (2013) (2)
China, eastern	Lake Chaohu	2008 (spring, summer and winter)	Surface: 10 sites (0) Core: 10 sites (0)	105.8-230.5[h] (518.3 max) 88-155[h]	means: 230.5 in spring, 130.2 in summer, and 105.8 in winter	Adjacent to most developed regions in China; highest levels at the entrance of the most polluted inflow rivers and nearest an industrial city	Yang et al. (2012) (2)
China, southern; Pearl River Delta	Dongjiang River catchment	2010	Surface = 42 (3) Core 1 = 19 (0) Core 2 = 19 (0)	ND-82.3 7.9-450 0.2-14	15.2 mean 91.6 mean 2.9 mean	Highly industrialized; core expected to encompass ~15 years. Detection limit not provided.	He et al. (2013) (2)
China, southern; Pearl River Delta	Dongjiang River	2009-2010	42 (3)	<0.025-82.3	15.16 mean; 6.43 median	Electronics	Feng et al. (2012) (2)
	Zhujiang River		19 (0)	0.10-127	28.37 mean; 13.38 median	Electronics	
	Beijiang River		14 (0)	0.537-6.2	2.80 mean; 2.70 median	Rural and urban areas	
	Xijiang River		13 (2)	>0.025-1.33	0.51 mean; 0.422 median	Rural/ industrialized	
	Shunde tributaries of Dayanhe River		8 (0)	0.264-27.1	4.59 mean; 1.38 median	Industrial (appliances)	
	Dayanhe River		12 (0)	0.741-304	64.7 mean; 13.38 median	Agricultural/e-waste	
	Pearl River Estuary		13 (0)	0.060-1.39	0.471 mean; 0.388 median	Receives input from all rivers in delta	
China, southern; Pearl River Delta	Dongjiang River	2006	Surface = 15 (0) Core 1 = 13 (NR) Core 2 = 15 (NR)	3.8-230 9.4 (max) 18 (max)	NR NR NR	Highly industrialized; no TBBPA manufacturing plants present	Zhang et al. (2009) (2)
Japan, western	Setouchi Sea (coastal areas)	2003	17 (0)	0.08-5	NR	Highest values from area with	Ohta et al. (2004)

Table S2-2. Measured Concentrations of TBBPA in Sediment

Location	Water Body	Year	N (# ND)[a]	TBBPA Concentration (µg/kg dw)		Comments	Reference (Reliability Rating [d])
				Range [b]	Central Tendency [c]		
						many chemical factories	(4)
Japan	Estuaries in Osaka Bay	1981-1983	6 (0)	0.5-4.5	NR	-Urban	Watanabe et al. (1983a) (2)
	Rivers in Osaka		6 (0)	22-140	NR	-Urban; STP, municipal incinerators, factories	
	Estuaries other than in Osaka		7 (5)	<0.5-1.8	NR	-Urban	
Japan; 64 sites		2007	192 (166)	< 0.57 – 6.2	NR		ENREF 19 MOE (2014) (4)

[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.

[e] Sum of both TBBPA and MeTBBPA. Quade (2003) noted that laboratory recoveries were small in some samples (34-38%), possibly due to organic content of the samples. The reported concentrations, however, accounted for the losses during preparation and clean-up because calculations were based on the response to the labeled internal standard.

[f] The authors stated that TBBPA was detected in two samples at a maximum of 0.58 µg/kg, however, this value is less than the reported LOD of 2.7 µg/kg.

[g] Values are mean of three samples per station.

[h] Mean values from spring, summer, and winter from each sampling station.

1.3 Measured Concentrations in Wastewater

Measured concentrations of TBBPA in wastewater, extracted from four sources, are summarized below and tabulated in Table S2-3.

North America

Potvin et al. (2012) compared removal efficiencies of TBBPA using typical wastewater treatment technologies, and identified the most significant mechanisms of removal. In this Canadian study, wastewater influent and effluent concentrations were determined at two types of plants: 1) a full-scale conventional activated sludge (CAS) reactor equipped with rotating biological contractors and a sand filter as tertiary treatment, and 2) at three pilot-scale membrane bioreactors (MBRs), each with different sludge retention times. All four reactors were fed the same municipal influent; TBBPA in the influent ranged from 0.001 to 0.041 µg/L (n=10). In effluent, TBBPA concentrations ranged from below the detection limit (<0.0001) to 0.0022 µg/L for the CAS plant (n=3; 0.0007±0.0013 µg/L mean). Concentrations averaged 0.006 ± 0.006 µg/L for the three MBR plants (n=26). Potvin et al. (2012) determined that the average TBBPA removal was significantly higher by the CAS plant than the MBRs.

Africa

Chokwe et al. (2012) investigated a gas chromatography–mass spectrometry (GC–MS) method for the simultaneous analysis of two types of endocrine disrupting compounds. The method was tested on influent and effluent samples collected in 2012 from the Leeuwkuil wastewater treatment plant (WWTP) located in the Vereeniging region of South Africa. TBBPA concentrations were 6.629 to 6.806 µg/L in influent (n=2) and 3.269 µg/L in effluent (n=1).

Europe

de Boer et al. (2002) and Morris et al. (2004) reported TBBPA results in influent, effluent and sludge samples collected in 2002 from WWTPs in the Netherlands and southeast England. Influent and effluent were sampled from five WWTPs in the Netherlands with either high treatment capacity (population equivalents of 200,000 to 750,000; n=4) or small treatment capacity (population equivalent of 100,000; n=1). In England, five WWTPs were also sampled, which served populations varying from 4,750 to 143,000. According to Morris et al. (2004), all facilities received domestic wastewater only. In the Dutch samples, TBBPA was not detected in the particulate phase of any influent sample (<6.9 µg/kg dw) and was detected in the particulate phase of all effluent samples at 3.1 to 63 µg/kg dw (42±24 µg/kg dw mean). The dissolved phase was not analyzed. The Dutch influent and effluent samples were prepared in slightly different ways. Influent samples were filtered in the laboratory and the resulting residue was dried and used for analysis. Effluent samples were centrifuged at the location using a high throughput centrifuge, and then the residue was mixed with sodium sulphate and Soxhelt extracted.

In the English samples, which were filtered to obtain both dissolved and particulate phases for analysis, TBBPA was detected in the influent at <0.015 to 0.0852 µg/L in the dissolved phase and <3.9 to 21.7 µg/kg dw in the particulate phase. TBBPA was not detected in the effluent of any sample (<0.015 µg/L in the dissolved phase and <3.9 µg/kg dw in the particulate phase).

Table S2-3. Measured Concentrations of TBBPA in Wastewater

Location	Wastewater Type	Year	Influent			Effluent			Comments	Reference
			N (# ND) [a]	TBBPA Concentration		N (# ND) [a]	TBBPA Concentration			
				Range [b]	Central Tendency [c]		Range [b]	Central Tendency [c]		
North America										
Canada; Guelph, Ontario	Municipal	NR	3 (0)	0.013-0.029 µg/L	NR	3 (2)	<0.0001-0.0022 µg/L	0.0007±0.0013 µg/L mean	Conventional activated sludge (CAS) reactor with tertiary treatment	Potvin et al. (2012) (4)
			7 (0)	0.001-0.041 µg/L	0.021±0.014 mean	26 (0)	Max 0.025 µg/L	0.006 ± 0.006 µg/L mean	Three pilot-scale membrane bioreactors	
Africa										
South Africa; Vereeniging	NR	2012	2 (0)	6.629-6.806 µg/L	NR	1 (0)	3.269 µg/L	NR		Chokwe et al. (2012) (2)
Europe										
The Netherlands (5 sites)	Domestic	2002	Part.: 5 (5)	All <6.9 µg/kg dw	--	Part.: 5 (0)	3.1-63 µg/kg dw	42±24 mean µg/kg dw	Serves populations of 200,000 - 750,000 (n=4) or ~100,000 (n=1)	de Boer et al. (2002) (4) and Morris et al. (2004) (2)
England, southeast (5 sites)	Domestic	2002	Diss.:5 (1) Part.: 5 (4)	<0.015-0.0852 µg/L <3.9-21.7 µg/kg dw	NR 75±8 mean µg/kg dw	Diss.:5 (5) Part.: 5 (5)	All <0.015 µg/L All <3.9 µg/kg dw	-- --	Serves populations of 4,800 to 143,000	

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.

1.4 Measured Concentrations in Sewage Sludge and Biosolids

Measured concentrations of TBBPA in sewage sludge and biosolids are extracted from twelve sources and are summarized below and tabulated in Table S2-4.

North America

Quade (2003) measured concentrations of TBBPA in seven sewage sludge samples collected from five WWTPs in southern Ontario, Canada in 2002 and in seven biosolid samples collected from WWTPs in four states of the United States between 1999 and 2001. TBBPA (determined as the sum of TBBPA and methylated TBBPA) was detected in all Ontario sewage sludge samples (raw or digested) with concentrations ranging from 9.04 to 43.1 µg/kg dw. The Ontario WWTPs employed both primary and secondary treatment using aerobic digestion. One plant also employed tertiary filtration. TBBPA (determined as the sum of TBBPA and methylated TBBPA) was detected in all U.S. biosolid samples with concentrations ranging from 2.98 to 196 µg/kg dw. The samples were obtained from plants that utilize anaerobic digestion (n=4), lime stabilization (n=2), or composting (n=1) prior to land application. Laboratory recoveries were small (~43% for Ontario sewage sludge and ~53% for U.S. biosolids). However, losses during preparation and clean-up were accounted for by the use of isotopically labeled internal standard.

Lee and Pearl (2002) investigated the occurrence of TBBPA and other chemicals in 35 raw or digested sewage sludge samples collected between July 1994 and January 2001 from 21 large, medium and small municipalities across Canada. Raw sludge was sampled from primary sedimentation tanks and digested sludge was sampled from secondary clarifiers. TBBPA concentrations ranged from 2.9 to 46.2 µg/kg dw in 34 out of 35 samples, and was not detected (<1 µg/kg dw) in one sample.

Europe

In 2009, Gorga et al. (2013) collected sewage sludge samples from 17 WWTPs located throughout the Catalonia region of northeastern Spain for analysis of TBBPA and other brominated flame retardants. These WWTPs service from 83,500 to 1,151,500 equivalent habitants. Sewage sludge was treated following anaerobic digestion at the majority of these locations (n=14). In the remaining locations (n=3), sludge treatment was carried out by an activated sludge process. TBBPA in the anaerobically digested sludge was 15 to 472 µg/kg dw at 13 WTTPs and was not detected (<3 µg/kg dw) at the remaining WWTP. TBBPA in the activated sludge was 130 to 245 µg/kg dw at two WWTPs and was not detected (<3 µg/kg dw) at the remaining WWTP. Including all WWTPs (n=17), TBBPA was detected at a mean concentration of 104 µg/kg dw and a median concentration of 96.7 µg/kg dw.

In addition to sediment, Guerra et al. (2010) analyzed sewage sludge for TBBPA, HBCD, and related compounds from seven WWTPs in the northeast of Spain using the LC-QqLIT-MS method developed in the study. All, samples were collected in 2008 from WWTPs serving populations ranging from 37,300 to 650,000 inhabitants. TBBPA ranged from 411 to 1,329 µg/kg dw in sludge collected from three WWTPs treating both industrial and urban wastewater. Two of the facilities used primary settling and all facilities used activated sludge secondary treatment. In four WWTPs treating only urban wastewater, TBBPA was detected in three of the samples at 287 to 1,032 µg/kg dw (facilities using primary settling

and activated sludge secondary treatment) and was <LOQ (<8.9 µg/kg dw) in one sample (facility using primary settling and biologic filters).

In the environmental survey conducted by the Nordic Council of Ministers Schlabach et al. (2011), sewage sludge was analyzed for TBBPA from WWTPs in Denmark (n=2), Faroe Islands (n=2), Finland (n=3), Iceland (n=2), Sweden (n=2) and Norway (n=2). Samples were collected in 2009 (year not reported for Iceland), and included facilities receiving a variety of wastewater types: municipal/domestic, industrial, and hospital. TBBPA was only detected in two samples: at 32 µg/kg dw in one sample from Denmark (received wastewater from households and industry) and at 11 µg/kg dw in one sample from Faroe Islands (received municipal wastewater). TBBPA was not detected (<1 to <20 µg/kg dw) in the remaining samples.

Öberg et al. (2002) analyzed 57 sewage sludge samples from 22 Swedish municipal wastewater treatment plants for TBBPA. Samples were sent to the laboratory between October of 1999 and September of 2000. The reference did not provide specific details on the locations of the plants or the type of wastewater the plants processed. TBBPA concentrations were <0.3 µg /kg to 220 µg/kg ww, with a median of 2 µg/kg ww. Lower and upper quartiles of 0.51 and 4.0 µg/kg ww, respectively, were reported. The detection limit and number of samples below the detection limit were not provided.

Metzger and Kuch (2003) collected 32 sludge samples from different WWTPs in Baden-Württemberg in Southwestern Germany. No specifics were given on the characteristics or locations of the plants. TBBPA was found in samples at concentrations of 0.6 to 62 µg/kg dw, with a mean of 16 µg/kg dw.

Sellstrom and Jansson (1995) obtained sewage sludge from two sewage treatment plants in Sweden. In one sample collected from a sewage treatment plant that received leach water from a landfill with wastes from a producer of plastics containing TBBPA, TBBPA was detected at 56 µg/kg dw. In one sample collected from a sewage treatment plant where no known users of TBBPA are connected, TBBPA was detected at 31 µg/kg dw.

de Boer et al. (2002) and Morris et al. (2004) reported TBBPA results in sewage sludge samples collected from the same Dutch and English WWTPs in which wastewater influent and effluent samples were also collected (see Table S2-3). According to Morris et al. (2004), all facilities received domestic wastewater only. In the Netherlands, an additional four facilities were sampled, resulting in sewage sludge samples from nine facilities, including six high treatment capacity facilities (population equivalents of 200,000 to 750,000) and three small treatment capacity facilities (population equivalents of 100,000 to 150,000).

TBBPA ranged from 2 to 600 µg/kg dw in the sludge from the nine WWTPs. Morris et al. (2004) reported a mean of 79 ± 196 µg/kg dw from eight of the WWTPs. In southeast England, TBBPA in sewage sludge samples from five facilities (serving populations of 4,750 to 143,000) ranged from 15.9 to 112 µg/kg dw (59 ± 41 µg/kg dw mean). de Boer et al. (2002) and Morris et al. (2004) also sampled sewage sludge in 2002 from three WWTPs in Ireland, with TBBPA concentrations ranging from <2.4 to 192 µg/kg dw (95 ± 83 µg/kg dw mean). Morris et al. (2004) states that the accumulation of TBBPA in sludge may be due to the use of recycled thermal paper in the production of toilet paper, as documented in Kuch et al. (2001).

Asia

Hwang et al. (2012) investigated the presence of brominated flame retardants and PCDD/Fs in sewage sludge generated from industrial WWTPs (n=7) in Ulsan City, Korea and in municipal WWTPs (n=4) in Busan, Korea. The industrial WWTPs received wastewater from the chemical fiber industry, engineering plastic industry, textile industry (including dyeing), oil refineries and the pulp industry. The wastewater was first treated by a chemical treatment process to neutralize and precipitate impurities before the biological treatment process. TBBPA was detected in these samples at 4.01 to 144 µg/kg dw. The municipal WWTPs received wastewater from the second largest city in Korea. Three of the facilities received only sewage (serving populations of 200,000 to 1,100,000) and one facility received mixed wastewater (70%) in addition to municipal sewage (30%). With the exception of one sample, the Busan wastewater did not undergo an initial chemical treatment/precipitation process. One sample also went through anaerobic digestion. The levels of TBBPA in the Busan municipal sewage sludge were higher and ranged from 67.1 to 618 µg/kg dw. The highest concentration was from a facility that received mixed wastewater.

In addition to sediment, Feng et al. (2012) analyzed two sewage sludge samples from a wastewater treatment plant in Guangzhou, China. The WWTP treats water from both domestic and industrial sources at a proportion of approximately 6 to 4. The samples contained 657 and 732 µg/kg dw TBBPA, with a mean of 694 µg/kg dw.

Table S2-4. Measured Concentrations of TBBPA in Sewage Sludge and Biosolids

Location	Wastewater Type	Year	N (# ND) [a]	TBBPA Concentration (µg/kg dw, unless noted otherwise)		Preparation/ Comments	Reference (Reliability Rating [d])
				Range [b]	Central Tendency [c]		
North America							
Canada; Ontario	7 samples collected from 5 WWTP sites	2002	7 (0)	9.04 to 43.1	NR	Raw or digested (aerobic)	Quade (2003)
United States; 4 states	7 samples collected from WWTPs in four states	1999-2001	7 (0)	2.98 to 196	NR	Anaerobic digestion (n=4), Lime stabilization (n=2), Composted (n=1)	Quade (2003)
Canada; across 7 provinces	Municipal (21 municipalities)	1994 -2001	35 (1)	ND-46.2	NR	Raw (n=13) and digested (n=22); small, medium and large facilities. Detection limit not reported.	Lee and Pearl (2002) (2)
Europe							
Spain; Catalonia	NR (17 sites)	2009	14 (1) 3 (1)	<3-472 <3-245	Overall (n=17): 104 mean; 96.7 median	Anaerobic digested Activated sludge	Gorga et al. (2013) (2)
Spain; Ebro River	Urban/industrial (3 sites)	2008	3 (0)	411-1,329	NR	Activated sludge	Guerra et al. (2010) (2)
	Urban (4 sites)	2008	3 (0) 1 (1)	287-1,032 All <8.9	NR --	Activated sludge Biologic filter	
Denmark	Domestic/Industrial (2 sites)	2009	2 (1)	<3-32	NR	NR	Schlabach et al. (2011) (4)
Faroe Islands	-Hospital (1 site) -Municipal (1 site)	2009 2009	1 (1) 1 (0)	All <4 11	-- --	NR NR	
Finland	Municipal/Industrial (3 sites)	2009	3 (3)	All <1-<3	--	Dewatered	
Iceland	NR (1 site)	NR	2 (2)	All <4	--	Non-processed, non-dehydrated	
Sweden	Mixed sewage water from many communities (2 sites)	2009	2 (2)	All <1-<20	--	Digested dewaterised sludge	
Norway	NR (2 sites)	2009	2 (2)	All <1-<2	--	NR	
Sweden	Municipal (22 plants)	1999-2000	57 (NR)	<0.3-220 (wet)	2 median (wet)	NR	Öberg et al. (2002) (4)
Germany; Baden-Württemberg	32 sites	2003	32 (NR)	0.6-62	16 mean	NR	Metzger and Kuch (2003) (4)
Sweden	-Receives leach water from landfill with wastes from plastics industry.	1995	1 (0)	56	--	NR	Sellstrom and Jansson (1995) (2)

Table S2-4. Measured Concentrations of TBBPA in Sewage Sludge and Biosolids

Location	Wastewater Type	Year	N (# ND) [a]	TBBPA Concentration (µg/kg dw, unless noted otherwise)		Preparation/ Comments	Reference (Reliability Rating [d])
				Range [b]	Central Tendency [c]		
	-No known users of TBBPA.		1 (0)	31	--	NR	
The Netherlands	Domestic (9 sites)	2002	9 (0)	2-600	79±196 mean (8 sites only)	NR	de Boer et al. (2002) (4) and Morris et al. (2004) (2)
England, SE	Domestic (5 sites)	2002	5 (0)	15.9- 112	59±41mean	NR	
Ireland	Domestic (3 sites)	2002	6 (1)	<2.4-192	95±83 mean	NR	
Asia							
Korea; Ulsan City (Industrial) and Busan (Municipal)	Industrial (7 sites) Municipal (4 sites)	2011 2011	7(0) 4 (0)	4.01-144 67.1-618	NR NR	-Chemical treatment + activated sludge -Chemical treatment + activated sludge, Activated sludge, or Activated sludge + sludge anaerobic digestion	Hwang et al. (2012) (2)
China; Pearl River Delta	Domestic and Industrial (1 site)		2 (0)	657-732	694 mean	NR	Feng et al. (2012) (2)

[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.

1.5 Measured Concentrations in Other Sediment/Sludge

Measured concentrations of TBBPA in sludge and/or sediment collected from sources other than WWTPs (i.e., stormwater collection areas, landfills, and recycling facilities) are summarized below and tabulated in Table S2-5. These data were extracted from three sources.

Europe

TBBPA levels were measured in stormwater sludge and sediment by Schlabach et al. (2011). TBBPA was not detected in sludge samples collected from urban drainage wells in Finland in 2009 (n=2; <0.2 µg/kg dw) or in sludge from landfill effluent in Iceland (n=1), but was detected in a sludge sample from a ditch near an industrial site in Finland in 2009 at 59 µg/kg dw (n=1).

In the Netherlands, de Boer et al. (2002) measured TBBPA in a sediment sample from a residential sewer at 3.7 µg/kg dw.

Schlabach et al. (2011) also measured TBBPA in sludge from landfill leachate basins in Sweden in 2009. TBBPA was not detected (<1 µg/kg dw) in any sample (n=2). TBBPA was also not detected (<0.4 µg/kg dw) in landfill sludge collected in the Netherlands (n=2) in 2002 de Boer et al. (2002).

In sludge from recycling facilities in Norway, including a car demolishing and e-waste recycling facility (n=1) and a municipal recycling and landfill facility (n=1), TBBPA was also not detected (<0.2 µg/kg dw) Schlabach et al. (2011).

Table S2-5. Measured Concentrations of TBBPA in Other Sediment/Sludge

Location	Site	Year	N (# ND) [a]	TBBPA Concentration (µg/kg dry)		Reference (Reliability Rating [d])
				Range [b]	Central Tendency [c]	
Europe						
Stormwater Sludge/Sediment						
Finland	-Ditch near industrial site (1 site) - Waste deposit drainage wells in urban area (2 sites)	2009 2009	1 (0) 2 (2)	59 All <0.1-<0.2	-- --	Schlabach et al. (2011) (4)
Iceland	From landfill effluent (1 site)	NR	1 (1)	ND (detection limit not provided)	--	
Residential Sewer Sludge/Sediment						
The Netherlands	Residential sewer (1 site)	2002	1 (0)	3.7	--	de Boer et al. (2002) (4)
Landfill Sludge/Sediment						
Sweden	Leachate basin from landfill (2 sites)	2009	2 (2)	All <0.6-<1	--	Schlabach et al. (2011) (4)
The Netherlands	Landfill (2 sites)	2002	2 (2)	All <0.3-<0.4	--	de Boer et al. (2002) (4) and Morris et al. (2004) (2)
Recycling Sludge/Sediment						
Norway	Leachate basin from recycling facilities (car demolishing/e-waste/municipal/ landfill) (2 sites)	2009	2 (2)	All <0.1-<0.2	--	Schlabach et al. (2011) (4)

[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.

1.6 Measured Concentrations in Landfill Leachate

Measured concentrations of TBBPA in landfill leachate, extracted from two sources, are summarized below and tabulated in Table S2-6.

Europe

de Boer et al. (2002) measured TBBPA concentrations in landfill leachate collected from nine locations in the Netherlands, three from southeast England, and three from Ireland. According to Morris et al. (2004), all landfills received domestic or municipal wastes only. de Boer et al. (2002) noted that the landfill leachate samples from the Netherlands were collected prior to purification and release to the environment as landfill effluent. de Boer et al. (2002) did not specifically state the sample collection timing for the English and Irish samples. In the particulate phase of samples collected in the Netherlands, TBBPA was measured at <5.5 to 320 µg/kg dw, with detection in only three of the nine samples (de Boer et al., 2002). Morris et al. (2004) reported a mean of 54 ± 108 µg/kg dw from 11 samples, which appears to include the nine landfill leachate samples in addition to the two landfill sludge samples discussed above. TBBPA was not detected in either the dissolved phase (<0.015 µg/L) or particulate phase (<3.9 µg/kg dw) of samples collected in southeast England (n=3) or Ireland (n=6), as reported in de Boer et al. (2002).

Table S2-6. Measured Concentrations of TBBPA in Landfill Leachate

Location	Site	Phase	Year	N (# ND) [a]	TBBPA Concentration		Comments	Reference (Reliability Rating [d])
					Range [b]	Central Tendency [c]		
Europe								
The Netherlands	Domestic and municipal waste only (9 sites)	Particulate	2002	9 (6)	<5.5-320 µg/kg dw	54±108 µg/kg dw (n=11, includes 2 landfill sludge samples)	Samples collected prior to treatment for release for to the environment.	de Boer et al. (2002) (4) and Morris et al. (2004) (2)
England, southeast	Domestic and municipal waste only (3 sites)	Dissolved Particulate	2002	3 (3) 3 (3)	All <0.015 µg/L All <3.9 µg/kg dw	-- --		
Ireland	Domestic and municipal waste only (3 sites)	Dissolved Particulate	2002	6 (6) 6 (6)	All <0.015 µg/L All <3.9 µg/kg dw	-- --		
Finland	Site 1	-	2002	1(1)	n.d.	--		Peltola (2002)
Finland	Metal dismantling	-	2002	1(0)	0.9 µg/L			
Iceland	Landfill effluent	-	2011	1(1)	n.d.	--		Schlabach et al. (2011)
Sweden	Sludge from landfill basins	-	2009	2(2)	< 1 µg/kg dw	--	--	
Asia								
Japan	Leachate from municipal landfills: incineration ash, incombustables, crushed bulk waste [and sewage treatment sludge at one site]	-	2004	6 landfills (raw)	< 0.010-0.620 µg/L (raw)			Osako et al. (2004)
Japan				3 landfills (treated)	< 0.001 – 0.011 µg/L (treated)			
Japan	Industrial waste landfill leachate; raw	Dissolved Overall	2004	-	0.0043 µg/L < 0.001 µg/L			
Japan	Industrial waste landfill leachate; treated	Dissolved Overall	2004	-	< 0.0005 µg/L < 0.0005 µg/L			
Japan	Leachate	-	-	5 landfills	0.0003 – 0.540 µg/L	0.130 µg/L (pre-treatment) 0.0077 µg/L (post-treatment)		Suzuki and Hasegawa (2006)

[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.

1.7 Measured Concentrations in Soil

Measured concentrations of TBBPA in soil, extracted from three sources, are summarized below and tabulated in Table S2-7.

North America

Pellizzari et al. (1978) reported the presence of TBBPA in soil samples collected between 1976 and 1977 in the vicinity of multiple organo-bromide production facilities in southern Arkansas. TBBPA concentrations ranged from <100 to 225,000 µg/kg (wet or dry weight not specified), with detection in 10 of 17 samples.

Asia

In addition to sediment, Qu et al. (2013) investigated the presence of TBBPA in agricultural surface soil samples collected in 2010, upstream and downstream of the effluent outlet for a brominated flame retardant manufacturing plant at the Liuyang River within the Hunan province of China. TBBPA was not detected (<0.03 µg/kg dw) in six agricultural soils samples.

In the analytical method development study conducted by Xu et al. (2012) using surface soil and sediment collected in the Beijing area in 2011, TBBPA was measured in soil from an e-waste recycling site at 26 to 104 µg/kg dw (n=4). TBBPA was detected at lower levels in agricultural soil at <LOD (<0.04) to 5.6 µg/kg dw (n=11), with detection in only two samples. According to Xu et al. (2012), the presence of TBBPA in the farmland soils could be due to the recent input of compost containing organic pollutants.

Table S2-7. Measured Concentrations of TBBPA in Soil

Location	Site	Year	N (# ND) [a]	TBBPA Concentration (µg/kg dw)		Reference (Reliability Rating [d])
				Range [b]	Central Tendency [c]	
North America						
United States; El Dorado, AR	Vicinity of multiple organo-bromide production facilities	1976-1977	17 (7)	<100 – 225,000 (weight type not reported)	NR	Pellizzari et al. (1978) (2)
Asia						
China, eastern; Liuyang, Hunan	Agricultural soil near BFR factory (upstream and downstream of effluent outlet at the Liuyang River)	2010	6 (6)	All <0.03	--	Qu et al. (2013) (1)
China, northern; Beijing	Open e-waste recycling site	2011	4 (0)	26-104	NR	Xu et al. (2012) (2)
	Farmland	2011	11 (9)	<0.04-5.6	NR	

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" 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.

1.8 Measured Concentrations in Ambient Air

Measured concentrations of TBBPA in ambient air, extracted from six sources, are summarized below and tabulated in Table S2-8.

North America

Pellizzari et al. (1978) reported the presence of TBBPA in the particulate phase of air from samples collected between 1976 and 1977 in the vicinity of multiple organo-bromide production facilities in southern Arkansas. Concentrations of TBBPA in eight samples ranged from ND (<10) to 1,800 ng/m^3.

Alaee et al. (2003) investigated the occurrence of brominated flame retardants, including TBPPA, in archived air samples that had been collected from 1994 to 1995. Samples came from three Arctic air monitoring stations: Alert and Tagish, Canada, and Dunai Island, Russia. Four samples, each one a composite of four weekly filter samples, were analyzed from each monitoring station. TBBPA was not detected (< 0.00007 ng/m^3) in samples from the Alert and Tagish monitoring stations. Only one sample was collected from Dunai (during the spring of 1994) had detectable levels of TBBPA (0.07 ng/m^3 in the particulate phase).

Europe

In the Nordic environmental screening study by Schlabach et al. (2011), combined phase air samples were collected from rural and urban locations in Denmark and Sweden; particulate phase samples were collected from an urban location in Oslo, Norway. Indoor air samples were also collected near the Oslo, Norway location (see Supplemental File 3: Residential Monitoring). Samples were collected in 2009 and 2010 In Sweden and Norway, samples were collected in 2009 and 2010. The sampling dates were not reported for Denmark. TBBPA was detected in two samples from Oslo at concentrations of 0.050 ng/m^3 and 0.284 ng/m^3. TBBPA concentrations at other sites were below detection limits (<0.0002-<0.001 ng/m^3).

Investigators collected five air samples in the West Midlands conurbation, a large urban and industrially developed area in the United Kingdom that includes the city of Birmingham. Sampling took place between February and December 2007 using low volume active air samples. TBBPA concentrations ranged from 0.0007 to 0.0009 ng/m^3 (0.0008 ± 0.0001 ng/m^3 mean; 0.0007 ng/m^3 median) in the particulate phase (Abdallah et al., 2008).

As part of an analytical method development study for determination of TBBPA following derivatization with silylation reagents, Xie et al. (2007) measured TBBPA concentrations in air samples collected over rural land (GKSS Research Centre Geesthacht , Northern Germany) and coastal regions of the Wadden Sea and the Northeast Atlantic from 2004 to 2006. TBBPA concentrations in the vapor phase ranged from ND (<0.00004) to 0.00025 ng/m^3 at the GKSS Research Centre Geesthacht location and from 0.00021 to 0.00050 ng/m^3 for samples collected over the Wadden Sea. Particulate phase concentrations ranged from 0.00016 to 0.00085 ng/m^3 at the GKSS Research Centre Geesthacht location and from 0.00010 to 0.00019 ng/m^3 for samples collected over the Wadden Sea. Concentrations of TBBPA were below the detection limit in all but two samples (vapor phase concentrations of 0.00005 and 0.00017 ng/m^3) collected off the Northeast Atlantic.

Asia

In a 2004 environmental survey conducted by the Environmental Agency of Japan, air samples (phase not reported) were collected in two areas of Japan and analyzed for TBBPA (MOE, 2014). TBBPA was not detected in any of the samples (<0.03 ng/m^3).

Table S2-8. Measured Concentrations in Ambient Air

Location	Site	Phase	Year	N (# ND) [a]	TBBPA Concentration (ng/m³)		Reference (Reliability Rating [d])
					Range [b]	Central Tendency [c]	
North America							
United States; El Dorado, AR	Vicinity of multiple organo-bromide production facilities	Particulate	1976-1977	8 (4)	<10 – 1,800	NR	Pellizzari et al. (1978) (2)
Canada and Russia	Remote Artic monitoring stations: Alert, Tagish, and Dunai Island	Particulate	1994-1995	12 (11)	< 0.00007-0.07	NR	Alaee et al. (2003) (4)
Europe							
Denmark; Lille Valby and Copenhagen	Rural and urban locations	Combined Phase	NR	2 (2)	All <0.001	--	Schlabach et al. (2011) (4)
Norway; Oslo	Urban location	Particulate	2009-2010	3 (1)	<0.001-0.284	NR	
Sweden; Rao and Stockholm	Rural and urban locations	Combined Phase	2009-2010	4 (4)	<0.0002-<0.0005	--	
United Kingdom; West Midlands conurbation	Large urban and industrially developed area	Particulate	2007	5 (0)	0.0007-0.0009	0.0008±0.0001 mean; 0.0007 median	Abdallah et al. (2008) (1)
Germany, northern	Rural area	Vapor Particulate	2004-2006	7 (1) 7 (0)	<0.00004-0.00025 0.00016-0.00085	NR NR	Xie et al. (2007) (2)
Wadden Sea	Coastal region	Vapor Particulate	2004-2006	2 (0) 2 (0)	0.00021-0.00050 0.00010-0.00019	NR NR	
Northeast Atlantic (North Sea to the Artic)	Coastal region	Vapor Particulate	2004-2006	7 (5) 6 (6)	<0.00004-0.00017 All <0.00004	NR --	
Asia							
Japan; 2 sites	Not reported	NR	2004	6 (6)	All <0.03	--	MOE (2014) (4)

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" 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.

1.9 Measured Concentrations in Precipitation

Measured concentrations of TBBPA in precipitation were only investigated in one study, as summarized below and tabulated in Table S2-9.

Europe

In a study initiated by Greenpeace (Peters, 2003) to investigate the presence of hazardous chemicals in precipitation, precipitation samples were collected from the Netherlands (n=47), Belgium (n=1), and Germany (n=2) during a 4-week period starting in February or March (year not reported). The samples were gathered using open samplers, thus it was not possible to differentiate between wet and dry deposition. TBBPA was detected in 8 of 50 samples, at levels of <MDL (<0.0005 µg/L) to 0.0026 µg/L. The authors noted that samples were collected in the winter when passive venting from homes and factories is low, which could result in lower TBBPA emissions than during other seasons.

Table S2-9. Measured Concentrations of TBBPA in Precipitation

Location	Year	N (# ND) [a]	TBBPA Concentration (µg/L)		Comments	Reference (Reliability Rating [d])
			Range [b]	Central Tendency [c]		
Europe						
The Netherlands, Belgium, Germany	NR	50 (42)	<0.0005-0.0026	NR	Wet and dry deposition	Peters (2003) (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.

1.10 Measured Concentrations in Wildlife Biota

Measured concentrations of TBBPA in wildlife biota (marine mammals, invertebrate, fish, and vegetation) are summarized below and tabulated in Table S2-10. The data were extracted from thirteen sources.

Marine Mammals

Johnson-Restrepo et al. (2008) reported the presence of TBBPA in the tissues of higher trophic level aquatic organisms collected from coastal waters of Florida between 1991 and 2004, as well as in humans (see Supplemental File 1: TBBPA Human Biomonitoring Data). TBBPA was present in all aquatic organism samples analyzed (n=31). Concentrations ranged from 0.056 to 8.48 µg/kg lw (1.2 ± 3 µg/kg lw mean) in blubber of bottlenose dolphins, from 0.035 µg/kg to 35.6 µg/kg lw (9.5 ± 12 µg/kg lw mean) in muscle of bull sharks, and from 0.495 to 1.43 µg/kg lw (0.872 ± 0.5 µg/kg lw mean) in the muscle of Atlantic sharpnose sharks.

Concentrations of TBBPA were also measured in stranded or by-caught harbor porpoise. Morris et al. (2004) reported TBBPA concentrations ranging from 0.1 to 418 µg/kg lw (83 ± 187 µg/kg lw mean) in the blubber (n=5) of harbor porpoise from UK rivers. However, TBBPA was not detected in the blubber (n=4; <12 µg/kg lw) or liver (n=1; <18 µg/kg lw) of harbor porpoise samples originating from the southern North Sea. Samples from UK rivers were obtained in 1998. North Sea samples were acquired from the Museum of Natural History in the Netherlands (year not reported). Law et al. (2006) also analyzed blubber samples from harbor porpoise. In samples originating from the UK coast between 1994 and 2003, TBBPA concentrations ranged from <4 to 35 µg/kg ww, with detection in 18 of 68 samples.

Additionally, de Boer et al. (2002) and Morris et al. (2004) investigated the presence of TBBPA in stranded or by-caught harbor seal originating from the Western Wadden Sea. Samples were acquired from the Centre for Research and Technology in Büsum, Germany (year not reported). TBBPA was not detected in either blubber (n=2, <15 µg/kg lw) or liver (n=3, <67 to <231 µg/kg lw).

Invertebrates

In the environmental survey conducted by the Nordic Council of Ministers (Schlabach et al., 2011), TBBPA was not detected in mussels (n=3; <0.03 µg/kg lw) collected in 2009 from Iceland and Norway. In Japan, TBBPA measurements in 2007 in mussels collected from seven areas with different levels of pollution showed TBBPA levels of <0.06 to 0.09 µg/kg ww (n=31), with detection in 2 samples (MOE, 2014).

Driffield et al. (2008) analyzed shellfish (oyster, mussel, and scallop) samples from Scotland for brominated flame retardants, including TBBPA, using a LC-MS/MS method developed and validated in-house. The samples were collected between January and March, 2006 during a pre-spawning period. Samples were homogenized and pooled, yielding a total of 5 composite oyster samples, 10 composite mussel samples, and 20 composite scallop samples, which were further divided into gonad and adductor subsamples. TBBPA was not detected in any of the shellfish samples, with LODs ranging from

0.010 to 0.35 µg/kg whole. The authors also present analytical results for food samples collected throughout the UK as part of the 2004 UK Total Diet Study (TDS) (see Supplemental File 1: TBBPA Human Biomonitoring Data).

de Boer et al. (2002) analyzed a variety of aquatic invertebrate species around Europe between 1999 and 2001. In the North Sea, TBBPA levels were 5 to 96 µg/kg lw (45 ± 46 µg/kg lw mean) in whole whelk (n=3), <1 to 10 µg/kg lw (4 ± 5 µg/kg lw mean) in digestive tract of sea star (n=3) and <1 to 35 µg/kg lw (11 ± 15 µg/kg lw mean) in the abdomen of the hermit crabs (n=9). In the United Kingdom, TBBPA was also present in one sea star collected in 2001 from mouth of the Tees Estuary at 205 µg/kg lw and in one starfish sample collected in 1999 in from the Tees River at 4.5 µg/kg ww. TBBPA was not detected (<0.4 µg/kg lw) in one mysid shrimp sample collected from the Western Scheldt in the Netherlands.

Fish

In the environmental survey conducted by the Nordic Council of Ministers (Schlabach et al., 2011), TBBPA was not detected in fish muscle (n=9; <0.03 µg/kg fresh weight) or fish liver (n=5; <0.4 µg/kg fresh weight) collected in 2009 from the Faroe Islands, Finland, Iceland, Norway and Sweden. Samples were collected from a variety of locations, including marine environment, receiving waters to a WWTP and an urban lake.

Harrad et al. (2009) measured TBBPA concentrations in fish muscle collected in the summer of 2008 from seven lakes in England with no known major point source inputs, as well as in water and sediment from the same lakes (see Tables S2-1 and S2-2). TBBPA concentrations ranged from <LOQ (<0.29) to 1.7 µg/kg lw, with detection in four of thirty samples.

Russell et al. (2008) measured brominated flame retardant levels, including TBBPA, in the muscle and liver of three deep water fish species (roundnose grenadier, black scabbard, and black dogfish) collected in 2006 from the Rockall fishing area, to the west of Scotland. TBBPA was below the LOQ (<0.3 µg/kg ww) in all samples (n=2 muscle and n=3 liver).

In the Norwegian study conducted by the Norwegian Institute for Water Research in 2003, TBBPA was analyzed in various fish species (orfe, trout eel, cod) from the Drammens River and the Drammensfjordd, located in an industrialized area in the southeast of Norway (Schlabach et al., 2004). In fish muscle (n=3), TBBPA was below the detection limit (<5 to <300 µg/kg lw) in two samples and detected at 0.3 µg/kg lw in one sample. In cod fish liver (n=1), TBBPA was also below the detection limit (<9 µg/kg lw).

de Boer et al. (2002) analyzed a variety of fish species around Europe between 1999 and 2001. TBBPA levels were <0.3 to 1.8 µg/kg lw in cod liver (n=2) and <97 to 245 µg/kg lw in whiting muscle (n=3) from the North Sea, <4.8 to 3.3 µg/kg ww in whiting muscle (n=2) from the Tees River in England (mouth of Tees estuary), <0.2 µg/kg lw in hake liver (n=1) from the Atlantic Ocean (SW of Ireland), and <0.1 µg/kg lw in gudgeon (n=1) from the Western Scheldt in the Netherlands. In eel, TBBPA ranged from <0.1 to 13 µg/kg lw (1.6 ± 3.2 µg/kg lw mean) in the Scheldt Basin of Belgium (n=18) and from <0.1 to 1.3 µg/kg lw (0.3 ± 0.5 µg/kg lw mean) in rivers of the Netherlands (n=11).

Two Chinese studies measured TBBPA concentrations in fish. He et al. (2013) measured TBBPA concentrations in three fish species (mud carp, Nile tilapia, and plecostomus) collected in 2009 in the Dongjiang River, which runs through a highly industrialized area of southern China. TBBPA levels in water, sediments, sediment cores were also identified in this study (see Tables S2-1 and S2-2). Reported TBBPA concentrations in fish ranged from ND to 66 µg/kg lw, with detection in the majority of the samples (31 of 34 samples). Mean concentrations for the three species ranged from 18.1 to 35.2 µg/kg lw; there were no significant differences in TBBPA level between the three fish species.

In the second Chinese study, Yang et al. (2012) investigated the tissue distribution of TBBPA in four fish species (*Culter alburnus, Cyprinus carpio, Carassius auratus and Silurus asotus*) in Lake Chaohu, located adjacent to the most developed regions in eastern China, and assessed the seasonal variation of TBBPA in the lake water and sediment (see Tables S2-1 and S2-2). In various fish species collected in 2008 from up to 10 sites on the lake, mean TBBPA concentrations ranged from 28.5 to 39.4 µg/kg dw in whole samples, 75.2 to 126.4 µg/kg dw in kidney, 16.0 to 37.5 µg/kg dw in liver, 6.3 to 46 µg/kg dw in muscle, and 12 to 21.9 µg/kg dw in adipose tissue, and below the detection limit (<10 µg/kg dw) in gills and spawns.

In the environmental survey conducted across Japan by the Environment Agency of Japan in 2007, TBBPA was detected in 73 of 80 fish samples from 16 sampling areas at concentrations ranging from <0.03 to 0.09 µg/kg ww. In 2003, TBBPA was detected in 10 of 70 samples (<0.03 – 0.15 µg/kg ww) from 14 sampling areas (MOE, 2014).

In the western Japanese environment, Ohta et al. (2004) investigated the levels of TBBPA and other brominated flame retardants in stock fish (Japanese sea bass) of the Osaka Bay and the mouth of the Yamato River which flows into the Osaka Bay. In samples collected between 1986 and 1999, TBBPA ranged from 3.4 to 23 µg/kg lw (n=14) in the edible filet tissue portion. Ohta et al. (2004) noted that accumulation levels of TBBPA in Japanese sea-bass were relatively low and unrelated to the increase in TBBPA demand and use in Japan.

Avian

TBBPA was measured in avian matrices collected in Nordic areas, the Netherlands, England, and Japan. As reported by Morris et al. (2004), TBBPA was detected in liver samples of cormorant collected in England between 1999 and 2000 at 2.5 to 14 µg/kg lw (7.1 ± 4.5 µg/kg lw mean). Results in wet weight units are reported in de Boer et al. (2002). TBBPA was not detected in any egg samples, which included those collected from guillemot in 2009 from the Faroe Islands (n=2, <0.1 µg/kg fresh weight) and Sweden (n=2; <0.3 µg/kg fresh weight). These were considered to be background areas and reflect long-range transport of chemicals (Schlabach et al., 2011). TBBPA was also not detected in eggs from the common tern collected in 2001 from the Western Scheldt of the Netherlands (n=10, <2.9 µg/kg lw and <0.3 µg/kg ww) (de Boer et al., 2002) and (Morris et al., 2004). In the environmental survey conducted in Japan in 2007, TBBPA was not detected (<0.06 µg/kg ww) in Gray starlings collected from two areas of Japan (n=10) (MOE, 2014).

Vegetation

In the Schlabach et al. (2011) study, moss was collected in the vicinity of two incineration plants in the Faroe Islands in 2009. TBBPA was not detected in either sample (n=2, <0.5 µg/kg dw).

Table S2-10. Measured Concentrations of TBBPA in Wildlife Biota

Species	Tissue Type	Location	Year	N (# ND) [a]	TBBPA Concentration (µg/kg lw, unless noted otherwise)		Reference (Reliability Rating [a])
					Range [b]	Central Tendency [c]	
Marine Mammal							
Bottlenose dolphin	Blubber	United States; FL coast	1991-1996	4 (0)	0.056-1.53	0.451 mean	Johnson-Restrepo et al. (2008) (1)
			2000-2001	5 (0)	0.1-8.48	1.86 mean	
			2001-2004	6 (0)	0.094-6.15	1.18 mean	
			Overall 1991-2004	15 (0)	0.056-8.48	1.2±3 mean	
Bull shark	Muscle	United States; FL coast	1993-1994	6 (0)	4.17-8.07	5.17 mean	Johnson-Restrepo et al. (2008) (1)
			2002-2004	7 (0)	0.035-35.6	13.2 mean	
			Overall 1993-2004	13 (0)	0.035-35.6	9.5±12	
Atlantic sharpnose shark	Muscle	United States; FL coast	2004	3 (0)	0.495-1.43	0.872±0.5 mean	Johnson-Restrepo et al. (2008) (1)
Harbor porpoise	Blubber	UK; various rivers	1998	5 (0)	0.1-418 0.05-376 (wet)	83±187 mean 75.3±168 mean (wet)	de Boer et al. (2002) (4) and Morris et al. (2004) (2)
	Blubber	UK; coast	1994-2003	68 (50)	<4-35 (wet)	NR	Law et al. (2006) (2)
	Blubber	North Sea	NR	4 (4)	All <11-<12	--	de Boer et al. (2002) (4) and Morris et al. (2004) (2)
	Liver		NR	1 (1)	All <18	--	
Harbor seal	Blubber	Western Wadden Sea	NR	2 (2)	All <14-<15	--	de Boer et al. (2002) (4) and Morris et al. (2004) (2)
	Liver		NR	3 (3)	All <67 -<231	--	
Aquatic Invertebrate							
Mussel	NR	Iceland	2009	1(1)	<0.03	--	Schlabach et al. (2011) (4)
	NR	Norway; Ase	2009	2(2)	<0.03	--	
	Edible Parts	Japan; 6 sites	2003	30 (18)	<0.03-0.16 (wet)	NR	MOE (2014) (4)
	Edible Parts	Japan; 7 sites	2007	31 (29)	<0.06-0.09 (wet)	NR	
Oyster	Whole	Scotland	2006	5 (5)	All < 0.020-<0.050 (whole)	--	Driffield et al. (2008) (2)
Mussel	Whole			10 (10)	All <0.010-<0.12 (whole)	--	
Scallop	Gonad and Adductor			20 (20)	All < 0.010-<0.35 (whole)	--	
Whelk	Whole	North Sea	1999	3 (0)	5-96	45±46 mean	de Boer et al. (2002) (4) and Morris et al. (2004) (2)
Mysid Shrimp	NR	The Netherlands; Western Scheldt	NR	1 (1)	<0.4 <0.1 (wet)	--	de Boer et al. (2002) (4)
Starfish	Whole	UK; Tees River	2001	1 (0)	4.5 (wet)	--	
Sea star	Digestive tract	North Sea	1999	3 (1)	<1-10	4±5 mean	de Boer et al. (2002) (4) and Morris et

Table S2-10. Measured Concentrations of TBBPA in Wildlife Biota

Species	Tissue Type	Location	Year	N (# ND) [a]	TBBPA Concentration (µg/kg lw, unless noted otherwise)		Reference (Reliability Rating [a])
					Range [b]	Central Tendency [c]	
	Whole	UK; Tees estuary	2001	1 (0)	205	--	al. (2004) (2)
Hermit Crab	Abdomen	North Sea	1999	9 (4)	<1-35	11±15 mean	
Fish							
Various species	Muscle	Faroe Islands (marine), Finland, Iceland, Norway (receiving water to WWTP), Sweden (urban lake)	2009	9 (9)	All <0.03 (fresh)	--	Schlabach et al. (2011) (4)
	Liver		NR	5 (5)	All <0.4 (fresh)	--	
Various species (nine species)	Muscle	England; 7 lakes	2008	30 (26)	<0.29-1.7	NR	Harrad et al. (2009) (2)
Various species (roundnose grenadier, black scabbard, and black dogfish)	Muscle	Scotland	2006	2 (2)	All <0.3 (wet)	--	Russell et al. (2008) (4)
	Liver			3 (3)	All <0.3 (wet)	--	
Various species (orfe, trout eel, cod)	Muscle	Norway: Drammens River and the Drammensfjord	2003	3 (2)	ND (<5-<300)-0.3	NR	Schlabach et al. (2004) (4)
	Liver		2003	1 (1)	<9	NR	
Eel	Tissue	Belgium; Scheldt Basin (rivers)	2000	18 (10)	<0.1-13 <0.1-2.6 (wet)	1.6±3.2 mean	de Boer et al. (2002) (4) and Morris et al. (2004) (2)
		The Netherlands; various rivers	1999	11 (8)	<0.1-1.3 <0.1-0.2 (wet)	0.3±0.5 mean	de Boer et al. (2002) (4) and Morris et al. (2004) (2)
Cod	Liver	North Sea	1999	2 (1)	<0.3-1.8 <0.3-0.8 (wet)	NR	de Boer et al. (2002) (4) and Morris et al. (2004) (2)
Whiting	Muscle	North Sea	1999	3 (1)	<97-245	136±125 mean	de Boer et al. (2002) (4) and Morris et al. (2004) (2)
		UK; River Tees (mouth of Tees Estuary)	2001	2 (1)	<4.8-3.3 (wet)	NR	de Boer et al. (2002) (4)
Hake	Liver	Atlantic Ocean, SW of Ireland	NR	1 (1)	<0.2 <0.1 (wet)	--	de Boer et al. (2002) (4)
Gudgeon	NR	The Netherlands; Western Scheldt	NR	1 (1)	<0.1 (wet and lipid)	--	de Boer et al. (2002) (4)
Mud carp	Muscle	China, southern; Dongjiang River	2009	9 (0)[e]	6.5-66	35.2 mean	He et al. (2013) (2)
Nile tilapia				15 (NR)[e]	ND-51	18.1 mean	
Plecostomus				10 (NR)[e]	ND-53.4	21.2 mean	

Table S2-10. Measured Concentrations of TBBPA in Wildlife Biota

Species	Tissue Type	Location	Year	N (# ND) [a]	TBBPA Concentration (µg/kg lw, unless noted otherwise)		Reference (Reliability Rating [a])
					Range [b]	Central Tendency [c]	
arious species (*Culter alburnus, Cyprinus carpio, Carassius auratus, and Silurus asotus)*	Whole	China, eastern; Lake Chaohu	2008	10 sites[f]	28.5-39.4 (dry)	NR	Yang et al. (2012) (2)
	Kidney			10 sites[f]	75.2-126.4 (dry)	NR	
	Liver			10 sites[f]	16.0-37.5 (dry)	NR	
	Muscle			10 sites[f]	6.3-46 (dry)	NR	
	Adipose Tissue			10 sites[f]	12-21.9 (dry)	NR	
	Gills			10 sites[f]	All <10 (dry)	--	
	Spawns			10 sites[f]	All <10 (dry)	--	
Various species	Muscle	Japan; 9 sites	2003	70 (60)	<0.03-0.15 20 (wet)	NR	MOE (2014) (4)
	Muscle	Japan; 16 sites	2007	80 (73)	<0.06-0.09 (wet)	NR	
Sea Bass	Muscle	Japan; Osaka Bay and the mouth of the Yamato River	1986-1999	14 (0)	3.4-23	NR	Ohta et al. (2004) (4)
Avian							
Cormorant	Liver	England	1999-2000	5 (0)	2.5-14 0.07-0.28 (wet)	7.1±4.5 mean 0.12 mean (wet)	de Boer et al. (2002) (4) and Morris et al. (2004) (2)
Black guillemot	Eggs	Faroe Islands; background area	2009	2 (2)	All <0.1 (fresh)	--	Schlabach et al. (2011)
Guillemot	Eggs	Sweden; background area	2009	2 (2)	All <0.3 (fresh)	--	
Common tern	Eggs	The Netherlands; Western Scheldt	2001	10 (10)	All <2.9 All <0.3 (wet)	--	de Boer et al. (2002) (4) and Morris et al. (2004) (2)
Gray starling; gull	NR	Japan; 2 sites	2003	10 (10)	All <0.03 (wet)	--	MOE (2014) (4)
	NR	Japan; 2 sites	2007	10 (10)	All <0.06 (wet)	--	
Vegetation							
Moss	Uppermost part of the plant (representing 2-3 yrs of growth)	Faroe Islands (near 2 incineration plants)	2009	2 (2)	All <0.5 (dry)	--	Schlabach et al. (2011)

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" 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] Overall, TBBPA was not detected in 3 of the 34 samples. Detection frequency specifically for nile tilapia and plecostomus was not reported.

[f] Number of samples not reported; however, samples were collected from up to 10 sites on the lake

2 TBBPA-bis(dibromopropyl ether)

Monitoring information on TBBPA-bis(dibromopropyl ether) is provided 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.

2.1 Measurements in Environmental Media

Table S2-11. Environmental Monitoring Data for TBBPA-bis(dibromopropyl ether)

Environmental Medium/Area	Country	Location details	Date	Single Est @	Range (% ND)	Wt Type	Detection Limit	N	Units	Reference
Soil										
farms; 2 km from e-waste area	China	Qingyuan suburb	2006	n.d.	n.d.	dry	1.5	4	µg/kg	Shi et al. (2009)
farms; 10 km from industrial area	China	Pearl River Delta	2007	39 (mean)	17.3 – 60.4 (0%)	dry	1.5	4	µg/kg	Shi et al. (2009)
6 sites; near BFR factory	China	Liuyang	2010	-	< 25 – 85.3	dry	25 (DL) 60 (LOQ)	-	µg/kg	Qu et al. (2013)
Sediment										
urban industrial area	China	Dongjiang River	2002	-	< 1.5 – 190	dry	1.5	4	µg/kg	Shi et al. (2009)
urban industrial area	China	Dongjiang River	2006	858 (mean)	1.48 – 2300	dry	1.5	4	µg/kg	Shi et al. (2009)
6 sites; near effluent of BFR factory; surface	China	Liuyang River	2010	2500 (unknown)	-	dry	25 (DL) 60 (LOQ)	-	µg/kg	Qu et al. (2013)
near metal recycler	Norway	Loselva River	2009	n.d.	n.d.	dry	-	3	µg/kg	Nyholm et al. (2013)
marine harbor at 3 locations near WWTP	Norway	Drammen	2009	n.d. (all locations)	n.d.	dry	-	3 ea.	µg/kg	Nyholm et al. (2013)
marine harbor at 3 locations near WWTP	Norway	Tromso	2009	n.d. (all locations)	n.d.	dry	-	3 ea.	µg/kg	Nyholm et al. (2013)
lake at 3 locations near WWTP	Norway	Lake Mjosa	2009	n.d. (all locations)	n.d.	dry	-	3 ea.	µg/kg	Nyholm et al. (2013)
Sediment	Germany	-	2006	n.d.	n.d.	-	10	-	µg/kg	Koppen et al. (2006)
Sewage Sludge										
2 major WWTPs	China	Pearl River Delta	2007	4527 (mean)	238 - 8946	dry	1.5	5	µg/kg	Shi et al. (2009)
3 WWTPs	Norway	Drammen; Lille-hammer;	2009	n.d.	n.d.	dry	-	3 ea.	µg/kg	Nyholm et al. (2013)

Table S2-11. Environmental Monitoring Data for TBBPA-bis(dibromopropyl ether)

Environmental Medium/Area	Country	Location details	Date	Single Est @	Range (% ND)	Wt Type	Detection Limit	N	Units	Reference
		Tromso								
	Germany	-	2006	n.d.	n.d.	-	22	-	µg/kg	Koppen et al. (2006)
Waste Water										
Water leachate from metal recycler	Norway	Loselva River	2009	0.081 (mean)	-	-	-	3	µg/L	Nyholm et al. (2013)
WWTP near possible BFR discharge	Norway	Drammen	2009	n.d. (influent) n.d. (effluent)	n.d. (influent) n.d. (effluent)	-	-	3 ea.	µg/L	Nyholm et al. (2013)
WWTP near possible BFR discharge	Norway	Lille-hammer	2009	n.d. (influent) n.d. (effluent)	n.d. (influent) n.d. (effluent)		-	3 ea.	µg/L	Nyholm et al. (2013)
WWTP near possible BFR discharge	Norway	Tromso	2009	0.018 (influent) n.d. (effluent)	(66%; influent) n.d. (effluent)		-	3 ea.	µg/L	Nyholm et al. (2013)
Ambient Air										
30 m above ground; industrial area	China	Guangzhou City	2007	0.528 (mean)	0.131-1.24		-	-	ng/m^3	Shi et al. (2009)

@type of value in parentheses
*May have been converted from the publication if it was only a simple mathematical conversion (e.g., ng/L => µg/L)
**Type of limit will be specified if known
- Information not available in publication
N.d. = not detected

2.2 Measurements in Wildlife

Table S2-12. TBBPA-bis(dibromopropyl ether) in Wildlife Biota

Species	Tissue Type	Location	Year	N (% n.d.)	Concentration (µg/kg lipid weight, unless noted)		Wt. type	Detect. limit**	Units*	Reference
					Range	Central Estimate				
Mammals										
Ringed seal	Liver	Norway; Svalbard Islands/remote area	2007 – 2009	10 (100%)	n.d.	n.d.	wet	0.0005 – 0.292	µg/kg	Sagerup et al. (2010)
Arctic fox	Liver	Norway; Svalbard Islands/remote area	2007 – 2009	10 (100%)	n.d.	n.d.	wet	0.0005 – 0.292	µg/kg	Sagerup et al. (2010)
Polar bear	Plasma	Norway; Svalbard Islands/remote area	2007 - 2009	10 (100%)	n.d.	n.d.	wet	0.0005 – 0.292	µg/kg	Sagerup et al. (2010)
Fish and Shellfish										
Capelin	Whole fish	Norway; Svalbard Islands/remote area	2007 - 2009	10 (100%)	n.d.	n.d.	wet	0.0005 – 0.292	µg/kg	Sagerup et al. (2010)
Common carp (farmed)	Muscle	China; e-waste area near city of Qingyuan	Not known	1 (100%)	n.d.	n.d.	lipid	2.3	µg/kg	Shi et al. (2009)
	Liver			1 (100%)						
Bighead carp (farmed)	Muscle	China; e-waste area near Qingyuan (city)	Not known	2 (100%)	n.d.	n.d.	lipid	2.3	µg/kg	Shi et al. (2009)
	Liver			2 (100%)						
Tilapia (farmed)	Muscle	China; e-waste area near Qingyuan (city)	Not known	2 (100%)	n.d.	n.d.	lipid	2.3	µg/kg	Shi et al. (2009)
	Liver			2 (100%)						
Mollusks	Soft	China; 9 sampling	2010	Unknown (9	< LOQ		-	0.8 (d.l.)	µg/kg	Qu et al.

Table S2-12. TBBPA-bis(dibromopropyl ether) in Wildlife Biota

Species	Tissue Type	Location	Year	N (% n.d.)	Concentration (µg/kg lipid weight, unless noted)		Wt. type	Detect. limit**	Units*	Reference
(11 species)		sites in Bohai Sea on urban coast		sampling sites)				50 (LOQ)		(2013)
Birds										
Common eider	Liver	Norway; Svalbard Islands/remote area	2007 - 2009	10 (100%)	n.d.	n.d.	wet	0.0005 – 0.292	µg/kg	Sagerup et al. (2010)
Black legged kittiwake	Liver	Norway; Svalbard Islands/remote area	2007 - 2009	10 (100%)	n.d.	n.d.	wet	0.0005 – 0.292	µg/kg	Sagerup et al. (2010)
Weathercock	Muscle	China; e-waste area near Qingyuan (city)	Not known	3 (100%)	n.d.	n.d.	lipid	2.3	µg/kg	Shi et al. (2009)
	Liver			3 (100%)						
	Kidney			3 (100%)						

@type of value in parens

*May have been converted from the publication if it was only a simple mathematical conversion (e.g., ng/L => µg/L)

**Type of limit will be specified if known

- Information not available in publication

N.d. = not detected

3 TBBPA-bis(allyl ether)

Monitoring information on TBBPA-bis(allyl ether) is provided 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 S2-13. Environmental Monitoring Data for TBBPA-bis(allyl ether)

Env. Medium	Country	Location Details	Sample Date	Single Est.@	Range (% non-detects)	Wt. type	Detect. limit**	N	Units*	Reference
Soil										
Surface; from 6 agricultural sites; near BFR factory	China	Liuyang River (nearby)	2010	-	< 5 – 24.1	dry	5	-	µg/kg	Qu et al. (2013)
near BFR factory	China	Liuyang City	2009	-	< d.l. – 41.7	dry	40 pg		µg/kg	Qu et al. (2011)
Sediment										
Surface; 6 sites; near BFR factory discharge	China	Liuyang River	2010	13 (unknown)	-	dry	5 (DL) 1.5 (LOQ)	-	µg/kg	Qu et al. (2013)
near BFR factory	China	Liuyang City	2009	-	143.4 – 10183.4	dry	40 pg	-	µg/kg	Qu et al. (2011)
Sediment recycler	Norway	Loselva River	2009	0.37 (unknown)	n.d.	dry	-	-	µg/kg	Nyholm et al. (2013)
near municipal landfill	Norway	-	2009	2.4 (unknown)	-	dry	-	-	µg/kg	Nyholm et al. (2013)
marine harbor; 3 locations near WWTP	Norway	Drammen	2009	0.81 +/- 0.47 (mean, sd at 1 loc) n.d. (2 loc's)	-	dry	-	3 ea.	µg/kg	Nyholm et al. (2013)
marine harbor; 3 locations near WWTP	Norway	Tromso	2009	n.d. (all loc's)	n.d.	dry	-	3 ea.	µg/kg	Nyholm et al. (2013)
Lake; 3 locations near WWTP	Norway	Lake Mjosa	2009	n.d. (all loc's)	n.d.	dry	-	3 ea.	µg/kg	Nyholm et al. (2013)
Sludge										
3 WWTPs	Norway	Drammen; Lille-	2009	n.d.	n.d.	dry	-	3	µg/kg	Nyholm et al.

Table S2-13. Environmental Monitoring Data for TBBPA-bis(allyl ether)

Env. Medium	Country	Location Details	Sample Date	Single Est.@	Range (% non-detects)	Wt. type	Detect. limit**	N	Units*	Reference
		hammer; Tromso						ea.		(2013)
From surface water near BFR factory	China	Liuyang City	2009	-	< d.l. – 0.049	-	-	-	µg/L	Qu et al. (2011)
Waste Water										
Water leachate (seepage) from metal recycler	Norway	-	2009	0.002 (unknown)	-	-	-	3	µg/L	Nyholm et al. (2013)
Water leachate (seepage) from municipal landfill	Norway	-	2009	n.d.	-	-	-	-	µg/L	Nyholm et al. (2013)
WWTP near possible BFR discharge	Norway	Drammen	2009	n.d. (influent) n.d. (effluent)	n.d. (influent) n.d. (effluent)	-	-	3 ea.	µg/L	Nyholm et al. (2013)
WWTP near possible BFR discharge	Norway	Lille-hammer	2009	n.d. (influent) n.d. (effluent)	n.d. (influent) n.d. (effluent)	-	-	3 ea.	µg/L	Nyholm et al. (2013)
WWTP near possible BFR discharge	Norway	Tromso	2009	n.d. (influent) n.d. (effluent)	n.d. (influent) n.d. (effluent)	-	-	3 ea.	µg/L	Nyholm et al. (2013)

@type of value in parentheses
*May have been converted from the publication if it was only a simple mathematical conversion (e.g., ng/L => µg/L)
**Type of limit will be specified if known
- Information not available in publication
N.d. = not detected

3.1 Measurements in Wildlife Biota

Table S2-14. TBBPA-bis(allyl ether) in Wildlife Biota

Species	Tissue Type	Location	Year	N (% n.d.)	Concentration (µg/kg lipid weight, unless noted)		Wt. type	Detect. limit**	Units*	Reference
					Range	Central Estimate				
Lake trout		Canada-United States; Lake Ontario	1997 – 2004	30 (83%)	n.d. – 1.7	-	wet	-	µg/kg	Ismail et al. (2006)
Mollusks (11 species)	Soft	China; 9 sampling sites in Bohai Sea on urban coast	2010	Unknown (9 sampling sites)	< LOQ	< LOQ	-	0.13 (d.l.) 20 (LOQ)	µg/kg	Qu et al. (2013)

@type of value in parens
*May have been converted from the publication if it was only a simple mathematical conversion (e.g., ng/L => µg/L)
**Type of limit will be specified if known
- Information not available in publication
N.d. = not detected

4 TBBPA-bis(methyl ether)

Monitoring information on TBBPA-bis(methyl ether) is provided 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.

4.1 Measurements in Environmental Media

Table S2-15. Environmental Monitoring Data for TBBPA-bis(methyl ether)

Env. Medium	Country	Location Details	Sample Date	Single Est.@	Range (% non-detects)	Wt. type	Detect. limit**	N	Units*	Reference
Sediment										
Sediment	Japan	Estuaries, not near Osaka	1981-1983	n.d.	n.d.	dry	-	7	µg/kg	Watanabe et al. (1983b)
Sediment	Japan	Estuaries in Osaka Bay	1981 - 1983	n.d.	n.d.	dry	-	6	µg/kg	Watanabe et al. (1983b)
Sediment	Japan	Rivers near Osaka	1981 - 1983	-	n.d. – 1.8	dry	-	6	µg/kg	Watanabe et al. (1983b)
Sediment	Belgium	Rivers in Scheldt Basin; reference sites	2001		< 0.1	wet	-	3	µg/kg	de Boer et al. (2002)
Sediment	Belgium	Rivers in Scheldt Basin; other sites	2001	-	< 0.1 – 0.3 (87.5% < 0.1)	wet	-	16	µg/kg	de Boer et al. (2002)
Sediment	Belgium	Rivers in Scheldt Basin; reference sites	2001	-	< 0.1	dry	-	3	µg/kg	de Boer et al. (2002)
Sediment	Belgium	Rivers in Scheldt Basin; other sites	2001	-	< 0.1 – 0.5 (87.5% < 0.1)	dry	-	16	µg/kg	de Boer et al. (2002)
Sediment	Belgium	Rivers in Scheldt Basin; reference sites	2001	-	< 0.6 or < 0.8	TOC	-	3	µg/kg	de Boer et al. (2002)
Sediment	Belgium	Rivers in Scheldt Basin; reference sites	2001	-	n.d. - 13 (87.5% < d.l.) n.d. range is < 0.1 to < 5.3	TOC	-	16	µg/kg	de Boer et al. (2002)
Sediment	Ireland	Rivers Nore and	2002	-	< 2.4 - < 2.4	dry	-	4	µg/kg	de Boer et al.

Table S2-15. Environmental Monitoring Data for TBBPA-bis(methyl ether)

Env. Medium	Country	Location Details	Sample Date	Single Est.@	Range (% non-detects)	Wt. type	Detect. limit**	N	Units*	Reference
		Bregagh								(2002)
Sediment	United Kingdom	River Tees	2002	-	< 2.4 - < 2.4	dry	-	10	µg/kg	de Boer et al. (2002)
Sediment	The Netherlands	Estuary in Western Scheldt	2002	-	< 0.1 - < 0.1	wet	-	19	µg/kg	de Boer et al. (2002)
Sediment	The Netherlands	Estuary in Western Scheldt	2002	-	< 0.1 - < 0.1	dry	-	19	µg/kg	de Boer et al. (2002)
Sediment	The Netherlands	Estuary in Western Scheldt	2002	-	< 0.4 - < 3.0	TOC	-	19	µg/kg	de Boer et al. (2002)
Sediment	The Nether-lands	Multiple rivers	2002	-	< 0.1 – 0.4 (44% < d.l.)	wet	-	9	µg/kg	de Boer et al. (2002)
Sediment	The Nether-lands	Multiple rivers	2002	-	< 0.1 – 0.6 (44% < d.l.)	dry	-	9	µg/kg	de Boer et al. (2002)
Sediment	The Nether-lands	Multiple rivers	2002	-	< 0.6 – 6.7 (44% < d.l.)	TOC	-	9	µg/kg	de Boer et al. (2002)
Sediment (surficial)	Sweden	Upstream (2 km) from plastics industry using TBBPA	1995	36 (unknown)	-	Igni-tion loss		1	µg/kg	Sellstrom and Jansson (1995)
Sediment (surficial)	Sweden	Upstream (2 km) from plastics industry using TBBPA	1995	24 (unknown)	-	dry		1		Sellstrom and Jansson (1995)
Sediment (surficial)	Sweden	Down-stream (5 km) from plastics industry using TBBPA	1995	2400 (unknown)	-	Igni-tion loss	-	1	µg/kg	Sellstrom and Jansson (1995)
Sediment (surficial)	Sweden	Down-stream (5 km) from plastics industry using TBBPA	1995	1500 (unknown)	-	dry	-	1	µg/kg	Sellstrom and Jansson (1995)
Sediment	Norway	Effluents from waste dumps	2002		< d.l. – 1.23 (8% below	dry	-	12	µg/kg	As cited in EC (2008)

Table S2-15. Environmental Monitoring Data for TBBPA-bis(methyl ether)

Env. Medium	Country	Location Details	Sample Date	Single Est.@	Range (% non-detects)	Wt. type	Detect. limit**	N	Units*	Reference
					detection)					
Sediment	Germany	Multiple rivers	2001	-	< 0.2 - < 0.2	-	0.2	19	µg/kg	As cited in EC (2008)
Sludge										
Sewage sludge	United Kingdom	Burnham (city)	2002	-	< 2.4 - < 2.4	dry	2.4	6	µg/kg	de Boer et al. (2002)
Sewage sludge	Ireland	Multiple cities	2002	-	< 2.4 - < 2.4	dry	2.4	6	µg/kg	de Boer et al. (2002)
Sewage sludge	The Nether-lands		2002	-	< 0.1 – 5.5	dry		9	µg/kg	de Boer et al. (2002)
Sewage sludge	The Nether-lands	Residential sewer	2002	< 0.1	-	dry		1	µg/kg	de Boer et al. (2002)
Sewage sludge	The Nether-lands	2 landfills	2002	< 0.1	-	dry		1 ea.	µg/kg	de Boer et al. (2002)
Sewage sludge from sewage treatment plant	Sweden	Plant gets leach water from landfill (plastics waste)	1995	< 3.7	-	Igni-tion loss	-	1	µg/kg	Sellstrom and Jansson (1995)
Sewage sludge from sewage treatment plant	Sweden	Plant gets leach water from landfill (plastics waste)	1995	< 1.9	-	dry	-	1	µg/kg	Sellstrom and Jansson (1995)
Sewage sludge from sewage treatment plant	Sweden	Plant has no known TBBPA user waste	1995	< 3.7	-	Igni-tion loss	-	1	µg/kg	Sellstrom and Jansson (1995)
Sewage sludge (activated, primary or clarified/settled)	Germany	From eight waste water treatment plants	2001		< d.l. – 11 (42% nondetects)	dry	0.2	12	µg/kg	As cited in EC (2008)
Waste Water and Leachate										
Waste water (influent; dissolved phase)	United Kingdom	Five cities	2002	-	< 0.015 – < 0.015	-	-	5	µg/L	de Boer et al. (2002)
Waste water (influent; particulate phase)	United Kingdom	Five cities	2002	-	< 3.9 – < 3.9	-	-	5	µg/kg	de Boer et al. (2002)
Waste water (effluent;	United	Five cities	2002	-	< 0.015 –	-	-	5	µg/L	de Boer et

Table S2-15. Environmental Monitoring Data for TBBPA-bis(methyl ether)

Env. Medium	Country	Location Details	Sample Date	Single Est.@	Range (% non-detects)	Wt. type	Detect. limit**	N	Units*	Reference
dissolved phase)	Kingdom				< 0.015					al. (2002)
Waste water (effluent; particulate phase)	United Kingdom	Five cities	2002	-	< 3.9 – < 3.9	-	-	5	µg/kg	de Boer et al. (2002)
Leachate from landfill (dissolved phase)	United Kingdom	Three cities	2002	-	< 0.015 – < 0.015	-	-	3	µg/L	de Boer et al. (2002)
Leachate from landfill (particulate phase)	United Kingdom	Three cities	2002	-	< 3.9 – < 3.9	-	-	3	µg/kg	de Boer et al. (2002)
Leachate from landfill (dissolved phase)	Ireland	Three landfills	2002	-	< 0.015 – < 0.015	-	-	2 ea.	µg/L	de Boer et al. (2002)
Leachate from landfill (particulate phase)	Ireland	Three landfills	2002	-	< 3.9 – < 3.9	-	-	2 ea.	µg/kg	de Boer et al. (2002)
Wastewater from sewage treatment plants (influent; particulate phase)	The Nether-lands	Various samples	2002	-	< 0.8 - < 5.6	dry	-	5	µg/kg	de Boer et al. (2002)
Wastewater from sewage treatment plants (effluent; particulate phase)	The Nether-lands	Various samples	2002	-	< 0.1 - 0.6 (40% not detected)	dry	-	5	µg/kg	de Boer et al. (2002)
Leachate from landfills (particulate phase)	The Nether-lands	Nine landfills	2002	-	< 0.1 - < 6.2	dry	-	2	µg/kg	de Boer et al. (2002)
Waste water (influent; dissolved and particulate)	Germany	Baden-Württemberg	2001	-	Not detected		0.0002 0.2	5 ea.	µg/L µg/kg	Ad cited in EC (2008)
Waste water (effluent)	Germany		2001	-	< 0.00033 – 0.00145 (74% not detected)		0.0002	19	µg/L	As cited in EC (2008)

Table S2-15. Environmental Monitoring Data for TBBPA-bis(methyl ether)

Env. Medium	Country	Location Details	Sample Date	Single Est.@	Range (% non-detects)	Wt. type	Detect. limit**	N	Units*	Reference
Surface Water										
Surface water	Germany	Upstream of WWTPs	2001	-	< 0.00042 – 0.00086 (73% not detected)	-	0.0002	15	µg/L	As cited in EC (2008)
Surface water	Germany	Down-stream of WWTPs	2001	-	< d.l. – 0.00106 (93% not detected)	-	0.0002	15	µg/L	As cited in EC (2008)

@type of value in parentheses; *May have been converted from the publication if it was only a simple mathematical conversion (e.g., ng/L => µg/L)
**Type of limit will be specified if known; - Information not available in publication; N.d. = not detected

4.2 Measurements in Wildlife

Table S2-16. Environmental Monitoring Data for TBBPA-bis(methyl ether) in Wildlife Biota

Species	Tissue Type	Location	Year	N (% n.d.)	Concentration (µg/kg lipid weight, unless noted)		Wt. type	Detect. limit**	Units*	Reference
					Range	Central Tendency				
Mammals										
Harbor porpoise	Liver	North Sea	2002	1 (100%)	< 11 (all)	-	Lipid	-	µg/kg	de Boer et al. (2002)
	Fat			4 (75%)	< 4 - 223					
Harbor seal	Liver	Western Wadden Sea	2002	3 (100%)	< 3 - < 24	-	lipid	-	µg/kg	de Boer et al. (2002)
	Fat			2 (50%)	< 3 -153					
Harbor porpoise	Fat	United Kingdom	2002	5 (100%)	< 5 (all)	-	Wet	-	µg/kg	de Boer et al. (2002)
Fish and Shellfish/Invertebrates										
Whiting	Muscle	North Sea	1999	3 (100%)	< 9	-	lipid	-	µg/kg	de Boer et al. (2002)
Cod	Liver	North Sea	2002	2 (100%)	< 0.1	-	wet	-	µg/kg	de Boer et al. (2002)
Cod	Liver	North Sea	2002	2 (100%)	< 0.2	-	lipid	-	µg/kg	de Boer et al. (2002)
Whiting	Muscle	United Kingdom	2002	3 (100%)	< 4.8	-	wet	-	µg/kg	de Boer et al. (2002)

Table S2-16. Environmental Monitoring Data for TBBPA-bis(methyl ether) in Wildlife Biota

Species	Tissue Type	Location	Year	N (% n.d.)	Concentration (µg/kg lipid weight, unless noted)		Wt. type	Detect. limit**	Units*	Reference
					Range	Central Tendency				
Gudgeon	-	Netherlands; Western Scheldt	2002	1 (100%)	< 0.1	-	Wet	-	µg/kg	de Boer et al. (2002)
				1 (100%)	< 0.1		Lipid			
Hake	Liver	Atlantic Ocean, near Ireland	2002	1 (100%)	< 0.1	-	wet	-	µg/kg	de Boer et al. (2002)
Cod	Liver	Norway	2002	6 (100%)	< 0.5 (all)	-	-	0.5	µg/kg	As cited in EC (2008)
Yellow eel	Tail end	Belgium; Scheldt basin - reference sites	2000	3 (100%)	< 0.1	-	wet	-	µg/kg	de Boer et al. (2002)
Yellow eel	Tail end	Belgium; Scheldt basin - other sites	2000	15 (53%)	< 0.1 – 2.5	-	wet	-	µg/kg	de Boer et al. (2002)
Yellow eel	Tail end	Belgium; Scheldt basin - reference sites	2000	3 (100%)	< 0.1 - < 0.2	-	lipid	-	µg/kg	de Boer et al. (2002)
Yellow eel	Tail end	Belgium; Scheldt basin - other sites	2000	15 (47%)	< 0.1 – 12	-	lipid	-	µg/kg	de Boer et al. (2002)
Eel	-	Netherlands; Waal River	2002	11 (9%)	< 0.1- 1.3	-	Wet	-	µg/kg	de Boer et al. (2002)
				11 (9%)	< 0.3 – 6.8		lipid			

Table S2-16. Environmental Monitoring Data for TBBPA-bis(methyl ether) in Wildlife Biota

Species	Tissue Type	Location	Year	N (% n.d.)	Concentration (µg/kg lipid weight, unless noted)		Wt. type	Detect. limit**	Units*	Reference
					Range	Central Tendency				
Fish and shellfish	-	Japan	1983	19 (89%)	< d.l. – 4.6	-	wet	-	µg/kg	As cited in EC (2008)
Common whelk	Soft, whole	North Sea	1999	3 (100%)	< 3 (all)	-	lipid	-	µg/kg	de Boer et al. (2002)
Sea star	Digestive tract; pyloric caeca	North Sea	1999	3 (100%)	< 3 (all)	-	lipid	-	µg/kg	de Boer et al. (2002)
Hermit crab	Digestive tract	North See	1999	9 (100%)	< 3 (all)	-	lipid	-	µg/kg	de Boer et al. (2002)
Starfish	Whole	United Kingdom	2002	1 (100%)	< 4.8	-	wet	-	µg/kg	de Boer et al. (2002)
Mysid shrimp	-	Netherlands	2002	2 (100%)	< 0.1 - < 0.3	-	wet	-	µg/kg	de Boer et al. (2002)
Blue mussel	-	Norway	2002	6 (100%)	< 0.1 (all)	-	-	0.1	µg/kg	As cited in EC (2008)
Mussel	-	Japan	1983	1 (0%)	5	-	wet	-	µg/kg	As cited in Simonsen et al. (2000)

Table S2-16. Environmental Monitoring Data for TBBPA-bis(methyl ether) in Wildlife Biota

Species	Tissue Type	Location	Year	N (% n.d.)	Concentration (µg/kg lipid weight, unless noted)		Wt. type	Detect. limit**	Units*	Reference
					Range	Central Tendency				
Birds										
Cormorant	Liver	United Kingdom	2002	5 (100%)	< 5	-	wet	-	µg/kg	de Boer et al. (2002)
Common tern	Eggs	Netherlands; Western Scheldt	2002	10 (60%)	< 0.2 – 0.8	-	wet	-	µg/kg	de Boer et al. (2002)
				10 (60%)	< 2 – 7.6		lipid			

@type of value in parentheses

*May have been converted from the publication if it was only a simple mathematical conversion (e.g., ng/L => µg/L)

**Type of limit will be specified if known

- Information not available

References

Abdallah, M. A. E., S. Harrad, and A. Covaci. 2008. *Hexabromocyclododecanes and Tetrabromobisphenol-A in Indoor Air and Dust in Birmingham, UK: Implications for Human Exposure*. Environmental Science and Technology, 42(18), 6855-6861.

Alaee, M., D. Muir, C. Cannon, P. Helm, T. Hamer, and T. Bidleman. 2003. New Persistent Chemicals in Arctic Air and Water. In T. Bidleman, R. M., and J. Stow, *Canadian Arctic Contaminants Assessment Report II. Sources, Occurrences, Trends and Pathways in the Physical Environment* (Chapter B.4, pp. 116-124). Minister of Indian Affairs and Nothern Development, Ottawa, Canada.

Baron, E., P. Gago-Ferrero, M. Gorga, I. Rudolph, G. Mendoza, A. Mauricio Zapata, S. Diaz-Cruz, R. Barra, W. Ocampo-Duque, M. Paez, R. Maria Darbra, E. Eljarrat, and D. Barcelo. 2013. *Occurrence of Hydrophobic Organic Pollutants (BFRs and UV-Filters) in Sediments from South America*. Chemosphere, 92(3), 309-316.

Chokwe, T. B., J. O. Okonkwo, L. L. Sibali, and E. J. Ncube. 2012. *Optimization and Simultaneous Determination of Alkyl Phenol Ethoxylates and Brominated Flame Retardants in Water after SPE and Heptafluorobutyric Anhydride Derivatization Followed by GC/MS*. Chromatographia, 75(19-20), 1165-1176.

de Boer, J., C. Allchin, B. Zegers, J. P. Boon, S. H. Brandsma, S. Morris, A. W. Kruijt, I. van der Veen, J. M. van Hesselingen, and J. J. H. Haftka. 2002. *HBCD and TBBPA in Sewage Sludge, Sediments and Biota, Including Interlaboratory Study*. RIVO report number CO33/02. RIVO - the Netherlands Institute for Fisheries Research, Ymuiden and Yerseke, Netherlands.

Driffield, M., N. Harmer, E. Bradley, A. R. Fernandes, M. Rose, D. Mortimer, and P. Dicks. 2008. *Determination of Brominated Flame Retardants in Food by LC-MS/MS: Diastereoisomer-Specific Hexabromocyclododecane and Tetrabromobisphenol A*. Food Additives and Contaminants. Part A: Chemistry, Analysis, Control, Exposure and Risk Assessment, 25(7), 895-903.

EC (European Commission). 2008. *Risk Assessment of 2,2',6,6-Tetrabromo-4,4'-Isopropylidene Diphenol (Tetrabromobisphenol-A): CAS Number: 79-94-7; EINECS Number: 201-236-9; Final Environmental Rar of February 2008*. R402_0802_env. Rapporteur: United Kingdom. http://echa.europa.eu/documents/10162/17c7379e-f47b-4a76-aa43-060da5830c07.

Feng, A. H., S. J. Chen, M. Y. Chen, M. J. He, X. J. Luo, and B. X. Mai. 2012. *Hexabromocyclododecane (HBCD) and Tetrabromobisphenol A (TBBPA) in Riverine and Estuarine Sediments of the Pearl River Delta in Southern China, with Emphasis on Spatial Variability in Diastereoisomer- and Enantiomer-Specific Distribution of HBCD*. Marine Pollution Bulletin, 64, 919-925.

Gorga, M., E. Martinez, A. Ginebreda, E. Eljarrat, and D. Barcelo. 2013. *Determination of PBDEs, HBB, PBEB, DBDPE, HBCD, TBBPA and Related Compounds in Sewage Sludge from Catalonia (Spain)*. Science of the Total Environment, 444, 51-59.

Guerra, P., E. Eljarrat, and D. Barcelo. 2010. *Simultaneous Determination of Hexabromocyclododecane, Tetrabromobisphenol A, and Related Compounds in Sewage Sludge and Sediment Samples from Ebro River Basin (Spain)*. Analytical and Bioanalytical Chemistry, 397, 2817-2824.

Harrad, S., M. A. Abdallah, N. L. Rose, S. D. Turner, and T. A. Davidson. 2009. *Current-Use Brominated Flame Retardants in Water, Sediment, and Fish from English Lakes*. Environmental Science and Technology, 43(24), 9077-9083.

He, M.-J., X.-J. Luo, L.-H. Yu, J.-P. Wu, S.-J. Chen, and B.-X. Mai. 2013. *Diasteroisomer and Enantiomer-Specific Profiles of Hexabromocyclododecane and Tetrabromobisphenol A in an Aquatic Environment in a Highly Industrialized Area, South China: Vertical Profile, Phase Partition, and Bioaccumulation*. Environmental Pollution, 179, 105-110.

Hwang, I.-K., H.-H. Kang, I.-S. Lee, and J.-E. Oh. 2012. *Assessment of Characteristic Distribution of PCDD/Fs and BFRs in Sludge Generated at Municipal and Industrial Wastewater Treatment Plants*. Chemosphere, 88(7), 888-894.

Ismail, N., K. Pleskach, C. Marvin, M. Whittle, M. Keir, P. Helm, and G. T. Tomy. 2006. *Temporal Trends of Flame Retardants in Lake Ontario Lake Trout (1979–2004)*. Organohalogen Compounds, 68, 1808-1811. (as cited in de Wit et al., 2011).

Johnson-Restrepo, B., D. H. Adams, and K. Kannan. 2008. *Tetrabromobisphenol A (TBBPA) and Hexabromocyclododecanes (HBCDs) in Tissues of Humans, Dolphins, and Sharks from the United States*. Chemosphere, 70, 1935-1944.

Koppen, G., R. Becker, C. Jung, C. Piechotta, and I. Nehls. 2006. *Investigation of Extraction Procedures and HPLCc-Dad/MS for the Determination of the Brominated Flame Retardant Tetrabromobisphenol A Bis(2,3-Dibromopropylether) in Environmental Samples 384:1485–1492*. Anal Bioanal Chem, 384, 1485-1492. (as cited in de Wit et al, 2011).

Kuch, B., W. Korner, and H. Hagenmaier. 2001. *[Monitoring Von Bromierten Flammschutzmitteln in Fliessgewassern, Abwassern Und Klarschlammen in Baden-Wurttemberg]*. (as cited in EC/HC, 2013).

Labadie, P., K. Tlili, F. Alliot, C. Bourges, A. Desportes, and M. Chevreuil. 2010. *Development of Analytical Procedures for Trace-Level Determination of Polybrominated Diphenyl Ethers and Tetrabromobisphenol A in River Water and Sediment*. Analytical and Bioanalytical Chemistry, 396, 865-875.

Law, K., T. Halldorson, R. Danell, G. Stern, S. Gewurtz, M. Alaee, C. Marvin, M. Whittle, and G. Tomy. 2006. *Bioaccumulation and Trophic Transfer of Some Brominated Flame Retardants in a Lake Winnipeg (Canada) Food Web*. Environmental Toxicology and Chemistry, 25(8), 2217-2186.

Lee, H. B., and T. E. Pearl. 2002. *Organic Contaminants in Canadian Municipal Sewage Sludge - Part I: Toxic or Endocrine-Disrupting Phenolic Compounds*. Water Quality Research Journal of Canada, 37(4), 681-696.

Metzger, J. W., and B. Kuch. 2003. *Organic Flame Retardants in Wastewater Treatment Plants*. Chimia, 57, 24-26.

Morris, S., C. R. Allchin, B. N. Zegers, J. J. H. Hafta, J. P. Boon, C. Belpaire, P. E. G. Leonards, S. P. J. van Leeuwen, and J. de Boer. 2004. *Distribution and Fate of HBCD and TBBPA Brominated Flame Retardants in North Sea Estuaries and Aquatic Food Webs*. Environmental Science and Technology, 38(21), 5497-5504.

Nyholm, J. R., R. Grabic, H. P. H. Arp, T. Moskeland, and P. L. Andersson. 2013. *Environmental Occurrence of Emerging and Legacy Brominated Flame Retardants near Suspected Sources in Norway*. Science of the Total Environment, 443, 307-314.

Öberg, K., K. Warman, and T. Oberg. 2002. *Distribution and Levels of Brominated Flame Retardants in Sewage Sludge*. Chemosphere, 48, 805-809.

OECD (Organisation for Economic Cooperation and Development). 2003. *Guidance Document on Reporting Summary Information on Environmental, Occupational and Consumer Exposure*. ENV/JM/MONO(2003)16. Environment Directorate, Joint Meeting of the Chemicals Committee and the Working Party on Chemicals, Pesticides and Biotechnology, Paris, France. http://www.oecd-ilibrary.org/environment/guidance-document-on-reporting-summary-information-on-environmental-occupational-and-consumer-exposure_9789264079113-en.

Ohta, S., T. Okumura, H. Nishimura, T. Nakao, A. Osamau, and H. Miyata. 2004. *Characterization of Japanese Pollution by PBDEs, TBBPA, PCDDs/DFs, PBDDs/DFs and PXDDs/DFs Observed in the Long-Term Stock- Fishes and Sediments*. Abstracts of the 3rd International Workshop on brominated flame retardants, 175-178.

Osako, M., Y.-J. Kim, and S. Sakai. 2004. *Leaching of Brominated Flame Retardants in Leachate from Landfills in Japan*. Chemosphere, 57, 1571-1579.

Pellizzari, E. D., R. A. Zweidinger, and M. D. Erickson. 1978. *Environmental Monitoring near Industrial Sites: Brominated Chemicals. Part I and II*. Contract Number 68-01-1978. Research Triangle Institute, for Office of Toxic Substances, U.S. Environmental Protection Agency, Washington, D.C.

Peltola, J. 2002. *An Environmental Screening of Four Brominated Flame Retardants in Finland*. to be published in Chemosphere. (as cited in EC, 2008).

Peters, R. J. B. 2003. *Hazardous Chemicals in Precipitation*. TNO Report R2003/198. Netherlands Organisation for Applied Scientific Research; TNO Environment, Energy and Process innovation, Apeldoorn, the Netherlands.

http://www.greenpeace.org/sweden/Global/sweden/p2/miljogifter/report/2006/hazardous-chemicals-in-precipitation.pdf.

Potvin, C. M., Z. Long, and H. Zhou. 2012. *Removal of Tetrabromobisphenol a by Conventional Activated Sludge, Submerged Membrane and Membrane Aerated Biofilm Reactors*. Chemosphere, 89(10), 1183-1188.

Qu, G., A. Liu, T. Wang, C. Zhang, J. Fu, M. Yu, J. Sun, N. Zhu, Z. Li, G. Wei, Y. Du, J. Shi, S. Liu, and G. Jiang. 2013. *Identification of Tetrabromobisphenol a Allyl Ether and Tetrabromobisphenol A 2,3-Dibromopropyl Ether in the Ambient Environment near a Manufacturing Site and in Mollusks at a Coastal Region*. Environmental Science and Technology, 47(9), 4760-4767.

Qu, G., J. Shi, T. Wang, J. Fu, Z. Li, P. Wang, T. Ruan, and G. Jiang. 2011. *Identification of Tetrabromobisphenol A Diallyl Ether as an Emerging Neurotoxicant in Environmental Samples by Bioassay-Directed Fractionation and HPLC-APCI-MS/MS*. Environmental Science and Technology, 45, 5009-5016.

Quade, S. C. 2003. *Determination of Tetrabromobisphenol A in Sediment and Sludge.* (M.S. dissertation), University of Guelph, Ottawa, Canada.

Russell, M., L. Webster, P. Walsham, G. Packer, and C. F. Moffat. 2008. *Brominated Flame Retardants in Deep Water Fish Species Collected Off the West Coast of Scotland*. Organohalogen Compounds, 70, 255-258.

Sagerup, K., D. Herzke, M. Harju, A. Evenset, G. N. Christensen, H. Routti, E. Fuglei, J. Aars, H. Strom, and G. W. Gabrielsen. 2010. *New Brominated Flame Retardants in Arctic Biota*. Rapportnr. 1070/2010. Statlig program for forurensningsovervåking, Oslo, Norway. http://www.klif.no/publikasjoner/2630/ta2630.pdf.

Schlabach, M., E. Fjeld, and A. R. Borgen. 2004. *Brominated Flame Retardants in Drammens River and the Drammensfjord, Norway*. Abstracts of the 3rd International Workshop on brominated flame retardants, June 6-9, 2004, Toronto, Canada, 147-150.

Schlabach, M., M. Remberger, E. Brorstrom-Lunden, K. Norstrom, L. Kaj, H. Andersson, D. Herzke, A. Borgen, and M. Harju. 2011. *Brominated Flame Retardants (BFR) in the Nordic Environment*. TemaNord 2011:528. Nordic Council of Ministers, Copenhagen, Denmark. http://www.norden.org/en/publications/publikationer/2011-528.

Sellstrom, U., and B. Jansson. 1995. *Analysis of Tetrabromobisphenol A in a Product and Environmental Samples*. Chemosphere, 31(4), 3085-3092.

Shi, T., S. J. Chen, X. J. Luo, X. L. Zhang, C. M. Tang, Y. Luo, Y. J. Ma, J. P. Wu, X. Z. Peng, and B. X. Mai. 2009. *Occurrence of Brominated Flame Retardants Other Than Polybrominated Diphenyl Ethers in Environmental and Biota Samples from Southern China*. Chemosphere, 74(7), 910-916.

Simonsen, F. A., M. Stavnsbjerg, L. M. Moller, and T. Madsen. 2000. *Brominated Flame Retardants; Toxicity and Ecotoxicity*. Environment Project No. 568. Centre for Integrated Environment and Toxicology.

Suzuki, S., and A. Hasegawa. 2006. *Determination of Hexabromocyclododecane Diastereoisomers and Tetrabromobisphenol A in Water and Sediment by Liquid Chromatography/Mass Spectrometry*. Analytical Sciences, 22(March), 469-474.

Watanabe, I., T. Kashimoto, and R. Tatsukawa. 1983a. *The Flame Retardant Tetrabromobisphenol-A and Its Metabolite Found in River and Marine Sediments in Japan*. Chemosphere, 12(11/12), 1533-1539.

Watanabe, I., T. Kashimoto, and R. Tatsukawa. 1983b. *Identification of the Flame Retardant Tetrabromobisphenol A in the River Sediment and Mussel Collected in Osaka*. Bulletin of Environmental Contamination and Toxicology, 31, 48-52.

Xie, Z., R. Ebinghaus, R. Lohmann, O. Heemken, A. Caba, and W. Puttmann. 2007. *Trace Determination of the Flame Retardant Tetrabromobisphenol A in the Atmosphere by Gas Chromatography-Mass Spectrometry*. Analytica Chimica Acta, 584, 333-342.

Xu, J., Y. Zhang, C. Guo, Y. He, L. Li, and W. Meng. 2013. *Levels and Distribution of Tetrabromobisphenol A and Hexabromocyclododecane in Taihu Lake, China*. Environmental Toxicology and Chemistry, 32(10), 2249-2255.

Xu, T., J. Wang, S.-z. Liu, C. Lu, W. L. Shelver, Q. X. Li, and J. Li. 2012. *A Highly Sensitive and Selective Immunoassay for the Detection of Tetrabromobisphenol A in Soil and Sediment*. Analytica Chimica Acta, 751, 119-127.

Yang, S., S. Wang, F. Wu, Z. Yan, and H. Liu. 2012. *Tetrabromobisphenol A: Tissue Distribution in Fish, and Seasonal Variation in Water and Sediment of Lake Chaohu, China*. Environmental Science and Pollution Research, 19, 4090-4096.

Zhang, X. L., X. J. Luo, S. J. Chen, J. P. Wu, and B. X. Mai. 2009. *Spatial Distribution and Vertical Profile of Polybrominated Diphenyl Ethers, Tetrabromobisphenol A, and Decabromodiphenylethane in River Sediment from an Industrialized Region of South China*. Environmental Pollution, 157, 1917-1923.