

Distribution of Polychlorinated Biphenyl Congeners in Pine Needles Collected In and Around a Superfund Site Contaminated with Aroclor 1268

B.G. Loganathan^{*}, J.R. Neale^{*}, K.S. Sajwan[†], L. Francendese[‡] and D.A. Owen^{*}

^{*}MSU Chemical Services Laboratory, Department of Chemistry, Murray State University, Murray, KY 42071, U.S.A.

[†]Department of Biology and Life Sciences, Savannah State University, Savannah, GA 31404, U.S.A.

[‡]LCP Site, U.S. Environmental Protection Agency, Brunswick, GA 31520, U.S.A.

Introduction

Polychlorinated biphenyls (PCBs) are priority environmental pollutants and are ubiquitous and toxic to wildlife and humans[1]. Although the production of PCBs has been banned in many developed nations over two and a half decades ago, due to their recalcitrant properties, they continue to cycle among various environmental compartments. Ecosystems located near or at contaminated sites are at the greatest risk from exposure to PCBs through air, water or contaminated soil or fish. There are several PCB-contaminated superfund sites in the United States and these sites were protected to limit dispersal of PCBs from these sites. However, volatilization or leaching of contaminants from these sites continue to occur. The LCP Chemicals Superfund site in Glynn County, Brunswick, Georgia, U.S.A., had a chlor-alkali plant, which was established on site in 1955 and was operated until 1994, when it was designated as a Superfund site (Fig. 1). As a result of multi-industrial operations, the site and the adjacent brackish water have been severely contaminated by metals (mercury, lead, chromium and zinc) and organics (PCBs, PAHs and phenolic compounds)[2,3]. Aroclor 1268 is a highly chlorinated PCB formulation which was applied to electrical equipment used in the chlor-alkali process at the LCP site[2]. Our earlier study showed the presence of Aroclor 1268 congeners in street dusts and soil collected near the superfund site, suggesting the escape of the PCBs beyond the restricted area of the site[4]. Present study was conducted to examine the possibility of atmospheric contamination of the PCBs from this site. Since semi-volatile organic compounds are known to partition between the vapor phase and lipophilic substances, plant foliage concentrations of organic pollutants have been reported as indicators of atmospheric contamination[5]. Pine needles were demonstrated as a fixed site, regenerative, annual monitoring matrix for the evaluation of local and regional distribution of lipophilic air pollutants[6-8]. In this paper, we present selected PCB congener data from second year class (one year old) needles of Loblolly (*Pinus taeda*) collected adjacent to the superfund site, near the site and away from the site. PCB congener distribution with distance from the source are discussed.

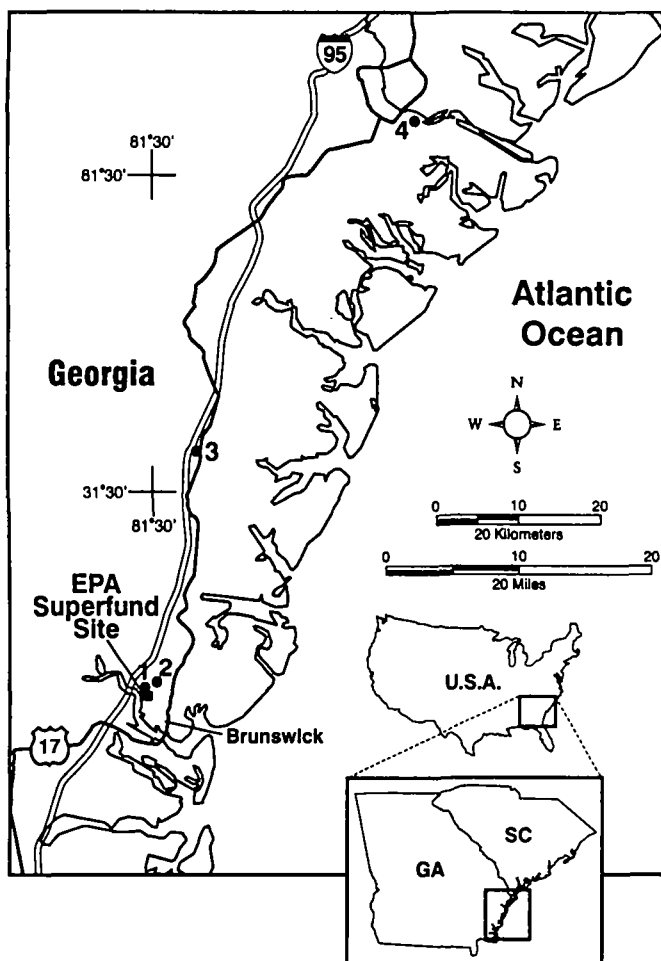


Fig. 1. Map showing pine needle sampling locations (●).

Materials and Methods

Figure 1 shows the east coast of Georgia and the pine needle sampling locations. Sample #1 was collected adjacent to the LCP site. Sample #2 was collected about 1.5 km from the superfund site near a residential area. Sample #3 was collected at I-95 near Hinsville, GA and #4 was collected at River Street, Savannah, GA. Most common pine species available and easily accessible for sampling in this region is Loblolly (*Pinus taeda*). Second year class needles were plucked from the tree branches and wrapped in pre-cleaned aluminum foil, transported to the laboratory in ice cooler and stored under -20°C until analysis. The pine needles were cut in to small pieces (<3 cm). About 40 - 50 g of the needles was used for Soxhlet extraction. Clean-up procedures and quantitations of PCB congeners were similar to the one described elsewhere [9]. Shimadzu Model 17-A gas chromatograph and Shimadzu Model AOC-17 Model Autoinjector was used for the analysis. DB-5 and DB-17 capillary

columns (30 m x 0.25 mm diameter and 0.25 μ film thickness) were used for separation of the analytes. Helium (1.5 mL/min.) and nitrogen (28 mL/min.) were used as carrier and make-up gases, respectively. The NIST (National Institute of Standards and Technology) SRM 2262 PCB calibration standard was used instrument calibration and to generate response factors. Co-eluting congeners are PCB-66/95, PCB-138/163/164, PCB-187/182/159, PCB-170/190 and PCB-105/132. Therefore, the concentrations of these congeners are summed. Sum of all the above (35) congeners is multiplied by a factor of 2 to obtain total PCB concentration. Aroclor 1268 standard was obtained from Ultra Scientific. Total Aroclor 1268 concentration was calculated using a response factor derived from selected Aroclor 1268 peaks in the Gaussian distribution.

Results and Discussion

PCB concentrations in pine needles collected from four different locations around the superfund site is shown in Table 1. Greatest concentration (48.48 ng g⁻¹ d wt.) was found in needles collected adjacent to the LCP site. Total PCB concentration dropped to 23.86 ng g⁻¹ d wt. within about 1.5 km from the superfund site. Pine needles from Hinesville, GA., and Savannah, GA., showed relatively less total PCB concentration than sites in the Brunswick.

Table 1. Total PCBs and Aroclor 1268 concentrations in pine needles (*Pinus taeda*) collected near a superfund site contaminated with PCBs. Sampling was done on July 24, 1997.

Location	Total PCB concentration ng g ⁻¹ dry wt.	Aroclor 1268 concentration ng g ⁻¹ dry wt.
Superfund site, Brunswick.	48.48	8.30
Brunswick, GA	23.86	4.99
Hinesville, GA	19.90	0.16
River St. Savannah, GA	15.64	0.17

Fig. 2 presents congener composition in *P. taeda* collected at various locations. Interestingly, the sample collected near superfund site showed presence of several lower chlorinated (di-, tri- and tetrachlorobiphenyl congeners) as well as higher chlorinated (penta-, hexa-, hepta-, octa-, nona- and decachlorobiphenyls) PCBs. Whereas, lower chlorinated PCBs were barely detectable in pine needles from Hinesville and Savannah, GA. PCB congeners 101 (2,2',4,5,5'-P₅CB), PCB-87 (2,2',3,4,5'-P₅CB), PCB-153 (2,2',4,4',5,5'-P₆CB), PCB-118 (2,3',4,4',5-P₅CB) and PCB128 (2,2',3,3',4,4'-P₆CB) were present in almost all the samples analyzed. This indicated that the pine needles were exposed to persistent Aroclors such as Aroclor 1254 and 1260. Kannan *et al.*[2] showed presence of congeners characteristic of Aroclor 1268 in sediments from the superfund site. Elevated concentration of nona-, octa- and hepta- chlorobiphenyl congeners in these needles indicate that the pine needles were exposed to Aroclor 1268 from the LCP site. Due to hydrophobicity (Octanol-water partition coefficient >3) translocation of PCBs via root is not possible [5]. Therefore, contamination of pine needles should be from atmospheric routes. The results suggest that even the higher chlorinated PCBs (hepta, octa, nona and decachlorobiphenyls) are carried through atmosphere at (near) the superfund site. Therefore, it is possible that people living closer to this site are also exposed to PCBs characteristics of this superfund site. The pine needle

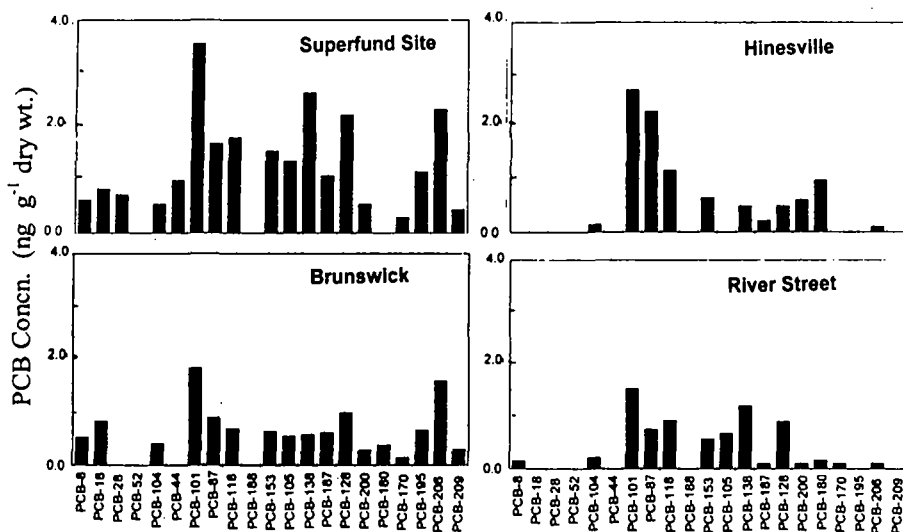


Fig. 2. PCB Congener composition in pine needles collected in and around PCB contaminated superfund site.

samples from Hinesville and River Street, Savannah which are about 30 and 80 miles from the LCP site, did not (or barely detected) show the presence of Aroclor 1268 congeners. It may be possible that heavier congeners are not transported through atmospheric route. Further, studies with more samples from different (downwind) directions are needed to elucidate the atmospheric transport of Aroclor 1268 congeners.

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