

# FORMATION AND SOURCES: FIELD CASES

## POLYCHLORINATED BIPHENYL (PCB) CONCENTRATIONS IN ATMOSPHERICALLY DERIVED ORGANIC FILMS FROM LOWER MANHATTAN AFTER SEPTEMBER 11, 2001

Craig M. Butt<sup>1</sup>, Jennifer Truong<sup>1</sup>, Miriam L. Diamond<sup>1</sup> and Gary A. Stern<sup>2</sup>

<sup>1</sup>Department of Geography, University of Toronto, Toronto, Ontario, Canada M5S 3G3

<sup>2</sup>Freshwater Institute, Department of Fisheries and Oceans, Freshwater Institute, 501 University Crescent, Winnipeg, Manitoba, Canada R3T 2N6

### Introduction

On September 11, 2001, two airplanes struck the north and south towers of the World Trade Center (WTC). The fires caused by the collisions were estimated to initially exceed 10,000 °C and continued to burn, at lower temperatures for at least three months, causing fumes to extend throughout Manhattan and adjacent boroughs of New York City. The fires consumed office equipment, furnishings, and building materials. The collapse of the twin towers and adjacent buildings, also dispersed debris, such as pulverized cement and asbestos, throughout the area. Further, an electricity substation, located underneath “7 World Trade Center”, containing 492,000 litres of PCB contaminated transformer oil was destroyed<sup>1</sup>.

Household and building fires are known to produce high concentrations of toxic gases, including PCB, PAH, chlorophenols and polychlorinated dibenzodioxins and furans<sup>2,3</sup>. Surface wipes taken after household fires have measured very high contaminant concentrations, such as between 2.6 – 6.4 mg/m<sup>2</sup> for  $\Sigma$ PCB<sup>3</sup>.

We now appreciate that surface films develop on the interior and exterior of surfaces<sup>4,5</sup>. The composition of surface films is representative of the particulate-associated and gas-phase contaminants that comprise the complex mixture of urban air. This paper presents the polychlorinated biphenyl (PCB) concentrations found in organic films from exterior building surfaces, namely windows. Seven sites were sampled in Lower Manhattan, with three sites located within ~0.5 km of the WTC, in addition to a control site in Brooklyn.

### Methods and Materials

Organic film samples were collected from the outside of windows by scrubbing the surfaces with pre-cleaned laboratory Kimwipes, soaked in HPLC grade isopropanol to aid in the removal of the organic constituents. Between 1 and 5 m<sup>2</sup> of window surface area were cleaned at each site, dependant upon the apparent “dirtiness” of the window. Field blanks were prepared at three sites by soaking 10 precleaned Kimwipes with isopropanol and waving in the air until dry.

Sampling was conducted between October 27 and October 29, 2001. Air temperatures during that period ranged between 5 and 14.5 °C. Eight samples were collected from seven sites in lower Manhattan and at one location in Brooklyn. Samples were collected from either ground level or second story windows. Three sites (Church/Warren, WTC East and the paired Museum-North and Museum-South) were located within 0.5-0.75 km of the WTC and were expected to be most immediately impacted by the contaminant plume. The windows at these sites directly faced the WTC, with the

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exception of Museum-South that faced directly away. The remaining four Manhattan sites (Worth/Broadway, Canal/Broadway, NYU and Union Square) were located along a north-south transect northward from the WTC. The furthest site, Union Square, was ~4 km from the WTC. The Brooklyn location, which served as a control site, was approximately 3.5 km away from the WTC. The last time of cleaning was before September 11, 2001.

After sample collection, Kimwipes were DCM extracted using a soxhlet apparatus for approximately 18 hours following the methods described by Diamond et al.<sup>4</sup>. Samples were passed through a Florisil column for cleanup and analyzed by high-resolution gas chromatography (GC) with <sup>63</sup>Ni electron capture detection (ECD). A total of 103 PCB congeners (including coeluting congeners) were quantified using external standard mixtures. Data were blank corrected for each congener using the method detection limit (MDL – calculated as the mean field blank value plus three times the field blank standard deviation). The field blanks were typically less than 5% of the sample signal.

### Results and Discussion

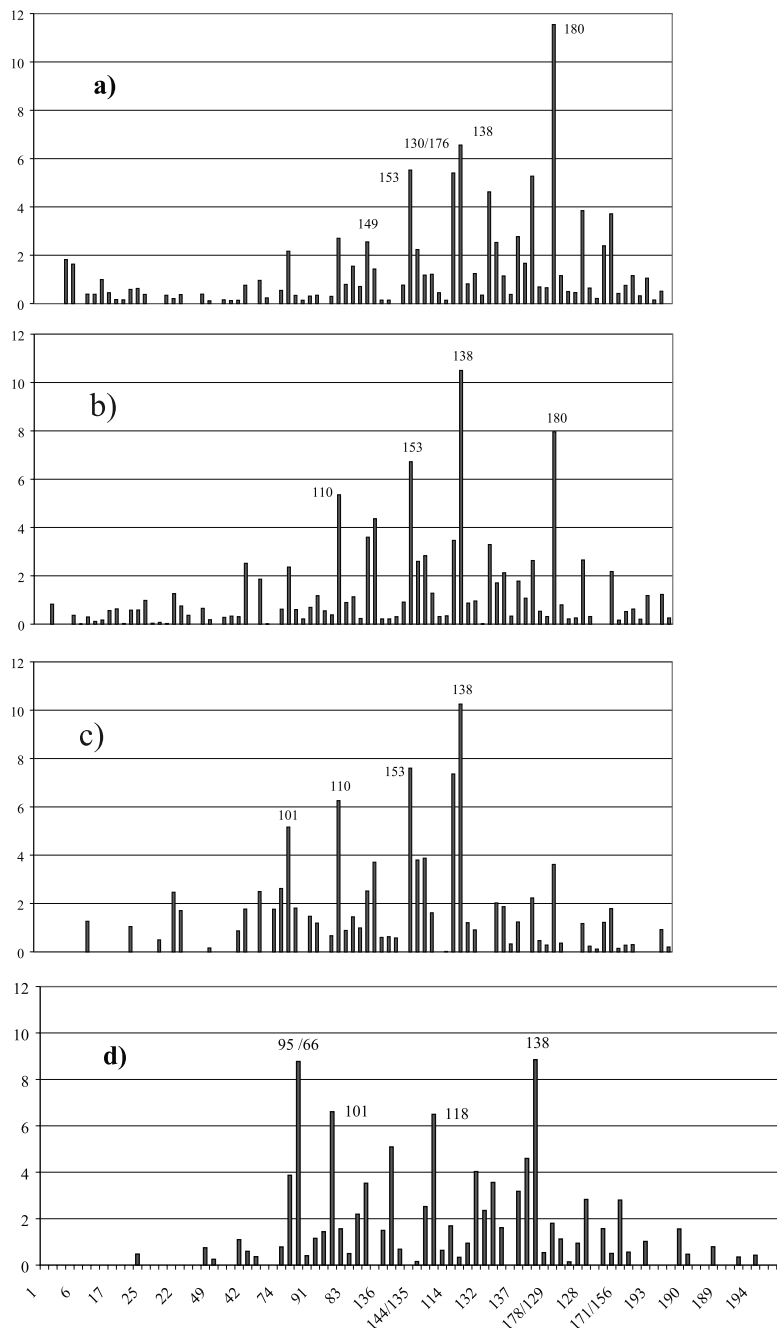
Total PCB concentrations decreased with increasing distance from the WTC site (see Table 1) with the highest concentrations measured at the three sites near the WTC. The highest PCB concentrations were measured in the two samples from the Museum site, a building located just south of the WTC, the direction of prevailing winds for several days after September 11<sup>th</sup>. These concentrations were nearly three times greater than the Church/Warren site, which was located closer to the WTC than the Museum site, but to the north. Paired samples were collected on the north (Museum – North Side) and south (Museum – South Side) facing windows at the Museum site, corresponding to the sides of the building that directly face and face away from the WTC, respectively. The total PCB concentration on the Museum – North windows were about 10 % greater than south facing windows. This is a minimal difference and indicates that the atmospheric plume was relatively well mixed at close range.

**Table 1.**  $\Sigma$ PCB Concentrations (ng/m<sup>2</sup>) in Organic Films from Lower Manhattan and Brooklyn

Location	$\Sigma$ PCB (ng/m <sup>2</sup> )	Distance from WTC (km)
Museum – North Side	1398	0.75
Museum – South Side	1260	0.75
Church/Warren	404	0.5
Park Row/Spruce	105	0.75
Worth/Broadway Street	511	1.0
Canal/Broadway Street	107	1.5
NYU	10	2.75
Union Square	89	3.5
Brooklyn	82	4.0

The control site, Brooklyn, had similar concentrations to that of the site furthest from the WTC, Union Square. Concentrations at these sites were about 82 and 89 ng/m<sup>2</sup>, respectively. The similarity between these two sites suggests that either the background PCB concentration for the New York City area was ~85 ng/m<sup>2</sup> or that the contaminant plume from the explosion had equally impacted these two sites.

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**Figure 1.** PCB Congener Profiles (percent of  $\Sigma$ PCB) for a) Church/Warren, b) Museum – North, c) NYU, and d) Urban/Lt. Industrial Toronto

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The PCB concentrations of window films at sites near the WTC were about one order of magnitude higher than those measured in downtown Baltimore (~100 ng/m<sup>2</sup>) and Toronto films (~95 ng/m<sup>2</sup>). The PCB film concentrations from downtown Baltimore and Toronto were similar to the Brooklyn and Union Square sites, suggesting that all three cities have somewhat equal background PCB concentrations. These concentrations were considerably lower than those consistently found at a downtown Toronto site located immediately beside a suspected PCB “hotspot” (~ 5000 ng/m<sup>2</sup>). PCB concentrations in films sampled nearby WTC were lower than those sampled after a simulated house fire<sup>3</sup> (2600-6400 ng/m<sup>2</sup>) and suggest an exponential drop off in concentrations from the site of combustion.

PCB homologue patterns were similar among all sites with the dominant homologues being P<sub>6</sub>CBs (constituting between 30-40% of total PCB, ~34 % geometric mean) followed by the P<sub>5</sub>CBs (~22 %) and the P<sub>7</sub>CBs (~23 %). PCB congener profiles were, in most cases, dominated by congeners 138, 180, 153 and 110 (Figure 1). Three general patterns were evident. First, the profile of Church/Warren, the site closest to Ground Zero, was unique in that PCB 180 comprised the greatest proportion of total PCB concentration. This site was characterized as having a “heavier” profile. Second, the other sites that were close to the WTC, Museum and Park Row/Spruce, had similar congener profiles to those sites that were a moderate distance away, Worth/Broadway and Canal/Broadway. These profiles had roughly equal proportions of PCB 138 and PCB 180. Third, the sites furthest from the WTC, Brooklyn, NYU and Union Square; had similar congener profiles in which PCB 180 constituted a low proportion of the total PCB concentration.

The PCB congener profiles of Manhattan films had a greater proportion of higher chlorinated congeners than typical downtown Toronto films, as indicated through an enrichment of the higher molecular weight congeners such as PCB 180 (Figure 1). Manhattan films were comprised of lower chlorinated congeners than that sampled nearby a medical waste incinerator in Baltimore<sup>6</sup>. The latter site was dominated by the P<sub>9</sub>CBs, in particular PCB 206 (~28 % of total PCB).

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### References

1. Nordgrén, M.D., Goldstein, E.A., Izeman, M.A. (2002), The Environmental Impacts of the World Trade Center Attacks: A Preliminary Assessment, National Resources Defense Council.
2. Wobst, M., Wichmann, H., Bahadir, M. (1999), *Chemosphere* 38, 1685-1691.
3. Ruokojärvi, P. Aatamila, M., Ruuskanen, J. (2000) 41, 825-828.
4. Diamond, M.L., Gingrich, S.E., Fertuck, K., McCarry, B.E., Stern G.A., Billeck, B., Grift, B., Brooker, D., Yager, T.D. (2000), *Environ. Sci. Technol.* 34, 2900-2908.
5. Gingrich, S.E., Diamond, M.L., Stern, G.A., McCarry, B.E. (2001), *Environ. Sci. Technol.* 35, 4031-4037.
6. Liu, Q.-T., M.L. Diamond, S.E. Gingrich, J.M. Ondov, P. Maciejczyk, G.A. Stern. *Environ. Pollut.* In press.