DISTRIBUTION OF POLYCHLORINATED BIPHENYLS IN UPPER AND LOWER LAYERS OF ER-JEN RIVER SEDIMENT IN SOUTHERN TAIWAN

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Introduction

Until the latter part of this century, polychlorinated biphenyls (PCBs) were a common component of electrical capacitors and transformers. Attached to soil particles or floating on the surface of water, PCBs may be volatilized, buried, or transported to aquatic systems. Their low biodegradability and high environmental persistence means that they remain a major contaminant even though their production has been banned for at least two decades in many countries[1,2].
The presence of PCBs in Taiwanese river sediments is currently under investigation[3,4,5]. While quantities and concentrations have been measured in river sediment and water samples, data is lacking on PCB congener distribution. Since soils and sediments are known repositories of these stable compounds[6], analyses of PCB distribution are necessary for understanding their environmental fates. For this reason, the present study was designed to analyze PCB distribution in sediment samples collected from the Er-Jen River in the southern Taiwanese prefecture of Tainan--- a known site of industrial waste water and burned scrap metal pollution for over 20 years. Specific distribution analyses were made for eight PCB congeners in different layers of sediment samples collected from the Er-Jen River.

Materials and methods

Columns of Er-Jen River sediment samples (35-45 cm depth) were collected at several locations in the Wan-Li area of Tainan prefecture. The five Sampling sites were spaced 50 m apart on the eastern side of Nan-Din Bridge (Column A to E, downstream to upstream). Soil columns were sliced into 5 cm sections and labeled (e.g., samples A1 to A8). Samples were air-dried, ground, and sieved (< 2 mm) prior to being stored at 4°C until used.
Total PCB concentrations and the distribution of specific PCB congeners were analyzed as follows: 2 g of soil from each sample was extracted with a hexane-acetone (9:1) solution by hand shaking and sonification two times each. Extracts were collected and cleaned on a Florisil column prior to analysis with an ECD gas chromatograph (Varian 3600, Walnut Creek, CA) equipped with a DB-5 fused silica capillary column (0.53 mm ID×30 m, film thickness 1.5 μgm) (J & W Scientific, Folsom, CA). Extraction and analysis was performed in triplicate. A detailed description of the analytic procedures (with minor modifications) can be found in previous study[7]. The recoveries of 8 selected PCB congeners were found in a range of 78.1 ~ 87.4% for quality control check sample test. The eight congener groups were chosen based on their presence in Aroclor 1242[9], Aroclor 1254[9], and certain intermediate and final products of PCB dechlorinaytion[4,5,7] (Table 1). GC temperatures were maintained at 170°C for 2 min, then increased to 260°C at a rate of 3°C/min and held for 18 min. Injector and detector temperatures were set at 280 and 300°C, respectively. Nitrogen was used as both carrier and make-up gases; linear velocity was 27.3 cm/s with a 15:1 split ratio. Individual PCB congener concentrations were calculated as described in previous study[7]. Two sets of mixture, each contained 15 separate PCB congeners, were used to establish a correction curve to Mullin et al.'s chromatographic

data[8]. Total PCB concentrations in each sample are reported as the sum of all individual PCB congeners.

Table 1. Eight PCB congener groups as components of Aroclor 1242, Aroclor 1254, or the products of PCB dechlorination.

Congener	Peak Number	Major component of
2,4'-Chlorobiphenyl(2,4'-CB)	7	Aroclor 1242 , Dechlorination product
2,6,2'-CB	9	Dechlorination product
2,3,2'-CB/2,6,4'-CB [a]	15	Dechlorination product
2,3,4'-CB/2,4,2',6'-CB	23	Aroclor 1242
2,3,2',5'-CB/2,4,6,2',6'-CB	30	Aroclor 1242 , Dechlorination product
3,4,3',4'-CB/2,3,6,3',4'-CB	51	Aroclor 1254 , (Aroclor 1242)[b]
2,4,5,3',4'-CB	55	Aroclor 1254 , (Aroclor 1242)[b]
2,3,4,2',4',5'-CB/2,3,4,6,3',4'-CB	64	Aroclor 1254

[a] 2,3,2'-CB and 2,6,4'-CB are co-eluting congeners
[b] parentheses indicate minor Aroclor component.

Results and discussion

As shown in Table 2, total PCB concentration in the sediment samples ranged from 0.48£gg /g soil (sample D1, 0-5 cm) to 4.32£gg /g soil (sample B6, 26-30 cm). The data show that total PCB concentrations were generally higher in downstream sample columns than in upstream columns, as well as in middle layers (nos. 4-6 at depths of 16-30 cm) compared to the top (nos. 1-3, 0-15 cm) and bottom (nos. 7-9, 31-45 cm) layers in each sample column. This may be explained by the history of unchecked dumping of burned scrap metal by an industry which thrived in the Wan-Li area in the 1970s but which was banned in the late 1980s; the top and bottom sediment layers reflect the pre- and post-pollution periods in the area.

PCB congener distribution in the column A sediment sample reflects the major components of Aroclor 1242 (2,4'-CB, 2,3,4'-CB/2,4,2',6'-CB and 2,3,2',5'-CB/2,4,6,2',6'-CB) (Table 3). In addition, several dechlorination products were identified in column A sediment---for example, the mole percentages of 2,6,2'-CB (which exists in trace amounts in Aroclor 1242 and 1245) were 7.1 ~ 14.1% in the column A sample. Several studies have shown 2,6,2'-CB to be a product of both 2,4,2',6'-CB and 2,5,2',6'-CB dechlorination by Er-Jen River microorganisms (£Gln RRT values 0.33 and 0.35, respectively)[4,5,7].

Table 2. Total PCB concentrations at different sediment layers.

Column	A	B	C	D	E
Layer (depth)	Concentration (μg / g soil)				
1(0~5 cm)	1.63	1.66	1.55	0.49	0.5
2(6~10 cm)	1.53	1.69	0.84	0.52	0.46
3(11~15 cm)	0.84	1.69	0.88	1.42	0.61
4(16~20 cm)	3.29	2.9	2.24	0.98	1.17
5(21~25 cm)	1.91	2.03	3.58	2.48	2.34
6(26~30 cm)	2.4	4.32	2.54	0.84	1.37
7(31~35 cm)	1.23	1.02	2.24	0.77	0.84
8(36~40 cm)	1.55	1.31			
9(41~45 cm)		0.81			

Table 3. Mole percentage of PCB congeners in different sediment layers.

PCB congener	24'-CB	262'-CB	232'-/ 264'-CB	234'-/ 242'6'-CB	232'5'-/ 2462'6'-CB	343'4'-/ 2363'4'-CB	2453'4'-CB	2342'4'5'-/ 23463'4'-CB
Layer	Mole percentage (%)							
A1	14.1	12.2	6.8	6.8	13.9	4.8	5.2	1.5
A2	13.2	9.9	5.2	4.0	11.2	4.4	3.7	2.1
A5	12.2	7.1	12.4	3.1	5.9	3.7	1.7	1.6
A7	15.3	14.1	9.0	1.1	7.1	3.8	2.2	2.5
A8	16.3	11.2	6.8	3.2	5.3	3.1	2.8	3.3
D1	10.1	0	0	6.3	7.2	0	3.2	0
D2	7.2	0	0	5.3	6.8	2.6	4.3	2.2
D4	6.7	4.0	0	6.2	12.8	8.3	7.8	10.3
D5	6.7	8.3	3.2	2.8	3.0	10.2	9.6	4.5
D6	8.1	4.5	3.3	4.9	1.8	5.8	4.6	5.9

As shown in Table 3, differences were noted in PCB congener distribution between column D and column A sediment samples, even though their collections sites were only 150 meter apart. Concentrations of dechlorination products 2,6,2'-CB and 2,3,2'-CB/2,6,4'-CB were lower in column D than in column A sediment--- indicating either a lesser degree of dechlorination or some unexplained disappearance of dechlorination products in the former. In addition, equal percentages of Aroclor 1254 and 1242 components (3,4,3',4'-CB/2,3,6,3',4'-CB, 2,4,5,3',4'-CB and 2,3,4,2',4',5'-CB/2,3,4,6,3',4'-CB) were found in the middle layers (nos. 4-6) of the column D sediment sample, suggesting equal contamination rates by these pollutants. A similar tendency was noted in column B, C and E (data not shown), with higher levels of Aroclor 1242 found in the upper layers, and higher levels of Aroclor 1254 generally found in the middle layers. In summary, PCB congener distribution in Er-Jen River sediments differs in terms of

composition, concentration, and sediment location. The data suggest that section-by-section analysis of sediment columns is required to obtain an accurate assessment of contaminant concentration, sequential discharge, and pollutant transformation; a reliable evaluation of current environmental damage; and a prediction of the translocation potential of these permanent organic compounds.

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