Environment International 42 (2012) 138–143

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Dietary intake of polybrominated diphenyl ethers (PBDEs) and polychlorinated biphenyls (PCBs) from fish and meat by residents of Nanjing, China

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ARTICLE INFO

Available online 20 July 2011

Keywords:
Hazard
Risk
Food
Human exposure
Gas Chromatography–Mass Spectrometry

ABSTRACT

Concentrations of 14 polybrominated diphenyl ether (PBDEs) and 28 polychlorinated biphenyl (PCBs) congers were measured in 137 samples of fish and meat from Nanjing, a city in the Yangtze River Delta, China. Total concentrations of PBDEs were less in fish (mean of 180 pg/g ww; range 8.0–1100 pg/g ww), but more in non fish foods (mean of 180 pg/g ww; range 15–950 pg/g ww) than those reported from other countries. The total dietary intake of PBDEs and PCBs by humans were 9.9 ng PBDE/d and 870 ng PCB/d, respectively. The daily intake by a 60 kg adult of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin equivalents (TEQ_{WHO}) from PCBs was estimated to be 49 pg $^{PCB}TEQ_{WHO}$/d (0.82 pg $^{PCB}TEQ_{WHO}$/kg bw), which is less than the tolerable daily intake suggested by the World Health Organization (WHO). The daily intake of meat and fish accounted for 57.2% and 42.8% of the total intake of $^{PCB}TEQ_{WHO}$.

1. Introduction

Over the past 20 years, China has been rapidly industrializing which has resulted in greater releases of some organic compounds into the environment (Mai et al., 2005). The Yangtze River Delta (YRD), located in East China, has undergone particularly rapid industrialization and economic growth. The gross industrial output of the YRD was about 618 billion dollars in 2007 and accounted for 18.8% of the total Chinese gross domestic product (GDP). Nanjing is one of six major industrial cities, in terms of size, population and GDP, and is the center of petroleum processing and chemical manufacturing in this region. With rapid economic development, new industrial and commercial enterprises have been established along both sides of the river from which both polybrominated diphenyl ethers (PBDEs) and polychlorinated biphenyls (PCBs) have been reported to be released (Gao et al., 2009; Xian et al., 2008; Xu et al., 2009). These two classes of compounds are ubiquitous in the environment due to persistence and long-range transport (Covaci et al., 2003). Penta- and octa-formulations of PBDEs have recently been added to the list of emerging Persistent Organic Pollutants (POPs), and polychlorinated biphenyls (PCBs) are one of the classic POPs. Though PCBs are no longer manufactured in China, they are still present in a variety of applications, including dielectric fluids in capacitors and transformers, heat transfer fluids and hydraulic fluids, and are present in the environment due to these uses and other historical uses such as lubricating and cutting oils, and additives in pesticides, paints, copying paper, carbonless copy paper, adhesives, sealants and plastics. China has been one of the greater consumers of PBDEs, as well as PCBs and both classes of chemicals are found in sediments (Chen et al., 2006; Shen et al., 2006) and fishes (Xian et al., 2008) of the Yangtze River. PBDEs are a class of brominated flame retardants that are still widely used in plastics, textiles, and electronic appliances, including television sets, computers, and so on. Because of their lipophilicity, both PCBs and PBDEs can be accumulated in animals, especially aquatic animals (Kuehl and Haebler, 1995), and humans can be exposed through food (Burreau et al., 1997; Bremle et al., 1995; Zhao et al., 2007). Both of these classes of compounds can cause adverse effects on wildlife (Cagliano, 1998) and can be accumulated to sufficient concentrations to cause adverse effects in humans (Meerts et al., 2001; Meerts et al., 2000; Winneke et al., 1998). Studies of the

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doi:10.1016/j.envint.2011.05.015

exposure of humans to PBDEs through food have been conducted in North America (Schecter et al., 2004) and Europe (Bocio et al., 2003; Darnerud et al., 2006). However, while there has been an increasing interest in exposure of people to these compounds in China, fewer studies have been conducted (Jiang et al., 2007; Meng et al., 2007; Zhao et al., 2009).

Since one of the major routes of exposure of humans to PBDEs and PCBs is via food, especially fish and meat (Zhao et al., 2009), the human population of China, especially that in the more industrialized southeast coast, might be exposed to relatively great concentrations of PBDEs and PCBs. However no information was available on concentrations of PBDEs in foods of people living along the lower Yangtze River in Jiangsu Province. Concentrations of 28 PCBs and 14 PBDEs were measured in fish and meat from Nanjing City in the Yangtze River Delta. The main objectives of this study were to: 1) determine concentration and distribution of PBDEs and PCBs in fish and meat; 2) to estimate current exposures of people to these compounds and 3) to determine the potential risks of PCBs, based on dietary survey and by use of World Health Organization (WHO) 2,3,7,8-TCDD-equivalency factors ($^{PCB}TEQ_{WHO}$).

2. Materials and methods

2.1. Sampling

Samples of selected food items were purchased from 10 different markets in Nanjing City during July, 2006. The 10 markets which were located in different regions of the city, included: Jinxianghe Market, Shanghai Road Market, Nanchang Road Market, Daijiaxiang Market, Kingrunfa Supermarket, Fuzimiao Market, Maigaoqiao Market, Nengrenli Market, Xiaolingwei Market, and Weigang Market. The items included seven aquatic foods including Mandarin fish (*Siniperca chuatsi*), Catfish (*Clarias lazera*), Chinese Snakehead (*Channa argus*), Black bass (*Micropterus salmoides*), Crucian Carp (*Carassius auratus*), White amur bream (*Parabramis pekinensis*), Oriental river prawn (*Macrobrachium nipponensis*), and five domestic meat products including Pork sausage, Chicken, Duck, Beef and Pork (Table 1). Samples were kept on ice during transportation to the laboratory and kept frozen at −20 °C until further analysis.

2.2. Analytical methods

2.2.1. Extraction and cleanup

Samples were prepared for instrumental analyses by homogenization and lyophilization. After determining the length and mass of individual fish, the edible proportion of fish was collected to analyze while samples of meat were processed directly. Samples were freeze dried then homogenized with a food grinder. Approximately 4 g of dry sample, spiked with internal standard ($^{13}C_{12}$-BDE-139), and residues were Soxhlet extracted for 24 h with 200 ml 50% dichloromethane in hexane. Lipid content was determined by gravimetric measurement from an aliquot of extract. Another aliquot of extract to be used for quantification of PBDEs and PCBs, was concentrated by rotary evaporation to 1 ml. Sulfuric acid (5 ml) was added to the extract for lipid removal, and the organic phase was extracted with a mixture of dichloromethane and hexane. The extract was then concentrated and passed through a mini silica column, which consisted of a Pasteur pipette packed from bottom to top with glass-wool, silica gel (0.25 g), 44% H_2SO_4 acid silica gel (1.0 g), silica gel (0.25 g), anhydrous sodium sulfate (0.3 g). The column was pre-eluted with 10 ml dichloromethane followed by 10 ml hexane. The fraction containing both PBDEs and PCBs was eluted with 12 ml of hexane. The eluate was concentrated by rotary evaporation to near dryness under a gentle nitrogen flow and an internal injection standard of 5 ng $^{13}C_{12}$–PCB-52, PCB-111, PCB-178 was added and the volume was adjusted to 100 μL hexane.

2.2.2. GC/MS analysis

Concentrations of 14 PBDEs and 28 PCBs were determined by use of a Polaris Q GC/MS (Thermo Finnigan, Austin, USA) coupled with a DB-XLB column (15 m × 0.25ID × 0.25 μm) in EI MS/MS mode. The 14 PBDE congeners were: BDE-17, 28, 71, 47, 66, 100, 99, 85, 138, 153, 154, 183, 190, and 209, in order of retention times. The 28 PCB congeners were: CB-8, 18, 28, 52, 44, 66, 101, 81, 77, 123, 118, 114, 105, 153, 126, 138, 128, 187, 167, 156, 157, 170, 180, 189, 169, 195, 206, and 209, in order of retention times. 2 μL was injected by auto-sampler in splitless mode. The injector temperature and transfer line temperature were both 300 °C. The mass spectrometer was operated with electron impact ionization (EI) mode at source temperature of 240 °C and the electron energy was 70 eV. GC conditions for PBDEs were: initial oven temperature of 80 °C was held for 1 min, then increased to 320 °C at 15 °C/min and held for 15 min. The GC conditions for PCBs were: initial oven temperature of 100 °C was held for 1 min then increased to 200 °C at 20 °C/min and held for 1.5 min, then increased to 270 °C finally at 15 °C/min and held for 15 min. All samples and the standards were analyzed in MS/MS mode, the precursor ions and product ions mass range for each chemical are listed (Table 2). Instrumental parameters, such as resonant excitation voltage (REV) were optimized in order to obtain maximum selectivity and sensitivity.

2.2.3. Quality assurance/quality control

QA/QC was conducted by performing laboratory blanks, GC/MS detection limit (based on 3S/N) and standard spiked recoveries. Concentrations of target analytes in laboratory blanks were less than 5% of the sample minimum concentration, which demonstrated that samples were free from contamination. The limits of quantification

Table 1
General information for samples.

Sample	Sample size	Body length (cm)	Weight (g)	Water content (%)	Lipid content (%)
Fishery product					
Mandarin fish	10	25–35	505–670	77.2	2.4
Catfish	11	33–45	435–810	69.0	14.9
Chinese snakehead	11	27–37	262–675	76.8	3.1
Black bass	10	23–29	485–645	75.5	3.3
Crucian Carp	14	20–23	213–370	77.7	2.7
White amur bream	11	23–33	264–980	79.2	2.3
Oriental river prawn	18[a]	4–8	3–10	76.5	1.3
Meat					
Pork sausage	10	–	52–113	10.2	70.2
Chicken	11	–	102–289	73.7	1.6
Duck	10	–	85–234	61.4	24.7
Beef	10	–	50–207	74.0	5.1
Pork	11	–	91–217	52.4	33.9

[a] The oriental river prawn samples were analyzed in 18 batches that included 132 individuals.

Table 2
Ion pairs for quantification of PBDEs and PCBs with GC-MS.

PBDEs			PCBs		
Congeners	Precursor ion (m/z)	Product ion mass range (m/z)	Congeners	Precursor ion (m/z)	Product ion mass range (m/z)
Di-	–	–	Di-	222	111–200
Tri-	406.0	220–420	Tri-	258	129–240
Tetra-	485.8	280–500	Tetra-	293	217–227
Penta-	563.7	380–580	Penta-	328	250–265
Hexa-	643.4	450–680	Hexa-	362	285–300
Hepta-	723.6	520–750	Hepta-	394	314–335
Octa-	–	–	Octa-	430	350–370
Nona-	–	–	Nona-	464	380–410
Deca-	959.7	760–1000	Deca-	498	420–440

(LOQ) defined as 10 S/N ranged from 5.8 pg BDE-71/g ww to 140 pg BDE-209/g ww and 9.2 pg CB-209/g ww to 23 CB-105 pg/g for PBDEs and PCBs, respectively. For samples where concentrations of a congener were less than the LOQ, they were reported as not detected. Before sample analysis, matrix spike ($n=6$) for each target compound had been evaluated. And recoveries ranged from 55.7 to 120.1% for PBDEs and from 56.5 to 123.2% for PCBs, respectively. To ensure the analytical procedures were conducted properly, ^{13}C12-labeled BDE-139 was used as the internal standard for PBDEs and PCBs. Recoveries of the ^{13}C-labeled BDE-139 internal standard were between 72.1 and 109.0%.

2.3. Dietary survey

In 2007, the relative proportions of food items in the diets of healthy adults from the general population of Nanjing were determined by use of a questionnaire given to 131 randomly selected individuals. Dietary data were collected through detailed in-person interviews. All participants were local residents who were interviewed to determine the amounts of the two food categories: meat and fish, which included 12 species that were consumed. Data collected for each food item included frequency of consumption and the quantity consumed on each occasion. Daily intake, expressed as grams per day (g/d) was determined for each food item for each person.

Concentrations of PCBs were converted to 2,3,7,8-TCDD equivalents ($^{PCB}TEQ_{WHO}$) by use of TEF_{WHO}. Statistical analyses were conducted using SPSS for Windows, and all tests were considered significant at $p<0.05$.

3. Results and discussion

3.1. PBDEs in fish and meat

Concentrations of PBDEs and PCBs are presented on a wet weight basis (fat content also provided), and grouped into two categories: fishery product and meat. The greatest concentration of total PBDE ($1.1\times$pg $\sum$PBDEs/g ww) was observed in White amur bream while the least concentration was observed in the oriental river prawn (8.0 pg $\sum$PBDEs/g ww) (Table 3). Mean concentrations of $\sum$PBDEs ranged from 51 pg $\sum$PBDE/g ww (for shrimp) to 360 pg $\sum$PBDE/g ww in pork sausage. The ranking of mean concentrations of $\sum$PBDEs was: Pork sausage > Duck > Catfish > Mandarin Fish > White amur bream > Chinese Snakehead > Black Bass > Pork > Crucian Carp > Beef > Chicken > Oriental river prawn. Compared to other market basket surveys in other countries, concentrations of $\sum$PBDE in food from Nanjing were less in fish (mean of 180 pg $\sum$BPDE/g ww; range 8–1100 pg $\sum$PBDE/g ww), but more in non fishery foods (mean of 181 pg $\sum$BPDE/g ww; range 15–950 pg $\sum$BPDE/g ww) than those in the USA (fish:1100 pg PBDE/g ww; meat: 38 pg $\sum$PBDE/g ww) (Schecter et al., 2004, 2006), Spain (fish: 330 pg $\sum$PBDE/g ww; meat: 110 pg $\sum$PBDE/g ww) (Bocio et al., 2003), Sweden (fish: 630 pg $\sum$PBDE/g ww; meat: 46 pg $\sum$PBDE/g ww) (Darnerud et al., 2006), Finland (fish: 850 pg $\sum$PBDE/g ww; meat: 13 pg $\sum$PBDE/g ww) (Kiviranta et al., 2004) and Japan (fish: 910 pg $\sum$PBDE/g; meat: 29 pg/g) (Ohta et al., 2002). One reason for this observation could be that the meats in this study had relatively great lipid contents, especially in Pork sausage (70.2%) and Pork (33.9%). The mean $\sum$PBDEs concentration in fishes was similar to the result found in fish from Guangdong, South China (160 pg $\sum$PBDE/g ww) (Gao et al., 2009; Meng et al., 2007).

BDE-47 was the dominant BDE congener (42.1%–73.9%) in food samples from Nanjing, especially in fish samples, followed by BDE-100, BDE-28, BDE-99, BDE-154, BDE-153, BDE-66, BDE-71 and BDE-138 (Fig. 1). Similar to other studies, the Tetra-BDEs are the dominant BDE congeners in fish and meat products, with relative proportions from 47.8% to 80.4% of the overall BDEs (Chen et al., 2009; Gao et al., 2009; Zhao et al., 2009). The relative proportions of Penta-BDEs ranged from 5.6% to 22.6%, Hexa-BDEs from 8.0% to 20.8%, Tri-BDEs from 3.8% to 14.3% and Hepta-BDEs from 0.1% to 0.8%. The pattern of relative concentrations of BDE congeners varied among consumer products made in China. Some consumer products contain Penta-BDEs while others contain Octa-BDEs, or Deca-BDEs, but Deca-BDEs are used most widely. However, a major congener of the Deca-BDE mixture, BDE-209 was not detected in fish and meat sold in Nanjing. This observation could be explained by the fact that the lesser brominated BDEs are more easily

Table 3
Concentrations of $\sum$PBDEs and $\sum$PCBs in foods.

	Fishery product							Meat product				
	Mandarin fish	Catfish	Snakehead	Black bass	Crucian Carp	White amur bream	Oriental river prawn	Pork sausage	Chicken	Duck	Beef	Pork
N	10	11	11	10	14	11	18	10	11	10	10	11
BDE-17[a]	ND[f]	ND-9.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	ND	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BDE-28	ND-110	ND-180	ND-69	ND-72	ND-56	ND-100	ND-21	ND-150	ND-54	ND-63	ND-35	ND-69
	29	20	25	13	4.9	35	6.8	13	3.8	16	7.8	6.2
BDE-71	ND-22	ND-17	ND-62	ND-22	ND-33	ND-41	ND-13	ND-22	ND-14	ND-41	ND-20	ND-16
	3.9	3.8	4.0	11	2.2	3.9	0.6	12	1.0	5.1	1.1	3.7
BDE-47	17–400	14–480	33–410	36–370	ND-290	1.8–750	ND–120	33–650	11–180	26–430	13–200	9.9–190
	160	190	100	81	71	15	28	150	35	130	36	52
BDE-66	ND-25	ND-51	ND-33	ND-57	ND-26	ND-79	ND-22	ND-83	ND-18	ND-40	ND-20	ND-30
	8.1	6.0	16	19	4.0	4.9	2.2	8.5	2.6	13	4.7	3.7
BDE-100	ND-46	ND-630	ND-62	ND-47	ND-42	ND-100	ND-19	ND-86	ND-24	ND-68	ND-30	ND-18
	27	23	18	11	4.0	20	4.2	26	7.2	31	9.3	9.1
BDE-99	ND-17	ND-25	ND-43	ND-34	ND-23	ND-53	ND-13	ND-370	ND-13	ND-53	ND-17	ND-21
	5.3	6.6	6.6	8.4	1.3	3.4	2.2	76	6.5	36	7.1	15
BDE-154	ND-49	ND-110	ND-61	ND-46	ND-45	ND-90	ND-22	ND-95	ND-28	ND-62	ND-16	ND-19
	21	21	12	9.0	5.2	17	5.4	39	5.6	43	7.9	12
BDE-153	ND-20	ND-30	ND-18	ND-24	ND-22	ND-41	ND-11	ND-48	ND-6.7	ND-39	ND-13	ND-9.9
	8.1	5.7	2.8	5.0	3.4	6.6	2.1	30	2.7	19	1.8	9.3
$\sum$PBDEs[g]	26–590	24–960	49–630	52–590	16–440	32–1100 × 10	8.0–230	70–950	15–290	61–780	19–320	22–330
	270	270	190	160	96	240	52	360	64	300	76	110
Non-ortho PCBs[b]	3.2	5.3	2.3	2.1	2.3	2.5	0.28	7.7	1.8	2.9	2.0	1.5
Mono-ortho PCBs[c]	4.8	6.1	3.4	3.4	2.4	4.4	0.46	10	2.7	5.5	3.2	2.0
Other PCBs[d]	13	15	9.1	11	4.6	13	0.87	20	5.2	14	6.2	5.1
$\sum$PCBs	21	26	15	17	9.3	20	1.6	38	9.7	22	11	8.5
TEQ PCBs[e]	1.1	1.8	0.77	0.72	0.75	84	0.1	2.6	0.59	1.0	0.68	0.49

Values below the detection limit were considered none detected and set to zero when means were calculated.
[a] Concentrations of $\sum$PBDEs are expressed in pg/g wet weight.
[b] Non-ortho $\sum$PCBs include CB-77, -81, -126, -169 and are expressed in ng/g wet weight.
[c] Mono-ortho $\sum$PCBs include CB-105, -114, -118, -123, -156, -157, -167, -189 and are expressed in ng/g wet weight.
[d] Other $\sum$PCBs include the other PCBs excluded from the non-ortho PCBs and mono-ortho PCBs, and are expressed in ng/g wet weight.
[e] TEQ of PCBs are calculated based on the TEF from Wittsiepe et al. (2007) and are expressed in pg/g wet weight.
[f] ND: None Detected.
[g] BDE-85, 138, 183, 190 and 209 were not found in all samples and not shown in the table.

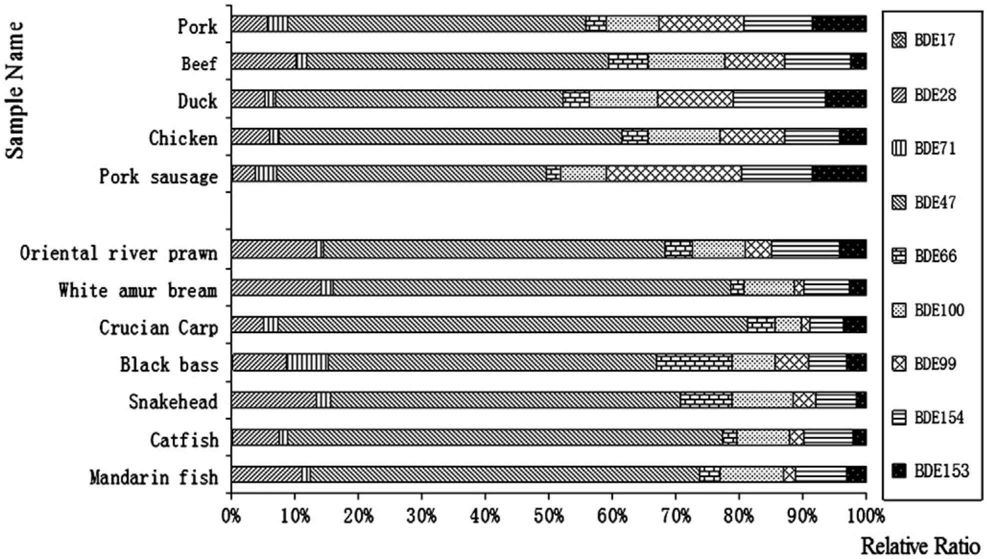

Fig. 1. Relative abundances of individual PBDE congeners in fishes and meats.

accumulated than are the more brominated congeners, which also have greater molecular weights (Su et al., 2010). Furthermore, BDEs with greater molecular weights, especially BDE-209, are more easily biotransformed than those with less molecular weight (Tokarz et al., 2008).

3.2. PCBs in fish and meat

Mean ∑PCB concentrations in fish and meat from Nanjing ranged from 1.6 ng ∑PCB/g ww for Oriental river prawn to 38 ng ∑PCB/g ww for Pork sausages (Table 3). Similar to PBDEs, the White amur bream and Catfish contained greater concentrations of ∑PCBs, while Black bass and Snakehead contained smaller concentrations. This is different from wildlife in the region that contained relatively great concentrations of ∑PCBs. The rank of mean concentrations of ∑PCB was as follows: Pork sausage > Catfish > Duck > Mandarin fish > White amur bream > Black bass > Chinese Snakehead > Beef > Chicken > Crucian Carp > Pork > Oriental river prawn.

Penta-CBs were the predominant PCB congeners in all samples, a pattern which was similar to that observed in marine fish in China (Jiang et al., 2007; Zhao et al., 2009). Penta-CBs contributed 22%–32% to the ∑PCBs, followed by Hexa-CBs ranging from 19%-37%, Tetra-CBs ranging from 14% to 26%, Hepta-CBs ranging from 14% to 21% and Tri-CBs ranging from 3% to 13% (see Fig. 2).

Concentrations of ∑PCBs observed in this study were comparable to or greater than those reported in other studies. For example, the ∑PCBs concentrations in fish from Finland (Kiviranta et al., 2004) and Sweden (Darnerud et al., 2006) were 25 and 9.6 ng ∑PCB/g ww, while ∑PCBs concentrations in meat were 1.8 and 3.1 ng ∑PCB/g ww. In samples from Nanjing, the mean ∑PCB concentration in the 7 species of fishery products was 16 ng ∑PCB/g ww which is comparable to the results reported for Finland and Sweden. However, mean ∑PCB concentrations of the five meats were greater. Values were as great as 18 ng ∑PCB/g ww. One reason that the concentrations of ∑PCBs in samples from Nanjing were greater than those from other areas could be that some of the meats in this study, such as Pork sausage (lipid content: 77.2%), pork (lipid content: 33.9%) and Duck (lipid content: 24.7%) had relatively greater lipid contents than samples from Sweden (13%) or Finland (11%). Concentrations of ∑PCBs in fishes from Nanjing were also greater than those in fishes from Guangzhou, South China (Jiang et al., 2007), in which the mean ∑PCBs in fish was 360 ng ∑PCB/g lw (2.8% lipid), which is equivalent to 10 ng ∑PCB/g ww).

Concentrations of ∑PCBs were 100- to 1000-fold greater than concentrations of PBDEs, however, concentrations of ∑PCBs and ∑PBDEs were highly correlated ($R^2 = 0.8716$) in fish and meat from Nanjing. A plausible explanation for this correlation is that the concentrations of ∑PBDEs and ∑PCBs are associated with the properties of the food. The high correlation between PBDEs and PCBS is likely due to similar sources to these items, such as atmospheric deposition. Concentrations of ∑PCBs and ∑PBDEs in chicken were much less than those in duck, probably because the lipid content (1.6%) was less than that of duck (24.7%).

3.3. Exposure of humans and hazard assessment

In order to assess the potential for adverse effect on humans from consumption of PCBs, the hazard to humans of consuming PCBs was assessed by determining the total daily intake (TDI) based on a dietary survey of people in Nanjing (Table 4), comparing the estimated potential daily intake with the allowable daily intake (ADI) suggested by the WHO. Although PBDEs are not aryl hydrocarbon receptor agonists, PBDEs might cause neuro-developmental defects, immunotoxicity, reproductive effects, teratogenicity, and endocrine disruption (Branchi et al., 2003; Hallgren and Darnerud, 2002). Here, the TDI of PBDEs in Nanjing was also calculated for comparison of relative exposure levels with other areas.

Total daily dietary intake by a 60 kg adult from Nanjing was estimated to be approximately 9.9 ng/d (170 pg ∑PBDE/kg bw) and 870 ng/d (14 ng ∑PCB/kg bw), respectively. The TDI from fish in Nanjing is consistent with other studies of foods in South China (1.7 to 13 ng ∑PBDE/d and 390 ng ∑PCB/d) (Meng et al., 2007; Jiang et al., 2007). However, due to the lack of data on concentrations in meat products from the

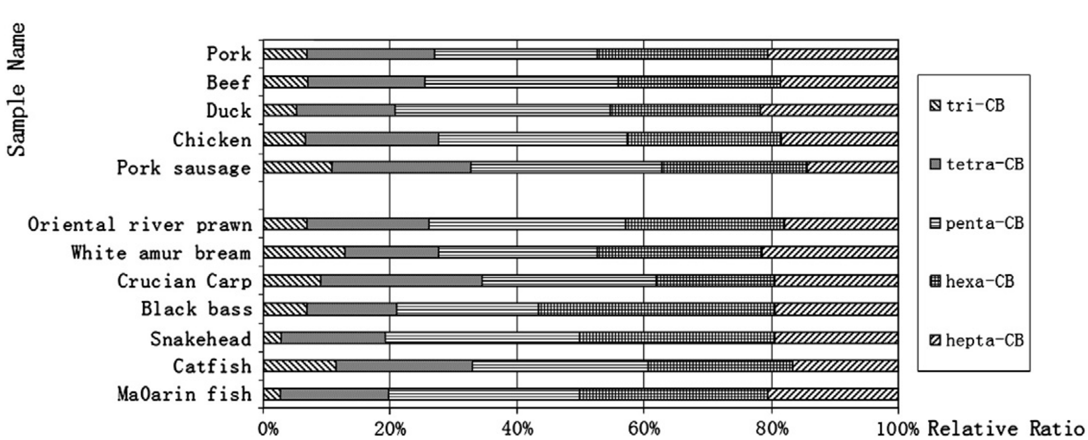

Fig. 2. Relative abundances of PCB congeners in fishes and meats.

Table 4
Mean daily intake of ∑PBDEs and ∑PCBs in fishes and meats.

Items	Daily consumption, (g/person)	Daily intake, ng, (pg/kg bw[b])		
		PBDEs	PCBs	TEQ[a,c]
Fishery product				
Mandarin fish	0.1	0.027 (0.45)	2.1 (35)	0.11 (0.0018)
Catfish	1.7	0.46 (7.7)	45 (750)	3.0 (0.05)
Chinese snakehead	3.1	0.59 (9.8)	46 (770)	2.4 (0.04)
Black bass	2.7	0.42 (7.0)	46 (770)	1.9 (0.032)
Crucian Carp	9.3	0.89 (15)	86 (1400)	7.0 (0.12)
White amur bream	7.1	1.7(29)	140 (2300)	6.0 (0.099)
Oriental river prawn	5.6	0.29 (4.8)	9.0 (150)	0.54 (0.0089)
Meat				
Pork sausage	2.1	0.75 (13)	80 (1300)	5.4(0.09)
Chicken	9.7	0.62 (10)	94 (1600)	5.7(0.096)
Duck	8.5	2.5(42)	190 (3100)	8.8(0.15)
Beef	3.4	0.26 (4.3)	39 (650)	2.3(0.039)
Pork	12	1.3(22)	100 (1700)	5.8(0.097)
Total	65	9.9(170)	870 (15,000)	49 (0.82)

[a] The unit of TEQ is pg, (pg/kg bw).
[b] The daily intake expressed in the unit pg/kg bw in the parenthesis is based on a hypothesis that the weight of adult is 60 kg.
[c] TEQ values are calculated for PCB congeners by using 2005 WHO toxic equivalency factors.

other locations in China, it was not possible to compare the TDI in Nanjing to that from meat in other areas of China. The TDI of ∑PBDEs in Nanjing was relatively less than in the other countries, but the TDI of PCBs in Nanjing is comparable to that in Finland and Sweden (Table 5). However, comparisons with TDI values described in the literature should be done carefully due to the different methodologies used to estimate TDI. Meat products in Nanjing are a more important source of PBDEs and PCBs, contributing 1.2- and 1.3-fold greater than fish on the estimated dietary intake for ∑PBDEs and ∑PCBs, respectively. This result is different than most other studies conducted in other areas, in which fish consumption is a more important source of PBDEs and PCBs. One reason for this observation could be that the people in Nanjing consume more meat products, especially duck which contains more lipids.

The TEQ_{WHO} values were also calculated for PCBs, which had been proved to be aryl hydrocarbon receptor agonists. The TDI of $^{PCB}TEQ_{WHO}$ by a 60 kg adult in Nanjing area was 0.82 pg $^{PCB}TEQ_{WHO}$/kg bw, which is less than the ADI of between 1.0 and 4.0 pg $^{PCB}TEQ_{WHO}$/kg bw suggested by WHO (Tables 4 and 5). Further investigation should assess the contributions of TEQ_{WHO} from other contaminants, such as polychlorinated dibenzo-*p*-dioxins and polycholorinated dibenzofurans, in human exposure.

Acknowledgments

We are grateful to the financial support of the National Natural Science Foundation of China (No. 20977047 and 20737001) and National Science and Technology Major Project (No. 2008ZX08526-003). Prof. Giesy was supported by the Canada Research Chair program, an at large Chair Professorship at the Department of Biology and Chemistry and State Key Laboratory in Marine Pollution, City University of Hong Kong, The Einstein Professor Program of the Chinese Academy of Sciences and the Visiting Professor Program of King Saud University.

Table 5
Estimated dietary intake of PBDEs, PCBs and TEQ_{PCBs}.

Locations	PBDEs (ng)		PCBs		TEQ_{PCBs}		Reference
	Fish	Meat	Fish	Meat	Fish	Meat	
This study	4.4	5.5	370	500	21	28	
China	7.7	–	320	–	9.6	–	(Jiang et al., 2007; Meng et al., 2007)
USA	64	11	–	–	–	2.2	(Huwe and Larsen, 2005; Schecter et al., 2006)
Sweden	23	7.1	350	75	18	4.8	Darnerud et al. (2006)
Findland	23	1.8	690	62	41	2.8	Kiviranta et al. (2004)
Spain	31	20	–	–	180 [a]		Bocio et al. (2003)
Japan	87	2.1	–	–	57	9.2	(Ohta et al., 2002; Tsutsumi et al., 2001)

[a] Total estimated dietary intake including other food.

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