POLYCHLORINATED BIPHENYLS IN WASTEWATER OF KONYA-TURKEY

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SUMMARY

In this work wastewater samples were collected from 12 points in a sewerage system, the general outlet of the system and different points of the main drainage channel. USEPA method 8082 was used to analyze the PCB congeners 28, 52, 101, 138, 153 and 180, extracted from wastewater by using solid phase extraction cartridges. Recovery ratios were determined to be between 78% and 93% with the analyses of fortified samples. PCB contents of Konya wastewater varied between 0 and 1.3 µg/L for each congener. Possible sources of PCBs in wastewater and some measures to prevent their discharges are discussed.

KEYWORDS: Polychlorinated biphenyls (PCBs), wastewaters, GC/ECD analysis, Konya, Turkey.

INTRODUCTION

Approximately 1.4 billion tons of PCBs have been produced commercially from 1929 to 1978. It has been estimated that 10 million tons of PCBs have been improperly disposed of and ultimately released into the environment. PCBs are recognized as a group of the most persistent pollutants in the environment and listed on the EPA national priority list. These compounds cause various human health problems, such as neurotoxicity, dermatological and pulmonary diseases [1].

The use of PCBs was restricted in many countries during the last 20 years. Toxic Substances Control Act (TSCA) in 1976 in USA regulated and restricted production, distribution and commercial use of PCBs. TSCA was revised in 1996 and the use of substances containing more than 500 ppm PCBs was strictly restricted, while less than 50 ppm PCB-containing substances are still allowed under certain circumstances in closed systems [2, 3].

Dangerous Chemicals Regulations in Turkey in 1993 restricted the use of substances containing 0.1 % PCBs (by weight) until 1996, but these substances have been banned since 1996. In 1995 PCBs were listed as hazardous waste in Turkish Hazardous Waste Control Regulation. Although use of PCBs is restricted or even banned, they are still released into the environment from previous uses and improper disposal of PCB-containing substances [4].

The "Konya sewer system" is a combined system discharging wastewaters to the main drainage channel, which is about 150 km long and open-built to collect excess water returning from irrigation and also rain water. The drainage channel discharges these waters to the Salt Lake, which is a unique natural source for salt production. Along the channel, these waters are also being used for irrigation by farmers. Therefore, it was the aim of this investigation to monitor the PCB contamination of the wastewaters as a basis for developing prevention measurements.

MATERIAL AND METHODS

Konya wastewater samples were collected from industrial areas (sampling points: S2, S3, S4, S5, S6, S8, S9, S11, S12, S13), residential areas (S1, S7, S10), general outlet of sewerage (S14), and main drainage channel (C1, C2, C3), which collects city wastewaters, run-off waters and excess waters from irrigation discharging them to Salt Lake [5].

PCB measurements were carried out according to Method 8082 by US EPA [6]. Sample preparation was optimized for PCB analyses. Fortification experiments were carried out by Liquid–Liquid Extraction (LLE) and Solid Phase Extraction (SPE) using C-18 octadecyl silane (ODS) Bakerbond-SPE cartridges. A 6 PCB-standard mixture was added to 250 mL distilled water and extracted with 50 mL n-hexane by shaking it in a separatory funnel. Solvent phase was separated and reduced to 1 mL by rotary-evaporation under nitrogen atmosphere before analysis.

A Hewlett Packard 5890 series II gas chromatograph equipped with 6890 series autosampler, ^{63}Ni-electron capture detector (ECD), split-splitless injector and DB-5 fused silica capillary column (30 m length, 0.25 mm id. and 0.25 µm film thickness, J&W Scientific) was used for GC analysis. Nitrogen was used as carrier gas at 1.40 mL/min and as make-up gas at 45 mL/min. PCB 28, PCB 52, PCB 101, PCB 138, PCB 153, and PCB 180 single standards were obtained from Promochem, Germany. PCB 209 from Promochem was used as internal standard. Recovery rates for SPE ranged from 78 to 93 % and for LLE from 40 to 60 % (Figure 1). Due to its better recovery rates, the SPE method was chosen for analysis. Solvents used were methanol and n-hexane from E. Merck, Germany. The chromatogram of the mixed PCB standard containing 6 congeners and PCB 209 as internal standard is given in Figure 2.

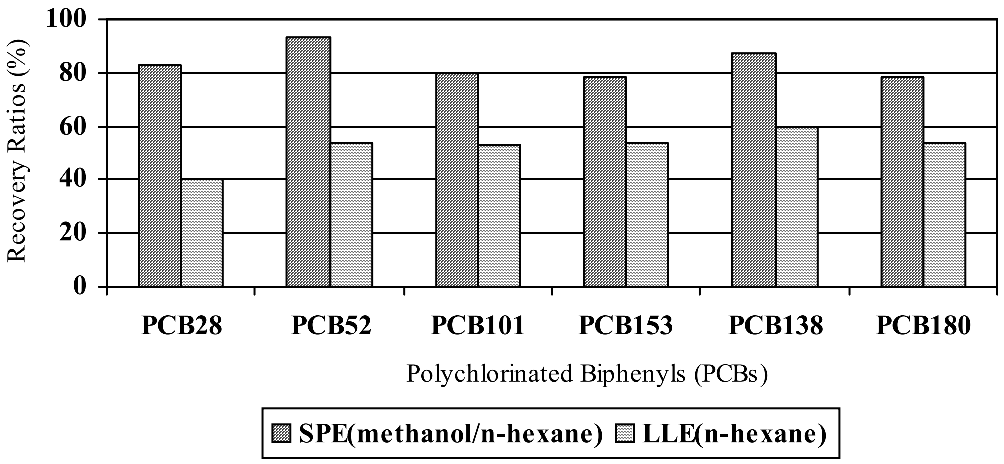

FIGURE 1 - Recovery rates of SPE and LLE methods (n=3).

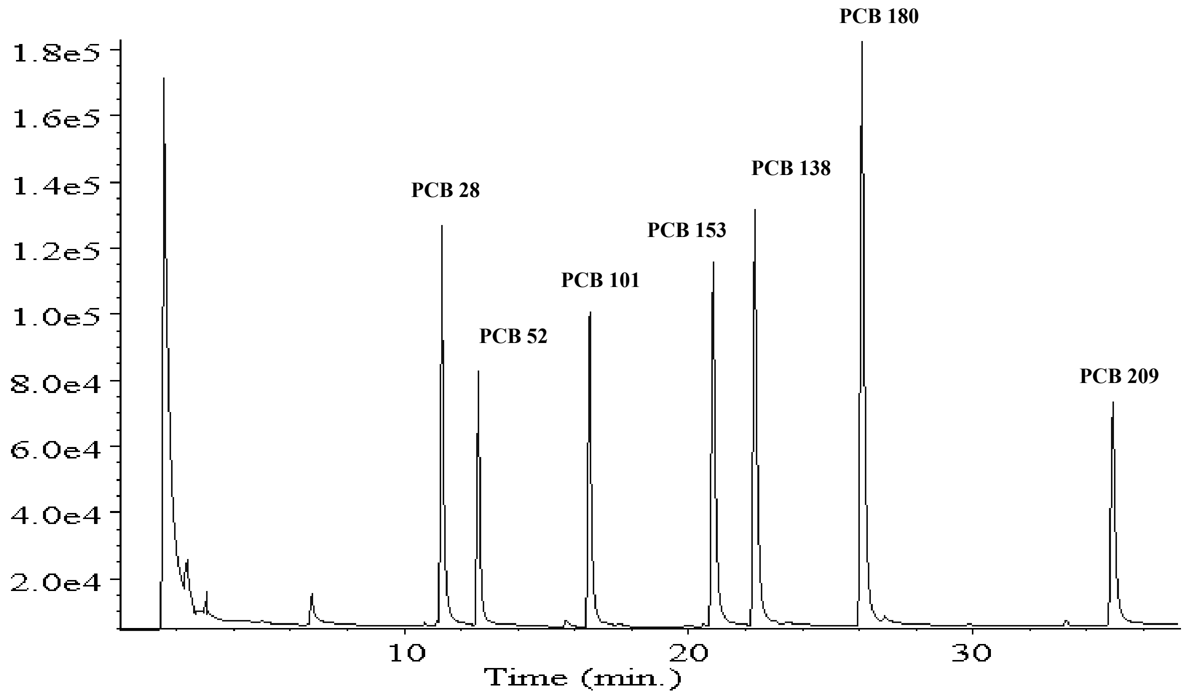

FIGURE 2 - Chromatogram of PCB-mix standard (1 mg/L).

TABLE 1 - Concentrations (µg/L; n=6) of PCB congeners found at S1-S14 and C1-C3.

Sampling	PCB28			PCB52			PCB101			PCB138			PCB153			PCB180		
	mean	min	max	mean	min	max	mean	min	max	mean	min	max	mean	min	max	mean	min	max
S1	0.415	0.205	0.525	0.463	0.226	0.623	0.230	0.025	0.595	0.017	-	0.050	0.005	-	0.014	0.020	-	0.058
S2	0.238	-	0.744	0.521	0.009	1.253	0.054	0.004	0.134	0.106	-	0.437	0.023	-	0.086	0.049	-	0.153
S3	0.471	0.027	1.331	0.616	0.028	2.019	0.082	0.015	0.217	0.036	-	0.075	0.010	-	0.034	0.047	-	0.179
S4	0.371	-	0.760	0.493	0.013	1.336	0.079	-	0.270	0.136	-	0.544	0.026	-	0.100	0.030	-	0.087
S5	0.687	0.069	1.100	0.716	0.016	1.663	0.240	0.027	0.566	0.355	-	0.872	0.177	-	0.706	0.202	-	0.614
S6	0.267	0.006	0.616	0.272	0.007	0.972	0.152	0.005	0.300	-	-	-	0.002	-	0.006	0.002	-	0.005
S7	0.242	0.047	0.436	0.225	0.017	0.432	0.028	0.012	0.043	0.080	-	0.239	0.181	0.006	0.355	0.023	0.002	0.044
S8	0.431	0.058	1.030	0.445	0.025	1.090	0.038	-	0.122	0.018	-	0.061	0.001	-	0.005	0.001	-	0.003
S9	0.423	0.032	0.800	0.664	0.007	2.000	0.126	0.027	0.257	0.152	-	0.324	0.079	-	0.252	0.018	-	0.047
S10	0.348	0.025	0.536	0.479	0.007	1.492	0.060	-	0.204	0.102	-	0.408	0.072	-	0.277	0.019	-	0.074
S11	0.326	0.014	0.545	0.125	0.026	0.296	0.043	-	0.069	-	-	0.001	0.006	-	0.016	0.005	-	0.010
S12	0.513	0.256	0.808	1.431	0.528	2.285	0.067	-	0.201	0.070	0.003	0.158	0.077	0.002	0.214	0.043	-	0.125
S13	0.445	-	0.710	0.803	0.370	1.316	0.074	0.017	0.174	0.031	0.022	0.045	0.050	0.013	0.071	0.089	-	0.247
S14	0.246	0.082	0.408	0.174	0.015	0.540	0.102	0.012	0.325	0.001	-	0.003	0.002	-	0.006	0.002	-	0.004
C1	0.575	0.164	0.848	1.158	0.880	1.581	0.224	0.123	0.340	0.061	-	0.115	0.045	-	0.079	0.120	0.027	0.252
C2	0.664	0.588	0.720	1.113	0.807	1.340	0.210	0.005	0.577	0.043	-	0.130	0.050	-	0.123	0.034	-	0.083
C3	0.419	-	0.687	0.716	0.265	1.547	0.045	0.034	0.053	0.064	-	0.191	0.049	-	0.147	0.086	-	0.258

- below detection limit (0.001 µg/L)

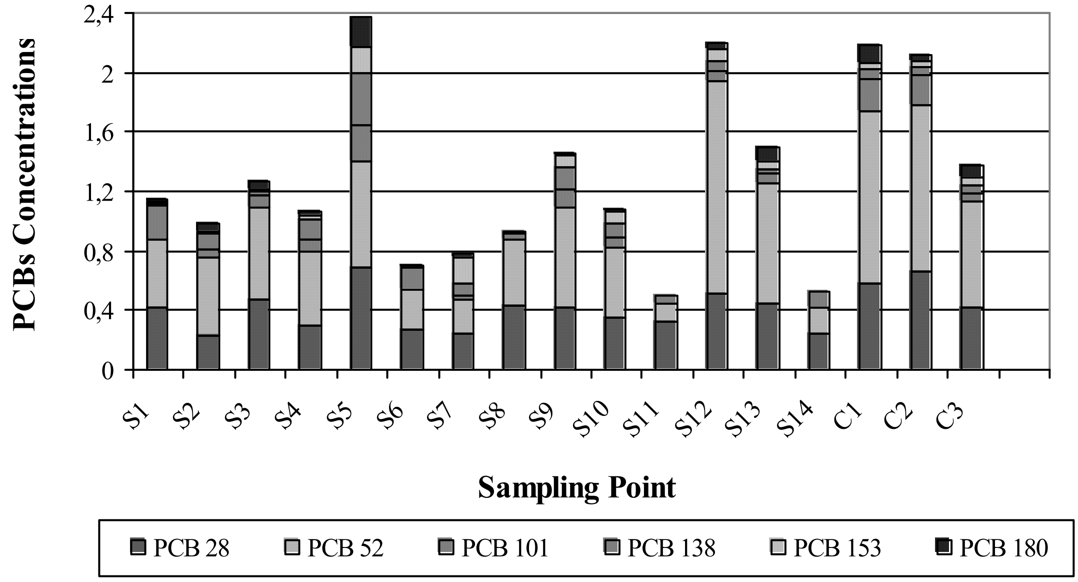

FIGURE 3 - Cumulative mean PCBs measured at each sampling point (µg/L).

RESULTS AND DISCUSSION

The PCB contents of wastewater samples from sewer system and drainage channel were determined following the analytical procedure optimized as described above. Minimum, mean and maximum PCB concentrations found at each sampling point are given in Table 1.

Mean values varied from 0.238 µg/L at point S2 to 0.687 µg/L at S5 for PCB 28, while they changed from 0.125 µg/L to 1.431 µg/L for PCB 52 and from 0.028 µg/L to 0.240 µg/L for PCB 101. The highest mean, 0.152 µg/L, evidenced PCB 138 at sampling point S9. PCB 153 and PCB 180 mean values changed from 0.001 µg/L to 0.181 µg/L and from 0.001 µg/L to 0.202 µg/L, respectively.

Cumulative mean PCB values at each sampling points are given in Figure 3, although there is no PCB regulation existing for the sewerage system. From Figure 3 it could be seen that sampling points S5, S9, S12, S13, C1, C2 and C3 had the highest PCB values.

CONCLUSIONS

In this research, PCBs analyzed in Konya wastewater samples changed between 0-1.3 µg/L for PCB 28, 0.01-2.3 µg/L for PCB 52, 0-0.6 µg/L for PCB 101, 0-0.9 µg/L for PCB 138, 0-0.7 µg/L for PCB 153, and 0-0.6 µg/L for PCB 180.

Cumulating these 6 PCBs, the values were highest at sampling points S5, S9, S12, S13, C1, C2 and C3. S5 receives wastewater from the industrial area including a tram maintenance workshop. S9 receives its wastewater from Meram industrial zone with an electric distribution center including big transformers. At S12 the wastewater inflow originates from an industrial zone characterized by a leather-processing factory and at S13 from a scrap-yard area, where old equipments and all sorts of metals are collected. Sampling points C1, C2 and C3 are located at the main drainage channel, which receives wastewaters from several towns as well as industrial areas, rain waters and excess waters from irrigation of farmlands. PCBs may come from various industries as well as atmospheric depositions on wide areas that could be washed out to the channel.

These PCB values are higher than those measured previously in Paris (1.3 µg/L) [6] and Montreal (0.018 µg/L) [7] sewerage systems. It has been suggested in previous works that no reduction in PCBs levels of sewer systems can be observed, even after 10 years of PCB ban. Possible explanations of these higher PCB levels found in Konya wastewaters may be:

- The use of PCB-containing substances was later restricted in Turkey than in the EU (Paris) or Canada (Montreal).
- The restriction requirements concerning the use and disposal of PCB-containing materials in Turkey (Konya) are only partly fulfilled.

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