Occurrence of polychlorinated dibenzo-*p*-dioxins, dibenzofurans and biphenyls pollution in sediments from the Haihe River and Dagu Drainage River in Tianjin City, China

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Abstract

The pollution status of polychlorinated dibenzo-*p*-dioxins, dibenzofurans (PCDD/Fs) and polychlorinated biphenyls (PCBs) in the sediments of Haihe River, which is the most polluted among the seven largest basins in China, Dagu Drainage River flowing through a chemical industry zone, and two other rivers flowing into Bohai Sea in Tianjin City, China were investigated. The concentrations of PCDD/Fs and PCBs in the sediments from the mainstream of Haihe River were 1.3–26 pg I-TEQ g⁻¹ dry weight (dw) and 0.07–0.54 pg TEQ g⁻¹ dw, respectively. Heavy PCDD/Fs and PCBs pollution, with 1264 pg I-TEQ g⁻¹ dw and 21 pg TEQ g⁻¹ dw, was found in sediment from Dagu Drainage River. The congener profiles of PCDD/Fs indicated that the principal contamination source was the production of pentachlorophenol (PCP) or PCP-Na in this area. The correlation between PCDD/Fs or PCBs and total organic matter (TOM) showed that PCDD/Fs or PCBs were independent on TOM.

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1. Introduction

With an area of 318 000 km² and flowing through many cities including Beijing and Tianjin, the Haihe River basin is the largest water system in northern China. Because of the rapid development of economy and explosion of city population, water pollution and shortage has become a stupendous obstacle to the sustainable development of the industry and agriculture in this area (Qin et al., 1998; Zhen et al., 1999). Now the Haihe River basin is the most polluted among the seven largest basins in China (Ding et al., 2005).

As a traditional base of chemical industry in China, Tianjin has produced chloralkali, technical HCH, lindane, chlorobenzene, and pentachlorophenol (PCP) for nearly 30–50 years (Gong et al., 2004; Hu et al., 2005). Although the production of PCP (Na) has been generally forbidden, it is still manufactured by one of plants in this area for controlling the spreading of snailborne schistosomiasis in the south of China. In 1999, about 342 000 tons alkali was produced and the capacity of chloralkali production in Tianjin was the second largest in China (Song, 2000, 2001). Many studies have reported that PCP production may be a very important source of polychlorinated dibenzo-*p*-dioxin and dibenzofurans (PCDD/Fs) (Hagenmaier and Hermann, 1987; Rappe et al., 1991; Bao et al., 1995; Zheng et al., 1997; Xu et al., 2000). Endemic chloracne among the workers in a plant located in this chemical industry zone had

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been noted since 1974 (Cheng et al., 1993). The prevalence of chloracne was 73.4% in total and 95.2% in trichlorobenzene tank area workers where PCDD/Fs levels were up to thousands of ppm. In addition, there are hundreds of small-scale chemical factories lacking of advanced technology and apparatus, which are potential contaminated sources in this area, including paper and pulp, printing and dyeing, leather, medicine, etc. (Zheng et al., 2001). Furthermore, abundant of wastewater is discharged without any treatment owing to the lack of adequate management and sewage treatment plants. The Dagou Drainage River is a channel especially used for wastewater discharge.

The pollutants, including heavy metal, organochlorine pesticides, 4-*tert*-octylphenol, 4-nonylphenol and bisphenol A etc., were found in Haihe River to be transported into Bohai Sea, which is located in the northeast of China, and seriously contaminate the marine environment (Jin et al., 2004; Shi et al., 2005; Yang et al., 2005). In addition, occurrence of PCDD/Fs and PCBs in mollusks and cores collected in or along Bohai Sea has been reported in several articles (Hu et al., 2005; Wan et al., 2005; Zhao et al., 2005).

It is generally accepted that sediments constitute a sink for the hydrophobic compounds including PCBs and PCDD/Fs. The contamination of sediments may pose an unacceptable risk to human through bioaccumulation or biomagnification. In order to assess the potential risk, the status of the pollution of PCBs and PCDD/Fs in sediments from Haihe River, Dagou Drainage River and two other rivers flowing into Bohai Sea were investigated. Since PCDD/Fs and PCBs are lipophilic organic compounds, the occurrence of PCDD/Fs or PCBs should in accord with TOM on

the distance from sources. However, the correlation is disputed because concentrations of organic compounds in sediments are not all dependent on TOM of the sediments (Jeong et al., 2001; Buckley et al., 2004; Mai et al., 2005). Therefore, the correlation between TOM and the occurrence of PCDD/Fs or PCBs in this research were also investigated to study the disputed correlation between TOM and organic compounds.

2. Materials and methods

2.1. Sampling

Sampling locations are shown in Fig. 1. Ten sediment samples along the Haihe River and three sediments from Dagou Drainage River were collected in July 2003. Starting from three tributary rivers, Beiyun River, Ziya River and Nanyun River, Haihe River flows through Tianjin City into Bohai Sea. Samples of H1–H8 were collected from the tributaries or typical sites along the Haihe River, H9 and H10 were just separated with a floodgate located at the estuary of Haihe River. Dagou Drainage River flows through a chemical industry zone and three sampling sites were set along the river according to the location of the chemical factories in the chemical industrial area. In addition, as reference points, two samples from Yongdingxin River and Kaifaqu River flowing into Bohai Sea in Tianjin City were also collected in the estuaries in July 2003. Surface sediments (about 5 cm in depth) were collected with a grab sampler (Ekman grab, Wildlife Supply Company, Buffalo, US) and placed in pre-cleaned glass bottles. The samples were stored at -20°C until analysis.

Fig. 1. Map of the Haihe River basin, Dagou Drainage River in Tianjin and sampling sites location (A1 and A2 are not sampling sites, A1: Chemical industry area; A2: Tianjin Economic and Technological Development Area) H1–H10, N1–N3, K1 and Y1 were collected along Haihe River, Dagou Drainage River, Kaifaqu River and Yongdingxin River, respectively.

2.2. Chemical reagents and standard solutions

All solvents were of pesticide residue grade and were purchased from Fisher (Fair Lawn, USA). Silica gel (0.063–0.100 mm) was obtained from Merck (Darmstadt, Germany). Acidic alumina (150 mesh), Florisil (60–100 mesh) and Bio-Beams SX-3 were purchased from Aldrich (Milwaukee, USA), Riedel-de Haën (Seelze, German) and Bio-Rad (Richmond, USA), respectively. Standard solutions of PCDD/Fs and PCBs according to EPA methods 1613B (US EPA, 1997) and 1668A (US EPA, 1999) were obtained from Cambridge Isotope Laboratories (Andover, USA) and Wellington Laboratories (Guelph, Canada).

2.3. Sample analysis procedure

Detailed descriptions of the sample extraction and fractionation procedures have been reported elsewhere (Zhang and Jiang, 2005). Briefly, sediment samples were freeze-dried and 1–2 g dry samples were spiked with ^{13}C -labeled surrogate standards prior to the 24-h Soxhlet extraction with toluene. All extracts were concentrated to about 2 ml for the following cleanup except the extract of sediment of site N3, of which only 10% due to its higher pollution was used for following analysis. The extract was then sequentially subjected to multi-layer silica gel and acid alumina chromatography columns for cleanup. Florisil was also used for separating the analytes into two groups. For sediment samples rich in high molecular weight interferences, which cause degradation of GC column performance, gel permeation chromatography (GPC) is very necessary to cleanup the PCB fraction by removing this kind of interferences (US EPA, 1999; Ahmed, 2003; Saito et al., 2004). The fractions of PCBs extracted from sediments collected from the site H9, H10 and Dagou Drainage River (N1–N3) were further purified by GPC. Recovery standards, 1613-IS (for PCDD/Fs) and 68A-IS (for PCBs) were added prior to the GC injection.

The quantification was performed on an Agilent 6890 gas chromatography coupled with an Autosepc Ultima mass spectrometer operating in EI mode at 35 eV and trap current of 600 mA. Exactly 1 μl of sample extract was injected with a CTC PAL autosampler in splitless mode into a DB-5MS fused silica capillary column (60 m $\times$ 250 μm i.d. $\times$ 0.25 μm film thickness, Agilent, USA). Helium was used as carrier gas with a constant flow of 1.2 ml min^{-1} . Details of MS analysis and quality control have been described elsewhere (Liu et al., 2006a).

Seventeen 2,3,7,8-substituted chlorinated congeners of PCDD/Fs, 12 WHO-specified PCBs, six indicator PCBs (CB28, 52, 101, 138, 153 and 180) and CB209 were quantitatively determined. Total PCDD/Fs and PCBs were calculated using total area of all the peaks detected in selected isobaric ions. The quality control (QC) of the method following QC of US-EPA methods 1613B and 1668A met the criteria of acceptance specified in the US-EPA methods,

which has been reported in detail elsewhere (Zhang and Jiang, 2005).

In addition, total organic matter (TOM) was determined by method of weight loss-on-ignition. A representative portion of the dry sediment was transferred into a pre-weighed crucible and sample weight was determined using an analytical balance. Samples were burned at 550 $^{\circ}\text{C}$ for 6 h in muffle furnace (A) to remove organic matter. After cooling in a desiccator, samples were reweighed (B). TOM was determined as follows:

$$\text{TOM}(\%) = 100 - 100 \times (A - B) \div A$$

3. Results and discussion

The levels of PCDD/Fs and PCBs in sediments are shown in Table 1. The concentrations of total PCDD/Fs and total PCBs in the surface sediments of the sampling sites ranged from 151 to 556961 pg g^{-1} dw and 775 to 153727 pg g^{-1} dw, respectively. Though the pollution levels of PCBs were higher than those of PCDD/Fs in this study, the total TEQs for PCBs were far lower than PCDD/Fs' because indicator PCBs with zero TEF dominated 88–97 percent contributions to total PCB congeners. Table 2 shows the total I-TEQ and WHO-TEQ for both PCDD/Fs and PCBs. TEQ were calculated based on the TEFs not only suggested by Ahlborg et al. (1994) but also revised WHO-TEFs for humans/mammals (Van den Berg et al., 1998) so as to compare pollution levels with other reported data. In addition, total WHO-TEQ for both PCDD/Fs and PCBs calculated based on the updated WHO-TEF were also list in Table 2 (Van den Berg et al., 2006).

3.1. Pollution levels of PCDD/Fs and PCBs in Haihe River

The concentration of total PCDD/Fs and TEQ in the surface sediments of the Haihe River and its tributary rivers ranged from 151 to 11546 pg g^{-1} dw and 1.3–26 pg I-TEQ g^{-1} dw, respectively. Comparing with the previous reports about the PCDD/Fs in other river and coast sediments listed in Table 3, the levels of PCDD/Fs in Haihe River were not significant higher. Relatively higher concentrations were detected at the estuary (H10) and the Machangjian River (H8), one of tributary rivers of Haihe River. The total I-TEQ of PCDD/Fs and PCBs in H8 and H10 were 20 and 27 pg TEQ g^{-1} dw, respectively, which have exceed the safe sediment value of 20 pg TEQ g^{-1} dw suggested by Evers et al. (1996). Because both of estuary and Machangjian River flow through the chemical industry zone, the heavier pollution might come from the chemical industry. Therefore, three sediments (N1–N3) were collected along the Dagou Drainage River, which flows into Bohai Sea through the chemical industrial area. The determined concentrations of PCDD/Fs and PCBs (with TEQ) among three sediments (N1–N3) collected along the Dagou Drainage River, which

Table 1

Concentrations of PCDD/Fs and PCBs in sediments from Haihe River, Dagu Drainage River, Kaifu River and Yongdingxin River (pg g⁻¹ dw)

Compounds	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	K1	Y1	N1	N2	N3
2378-TCDF	1.5	0.8	2.8	3.0	1.8	1.4	1.2	1.4	1.1	1.7	0.4	2.4	7.6	0.9	74
12378-PeCDF	0.8	3.9	1.1	4.5	1.1	1.3	0.9	2.6	1.1	3.3	0.3	1.1	8.2	21	38
23478-PeCDF	1.0	3.1	1.5	3.6	0.8	1.6	0.3	3.2	1.8	2.9	0.2	0.5	8.1	61	94
123478-HxCDF	2.0	3.7	3.5	3.7	1.5	4.7	1.2	22	8.2	16	2.1	1.2	30	480	758
123678-HxCDF	1.9	3.0	1.8	3.0	1.0	2.0	0.8	4.2	1.0	2.8	0.6	0.8	7.2	69	76
234678-HxCDF	1.0	2.6	2.4	2.7	0.9	1.5	1.4	2.6	2.4	3.6	0.5	0.5	7.4	32	132
123789-HxCDF	0.7	1.2	0.7	1.2	0.2	0.5	0.2	0.6	0.1	0.9	0.1	0.5	1.0	1.0	13
1234678-HpCDF	7.2	8.3	15	9.0	5.3	13	4.3	41	17	75	4.7	3.4	47	464	2721
1234789-HpCDF	0.9	2.6	1.3	3.0	0.7	2.1	0.3	11	3.9	16	0.8	0.6	11	129	678
OCDF	17	26	32	33	34	35	14	122	84	583	11	9.9	123	1223	32243
2378-TCDD	1.3	0.5	1.5	0.9	0.3	0.7	0.2	0.6	1.4	1.4	0.3	1.1	1.0	6.3	63
12378-PeCDD	0.9	2.3	1.0	3.0	0.4	0.6	0.2	1.8	1.3	3.4	0.3	0.6	4.5	32	172
123478-HxCDD	0.5	1.8	0.7	1.9	0.2	1.2	0.1	5.4	11	9.9	0.6	0.5	8.8	108	1304
123678-HxCDD	0.7	2.4	1.2	3.7	0.7	4.0	0.6	30	11	19	1.2	0.5	14	437	820
123789-HxCDD	1.4	2.7	0.8	3.0	0.3	1.5	0.1	16	5.1	5.2	0.5	0.5	9.7	237	381
1234678-HpCDD	12	10	12	30	4.9	68	8.4	513	162	427	30	7.9	152	6990	16786
OCDD	104	79	180	227	32	515	66	2573	1811	9602	264	145	929	26294	476781
PCB-77	11	21	55	57	5.5	44	2.1	22	16	13	5.8	3.0	303	212	790
PCB-81	0.7	0.5	2.5	1.1	0.2	0.6	0.1	0.8	0.3	0.2	0.2	0.4	17	1.0	23
PCB-105	13	12	78	35	7.9	33	3.4	39	13	22	11	3.4	338	313	862
PCB-114	1.5	1.2	1.4	1.4	0.8	1.7	0.1	2.3	0.2	1.4	0.2	0.6	37	21	0.4
PCB-123	1.6	0.9	1.5	2.4	0.1	2.6	0.4	2.9	0.2	0.3	0.2	1.1	0.8	27	0.5
PCB-126	1.8	1.1	3.0	1.9	0.6	1.4	0.8	4.3	3.7	5.1	0.7	0.9	8.5	27	201
PCB-156	2.6	3.5	20	8.7	2.7	9.0	1.6	17	6.2	10	2.5	1.4	65	154	445
PCB-157	1.0	0.8	4.0	2.2	0.6	4.9	0.5	9.4	2.3	3.8	1.0	0.5	15	86	256
PCB-167	0.9	1.3	5.5	3.5	1.1	4.9	0.7	12	4.6	9.0	1.2	0.9	19	105	368
PCB-169	1.1	0.3	1.4	0.5	0.2	0.5	0.1	0.6	0.6	0.5	0.2	0.6	5.4	5.0	18
PCB-189	0.5	0.7	2.3	1.5	0.5	2.3	0.4	7.0	2.3	3.6	0.8	0.3	7.1	61	190
PCB-28	244	202	1753	480	70	647	45	363	125	111	96	82	18377	5435	1049
PCB-52	22	31	137	72	35	59	11	59	38	26	19	15	1465	467	414
PCB-101	23	27	113	69	25	74	13	111	103	105	28	10	1161	1835	4466
PCB-138	12	22	84	72	25	50	11	87	43	46	20	4.5	524	858	1828
PCB-153	20	29	118	90	30	95	13	84	95	98	30	6.7	606	944	3104
PCB-180	13	11	64	37	13	49	6.5	104	44	38	11	7.4	15	158	2024
PCB-209	15	127	55	59	25	58	7.9	169	1437	307	59	27	147	1005	55481
Total PCDD/Fs	211	276	352	466	153	753	151	3808	2418	11546	372	210	1962	44946	556961
Total PCBs	1583	1703	7473	3274	1142	3473	775	4424	3931	2990	1169	922	70325	44266	153727

H1–H10 from Haihe River, N1–N3 from Dagu Drainage River, K1 from Kaifu River and Y1 from Yongdingxin River.

Table 2

TEQs for PCDD/Fs and PCBs using WHO-TEFs and I-TEFs (pg TEQ g⁻¹ dw)

Sampling sites	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	K1	Y1	N1	N2	N3
WHO-TEQ (PCDD/Fs) ^a	4.9	7.4	6.4	8.8	1.9	5.5	1.4	18	9.7	19	1.7	8.2	21	28	89
WHO-TEQ (PCBs) ^a	0.20	0.13	0.36	0.21	0.07	0.22	0.09	0.46	0.39	0.53	0.08	0.09	1.2	3.0	21
Total WHO-TEQ ^a	5.1	7.6	6.8	9.0	1.9	5.7	1.5	19	10	19	1.7	8.3	22	288	914
I-TEQ (PCDD/Fs) ^b	3.6	5.5	4.7	7.3	1.8	4.9	1.3	20	11	26	1.8	2.7	19	294	1264
TEQ (PCBs) ^b	0.20	0.13	0.38	0.24	0.07	0.19	0.08	0.47	0.40	0.54	0.08	0.10	1.2	3.0	21
Total TEQ ^b	3.8	5.7	5.1	7.6	1.9	5.1	1.4	20	11	27	1.9	2.8	21	297	1286
WHO-TEQ (PCDD/Fs) ^c	3.7	5.9	4.7	7.8	1.8	4.5	1.2	18	9.6	20	1.7	2.7	19	278	975
WHO-TEQ (PCBs) ^c	0.2	0.1	0.4	0.2	0.1	0.2	0.1	0.5	0.4	0.5	0.1	0.1	1.1	2.8	21
Total WHO-TEQ ^c	3.9	6.0	5.1	8.0	1.8	4.6	1.3	19	10.0	21	1.8	2.8	20	281	996

^a Van den Berg et al. (1998).^b Ahlborg et al. (1994).^c Van den Berg et al. (2006).

flows into Bohai Sea through the chemical industrial area, were up to 557 ng g⁻¹ dw (1264 pg I-TEQ g⁻¹ dw) and 154 ng g⁻¹ dw (21 pg TEQ g⁻¹ dw), respectively. These

results indicate that the Dagu Drainage River is the most heavily polluted with levels of PCDD/Fs and PCBs significantly above the safe sediment level of 20 pg TEQ g⁻¹ dw.

Table 3
Levels of PCDD/Fs and PCBs in surface sediments from rivers and coasts

Location	Concentration (pg g ⁻¹ dw)			TEQ (pg g ⁻¹ dw)			References
	PCDDs	PCDFs	PCBs	PCDDs	PCDFs	PCBs	
Haihe River, China	151–556 961		775–153 727	1.4–19 ^a 1.3–26 ^b		0.07–0.53 ^a 0.07–0.54 ^b	This study
Dagu Drainage River, China	1962–556 961		44 266–153 727	21–893 ^a 19–1264 ^b		1.2–21 ^a 1.2–21 ^b	
Taihu Lake, China	120.1–1315.1		889.7–29747.8		0.83–17.72 ^a		
Yaer Lake, China	3918–13845		–	10–420 ^b		–	Zhang and Jiang (2005)
Coast, Hong Kong	310–11000		–	3.0–33 ^b		–	Wu et al. (2001)
Tokyo Bay, Japan	–		–	3.1–49 ^a		0.18–3.0 ^a	Müller et al. (2002)
River Po, Italy	121–814		–	1.3–13 ^a		–	Hosomi et al. (2003)
Hyeongsan River, Korea	2.6–1200	2.2–640	10–10000	0.16–937 ^a	0.22–197 ^a	0.05–3.37 ^a	Fattore et al. (2002)
Venice Lagoon, Italy	16–13 642	49–126 561	2–2049	0.5–2857 ^b		0.05–404 ^b	Koha et al. (2004)
Southern Mississippi, USA	1.7–7206	0.06–126	–	1.3–619		–	Bellucci et al. (2000)
Coast, Spain	121–12037		22–30007	0.1–48 ^a		0.2–63 ^a	Frignani et al. (2001)
Harbour of Hamburg, Germany	–		–		25.6–174.2 ^b		Rappe et al. (1997)
River Elbe, Germany	–		–		82 ^b		Eljarrat et al. (2005)
							Götz et al. (1998)

^a Van den Berg et al. (1998).

^b Ahlborg et al. (1994).

PCDD/Fs in sediments collected from Dagu Drainage River were significantly higher than other areas except for the Venice lagoon (Table 3). The pollution of PCDD/Fs and PCBs were sharply increased along the flow direction of Dagu Drainage River, indicating that the pollutions might come from the chemical industry. In addition, it was reported that the concentrations of mercury and organochlorine pesticides in sediments from Dagu Drainage River were also very high (Shi et al., 2005; Yang et al., 2005). Therefore, more attention should be paid and further investigation should be done for this area. The pollution levels of PCBs, 0.07–0.54 pg I-TEQ g⁻¹ dw, were very low in Haihe River. Significant PCBs pollution was found in N3 with 21 pg I-TEQ g⁻¹ dw, beyond the safety level of sediment.

PCDD/Fs and PCBs levels in site H10 were higher than that of site H9. These two sites, H9 and H10, were just separated with a floodgate at the estuary of Haihe River. The potential pollution might come from the sewage outlet of the Dagu Drainage River at the south of H10. The estuary of Haihe River might be polluted easily by the effluents of Dagu Drainage River (Jin et al., 2004). Also, as shown in Fig. 2, similar congener profile was found between sites of H10 and N3. However, H9 was less contaminated due to the protection of the floodgate. Moreover, this result is accord with the report (Liu et al., 2006b), in which higher levels of PCP were found in sea than in river due to the salinity change between them.

In addition, samples collected from Kaifu River and Yongdingxin River, as reference points, were also analyzed to assess the pollution level of rivers flowing into Bohai Sea in Tianjin City sediment. Low levels of PCDD/Fs and PCBs were detected in these two rivers with TEQ of 1.8 and 0.08, 2.7 and 0.10 pg I-TEQ g⁻¹ dw, respectively.

3.2. Profile and possible sources of PCDD/Fs

Similar congener profile, in which OCDD was the most abundant congener followed by OCDF and 1,2,3,4,6,7,8-HpCDD, was found throughout Haihe River. The profile of PCDD/Fs in Haihe River, Dagu Drainage River and two other rivers in Tianjin is in accord with the profiles reported in other sediments of rivers (Eljarrat et al., 2005; Hu et al., 2005; Zhang and Jiang, 2005). Percentage contributions of OCDD, HpCDD and OCDF to the total PCDD/Fs were shown in Fig. 2. The profiles of PCDD/Fs in the tested sediments were consisted with the profile of main dominant congeners of impurities (OCDD (76%) as well as OCDF (10%) and 1,2,3,4,6,7,8-HpCDD (10%)) in PCP and PCP-Na (Bao et al., 1995). Higher percentages of OCDD were found in sites of H9, H10 and N3. These three sampling sites were all at the downstream of the rivers flowing through the chemical industrial area where the PCP and PCP-Na have been manufactured for nearly half a century. Moreover, relatively higher or significant high concentrations were detected at the sampling sites located around the chemical industrial areas. In view of that, the source of the heavier PCDD/Fs pollutions in this area might come from the effluent of PCP and PCP-Na production.

3.3. Correlation between PCBs/PCDD/Fs and TOM

TOM in the 13 sediment samples except the three sediment samples collected from Dagu Drainage River, N1–N3 neared to pollution resource, was determined. The relationship between the concentration of PCBs and the data of TOM was investigated and presented in Fig. 3. The linear regression correlation between PCBs and TOM was 0.34. Thus, the concentrations of PCBs were

Fig. 2. Percentage contributions of OCDD, HpCDD and OCDF to the total-PCDD/Fs for all sediments samples and impurities in PCP and PCP-Na reported by Bao et al. (1995).

Fig. 3. Relationship between PCBs and TOM. (Data matrix without N1–N3 nearest to pollution resource was used.)

independent on the TOM of sediments. It is in accord with the result reported by Buckley et al. (2004) and Mai et al. (2005). But it differs from that of Jeong et al. (2001), in which significant correlation was found between PCBs and total organic carbon.

The relationship between PCDD/Fs and TOM was similar to that between PCBs and TOM with correlation coefficient of 0.21.

4. Conclusions

The pollution resource of PCDD/Fs and PCBs in sediments from Bohai Sea and the pollution status of PCDD/Fs and PCBs in rivers in Tianjin City were investigated. The levels of PCDD/Fs and PCBs in Haihe River

were lower than the value of safe sediment for samples from all sampling sites except for sites of H8 and H10. Comparing with the levels reported in literatures, significant contamination of PCDD/Fs and PCBs was found in Dagu Drainage River. The pollution source of PCBs could not be identified. But congener profiles of PCDD/Fs indicate that the production of PCP or PCP-Na may be one source of PCDD/Fs in this area.

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