

Analysis of Polychlorinated Biphenyls in the Sediment of the Kumho River

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Concentrations of PCBs in the sediment of the Kumho River was determined. Samples were collected at 23 locations along the river. Total PCB levels ranged from 2.7 to 87.6 ng/g dry weight. The site near the Keomdan factory district had the highest concentrations. The levels of PCB congeners significantly correlated with the total organic carbons in the sediment. The major fractions of PCBs were congeners containing 4, 5, or 6 chlorine atoms per biphenyl molecule.

Key Words : PCBs, Sediment, TOC, Kumho River

1. Introduction

Polychlorinated biphenyls (PCBs) were commercially produced by companies such as Aroclors by Monsanto Corporation, and widely used in dielectric fluids in capacitors and transformers, plasticizer, printing inks, paints, and many other products¹⁾. In 1978 the U.S. EPA banned the manufacture, processing, use, and distribution of commercial materials containing any detectable amounts of PCBs, unless specifically authorized, yet they contain a wide-spread organic pollutant. The volatilization of PCBs from contamination sources results in measurable atmospheric emissions. It is estimated that 9×10^5 kg per year of PCBs cycle through the U.S. atmosphere²⁾. Currently the global distribution of PCBs is primarily due to atmospheric transport. It is estimated that 99% of PCB mass is found in soil because of its high lipophilicity, high density (higher than water) and very low water solubility³⁾. PCBs are easily transported in adsorbant particulates in water rather than dissolving in water⁴⁾. The contents of adsorbed or partitioned PCBs depend on the surface area of, sur-

face properties of, and content of the organic species in the particulates⁵⁾. Therefore, the best method for determining PCB levels in sediment or soil seems to be monitoring PCB levels in the environment.

Japan MOE (Ministry of the Environment)⁶⁾ established the action level of PCBs for the dredging of sediment as 10,000 ng/g. The Water Quality Conservation Act of Korea⁷⁾ regulates PCBs as a specified substance hazardous to water quality and the Drinking Water Act also regulates that drinking water should not have detectable levels of PCBs.

We have measured the levels of PCBs in the surface soil and marine sediment in the Ulsan and Masan areas of Korea⁸⁻¹⁰⁾. These two cities have been heavily contaminated during the past 30 years due to rapid industrialization. The maximum levels of PCBs in these areas were comparable to that observed in the lower Nakdong River. Recently we determined the levels of PCBs in the sediment of the lower Nakdong River¹¹⁾. The total concentration in this lower area ranged from 1.1 to 141 ng/g dry weight.

The Kumho River is one of the major tributaries of the Nakdong River located in the southeastern region in Korea. In this study, we determined the concentrations of 26 PCB congeners in the sediment of the Kumho River which is located at midstream of the Nakdong River, a very important drinking water resource for Busan Metropolitan City with a

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population of over 4 million.

2. Materials and Methods

2.1. Sampling the sediment

Sampling was done at 23 sites along the main stream and tributaries of Kumho River, with a grab sampler in September 1999. Sampling sites are illustrated in Fig. 1 and Table 1. The sampling points were selected at the center part of the river. Sediments were freeze dried, sieved with a 2 mm mesh screen, and stored in the sealed polyethylene bottle at -4°C refrigerator until analysis.

2.2. Standard solutions and reagents

The individual 26 PCB congeners (Dr. Ehrenstorfer, 96.5%~99.5% purity) were used as the standard substances and 1-chloronaphthalene (Supelco. Inc.) was used as an internal standard. We made standard

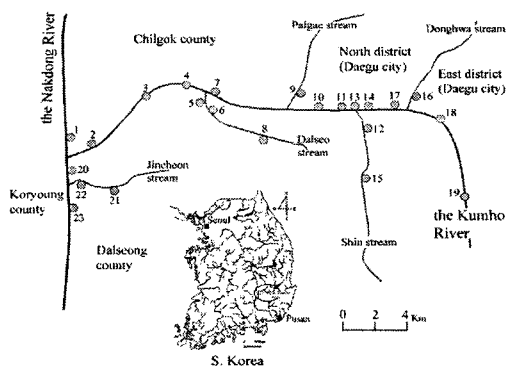


Fig. 1. Sampling sites along the Kumho River, Korea.

solutions of congeners by mixing and diluting 6-7 standard congeners with iso-octane (Fisher Scientific, HPLC grade) and cyclohexane (Fisher Scientific, HPLC grade). The reference soil SRM 1939a (NIST U.S.A.) was used in the recovery test. The average recovery rates ranged from 81.6% to 110.8% as

Table 1. Description of sampling sites along the Kumho River

Site No	Location	Description
1	Gangjeong water supply office	Before confluence of the Kumho River
2	Gangchang bridge	Lower stream of the Kumho River
3	Hailang bridge	Near landfill of Daegu metropolitan city
4	Kumho big bridge	After confluence of Dalseo stream
5	End-treatment plant	Lower stream of Dalseo stream West Daegu city factory district
6	Discharge port of Dalseo stream	Discharge port of dye works
7	Across the Beomyang Food Co.	Before confluence of Dalseo stream
8	The 2nd Dalseo bridge	Midstream of Dalseo stream
9	Oicheon bridge	Lower stream of Palgae stream
10	Joya bridge	Near the 3rd factory district
11	Seobeon big bridge	After confluence of Shin stream
12	Chimsan bridge	Lower stream of Shin stream
13	Discharge port of Shin stream sewage water treatment plant	Confluence point of Shin stream
14	Mootai bridge	Before confluence of Shin stream
15	Shincheon bridge	Midstream of Shin stream
16	Dongbeon bridge	Lower stream of Donghwa stream
17	In front of Gumma Metals Co.	After confluence of Donghwa stream
18	Keomdan factory district	Before confluence of Donghwa stream
19	he 2nd Ayang bridge	Upper stream of the Kumho River
20	Seongseo dike	After confluence of the Kumho River Seongseo factory district
21	Daimyoung stream	Upper stream of Seongseo factory district
22	Discharge port of west sewage water treatment plant	Discharge port of Seongseo factory district
23	Hwawon park	1 km after confluence of the Nakdong River

shown in Table 2. These recovery rates were acceptable, so we did not correct the experimental results.

N-hexane (Merck, Aldrich Chemical Co., Inc.; Organic Trace Analysis grade) and acetone (Aldrich Chemical Co., Inc.; Pesticide Residue Analysis grade) were used as the solvents extracting and cleaning glassware. Anhydrous sodium sulfate (Yakuri, 1st grade) was dried for 4 hours at 130°C and used to remove trace levels of water in the extracts. Sulfuric acid (Matsunden Chemicals Ltd.) was used to remove the interfering substances. Silica gel (Wakogel S-1, Wako Pure Chemical Industries, Ltd.) and Florisil (J.T.Baker, 60-100 Mesh) were stored in an oven just before clean up after having been activated for 9 hours at 130°C and applied in the cleanup process.

2.3. Pretreatment of samples

Base digestion: About 50 g of dried sediment was put into a round-bottom flask and then 150 ml of 1-N KOH in ethanol was added to prepare a sample solution. A reflux condenser was connected to this flask, and boiled the sample solution for an hour in a water bath at 100°C and then cooled to 50°C.

Liquid-liquid extraction: 100 ml of n-hexane was mixed with the supernatant liquid obtained from the base digestion, and then transferred it into a separatory funnel. The n-hexane layer was taken after being mixed well with 70 ml of organic free water. The supernatant layer was shaken rigorously with a shaker at over 200 rpm for 20 minutes after adding 50 ml of n-hexane, and the n-hexane layer was taken. This process was repeated once more.

Sulfuric acid treatment: The interfering organic substances and colored substances contained in the extract were removed adding with 15 ml of concentrated sulfuric acid to the n-hexane extract. This process was repeated until the lower organic layer became colorless. The extract was passed through anhydrous sodium sulfate to remove trace amounts of water, concentrated to 10 ml using a rotary vacuum evaporator, and finally concentrated to 3 ml under a gentle stream of ultra pure nitrogen gas.

Cleanup process: Silica gel was activated for 9 hours at 130°C, and packed in a Pyrex column (1 mm i.d., 340 mm length). Glass wool was packed first, then 1 g of anhydrous sodium sulfate, 3 g of silica gel, and finally 1 g of anhydrous sodium sulfate was packed on the top of the column again. The con-

Table 2. Average recovery for selected PCB congeners from a sediment sample, SRM 1939a

IUPAC No.	Certified Conc. ($\mu\text{g}/\text{kg}$)	Observed Conc. ^a ($\mu\text{g}/\text{kg}$)	Recovery(%)
18	3210± 940	3063± 48.8	95.4± 1.5
28	2461± 78	2368± 51.2	96.2± 2.1
44	1131± 74	1033± 42.8	91.4± 3.8
52	4320± 130	4395± 48.7	101.7± 1.1
66	840± 130	882± 21.5	105.0± 2.6
105	201± 28	195± 12.9	96.8± 6.4
118	423± 88	345± 14.7	81.6± 3.5
128	91.2± 8.4	91.0± 2.2	99.4± 2.4
153	297± 19	329± 15.1	110.8± 5.1
180	140.3± 6.1	124± 7.5	88.1± 5.3

centrated sample was eluted with 250 ml of n-hexane. The eluent was concentrated with a rotary vacuum evaporator and the volume was further reduced to 2 ml under a gentle stream of an ultra pure nitrogen gas.

The Florisil column was prepared as above for a silica gel column. The 2 ml of extract from the silica gel column was put into the Florisil column and slowly eluted with 110 ml of n-hexane. The eluent was concentrated using a rotary vacuum evaporator, and then concentrated to 1 ml under a gentle stream of ultra pure nitrogen gas to provide a final analytical sample. The internal standard 1-chloronaphthalene (Supelco Inc.) was added just before introducing the analytical sample to the GC-ECD system.

2.4. Analysis

A calibration mix of twenty-six PCB congeners (IUPAC nomenclature: 8, 18, 28, 44, 52, 66, 77, 101, 105, 114, 118, 123, 126, 128, 138, 153, 156, 157, 158, 166, 167, 169, 170, 180, 187, 189) at a concentration of 2000 $\text{pg}/\mu\text{l}$ was diluted to produce five calibration standards ranging from approximately 10 $\text{pg}/\mu\text{l}$ to 200 $\text{pg}/\mu\text{l}$ together with an internal standard. Measurements were done three times for each concentration of calibration standards. First, 12 coplanar PCB congeners were selected due to their higher TEF values and 9 non-coplanar congeners were selected from the di-, tri-, and tetra-CBs where coplanar congeners are absent or rare.

Standard solutions and final samples were determined by using a gas chromatograph (Hewlett Packard 6890 series, U.S.A.) with a ⁶³Ni electron

capture detector and an automatic sampler. An HP-5 (5% diphenyldimethylsiloxane, Hewlett-Packard) capillary column with an 0.32 mm inner diameter, 30 m length, and 0.25 μm film thickness was used as a separation column. An autosampler (HP G1513A) injected 1 μl , through an injection port at 275°C in splitless mode. The oven program was as follows: initial temperature 30°C, 20°C min⁻¹ to 190°C, 6°C min⁻¹ to 275°C, 275°C for 5 min., and finally a post run for 5 min. at 290°C. The carrier gas was nitrogen, with a flow rate of 1 mL/min. The detection limit was defined as three times the standard deviation of the analytical blank levels.

2.5. Total organic carbon determination

Walkley-Black's wet oxidation method was used to determine the total organic carbon content (TOC) of the sediment in order to investigate the correlation between the organic carbon and PCBs. The process

was described in detail in a previous work¹¹⁾.

3. Results and Discussion

3.1. Concentrations of PCB congeners

Individual and total concentrations of PCB congeners are listed in Table 3. The variation trend of the total PCB levels along the main stream of the Kumho River is illustrated in Fig. 2.

Total PCB levels for the 26 congeners ranged from 2.7 to 87.6 ng/g dry weight. The highest level was at site-18 near Keomdan factory district, and a nearby site, site-17, also had the fourth highest level (57.5 ng/g). The second and third highest levels were also located near the West Daegu factory district (site-5) and the 3rd factory district (site-10), respectively. These results imply that PCB levels are highly dependent on the location of factory districts from which various organic pollutants may be

Table 3. Concentrations for the 26 PCB congeners (ng/g dry weight) and TEQ values (pg TEQ/g dry weight) in the sediment from the 23 sampling sites of the Kumho River

IUPAC No.	site 1	site 2	site 3	site 4	site 5	site 6	site 7	site 8	site 9	site 10	site 11	site 12
8	0.48	0.92	0.23	0.91	45.1	1.5	0.38	3.4	0.52	1.2	1.3	3.1
8	1.9	2.7	14.2	1.8	3.4	2.8	0.45	2.6	0.48	2.7	2.8	2.3
28	0.23	0.89	0.39	1.3	1.2	1.4	0.52	1.0	1.3	4.4	1.6	2.6
44	0.32	0.87	0.35	0.88	1.6	0.71	0.43	0.83	1.3	3.0	0.56	1.7
52	0.95	0.74	0.71	1.6	3.4	0.96	0.79	1.7	2.2	2.5	0.88	1.9
66	0.65	1.6	0.74	1.2	2.7	0.95	0.75	1.3	2.7	4.4	0.92	2.2
77	ND	1.3	1.1	0.55	2.3	0.37	1.4	3.0	6.2	6.0	0.31	2.6
101	1.5	1.5	1.3	2.6	3.0	0.32	1.0	2.7	3.5	2.4	3.2	3.0
105	ND	0.32	0.26	0.24	0.54	0.19	0.46	0.73	1.7	1.9	0.16	1.2
114	0.050	0.27	0.085	0.014	0.29	0.098	0.10	0.19	0.25	0.45	ND	0.2
118	0.053	0.26	ND	ND	0.46	1.8	1.4	0.12	4.1	6.1	ND	0.44
123	0.043	0.56	0.80	0.79	1.4	0.36	0.20	1.4	0.20	1.4	0.86	1.7
126	0.19	0.65	0.25	0.28	0.80	0.14	0.20	0.46	0.40	1.21	ND	0.64
128/167	0.018	0.20	0.12	0.24	0.90	0.24	0.21	0.59	0.74	0.75	0.074	0.77
138	0.093	0.47	0.078	ND	1.1	0.19	0.029	0.072	0.17	0.67	0.74	0.10
153	ND	0.52	0.72	0.80	1.5	0.22	0.68	1.2	1.9	4.9	0.61	1.2
156	ND	0.42	0.76	0.63	0.85	0.12	0.22	1.1	0.43	1.5	0.42	1.7
157	0.24	0.19	0.08	ND	0.25	ND	0.015	0.12	0.056	0.44	ND	0.24
158	ND	0.22	0.91	0.94	0.23	0.023	1.2	1.8	3.5	6.2	0.032	1.7
166/187	0.016	0.28	0.21	0.17	0.65	0.18	0.18	0.22	0.27	2.2	0.11	0.35
169	0.041	0.98	0.40	0.20	1.4	0.12	ND	0.54	0.017	0.94	0.38	0.95
170	0.18	0.62	0.47	0.40	1.2	0.31	0.32	0.45	0.56	3.7	0.53	0.74
180	ND	0.38	0.55	0.51	0.88	0.14	0.38	0.65	0.62	5.6	0.51	0.75
189	0.037	0.31	0.38	0.089	0.66	0.29	0.11	0.13	0.050	1.1	0.14	0.35
Total, ng/g	7.0	17.2	25.1	16.1	75.8	13.4	11.4	26.3	33.2	65.7	16.1	32.4
pg TEQ/g	19.2	66.3	26.2	28.8	82.3	14.6	21.1	48.5	44.1	127	0.54	66.8

Table 3. continued

IUPAC No.	site 13	site 14	site 15	site 16	site 17	site 18	site 19	site 20	site 21	site 22	site 23
8	2.0	0.18	0.31	0.030	1.6	6.8	0.43	0.31	2.4	ND	0.29
18	2.5	0.54	2.3	0.32	1.5	13.9	1.2	0.92	3.6	0.40	3.5
28	1.9	0.17	0.3	0.003	2.4	11.9	0.10	0.29	2.1	0.19	ND
44	1.3	ND	0.36	0.14	0.94	5.2	0.16	0.35	0.89	0.19	ND
52	1.9	0.026	0.04	0.27	1.3	6.0	0.087	0.75	1.1	0.39	ND
66	1.9	0.24	1.5	0.18	2.8	5.5	0.35	0.80	1.5	0.82	0.14
77	2.8	0.43	ND	0.10	7.3	6.1	ND	1.4	1.8	0.22	ND
101	3.8	0.75	0.19	0.39	4.0	3.3	0.96	1.2	1.3	1.1	ND
105	0.86	0.001	0.047	0.07	1.2	1.9	ND	0.42	0.71	0.43	ND
114	0.42	ND	0.043	0.13	0.68	0.41	ND	0.16	0.14	ND	ND
118	0.50	0.41	ND	0.054	3.1	2.0	ND	0.016	2.3	ND	0.060
123	2.2	ND	0.18	0.036	10	1.0	0.004	1.2	0.58	0.26	ND
126	1.2	ND	0.22	0.046	1.4	1.0	ND	0.41	0.43	ND	ND
128/167	0.72	ND	ND	ND	0.97	0.62	ND	0.28	0.25	ND	ND
138	0.45	0.44	0.08	0.075	1.0	0.58	ND	0.22	0.24	0.16	0.072
153	2.4	0.40	0.22	0.089	2.4	4.4	ND	0.94	2.4	0.19	ND
156	1.2	0.40	0.034	0.27	0.97	1.2	ND	0.48	0.49	0.43	0.094
157	0.39	ND	ND	0.062	1.8	0.29	0.13	0.073	0.074	ND	ND
158	2.7	ND	ND	0.025	2.8	5.4	ND	1.5	2.9	0.19	0.079
166/187	1.1	0.13	0.029	0.047	1.4	1.9	ND	0.43	0.98	0.073	ND
169	0.97	31.5	ND	0.19	1.0	0.33	ND	1.2	ND	1.8	ND
170	1.5	1.5	0.005	0.19	1.7	2.8	ND	0.93	1.3	0.85	ND
180	2.1	0.38	ND	ND	2.6	4.6	ND	0.52	2.4	0.13	0.56
189	0.79	0.35	ND	ND	2.6	0.48	ND	0.33	0.11	0.19	0.12
Total, ng/g	37.6	37.8	5.9	2.7	57.5	87.6	3.4	15.1	30.0	8.0	4.9
pg TEQ/g	123	0.64	22.1	4.92	147	105	0.07	42.4	44.8	0.50	0.07

discharged. In another study, highest concentrations of PCBs were in sediment taken from locations close to the industrial areas^{12,13}. The effects of point sources on the total PCB levels are clearly illustrated in Fig. 2. Total PCB levels dramatically increased at sites near factory districts, sites-18, 10, 5. These levels, however, were much lower than the action level of 10,000 ng/g needed for dredging sediment in Japan⁶. The maximum PCB level in this study (87.6 ng/g dry wt.) was much lower than the action level, so the contamination level of the sediment of the Kumho River was not believed to be serious. Frignani et al.¹³ reported that PCB levels in sediment from the Venice Lagoon area in Italy ranged from 2 to 2049 ng/g dry weight. The highest concentration was observed in sediment from an industrial area. Other nearby sites had PCB levels from 33 to 222 ng/g dry weight. They suggested that a particular source and the limited mobility of the PCBs combined to cause hot spots and sites with relatively

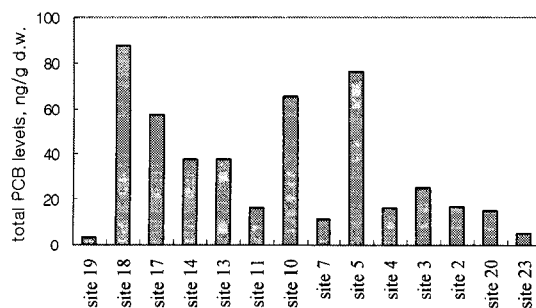


Fig. 2. The variation trend of total PCBs along the main stream Kumho River.

higher levels. Sediment from the Kumho River had much less contamination than the hot spot in the Venice Lagoon area. This result indicated that no serious point sources were located along the Kumho River.

By comparing these results with our previous study¹¹ of the lower Nakdong River, sediment from the Kumho River showed much higher levels and

more even distribution. In the lower Nakdong River, the average level was only 3.8 ± 2.6 ng/g excluding the three highest sites. In the Kumho River, however, the average level is 26.3 ± 23.9 ng/g, which was about 7 times higher than the average level of the lower Nakdong River.

The five sites (sites-1, 15, 16, 19, 23) which showed the lowest levels of 2.7~7.0 ng/g were all located in the upper (sites-15, 16, 19) stream of the Kumho River and in the main stream of the Nakdong River before and after the confluence of these two rivers (site-1, 23). The three sites (site-15, 16, 19) had PCB levels from 2.9 to 5.9 ng/g, which indicated the upper stream of the Kumho River was not contaminated by these sites. There are actually no point contamination sources beyond these sites. The main stream of the Nakdong River at site-23 had much lower levels of PCBs (4.9 ng/g) compared with the main stream of the Kumho River (mean 27.2 ng/g). These observations indicate that any specific point source exerts a great influence on the PCB levels in sediment and that most PCBs are deposited into nearby sediment. These results also imply that only a small proportion of PCBs is transported through the water stream. There were no apparent direct effects of the Kumho River on the PCB levels of the Nakdong River. The influence, however, may continue over a long period of time due to the exchange of PCBs between sediments and water layer.

Homolog profiles of PCBs in the sediment of the Kumho River is illustrated in Fig. 3. Mono-, octa-, nona-, and deca-CBs were not detected. The proportions of each homolog to total PCB levels were 11.6%, 16.7%, 21.2%, 18.8%, 23.3%, and 8.4% for di-, tri-, tetra-, penta-, hexa-, and hepta-CBs respectively. The strong predominance of light homologs (di- to penta-CBs) was clear and accounted for 68.3% of the total PCBs. The predominance of light homologs differs from the results from the soil samples of the Seine River basin, France¹⁴. They showed slightly higher proportions of the heavy homologs from the industrial sites. Frignani et al. also showed the predominance of heavy homologs of PCBs in the sediment of the Venice Lagoon¹³. They reported that the predominance of light homologs resulted from the input of PCBs from a particular source. At all sampling sites excluding site-14, light

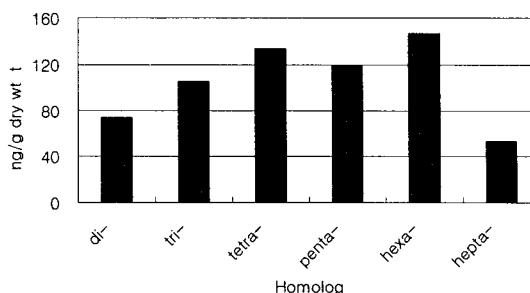


Fig. 3. Homolog profiles of PCBs in the sediment of the Kumho River.

homologs predominate including relatively highly contaminated sites such as sites-18, 17, 10, and 5. Thus, further investigations for source identification is strongly recommended.

3.2. Contribution of PCB 126 to the total TEQ value

The total TEQ value listed in Table 3 was calculated based on the TEF values of the World Health Organization (WHO). The total co-planar PCB level was 1,036 pg TEQ/g dry weight, and PCB 126 was 993 pg TEQ/g dry weight. This means PCB 126 whose WHO-TEF value is 0.1 contributes 96.0% of the total TEQ value although this congener accounted for only 1.6% of the total PCB level. For each sampling site, the contribution of PCB 126 to the total TEQ value ranged from 90.6% to 99.7%. The correlation coefficient, r , between the total TEQ value and the concentration of PCB 126 is 1.00. Thus, the value of the total TEQ in the sediment of this river was sufficient to determine only one specific congener PCB 126. The r between the total TEQ value and the total PCB level of 26 congeners was 0.782. Among 23 sampling sites, four sites (sites-10, 13, 17, 18) contributed 48.5% of the total TEQ value with average of 125 pg TEQ/g dry weight. These four sites were all located along the main stream of the Kumho River and located near factory districts. The average TEQ value of the other 13 sites was 41 pg TEQ/g dry weight, and PCB 126 was not detected from the other five sites.

3.3. Total organic carbon analysis

The content of TOC is depicted in Table 4. Site-18, where the highest total PCB levels were observed also had the highest content of organic carbons. Sites 16 and 19 had the lowest content of

Table 4. The content of total organic carbon in the sediment of the Kumho River, %

Site No.	1	2	3	Average (%)	
				OXC	TOC ^a
1	1.44	1.57	1.63	1.55±0.10	2.25±0.12
2	3.11	3.51	3.3	3.31±0.20	4.42±0.25
3	2.95	2.91	2.91	2.92±0.02	3.95±0.03
4	2.57	2.55	2.48	2.53±0.05	3.47±0.06
5	4.18	4.01	4.08	4.09±0.09	5.38±0.11
6	2.21	2.08	2.12	2.14±0.07	2.98±0.08
7	1.64	1.78	1.82	1.75±0.09	2.50±0.12
8	3.26	3.33	3.35	3.31±0.05	4.43±0.06
9	3.34	3.27	3.32	3.31±0.04	4.42±0.04
10	3.73	3.71	3.66	3.70±0.04	4.90±0.04
11	2.56	2.81	2.78	2.72±0.14	3.69±0.17
12	3.26	3.33	3.34	3.31±0.04	4.42±0.05
13	3.35	3.28	3.31	3.31±0.04	4.43±0.04
14	3.47	3.52	3.51	3.50±0.03	4.66±0.03
15	0.81	0.69	0.79	0.76±0.06	1.29±0.08
16	0.52	0.61	0.62	0.58±0.06	1.07±0.07
17	3.81	3.91	3.95	3.89±0.07	5.13±0.09
18	4.55	4.43	4.47	4.48±0.06	5.86±0.08
19	0.63	0.59	0.51	0.58±0.06	1.06±0.08
20	2.42	2.34	2.23	2.33±0.10	3.22±0.12
21	3.15	3.07	3.11	3.11±0.04	4.18±0.05
22	2.71	2.48	2.41	2.53±0.16	3.47±0.19
23	1.31	1.05	1.13	1.16±0.13	1.78±0.16

a: TOC was converted from OXC by the proposed general equation.

$$\text{TOC} = 1.23 \text{ OXC} + 0.35 \text{ (Sanchez-Monedero, 1996)}$$

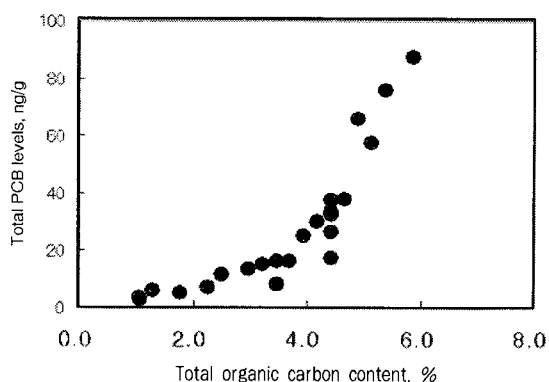


Fig. 4. Correlation diagram between total PCB concentrations in the sediment and corresponding content of organic carbon.

TOC, where total PCBs were also the lowest level. We found a general trend where total PCB levels increased as the TOC content increased. The

correlation coefficient of these two parameters was 0.84, which indicates significant correlation between them as illustrated in Fig. 4.

4. Conclusions

We determined the PCB levels of 26 individual congeners in the sediment of 23 locations along the Kumho River. We also determined the TOC levels and correlated these levels with total PCB levels.

Total PCB levels for the 26 congeners ranged from 2.7 to 87.6 ng/g dry weight. The most polluted point was site-18, near the Keomdan factory district. The most important parameter in determining the PCB contamination levels was likely to be the distance from the suspected point source such as a factory district.

Our results indicated that any specific point source exerted a great influence on the PCB level in sediment and most PCBs were deposited into nearby sediment. The profile of the PCB levels of the Kumho River suggested that the natural transfer of sediment along the river was not efficient. Thus the contamination of PCBs in the sediment of the Kumho River may not affect the water quality of the Nakdong River around the water treatment plant.

Total PCB levels and the TOC content significantly correlated with a coefficient of 0.84.

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