Dioxin2015

POLYCHLORINATED BIPHENYLS CONTAMINATION OF SEDIMENT AND WASTE MATERIALS

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Introduction

Polychlorinated biphenyls (PCBs) have numerous industrial applications, including mainly coolant in electronic industries (capacitors and transformers), but they are also used in paints, sealants for wood, cutting and lubricating fluids, plasticizers, and as dielectric fluids [1]. PCBs have been reported to cause many adverse health effects, such as immune deficiency, nervous system alteration, endocrine disruption, and gastrointestinal system bleeding and liver damage [2]. There are still many processes that release PCBs to the environment, such as chemical and industrial by–products and inadequate disposal of transformers and capacitors. The PCBs contamination of in various materials i.e. sediment, sludge and seawage was reported [3-12]. In the present work, the PCBs contamination in 26 samples of sediment , sludge, seawage and agricultural waste(AW) materials of the central India is described. The congener and concentration variations and sources of the PCBs are discussed.

Materials and methods

Three most industrial cities of central India namely: Raipur (21^o 23' N, 81^o 63' E), Bhilai (21^o 18' N, 81^o 28' E) and Korba (22^o 21' N, 82^o 40' E) lie above > 250 m from the sea level were selected for the proposed investigation. The Raipur is a capital of Chhattisgarh state with ≈ 2.0 million population and its neighborhood are now becoming an important regional commercial and industrial destination for the coal, power, steel and aluminum industries. Bhilai is the second–largest city in Chhattisgarh state with population of □ 1.0 million and is located in the west of Raipur ≈ 22 km away. The town is famous for the operation of one of the largest steel plant in the World (capacity: 3.153 MT Yr^{-1}). Korba is another city in Chhattisgarh state with □ 0.5 million population, famous for power supply.

The samples were collected using a stainless–steel scoop in the summer, 2008. Total 22 samples were collected from three cities. They were kept in glass bottle (250–ml) and dried at 30^{o}C in an oven for overnight. The samples were crushed into fine particles by mortar and sieved out the particles of mesh size < 1 mm. The samples were stored in aluminum foil.

The CHNSO–IRMS analyzer by SV instruments analytical Pvt. Ltd. was used for analysis of the total carbon (TC). The sample was oxidized with O_2 at 1020°C with constant helium flow. The phosphoric acid treated sample was used for analysis of black carbon(BC) and organic carbon(OC). The OC was analysed by titration method using $K_2Cr_2O_7$ as oxidant, and the excess of $K_2Cr_2O_7$ was determined by titrating with the $FeSO_4•7H_2O$ solution.

The samples were dried with sodium sulfate and extracted using a Dionex accelerated solvent extraction (ASE) system. The surrogate standards were added and the samples were extracted with solvent, methylene chloride and purified by silica/alumina column chromatography to isolate the PCB fractions. The quantitative analyses of PCBs were performed by the GC-MS in the SIM mode.

Results and discussion

The pH value (n = 26) was ranged from 6.7 – 8.2 with mean value of 7.7±0.1. All the extracts were found to be slightly alkaline. The lowest pH value of the sludge samples were recorded due to release of acids. The concentration of BC, OC and CC (n = 26) the samples was ranged from 4.9 – 10.3, 0.07 – 0.61 and 0.05 – 0.17% with mean value of 8.1±0.5, 0.17±0.04 and 0.11±0.01%, respectively. The BC had fair correlation with the OC and CC content (r = 0.81 – 0.84), indicating their origin from the same sources. The BC, OC and CC concentration was found to decrease with increasing depth profile from 0 to 30 cm (slope = -1.00, -0.04 and -0.05), respectively. The PCB concentration and congener frequency in the sediment and waste material of central India is summarized in **Table 1**. The sum of total concentration of PCBs in 26 samples was ranged from 201 –800 μg kg^{-1} with mean value of 470±66 μg kg^{-1}. The highest PCBs content was reordered in the AW sample due to occurence of higher fraction (84%) of congeners, 1 and 3. The total congener frequency in the samples (n = 26) was ranged from 45 – 88 with mean value of 63±5. The concentration of majorty of congeners in the sediment was found to increase as the depth profile was increased from 0 to 30 cm, **Figure 1**. However, the reverse trend was seen in the case of the sludge waste, may be binding with metals. The tolerance limit of the PCBs recommended in the soil is 60 µg kg^{-1}. The highest PCBs concentration was observed in pond sediment of Korba city. Therefore, they were selected for the correlation studies. The monochlorobiphenyls, MCBs content had fair correlation ($r = 0.61 – 0.70$) with the carbon content, indicating origin from the coal burning processes. In addition, the MCBs content was found to be well correlated ($r = 0.87$) with other chloro derivatives i.e. TCBs, TeCBs, PCBs and HCBs, indicating their production by further chlorination. The higher PCBs congeners are widely used as lubricating oils in high thermal instruments. They are distributed in the ecosystem either by leakage or/and evaporation. However, the lower PCBs (i.e. congener 1 and 3) are supposed to be formed by the atmospheric reaction (i.e. chlorination of biphenyls). The concentration of the higher PCBs congeners was found to be comparable to the sediments of other areas. The concentration of the lower PCBs was seen to be much higher than present in sediment and waste materials of other area [3-12].

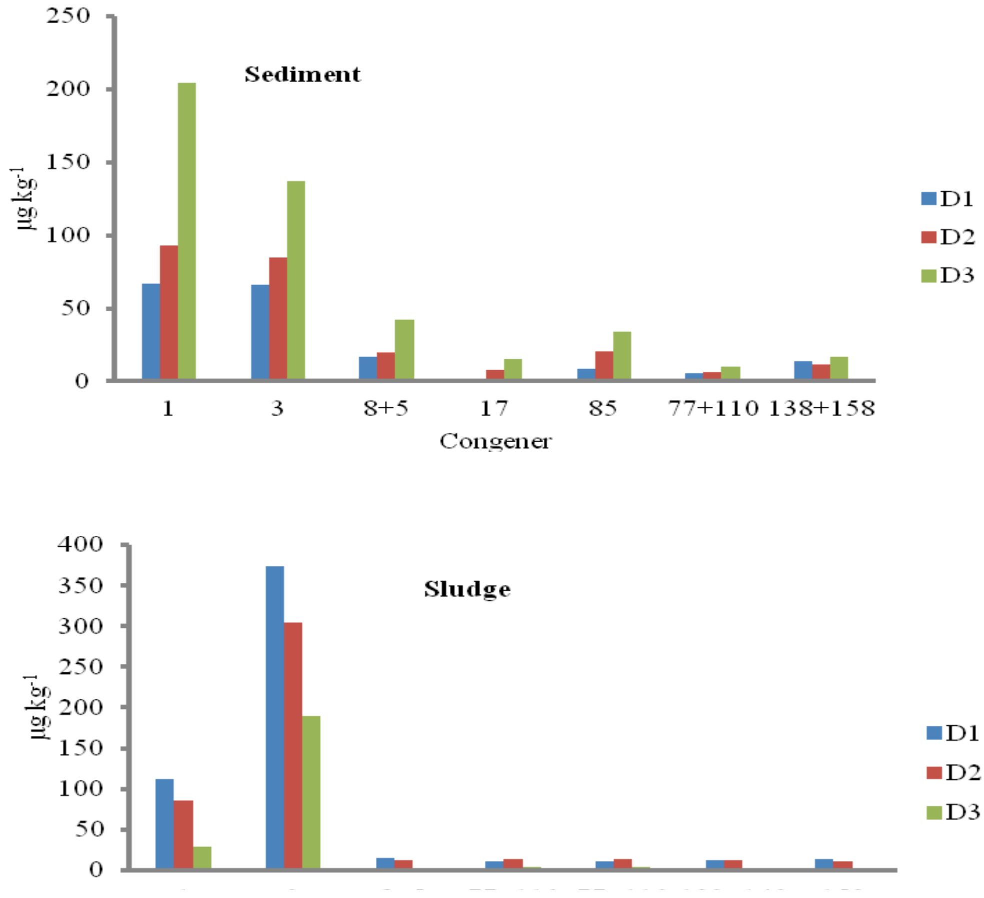

Fig. 1. Depth profile studies of PCBs in sediment and sludge

Conclusion

Significantly higher concentrations of PCBs in the sediments and waste materials of the central India were observed. The concentration of PCBs in the sediment was increased with respect to depth profile unlikely to the sludge materials. The major fraction of PCBs was contributed by monochlorobiphenyls (i.e. 1 and 3 congeners).

Table 1. Distribution of PCBs in sediment and waste of central India, μg kg^{-1}

S. No.	Congener	BSE (n=6)	RSE (n=11)	KSE(n=6)	SL (n=2)	SEW (n=1)	AW (n=1)
1	1	91	91	112	120	148	255
2	3	169	146	323	300	70	414
3	4+10	7.1	3.5	3.5	7.6	0.0	0.0
4	7+9	1.9	0.9	1.4	1.3	0.3	0.7
5	6	3.9	2.6	2.4	3.7	2.3	3.4
6	8+5	16.6	9.9	11.8	15.8	18.4	15.1
7	19	4.6	2.6	2.0	2.0	2.5	2.0
8	18	2.5	1.7	1.9	2.0	5.7	1.8
9	17	6.7	4.6	5.0	5.5	7.0	0.0
10	24	1.3	0.7	0.5	0.0	1.5	0.0
11	16+32	4.4	3.2	4.1	2.9	2.2	7.2
12	29	2.0	1.6	1.7	1.3	0.1	2.0
13	26	3.9	2.3	1.9	3.5	1.3	2.3
14	25	2.8	1.6	1.6	1.4	1.0	3.0
15	28+31	7.0	4.3	3.6	3.8	8.2	4.8
16	21+33+53	3.3	2.2	2.5	3.2	3.3	2.3
17	51	3.3	1.4	1.9	2.8	0.0	0.0
18	22	5.1	3.0	2.6	4.0	1.9	3.1
19	45	2.5	1.4	1.2	2.3	1.0	1.2
20	46	4.0	1.4	1.7	1.5	2.1	2.4
21	62	3.3	1.8	2.1	2.7	4.1	1.5
22	49	3.8	2.4	2.4	2.4	8.1	5.1
23	47+48	2.2	1.2	1.1	1.7	2.3	0.0
24	44	1.6	1.3	1.3	1.6	2.0	1.3
25	37+42	7.7	2.9	2.6	5.9	4.0	2.3
26	41+64+71	6.5	3.2	3.6	5.9	3.1	23.1
27	40	1.4	0.0	0.0	0	0	0
28	100	2.9	1.2	1.7	1.9	1.7	3.9
29	63	1.7	0.6	0.3	0.8	0	0.0
30	74	2.4	1.5	1.3	2.5	3.2	2.6
31	70.76	3.9	2.5	2.7	2.8	7.3	5.2
32	66+95	5.6	2.4	2.3	2.4	4.0	3.6
33	91	7.7	5.6	3.9	0	0	0
34	56+60	6.5	4.3	4.1	2.6	20.2	10.2
35	92+84	0.0	0.0	0	0		0
36	89	5.0	2.0	1.0	3.0	14.4	0
37	101	2.9	1.6	1.3	2.2	6.9	2.3
38	99	1.6	0.8	1.0	1.6	2.1	0.7
39	83	1.3	0.6	1.0	0.6	1.9	3.0
40	97	1.2	0.4	0.4	0.6	5.9	0.3
41	81+87	1.2	0.3	0.1	0.6	0.0	0
42	85	5.6	4.6	0.8	0.6	1.1	0
43	136	3.6	1.0	0.6	4.4	4.8	0
44	77+110	5.8	2.8	4.6	9.5	6.7	4.6
45	82+151	1.6	0.9	0.0	2.4	0.0	0
46	135+144	3.9	1.3	1.1	3.6	4.2	0
47	123+149	4.2	0.9	0.4	8.9	8.9	0
48	118	3.0	0.3	0.6	4.2	3.0	0
49	134	4.8	1.1	0	7.4	6.3	0
50	146	1.1	0.2	0	3.8	0.0	0

51	132	1.8	0.6	0.4	3.4	5.3	0
52	153	4.1	1.2	0.7	11.3	17.1	0
53	105	3.3	1.2	0.8	6.3	5.9	0
54	141	2.0	0.6	0.2	2.6	1.8	0
55	137+130+176	1.1	0.4	0	2.2	3.1	0
56	138+158	8.8	13.0	0	5.1	31.2	5.5
57	163	1.4	0.0	25.1	7.1	0.0	0
58	129+178	1.7	0.7	0.8	7.7	4.0	0
59	187+182	0.4	0.0	0.2	0	0	0
60	183	1.1	0.4	0.4	1.4	5.4	0
61	185	0.9	0.4	0.3	0.5	2.6	0
62	177	1.1	0.2	0.3	0.8	3.2	0
63	157	1.4	0.3	0	1.1		0
64	201	0.4	0	0	0	1.7	0
65	196+203	0.8	0	0.8	0	5.0	0
66	208+195	2.5	0.8	2.1	0	6.9	0
67	194	1.4	0.4	1.4	0	0.8	4.1

B = Bhilai, R = Raipur, K = Korba, SE = Sediment, SL = Sludge, SEW = Sewage, AW = Agricultural waste

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