PCBs are both legacy and emerging contaminants: Evidence for Current Manufacturing Sources of PCBs

Keri C. Hornbuckle
Dept of Civil and Environmental Engineering
IIHR-Hydroscience and Engineering
1. PCBs: Metabolism, Genotoxicity and Gene Expression in Vivo
   Larry Robertson, Gabriele Ludewig, Garry Buettner, Howard Glauert

2. Oxidative Stress and PCB Exposure in Mammalian Cells
   Prabhat Goswami, Douglas Spitz, Frederick Domann

3. PCBs and Hydroxysteroid (Alcohol) Sulfotransferases
   Michael Duffel, Larry Robertson, Hans-Joachim Lehmler

4. Atmospheric Sources of PCB Congeners
   Keri Hornbuckle, Greg Carmichael, Peter Thorne

5. Phytoremediation to Degrade Airborne PCB Congeners from Soil and Groundwater Sources
   Jerry Schnoor, Timothy Mattes, Benoit Van Aken, Hans Joachim-Lehmler

6. AESOP Study: Characterization of Exposures of Urban and Rural Cohorts to Airborne PCBs
   Peter Thorne, Keri Hornbuckle, Kai Wang, David Osterberg, Fredric Gerr

Semi-Volatile PCBs: Sources, Exposures, Toxicities
http://iowasuperfund.uiowa.edu/
The AROCLORS

Physical Properties and Suggested Applications

APPLICATION DATA BULLETIN No. D-74

Monsanto Chemical Company

NOW... NON-PRESSURIZED LIQUID-PHASE
HEAT TRANSFER SYSTEMS THAT
OPERATE UP TO 600°F.

AROCOLOR 1248

**Operates at atmospheric pressure...** cuts
installation and maintenance costs of ex-
ensive pressurized systems.

**Fluid is fire resistant...** increases safety
by eliminating direct-firing and heat trans-
fer with flammable fluids.

HERE’S PIN POINT CONTROL TO WITHIN 2° F.

**Burner Circuit**

**Processing Circuit**

**Heat**

**Flammable Oils**
- Asphalt, Varnishes
- Resins, Solvents
- Plastic or Rubber
- Chemical Reactions
- Dyestuffs
- Distillation Systems

The Equipment... capacities can range
from small portable units—usually elec-
trically heated—to large gas- or oil-fired
units generating from 250,000 to over
10,000,000 B.T.U.’s per hour. Circuits are
closed, forced-circulation. Compact de-
sign saves space, minimizes installation
and maintenance costs.

The Fluid... Aroclor 1248 is a highly
stable chlorinated polycarbonate, does not
support combustion up to its boiling range
650° to 750° F.; is non-corrosive. Aroclor
1248 operates in most systems four to
seven years without replacement.

Monsanto Chemical Co., Organic Chemicals Division
Department 1F-3, St. Louis 1, Missouri
Gentlemen:

**Please send:** Technical information about Aroclor 1248

Names of designers and manufacturers of Aroclor 1248
operated equipment.

Name

Firm

Address

City

State
Aroclors are different mixtures of PCBs

PCB 153
2,2′,4,4′,5,5′-HCB

PCB 77
3,3′,4,4′-TCB
Calculation of passive sampling rates from both native PCBs and deuterated compounds in indoor and outdoor environments

Carolyn Persoon, Keri C. Hornbuckle

The Department of Civil and Environmental Engineering, Iowa State University

ABSTRACT

Spatial Distribution of Airborne Polychlorinated Biphenyls in Cleveland, Ohio and Chicago, Illinois

CAROLYN PERSOON, THOMAS M. PETERS, NARESH KUMAR, AND KERI C. HORNBUCKLE

Department of Civil and Environmental Engineering, Iowa State University

Introduction

The global and regional distribution of persistent pollutants (PCBs) is now well understood, thanks in part to development of passive samplers that are lightweight, inexpensive, and transportable (Farrar et al., 2005; Gorula et al., 2007; Kow-Weske et al., 2007; Poppula et al., 2007; and others).

Passive samplers have been used in many studies to evaluate the spatial variability of airborne PCBs in urban areas. These samplers consist of different concentrations of PCBs on surfaces that are exposed to the atmosphere. By measuring the concentration of PCBs on the sampler, we can determine the spatial distribution of PCBs in the environment.

In this study, we collected passive samplers at various locations in Cleveland, Ohio, and Chicago, Illinois. We measured the concentration of PCBs at each location and compared the results to determine the spatial distribution of PCBs in these areas.

Methods and Materials

Selection of Sampling Sites

We selected sampling sites in Cleveland and Chicago based on their geographic location and exposure to the atmosphere. We used different types of passive samplers to measure the concentration of PCBs at each site.

Results

We found that the concentration of PCBs was highest in Cleveland and Chicago, with much lower concentrations in other areas. The spatial distribution of PCBs was found to be influenced by factors such as proximity to industrial areas and traffic density.

Discussion

Our results suggest that passive samplers can be used to evaluate the spatial distribution of PCBs in urban areas. Further studies are needed to investigate the factors that influence the spatial distribution of PCBs and to determine the impact of PCBs on human health.

Conclusion

We conclude that passive samplers are a valuable tool for evaluating the spatial distribution of PCBs in urban areas. Further research is needed to understand the factors that influence the spatial distribution of PCBs and to assess the health impacts of PCB exposure.

Acknowledgments

We would like to thank the participants who provided samples for this study. This research was supported by the National Science Foundation.

References


Thomas M. Peters, Naresh Kumar, and Keri C. Hornbuckle

Department of Civil and Environmental Engineering, Iowa State University

Atmospheric PCB congeners across Chicago

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Atmospheric Environment

1. Introduction

PCBs are a group of 209 semi-volatile alkylaromatic compounds (congeners) that are commonly measured in air throughout the world and used extensively in consumer products. PCBs are characterized by their persistence in the environment, making it difficult to accurately measure the spatial distribution of PCB concentrations and hence there are very few datasets available to support current monitoring and estimation methods (Brewer and Alcock, 2002; Brevik et al., 2002). The difficulty is due to the limitations of current measurement and estimation methods. This paper investigates the spatial distribution of PCB congeners across Chicago.
PCB Congener Profile in Chicago Air

PCBs, in order of increasing number of chlorines

- PCB11
Evidence for Unique and Ubiquitous Environmental Sources of 3,3’-Dichlorobiphenyl (PCB 11)

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The non-aromatic congener 3,3’-dichlorobiphenyl (PCB 11) has been recently detected in air, water, birds, sediment, and suspended sediment. Although it has been known since at least 1970, published studies have shown that PCB 11 concentrations also vary by season and temperature, following a typical trend of PCB levels found to be elevated in urban, industrial, and remote locations.

Research

Partial Pressures of PCB 11 in Air from Several Great Lakes Sites

ILOBA BASU, KAREN A. ARNOLD, ARLENE K. KENDALL, AND RONALD A. HITES

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Received manuscript received July 2008.

PCB 11 is a potent polychlorinated dibenzo-p-dioxin (PCDD) contaminant and has been suggested to contribute to the formation of dioxin-like PCDD/Fs. The partial pressures of PCB 11 were determined from a series of three Great Lakes sites in the U.S. and Canada, with the purpose of understanding the fate and transport of PCB 11 in the environment.

Experimental Section

Sampling Sites, This paper, data on atmospheric vertical profiles of PCB 11 at three sites in the Great Lakes region of the United States. The sites are: Lake Huron, Lake Erie, and Lake Superior, and the samples were collected on board the research vessel Nemo, which is operated by the Great Lakes Environmental Research Laboratory, National Great Lakes Research Laboratory, NCEA, University of Wisconsin, Madison, Wisconsin.

Sample Collection and Cleanup, The samples were collected using a high-volume, high-efficiency particulate air (HEPA) filter attached to an atmospheric pressure chamber. The samples were collected over a period of 3 to 7 days, with the samples being collected at different times of the day to minimize potential contamination.

Instrumental Analysis, The data were analyzed using a high-resolution gas chromatograph/mass spectrometer (HRGC/MS). The PCB 11 concentration was determined using a combination of two techniques: gas chromatography/mass spectrometry (GC/MS) and high-performance liquid chromatography (HPLC). The PCB 11 concentration was determined using a combination of two techniques: gas chromatography/mass spectrometry (GC/MS) and high-performance liquid chromatography (HPLC). The PCB 11 concentration was determined using a combination of two techniques: gas chromatography/mass spectrometry (GC/MS) and high-performance liquid chromatography (HPLC).

Discovery of Non-Aromatic PCB (3,3’-Dichlorobiphenyl) in Chicago Air

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Air samples were collected in Chicago, Illinois, in 2007, and 2008 (PCB11, CAS 99-87-5) was detected and quantified using GC/MS in 199 of 198 samples. To the best of our knowledge, this is the first published report of PCB11 in airborne particulate matter. This compound is ubiquitous in air throughout the city of Chicago. Airborne particulate matter was collected using a high-volume, high-efficiency particulate air (HEPA) filter attached to an atmospheric pressure chamber. The samples were collected over a period of 3 to 7 days, with the samples being collected at different times of the day to minimize potential contamination.

Analysis and data interpretation, The data were analyzed using a combination of two techniques: gas chromatography/mass spectrometry (GC/MS) and high-performance liquid chromatography (HPLC). The PCB 11 concentration was determined using a combination of two techniques: gas chromatography/mass spectrometry (GC/MS) and high-performance liquid chromatography (HPLC). The PCB 11 concentration was determined using a combination of two techniques: gas chromatography/mass spectrometry (GC/MS) and high-performance liquid chromatography (HPLC).

Environmental News

Detecting a New PCB in Chicago air

Although banned some 30 years ago, PCB compounds are being discovered in urban areas. Non-aromatic PCB (3,3’-dichlorobiphenyl), a PCB with no aromatic rings, was found in Chicago air for the first time. PCB concentrations also vary by season and temperature, following a trend of PCB levels found to be elevated in urban, industrial, and remote locations.

This is the first time that PCB 11 has been detected in Chicago air, and the concentrations found are comparable to those found in other urban areas. PCB 11 concentrations have been found to vary by season and temperature, following a trend of PCB levels found to be elevated in urban, industrial, and remote locations.

The non-aromatic congener 3,3’-dichlorobiphenyl (PCB 11) has been recently detected in air, water, birds, sediment, and suspended sediment. Although it has been known since at least 1970, published studies have shown that PCB 11 concentrations also vary by season and temperature, following a typical trend of PCB levels found to be elevated in urban, industrial, and remote locations.

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Summary of the Clues about PCB11:

1. Not present or trace in commercial Aroclor mixtures
2. Detected in the wastewater effluent from paint production (Litten et al., 2002, *Chemosphere*)
3. Widely distributed in the urban air of Chicago and Cleveland
4. Global pollutant
5. Concentration proportional to population
6. Present in many consumer products
7. Structural similarity of with some pigment intermediates
8. No direct significant emission from facilities

Hypothesis:

The source of airborne PCB11 is painted surfaces (paint).
Paint Bases contained no PCBs

Inorganic pigments contained no PCBs

- Titanium dioxides: white
- Iron oxide: yellow, orange, red, brown and black
- Carbon black
- Umber
- Sienna
- Ochre
Organic Pigments contain PCBs

Sherwin Williams

PPG Pittsburgh

Vogel

Hu and Hornbuckle, 2010 ES&T
Organic pigments

- **Azo** pigments: yellow, orange, red, brown
- **Phthalocyanine** pigments: blue and green
- Polycyclic pigments
- Heterocyclic pigments
Inadvertent Polychlorinated Biphenyls in Commercial Paint Pigments†

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Received August 7, 2009. Revised manuscript received September 17, 2009. Accepted November 16, 2009.

A polychlorinated biphenyl (PCB) that was not produced as part of the Aroclor mixtures banned in the 1980s was recently reported in air samples collected in Chicago, Philadelphia, the Arctic, and several sites around the Great Lakes. In Chicago, the congener 3,3′-dichlorobiphenyl or PCB11 was found to be the fifth most concentrated congener and ubiquitous throughout the city. The congener exhibited strong seasonal concentration trends that suggest volatilization of this compound from common outdoor surfaces. Due to these findings and also the compound’s presence in waters that received waste from paint manufacturing facilities, we hypothesized that PCB11 may be present in current commercial paint. In this study we measured PCBs in paint sold on the current retail market. We tested 33 commercial paint pigments purchased from three local paint stores. The pigment samples were analyzed for all 209 PCB congeners using gas chromatography with tandem mass spectrometry (GC-MS/MS). More than 50 PCB congeners including several dioxin-like PCBs were detected, and the PCB profiles varied due to different types of pigments and different manufacturing processes. PCB congeners were detected in azo and phthalocyanine pigments which are commonly used in paints but also in inks, textiles, paper, cosmetics, leather, plastics, food and other materials. Our findings suggest several possible mechanisms for the inadvertent production of specific PCB congeners during the manufacturing of paint pigments.

FIGURE 2. Examples of PCB profiles in paint pigments (top two plots) and the frequency of congener detection in the 15 pigments with detected PCBs (bottom plot).
PCBs are in human blood serum, including PCB11
PCB congeners detected in children and their mothers

**Table:**

<table>
<thead>
<tr>
<th>PCB Congener</th>
<th>Detection Frequency, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCB11</td>
<td>100</td>
</tr>
<tr>
<td>90/113/101</td>
<td>95</td>
</tr>
<tr>
<td>156/157</td>
<td>15</td>
</tr>
<tr>
<td>187</td>
<td>11</td>
</tr>
<tr>
<td>2013</td>
<td>100</td>
</tr>
</tbody>
</table>

*East Chicago Children (n=44)*

*Columbus Junction Children (n=48)*
Acknowledgements

From left: Jesse Liu, Andres Martinez, Scott Spak, Sean Nichols, Dingfei Hu, Rachel Yucuis, Caitlin Shanahan, Jaymie Vorhees, Nick Petrich, Rachel Marek, Andrew Awad, Keri Hornbuckle, Colin O’Sullivan, Wenxin Koh

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