

# PCB CONTAMINATION AT THE LCP CHEMICALS SUPERFUND SITE, BRUNSWICK, GEORGIA

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**REFERENCE:** *Proceedings of the 1997 Georgia Water Resources Conference*, held March 20-22, 1997, at The University of Georgia, Kathryn J. Hatcher, Editor, Institute of Ecology, The University of Georgia, Athens, Georgia.

**Abstract.** The use of PCBs at an industrial site in coastal Georgia has led to extensive contamination both on site and in the adjacent salt marsh. Congener-specific analyses have shown that high parts per million levels of PCBs, in a pattern resembling that of Aroclor 1268, exist in site soils and in inner marsh sediments. Although 2,3,7,8-TCDD toxic equivalents (TEQs) in Aroclor 1268 are relatively low, the concentration-weighted TEQs in these highly contaminated media are elevated. A 100-fold reduction in both PCBs and TEQs for outer marsh tidal creek sediments and high parts per billion levels of PCBs in forage/predator fish from nearby Purvis Creek suggest that PCB transport out of the heavily contaminated inner marsh may be dominated by ecological processes. Little or no change in the characteristic Aroclor 1268 congener signature in soil, sediment or fish samples underscores the mixture's environmental stability.

## INTRODUCTION

The Superfund site known as LCP Chemicals in Glynn County, Georgia near the city of Brunswick has been host to several industrial ventures between 1919 and 1994, including petrochemical, power generation, paint manufacturing and chlor-alkali operations. The chlor-alkali facility was established in 1955 and remained operational until 1994. During this period, process wastes and refuse containing mercury and PCBs (mostly as Aroclor 1268) were discharged into holding pits adjacent to an intertidal brackish marsh, and also directly into Purvis Creek, a tributary of the Turtle River.

Several agencies, including the U.S. Fish and Wildlife Service (FWS), the State of Georgia Environmental Protection Division (EPD), and the U.S. Environmental Protection Agency (EPA), began sampling sediments and biota from the area in the early 1990s and found concentrations as high as several parts per thousand of metals

(Hg, Pb, Cr, Zn) and organics (PCBs, PAHs, phenolics) (USFWS, 1994; USEPA, 1995). Subsequent tests performed on whole sediment and sediment porewaters from the site attributed elevated toxicity to organic compounds, namely PCBs and methylmercury (Winger et al., 1993). In response, Georgia's Department of Natural Resources (DNR) closed the area to commercial and recreational harvesters of seafood in early 1992 and EPA has been overseeing remediation efforts on site since 1995.

Several outstanding issues remain however, including the long term effects of chemical contamination on the local ecology and the appropriate remediation strategy for the severely contaminated inner marsh (USEPA, 1996). Although no obvious acute effects to biota have been linked to contaminants at this site, the potential for sub-lethal effects, both at the individual and population levels, is real based on other instances where gross environmental contamination was present (Kendall and Dickerson, 1996). The elucidation of probable effects is hampered, however, by the complexity of the local food web, which includes marsh grasses, microbial mats, estuarine invertebrates, amphibians and reptiles, fish, and fish-eating birds and the large uncertainty associated with ecological risk models.

The objectives of this study were to (i) determine concentrations and the relative distribution of PCB congeners in Aroclor 1268 and in soil, sediment and tissue samples from the site, (ii) identify congener/homolog shifts in these media, and (iii) compute the 2,3,7,8-TCDD toxic equivalents (TEQs) in Aroclor 1268 and in these environmental samples as one way of assessing the potential for detrimental biological effects resulting from PCBs at this site.

## MATERIALS AND METHODS

### Field Sampling

Surface sediments (0-5 cm) were collected using solvent-

rinsed implements at 3 intertidal sites in the marsh adjacent to the LCP Chemicals site in March of 1996 (Fig. 1). Sites MSL and MSR are ~50 m and ~75 m from the edge of the site in an area of the marsh (~10 acres) with the highest levels of PCBs (EPA, 1996). The tidal creek site (CS) is ~300 m down the causeway which ends at Purvis Creek. A soil sample (ES) was also collected from a large excavation pile on site. Samples were placed into pre-cleaned glass jars and immediately placed on ice. A complete description of our methodology for soils and sediments is given elsewhere (Kannan et al. in press).

Fish were collected by gill net from Purvis Creek at the discharge canal outfall in April of 1996. Several fish were also netted at a reference site near Dubenion Creek on St. Simons Island in St. Simons Sound. Whole fish were preserved on ice and were dissected upon return to the lab; muscle tissue was separated from skin and macerated using solvent-rinsed stainless steel razor blades and scissors.

#### Analysis of PCBs by GC/ECD and GC/MS

Five g of freeze-dried soil and sediment, and ~20 g wet fish muscle were extracted with 400 ml  $\text{CH}_2\text{Cl}_2$  in a soxhlet apparatus for 16 h. These extracts were concentrated and exchanged to hexane using a Kuderna-Danish apparatus and fractionated by

packed column solid-liquid chromatography. Silica gel (1.5 g activated at 130°C) and Florisil (18 g 1% water deactivated) were the solid adsorbents for sediment/soil and fish extracts, respectively. Lipid weight was determined gravimetrically after solvent evaporation of a portion of fish soxhlet extracts.

After post-column concentration using a TurboVap, extracts were analyzed on a Varian 3400CX gas chromatograph with electron capture detection (GC/ECD) and a Varian 3400CX GC/Saturn 3 ion trap mass spectrometer (GC/MS). The GC columns were 30 m fused silica coated with DB-5 and XLB stationary phases for ECD and MS, respectively. The quantitation of 28 PCBs in these samples was based on SRM 2262, a standard congener solution from NIST (Gaithersburg, MD). Detection limits were ~1 ng/g dry wt. for sediments and ~0.25 ng/g wet wt. for fish tissues. A standard preparation of Aroclor 1268 purchased from ULTRA Scientific (Kingston, RI) was diluted in hexane and analyzed by both instrumental methods.

## RESULTS AND DISCUSSION

### Congener Concentrations/Distributions in Aroclor 1268 and in LCP Soils and Sediments

The predominant homologs in Aroclor 1268 were octa- (8-Cl; 45%) and nonachlorobiphenyls (9-Cl; 38%) which accounted for >80% by weight of the total PCBs in this formulation. IUPAC No. 206 (2,2',3,3',4,4',5,5',6-nonaCB) was the largest single PCB component, accounting for 21%. The measured average chlorine per molecule was 8.5 which corresponds to a chlorine content of 67%. Eleven congeners with 7 to 10 chlorines each made up greater than 99% of all PCBs (Table 1).

Concentrations of total PCBs in excavation soil (ES), marsh left and right (MSL and MSR) and tidal creek sediments (CS) were 536, 429, 275 and 8.2  $\mu\text{g/g}$  dry wt., respectively. These levels are in agreement with previous monitoring work (EPA, 1996) and represents a nearly 100-fold attenuation by the marsh environment from the excavation site to the tidal creek site, a few hundred meters away. The homolog distributions and chlorine contents in soil and in marsh/creek sediments were in general similar to those of Aroclor 1268 (Table 1). Lower chlorinated homologs (3-6 Cl) were more prevalent in ES and CS, perhaps due to cross-contamination with Aroclor 1260, which was detected in low ppm concentrations in an area of the marsh between our inner marsh sites and our outer marsh creek site (USEPA, 1996) and whose historical usage on site can be traced to the operations of an electric power utility (P. Peronard, unpublished data).

Alternatively, it is possible that *in situ* dechlorination of higher chlorinated PCBs originating from Aroclor 1268 to lower chlorinated homologs is in part responsible for the slight enrichment of tri- through hexaCBs; however, if this

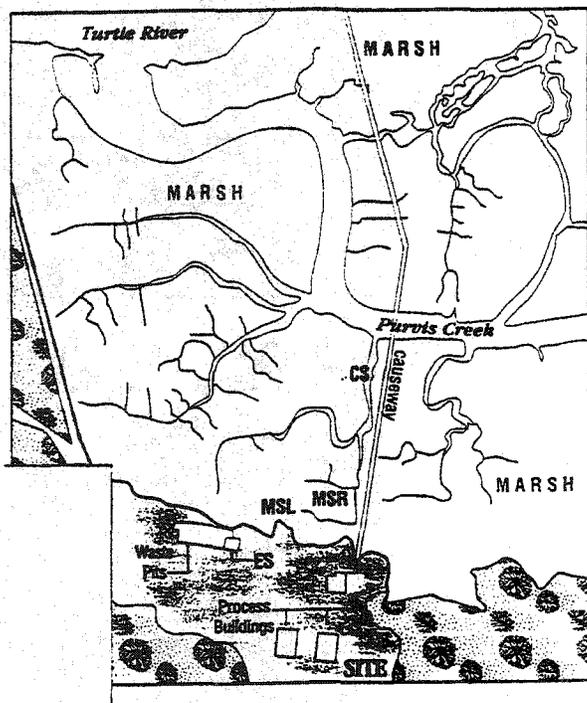


Fig. 1. Sites for marsh (MSL, MSR) and tidal creek (CS) sediment, and excavation soil (ES) samples at the LCP Chemicals Superfund Site.

**Table 1. PCB Homolog Distribution (weight%) in Aroclor 1268 and Soil/Sediment Samples.**

Sample	%Cl	hepta-	octa-	nona-	deca-
Excavation soil (ES)	68	7.1	39	47	6.9
Marsh left sediment (MSL)	68	8.9	39	46	6.3
Tidal Creek sediment (CS)	68	7.1	41	47	5.4
Aroclor 1268	67	12	45	38	5.4

was the case, the rate/extent of *in situ* processes would appear to be extremely slow/limited.

**Toxic Potential Based on 2,3,7,8-TCDD Equivalents**

As a measure of the toxic potential of Aroclor 1268, we calculated the 2,3,7,8-TCDD equivalents (TEQs) of non-, mono- and di-ortho substituted PCBs using the toxic equivalence factors of Ahlborg et al. (1994). The concentrations of the non-ortho coplanar congeners 3,3',4,4'-tetraCB (No. 77), 3,3',4,4',5-pentaCB (No. 126) and 3,3',4,4',5,5'-hexaCB (No. 169) were 10, 3.6 and 1.0 µg/g, respectively. The estimated TEQs for all coplanars in Aroclor 1268, which is the sum of the products of concentrations and toxic equivalency factors, was 2.0 µg/g, an order of magnitude lower than estimates for Aroclor 1260 (18 µg/g), Chlophen A60 (26 µg/g) and Kanechlor 600 (13 µg/g).

The concentrations of coplanars and their corresponding TEQs decreased in the following manner for LCP soils and sediment samples: ES > MSL, MSR > CS. The estimated toxic equivalents decreased by more than 2 orders of magnitude (0.17-29 ng/g dry wt.); however, the highest TEQ is ten times or more higher than the lowest sediment quality guidelines computed from equilibrium partitioning and tissue-based residue models (Iannuzzi et al., 1995).

The non-ortho congener IUPAC No. 126 contributed ~50% of the TEQs in marsh/creek sediments whereas it contributed >80% in excavation soil (Fig. 2). This provides further evidence of cross-contamination of site media with Aroclor 1260 and/or the selective *in situ* dechlorination of meta- and para-substituted congeners as reported by others (Rhee et al., 1993; Bedard and May, 1996). Thus, even though the inherent toxic potential (based on TEQs) for Aroclor 1268 is much lower than other PCB formulations, the elevated concentrations in LCP soil and marsh sediments

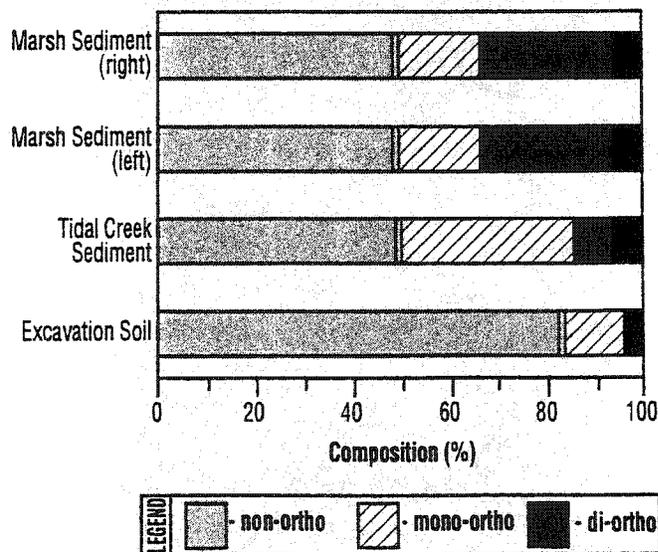
presents a potential risk to marsh biota from coplanar PCBs.

**Concentration and Distribution of PCBs in Fish**

Total PCBs (sum of > 25 congeners) in muscle of a mature female spotted seatrout (*Cynoscion nebulosus*) collected at the end of the causeway in Purvis Creek was 300 ng/g wet wt. Assuming a lipid content of 1 percent, this tissue burden corresponds to 30 µg/g lipid. Greater than 80% of the total PCBs had 7 chlorines or greater per PCB molecule. PCB No. 206 was again the most prevalent congener (18% of total PCBs) and decachlorobiphenyl constituted 2.5%. Several lower chlorinated PCBs, including di- through hexachlorinated congeners were detected in this tissue sample, however, no individual congener within these homologous series exceeded 2% of the total PCBs and in most cases were << 1%.

**SUMMARY AND CONCLUSIONS**

PCBs exist in high parts per million levels in soils and in inner marsh sediments at the LCP Chemicals Superfund site in coastal Georgia. The congener profile in these media was very similar to that of Aroclor 1268, a highly chlorinated formulation used extensively on site. Estimated toxic equivalents of coplanar congeners in Aroclor 1268 were lower than in other PCB mixtures; however, TEQs in LCP soils and near marsh sediments garners concern because of their high concentrations in these media.



**Fig. 2. Non-ortho coplanar PCB 126 contributed ≥50% of dioxin-like toxic potential in LCP soil and marsh/creek sediments.**

Very high sediment PCBs as Aroclor 1268 are confined to ~10 acres of the marsh closest to the site (EPA, 1996), suggesting that physicochemical transport away from the source is limited, most likely due to the extreme hydrophobicity and extremely low vapor pressure of Aroclor 1268. However, elevated tissue levels in fish collected in nearby Purvis Creek suggest that ecologically-mediated processes (i.e. food web transfer) are the predominant uptake and bioaccumulation mechanisms. This hypothesis is currently being tested by comparing transport of PCBs via suspended particle movement initiated by tidal energy with bioaccumulation profiles in media representing a simplified sediment-invertebrate-forage fish-predator fish biogeochemical transfer model. More research on the potential effects of contamination at this site on the reproductive success and endocrinology of important indicator species representing a diverse phylogeny is needed to provide a scientific basis for future decisions concerning site remediation and future monitoring strategies.

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