

Toxins Going Off the Wall

Measuring PCB Emissions from Paint

Jacob C. Jahnke, Keri C. Hornbuckle

11th International Passive Sampling Workshop

September 13, 2019



'Painting the Picture'

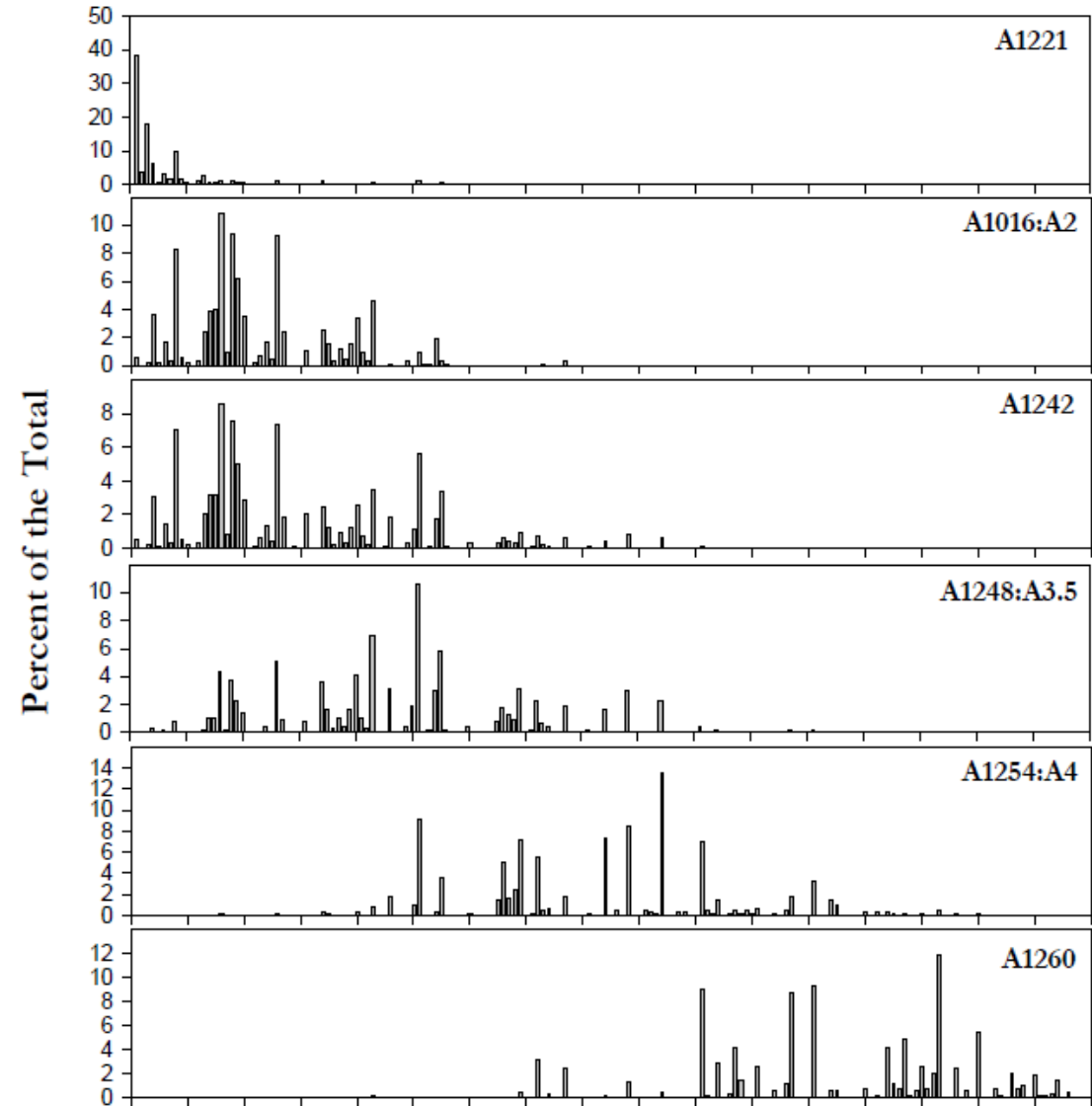
Legacy Sources: Aroclor Mixtures



A typical pre-1979 PCB-containing fluorescent light ballast (FLB)



A typical Non-PCB containing fluorescent light ballast. The ballast has a "No PCBs" marking on the top of the ballast and the text "electronic ballast". Only magnetic fluorescent light ballasts contained PCBs.



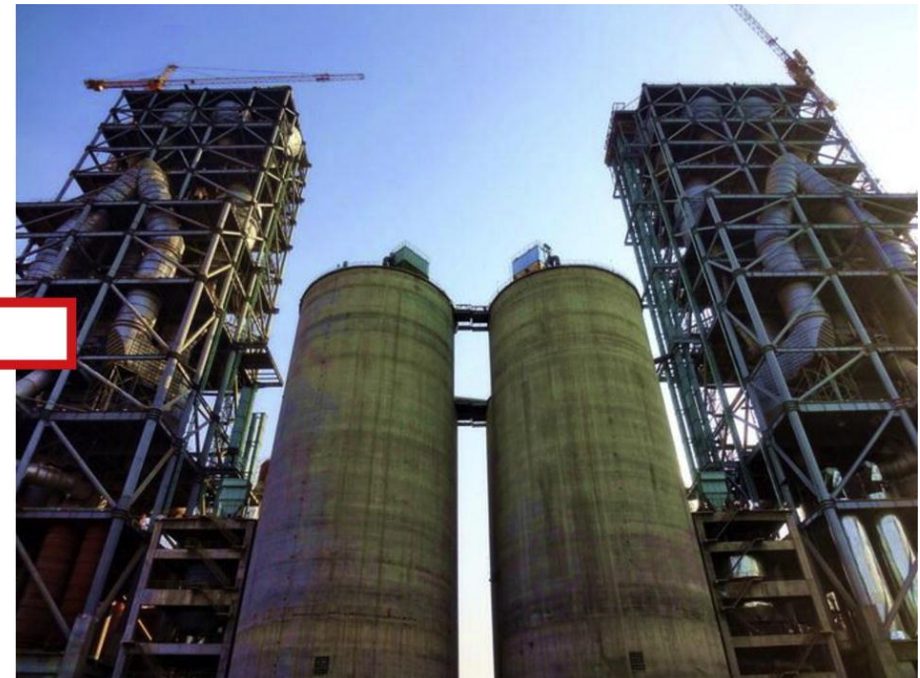
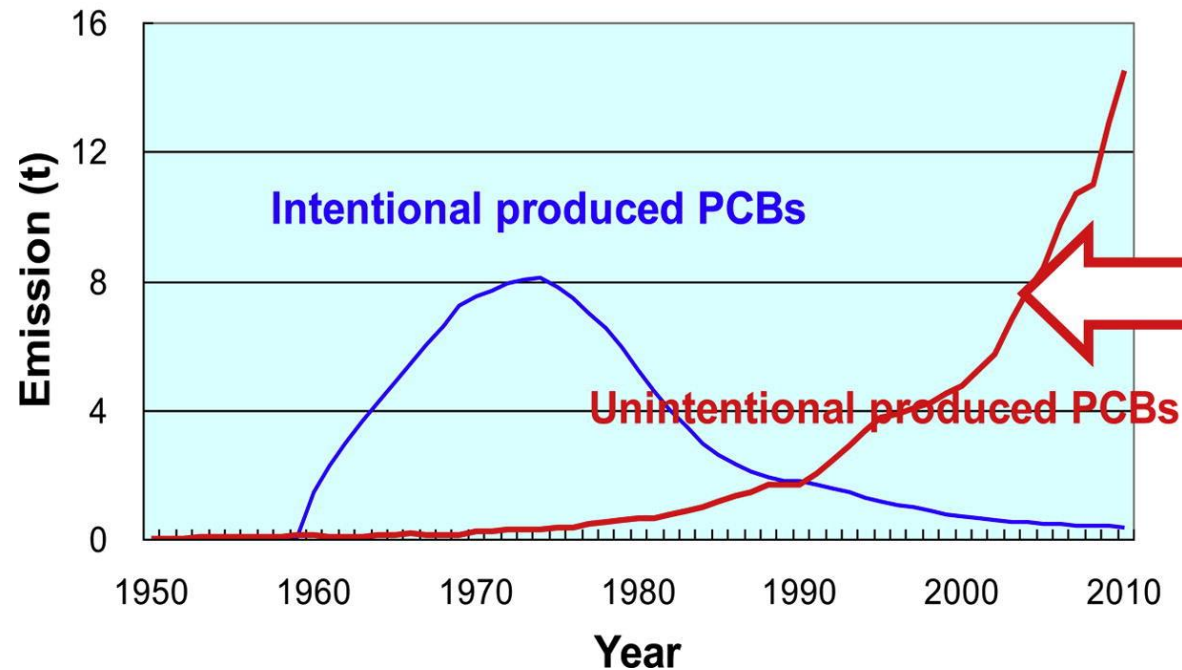
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Non-Legacy Sources: Non-Aroclor Sources

Inadvertent Production



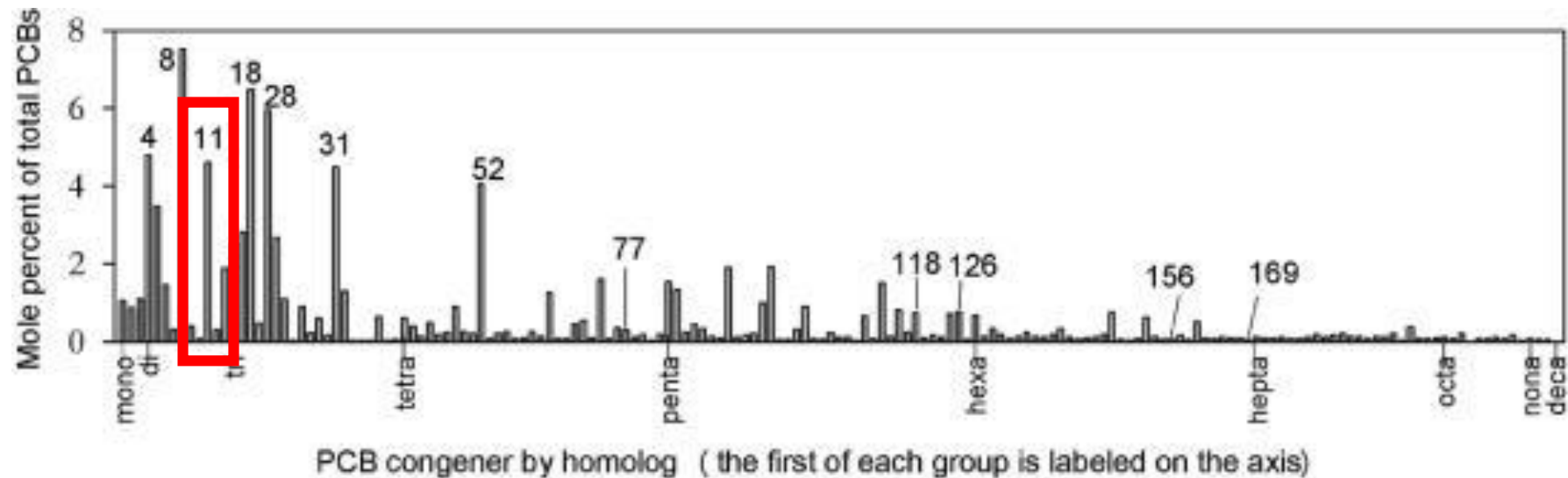
Unintentionally Produced PCBs (**UP-PCBs**)



Emission of unintentionally produced polychlorinated biphenyls (UP-PCBs) in China: Has this become the major source of PCBs in Chinese air? Cui et al. *Atmospheric Environment*, 2013

PCB 11 is a UP-PCB

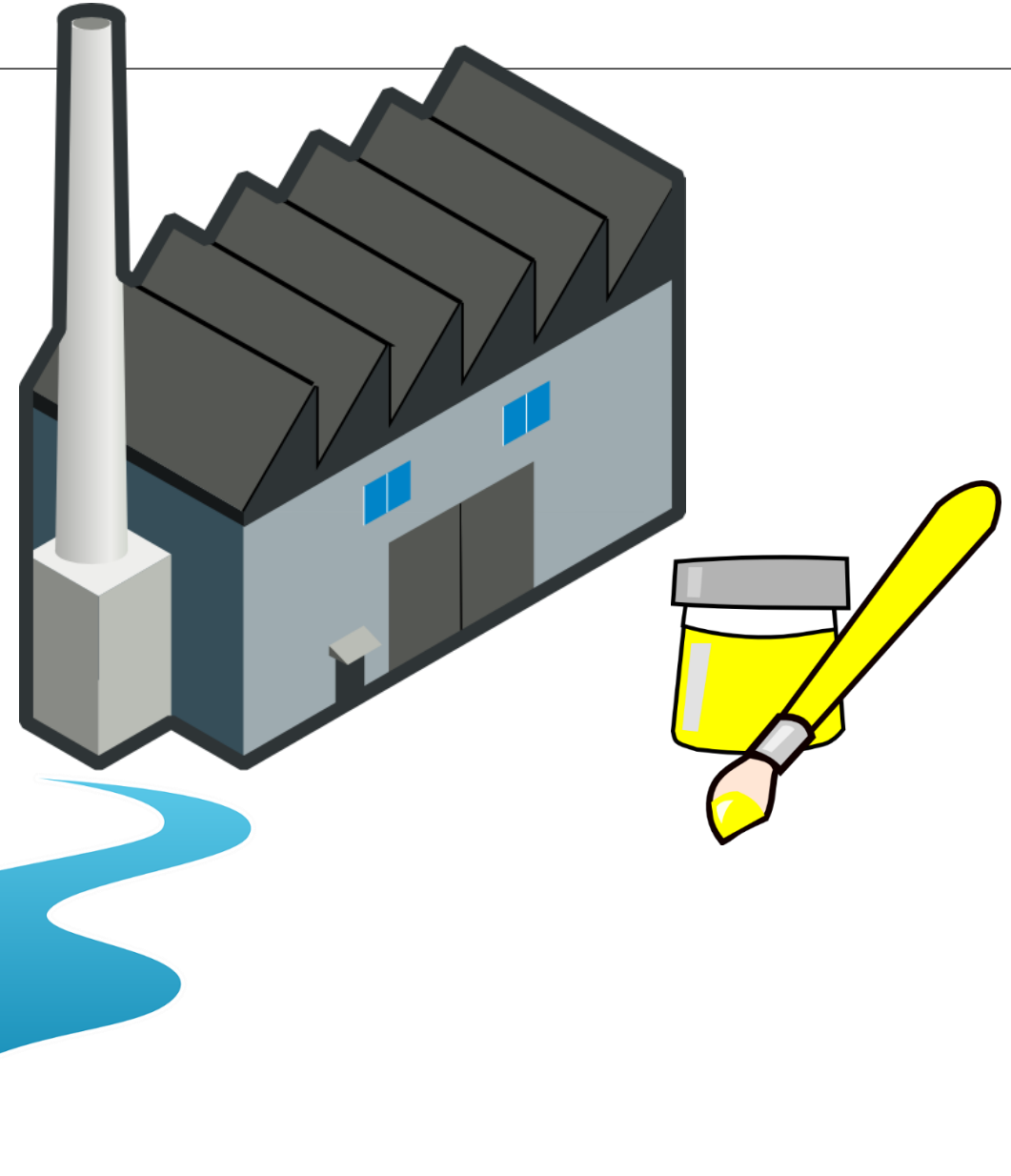
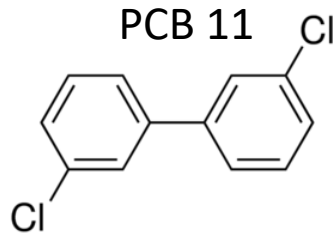
- Hu et al. found concentrations of PCB 11 of up to 15% of total PCBs in Chicago Air
- PCB 11 is non-detectable (<0.05%) in most Aroclor mixtures



PCB 11 Came from Pigment Manufacturing

- Detected in wastewater effluent from paint and pigment manufacturing facility
- Byproduct of 3,3'-dichlorobenzidine which is used in yellow pigments

Investigation of Isomer Specific
Polychlorinated Biphenyls in Printing Inks. Rastogi,
SC. *Bull Environ Conam Toxicol*, 1992



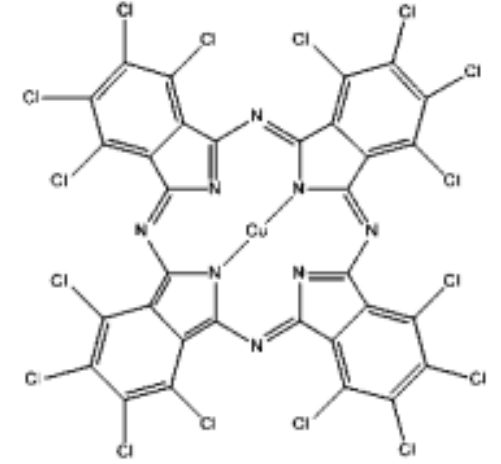
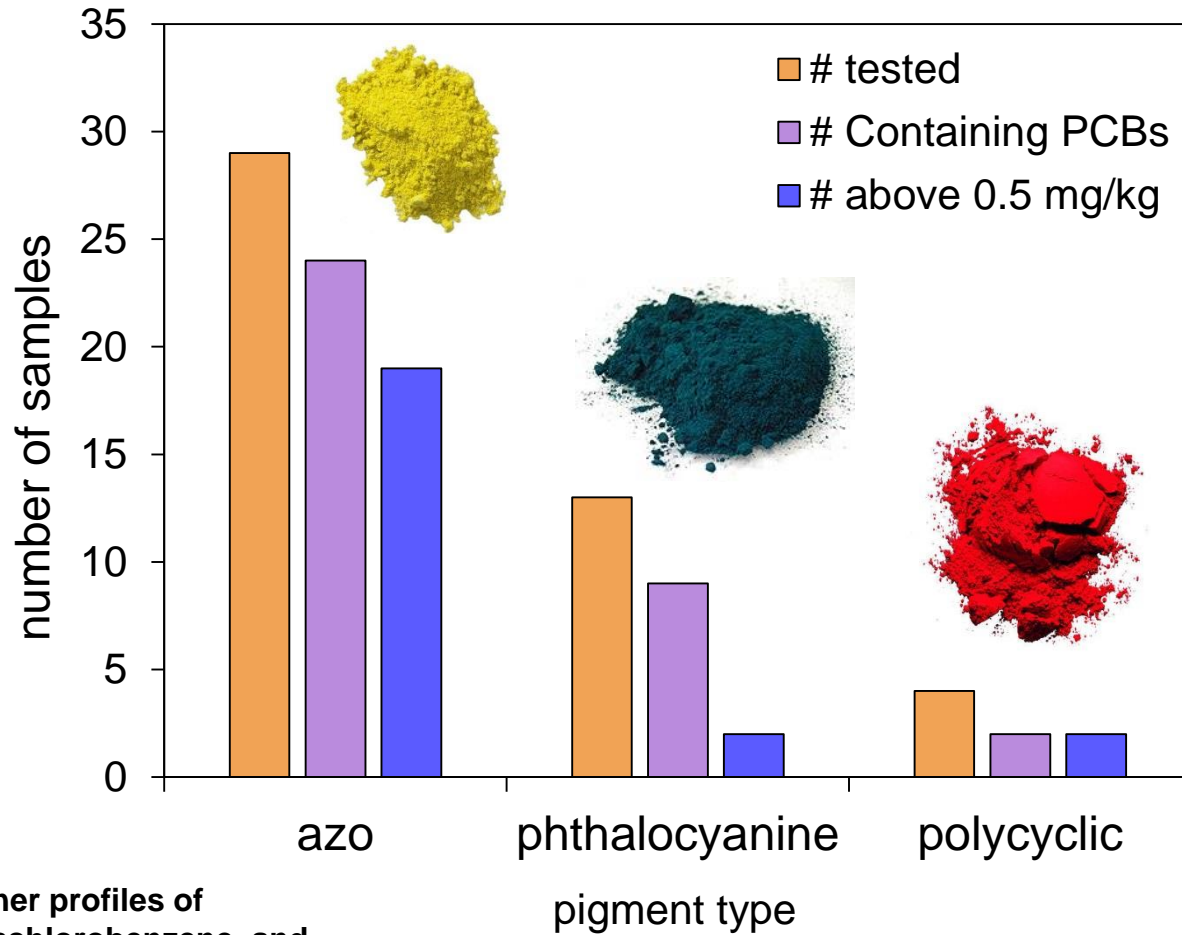
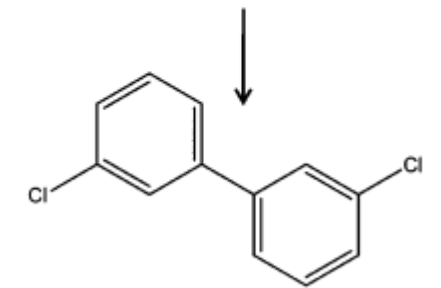
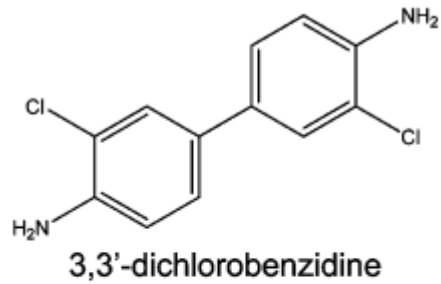
PCB 11 Found Everywhere

PCB 11 found to be the 5th most concentrated congener in Chicago air

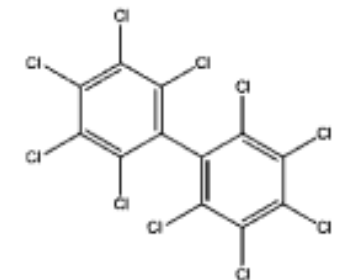


'Painting the Picture'

Non-Legacy Sources: PCBs in Modern Pigments



Phthalocyanine green



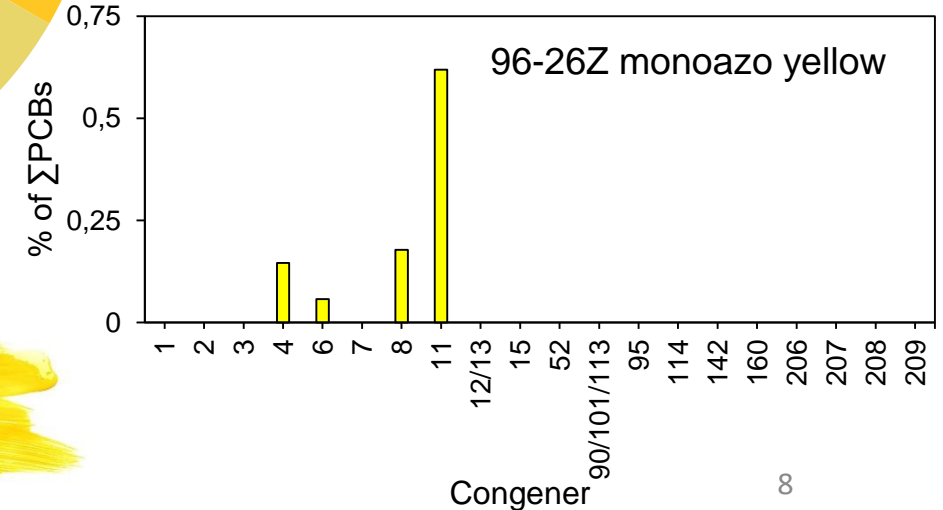
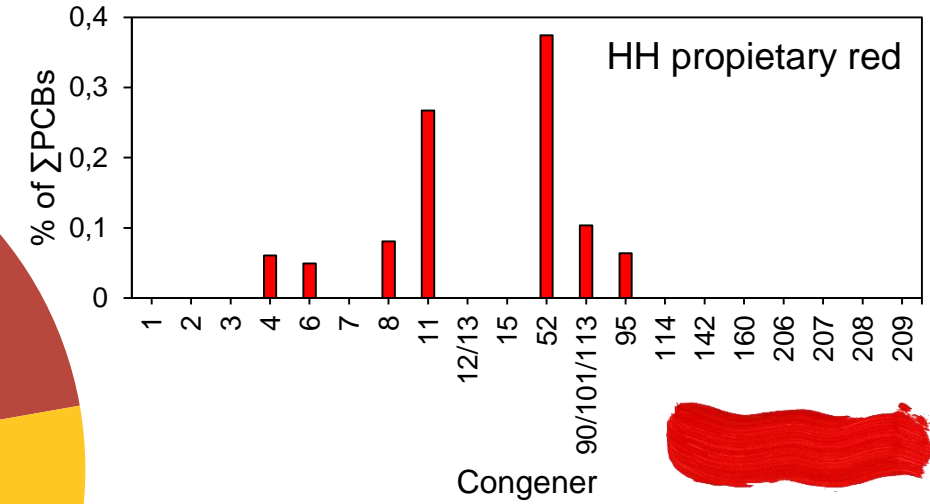
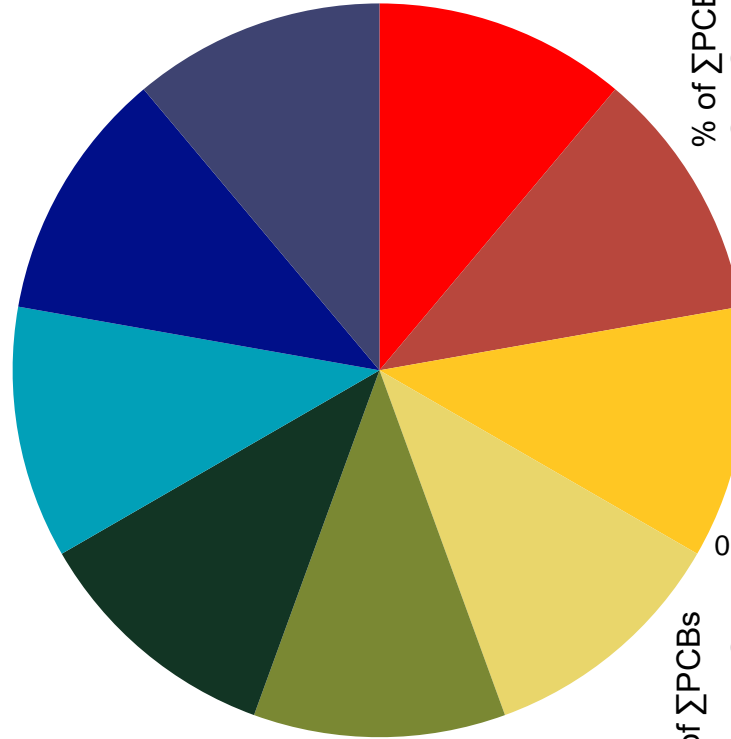
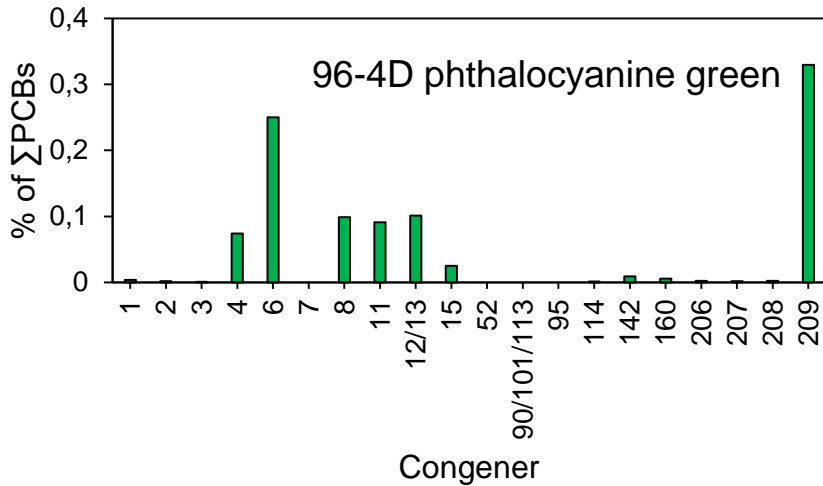
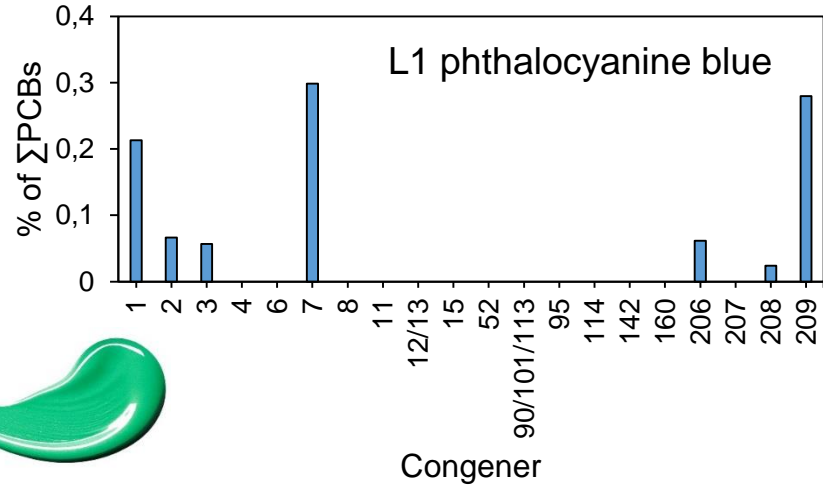
Decachlorobiphenyl (PCB209)

Concentration levels and congener profiles of polychlorinated biphenyls, pentachlorobenzene, and hexachlorobenzene in commercial pigments

Katsunori Anezaki, Takeshi Nakano
Environ Sci Pollut Res, 2014

'Painting the Picture'

Non-Legacy Sources: PCBs in Modern Pigments



Inadvertent Polychlorinated Biphenyls in Commercial Paint Pigments

Dingfei Hu and Keri C. Hornbuckle

Environmental Science and Technology, 2009

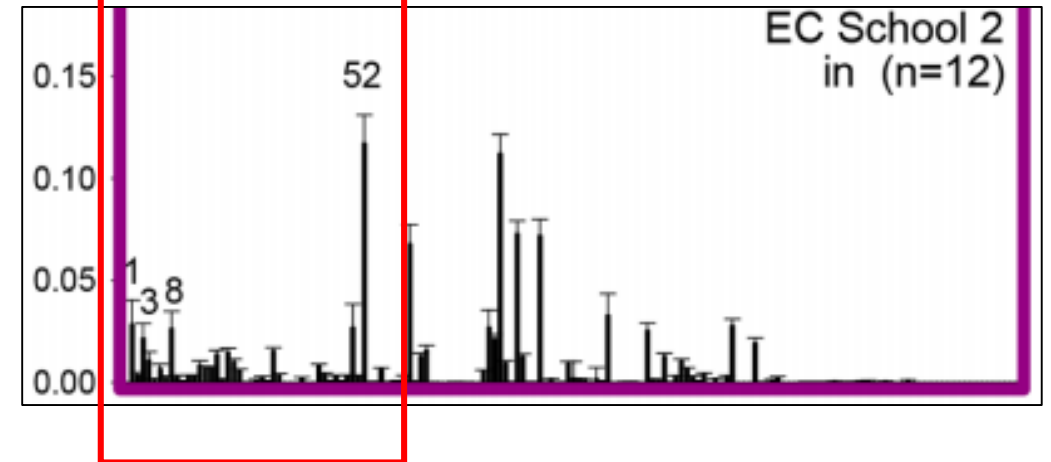
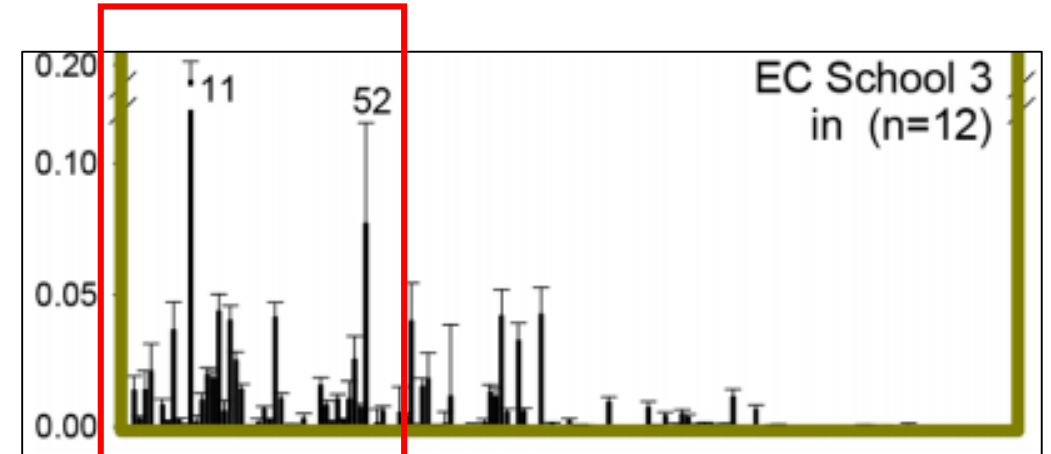
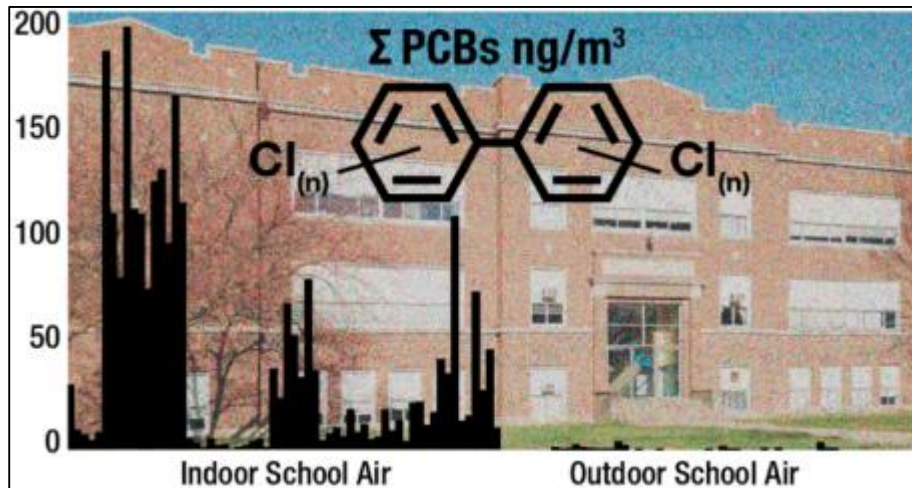
Evidence of PCBs from Colorants in Indoor Air

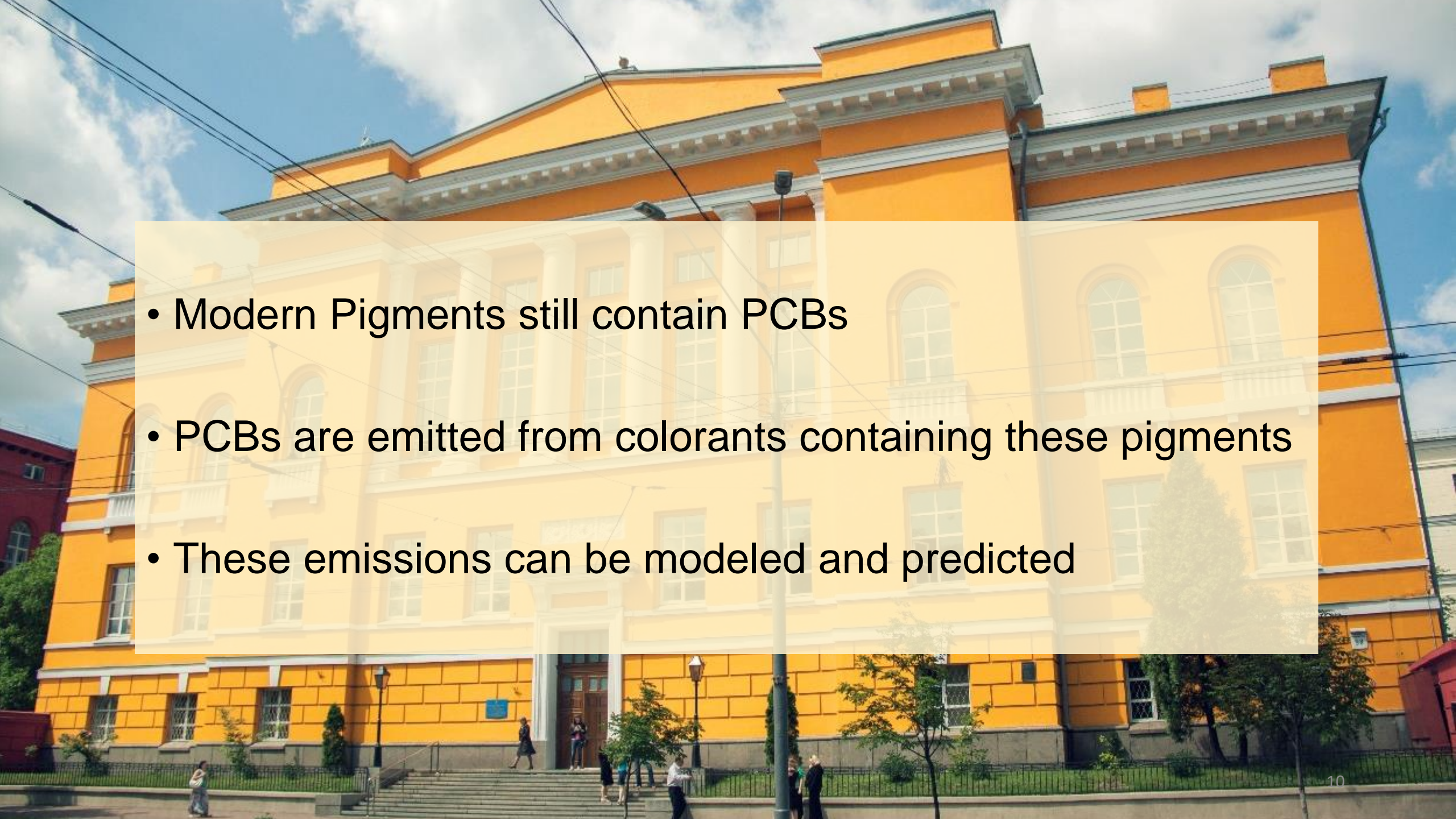
Airborne PCBs and OH-PCBs Inside and Outside Urban and Rural U.S. Schools

Rachel F. Marek,^{*,†,Ⓜ} Peter S. Thorne,^{*,†,Ⓜ} Nicholas J. Herkert,^{†,§} Andrew M. Awad,[†]
and Keri C. Hornbuckle,^{*,†,§,Ⓜ}

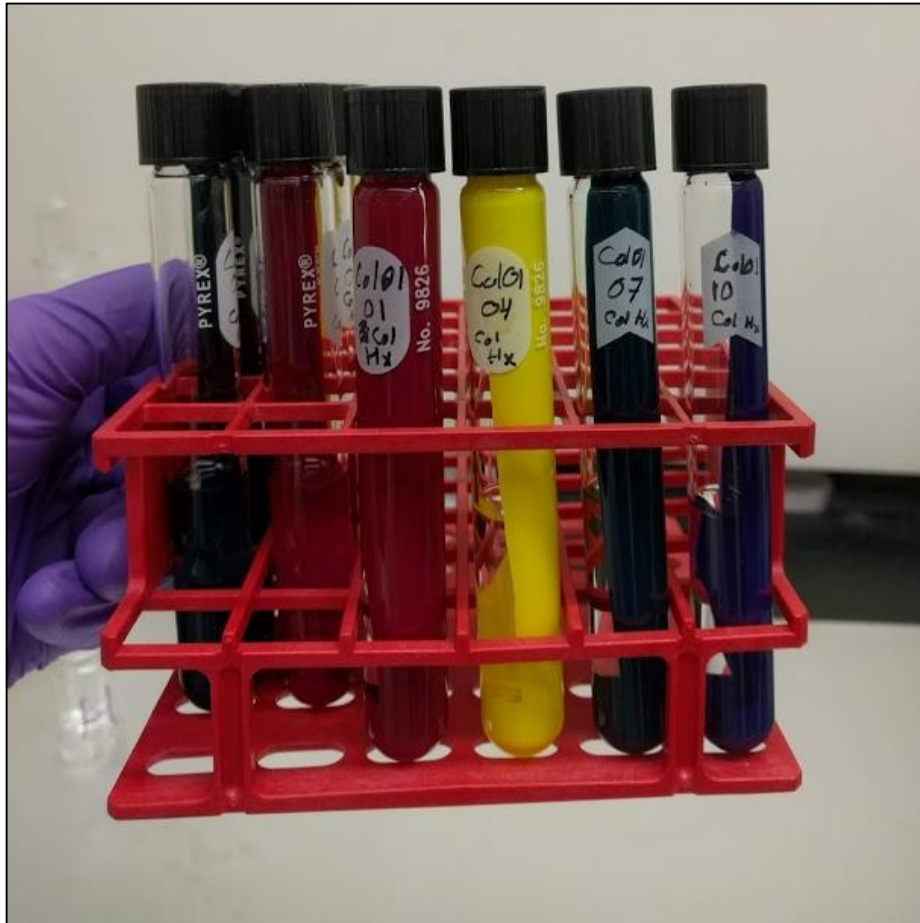
[†]IHR-Hydroscience and Engineering and [§]Department of Civil & Environmental Engineering, The University of Iowa, 103 South Capitol Street, 4105 SC, Iowa City, Iowa 52242, United States

[Ⓜ]Department of Occupational and Environmental Health, The University of Iowa, 100 CPHB, S341A, 145 N. Riverside Dr., Iowa City, Iowa 52242, United States

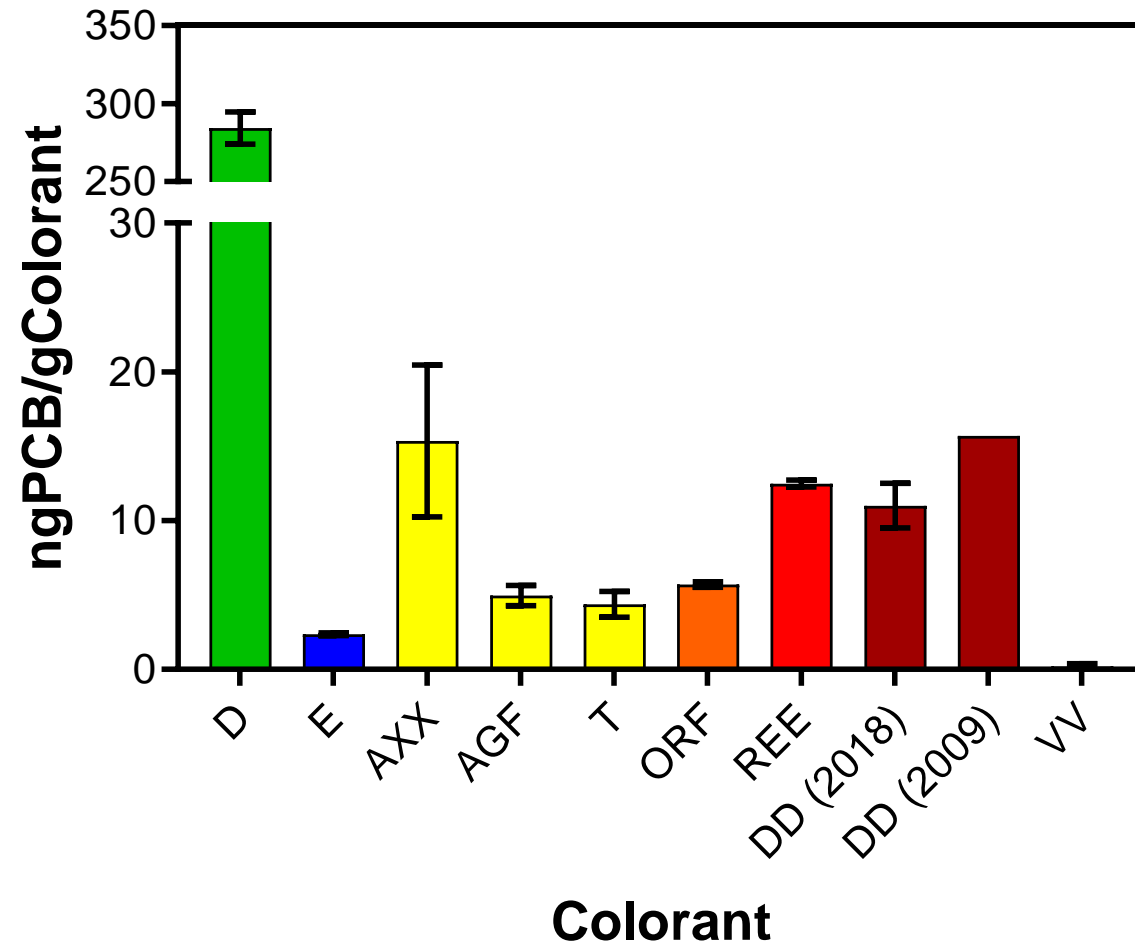


- 
- Modern Pigments still contain PCBs
 - PCBs are emitted from colorants containing these pigments
 - These emissions can be modeled and predicted

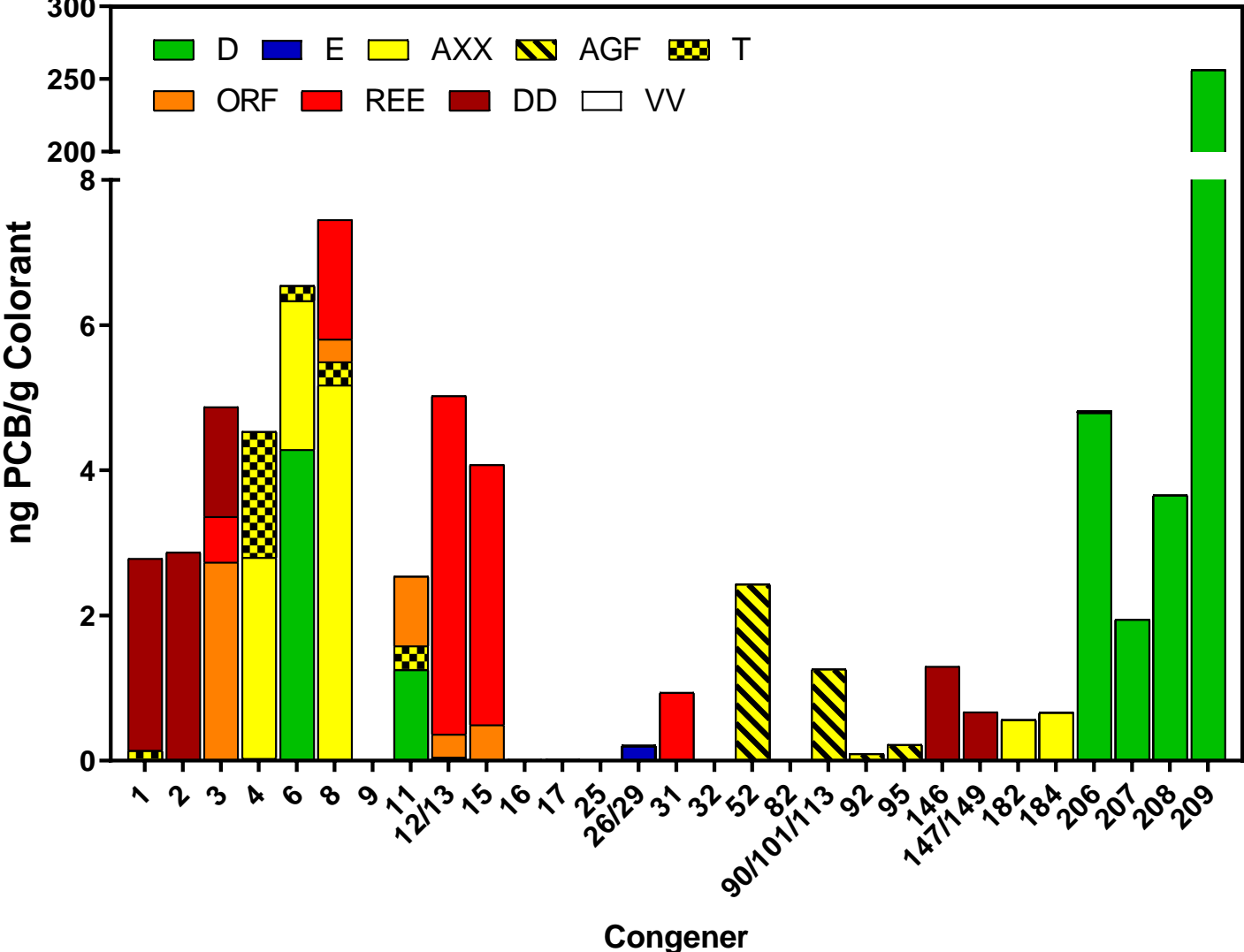
Measuring the Concentration of PCBs in Modern Colorants



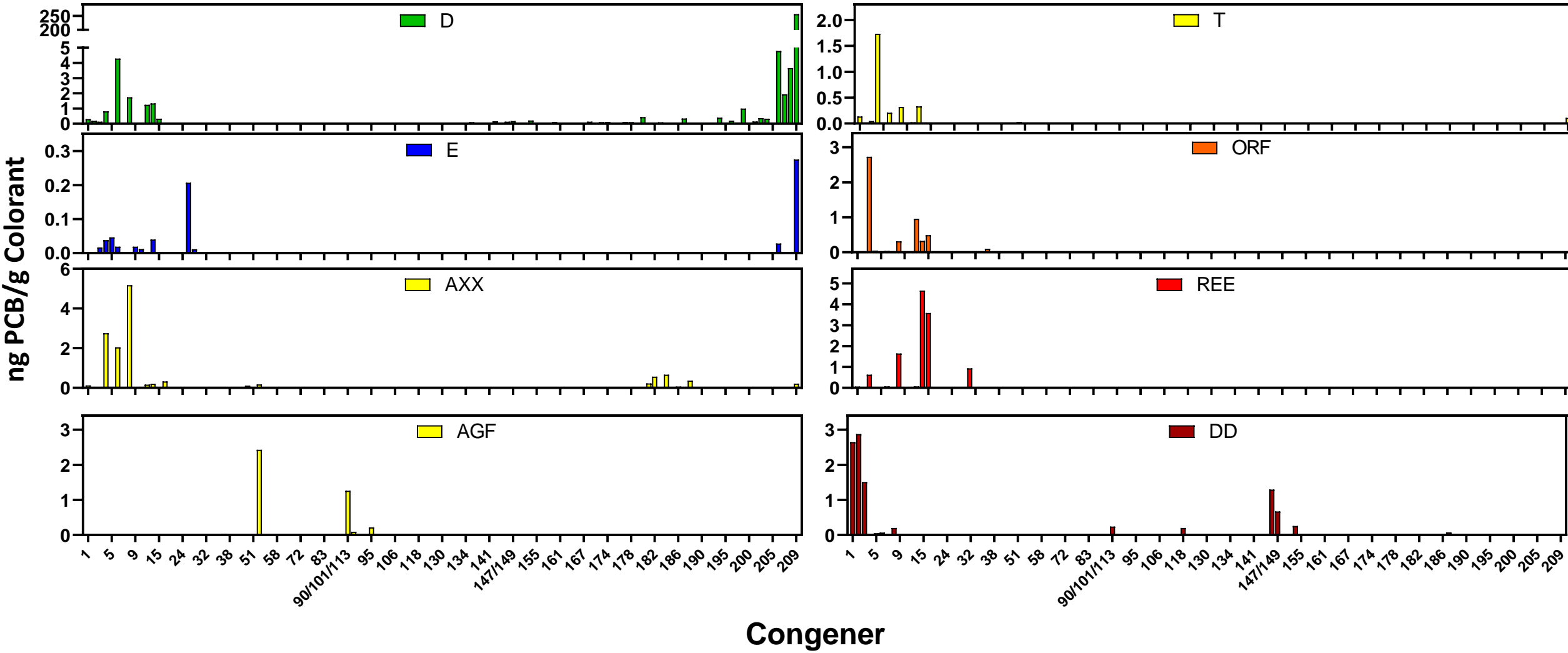
Different Colorants have Different Concentrations of PCBs



Different Colorants Contain Different Congeners

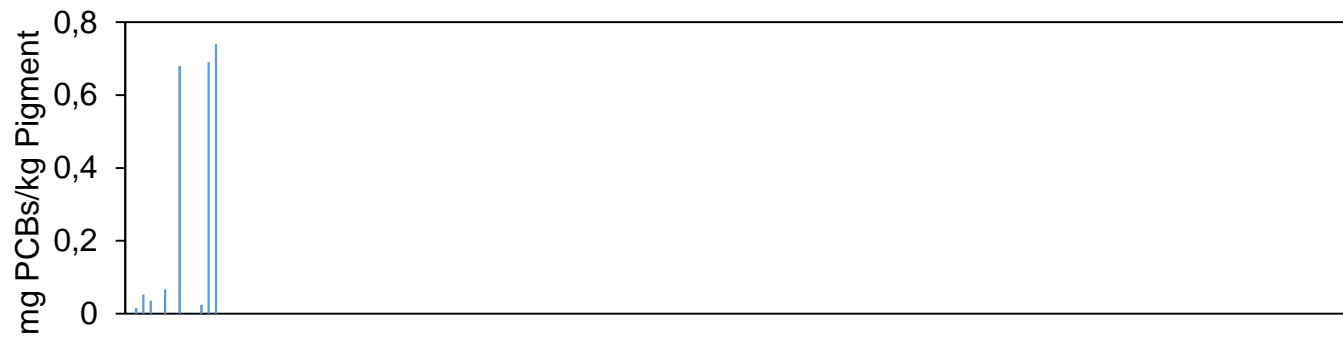


Different Colorants Contain Different Congeners

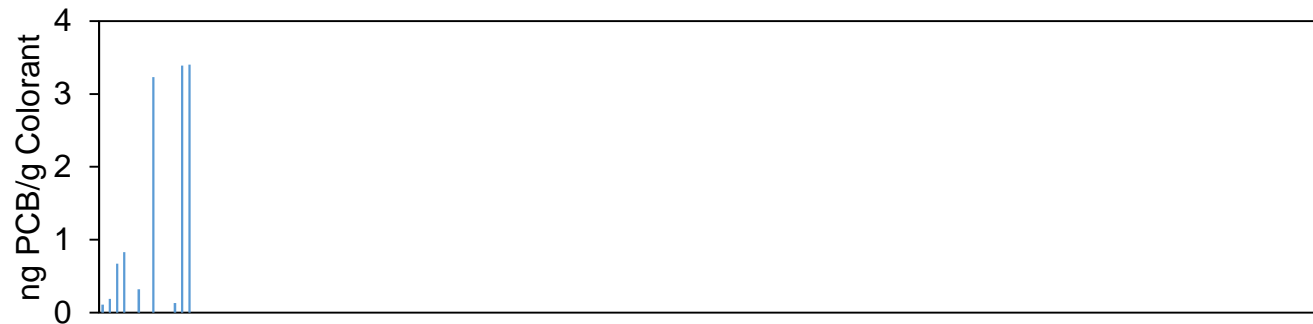




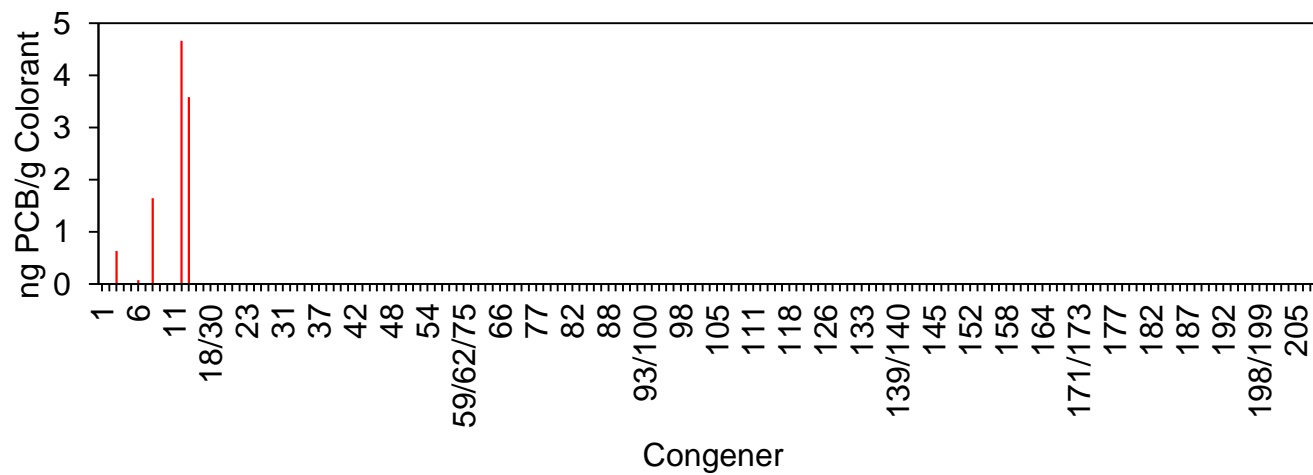
PR 254 (Anezaki)



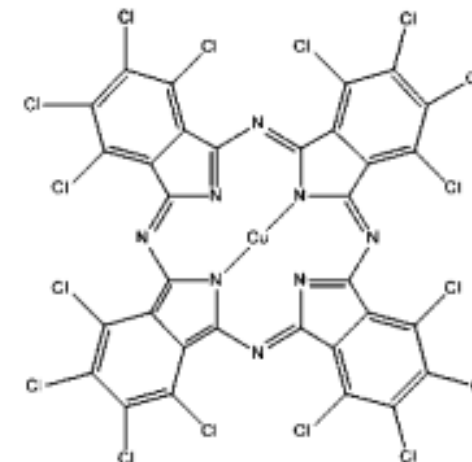
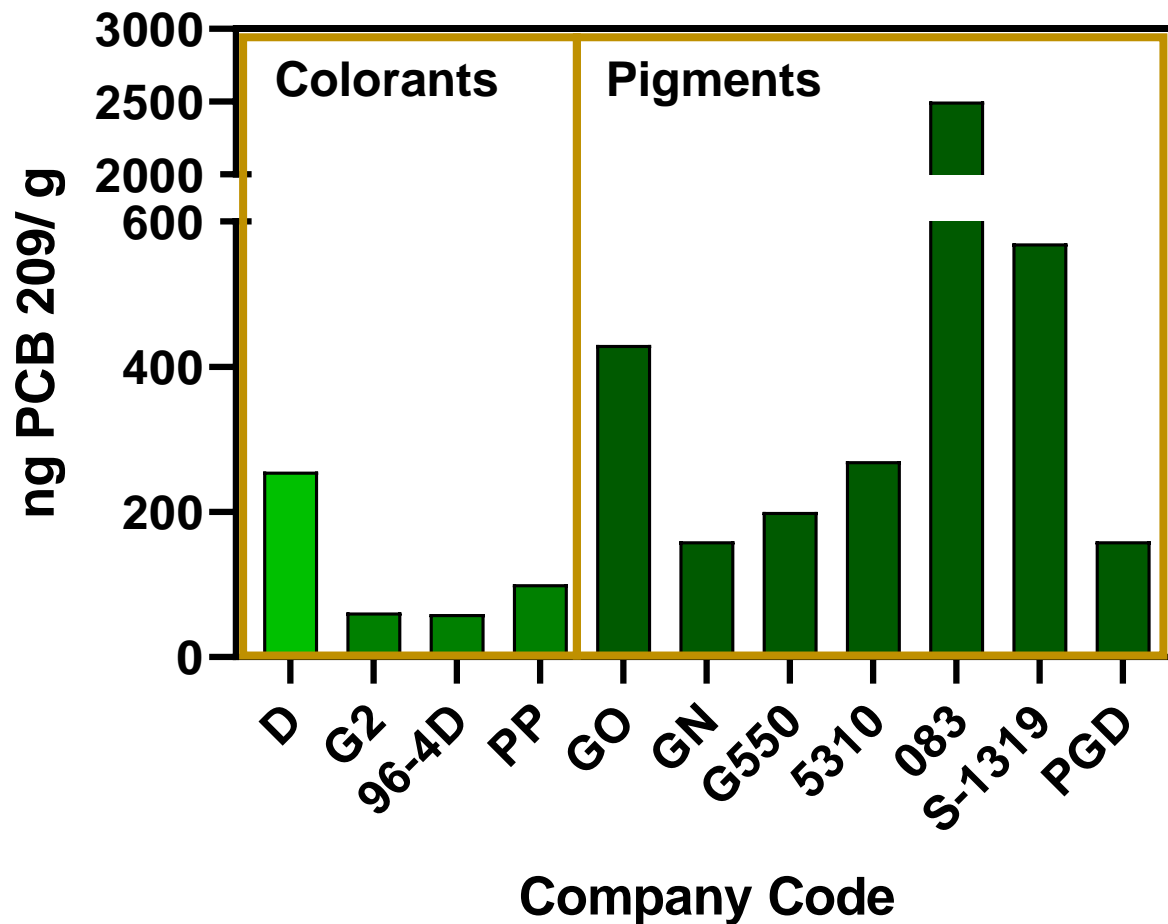
R4 (Hu)



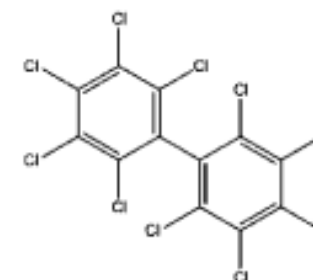
REE (This Study)



High Concentrations of PCB 209 in Green Pigments



Phthalocyanine green



Decachlorobiphenyl (PCB209)

Polyurethane Foam Passive Emission Sampler (PUF-PES)

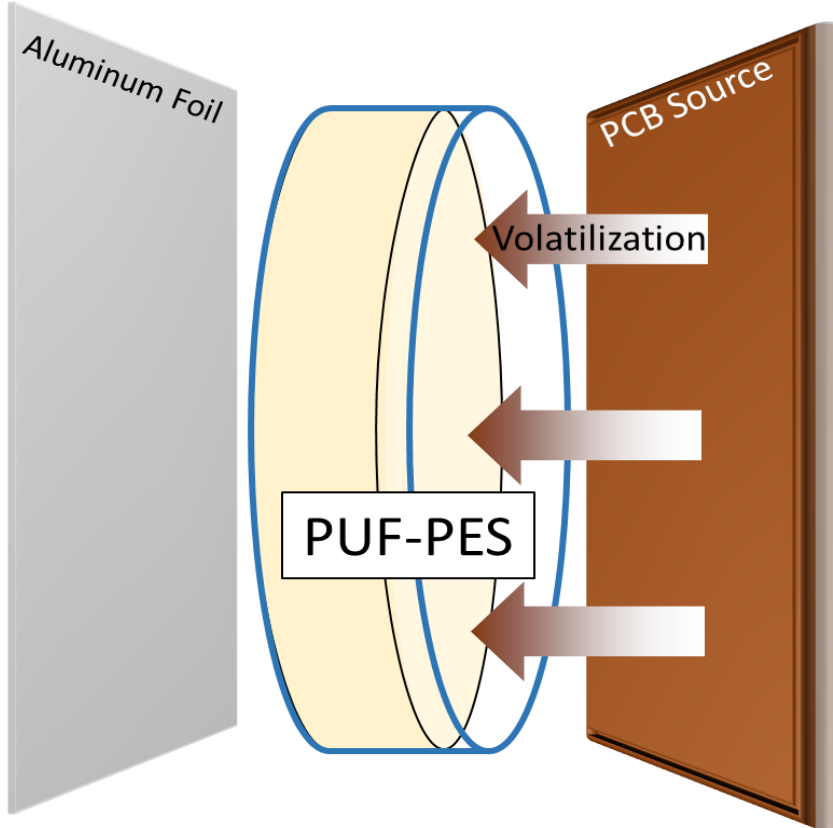
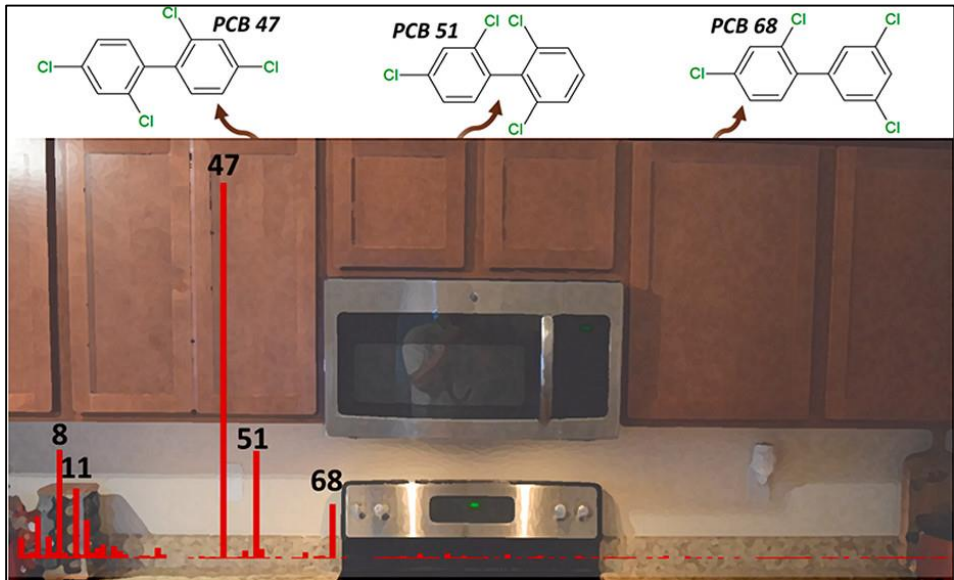
ENVIRONMENTAL
Science & Technology

Article
Cite This: *Environ. Sci. Technol.* 2018, 52, 5154–5160
pubs.acs.org/est

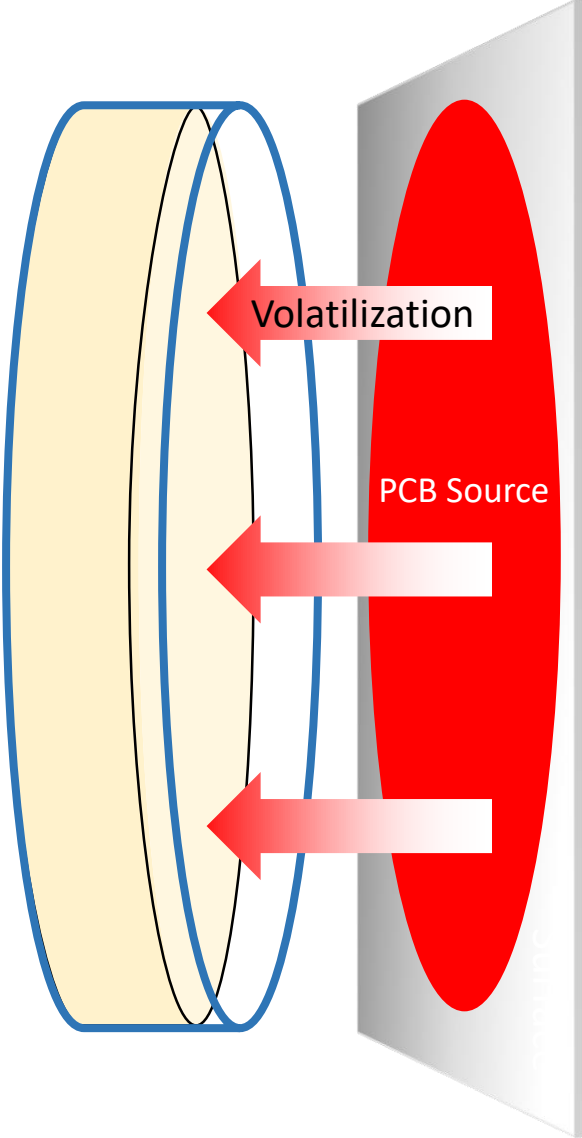
Emissions of Tetrachlorobiphenyls (PCBs 47, 51, and 68) from Polymer Resin on Kitchen Cabinets as a Non-Aroclor Source to Residential Air

Nicholas J. Herkert, Jacob C. Jahnke, and Keri C. Hornbuckle*¹

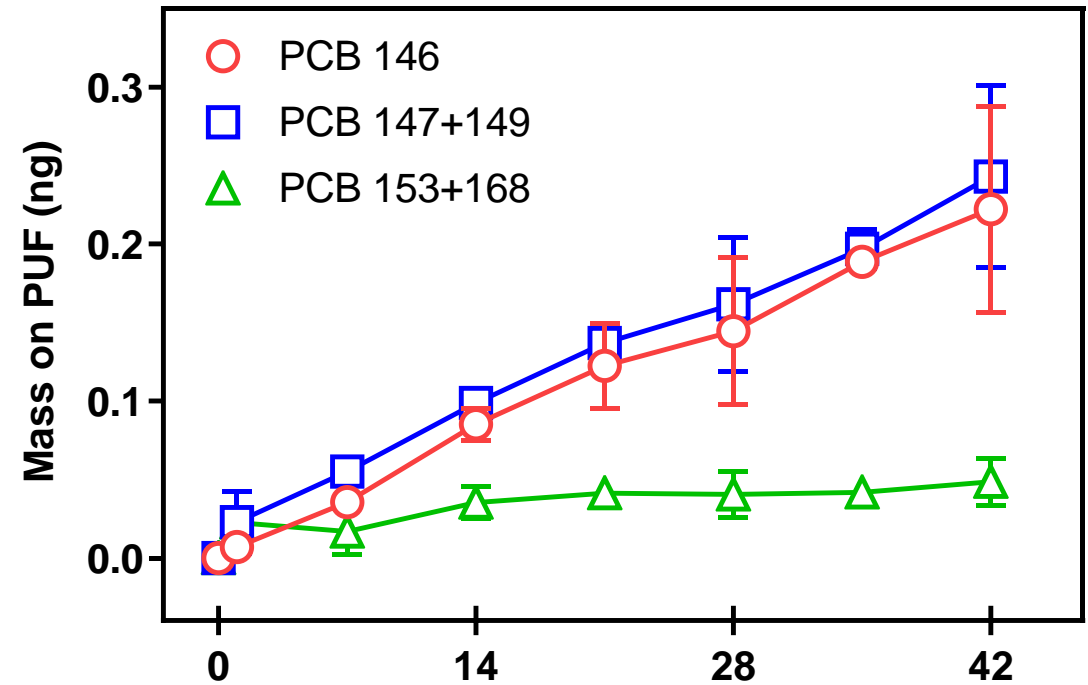
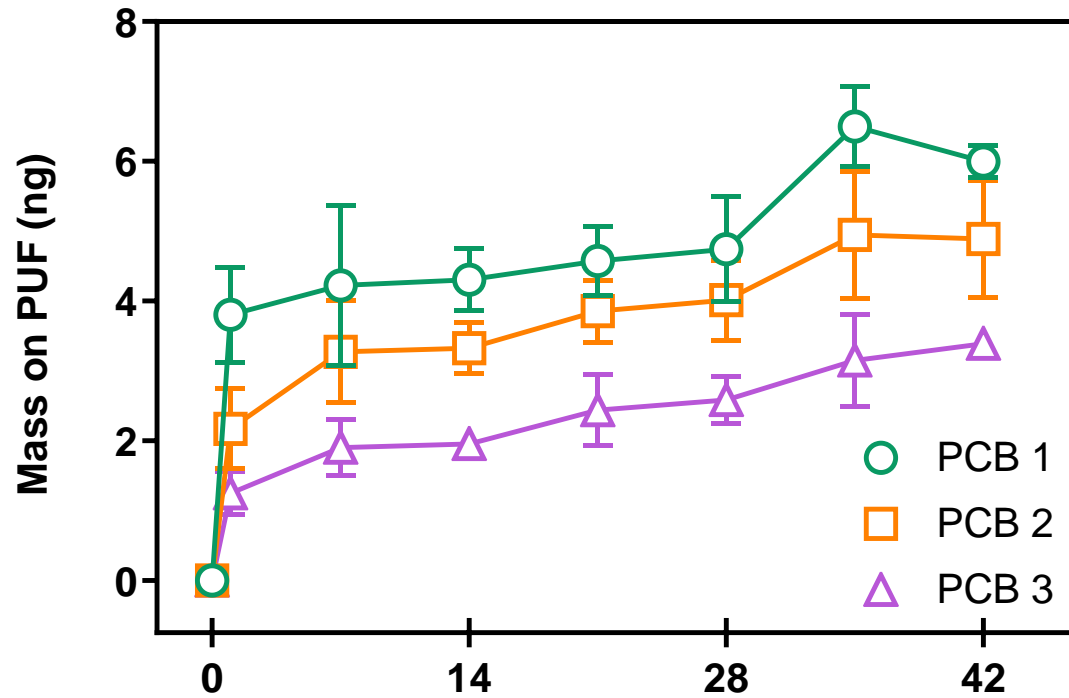
Department of Civil and Environmental Engineering, IIHR-Hydroscience and Engineering, The University of Iowa, Iowa City, Iowa 52242, United States



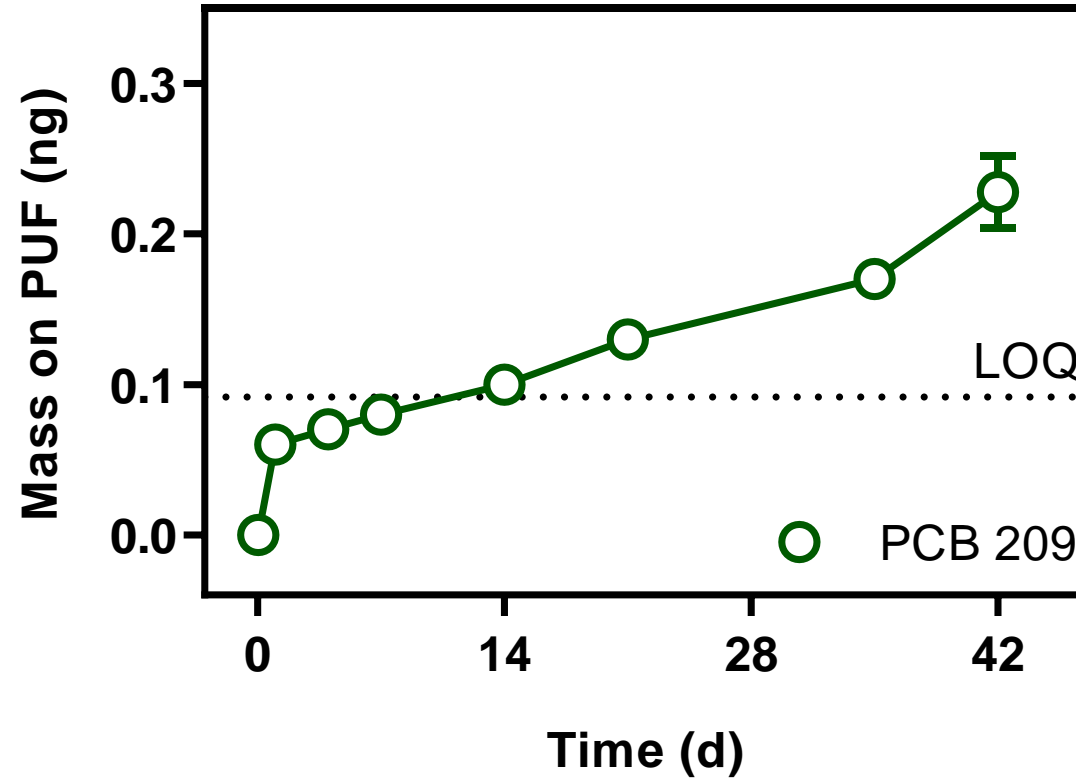
Capturing PCB Emissions from Colorant



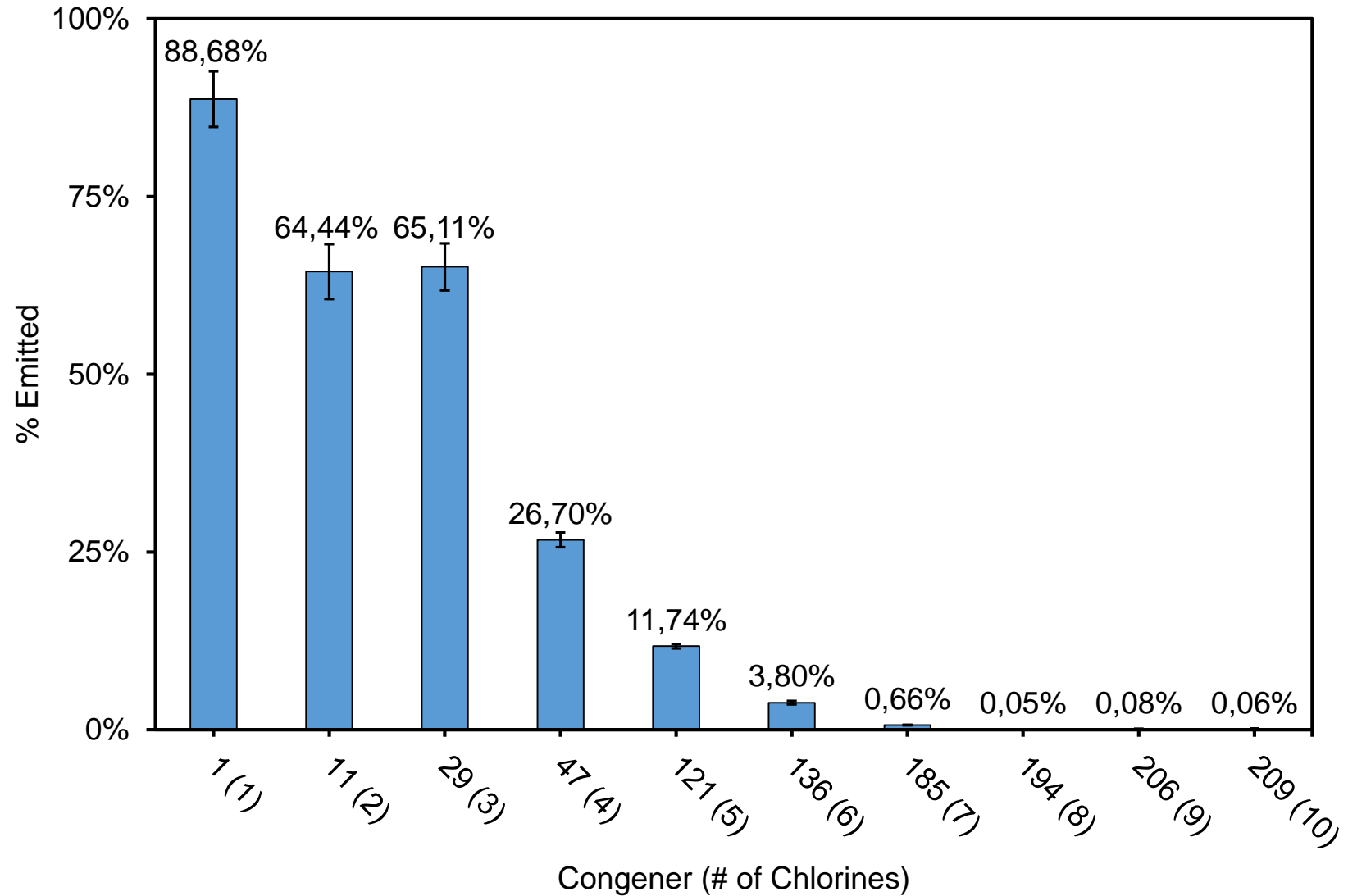
PCBs Accumulate in the PUF Over Time



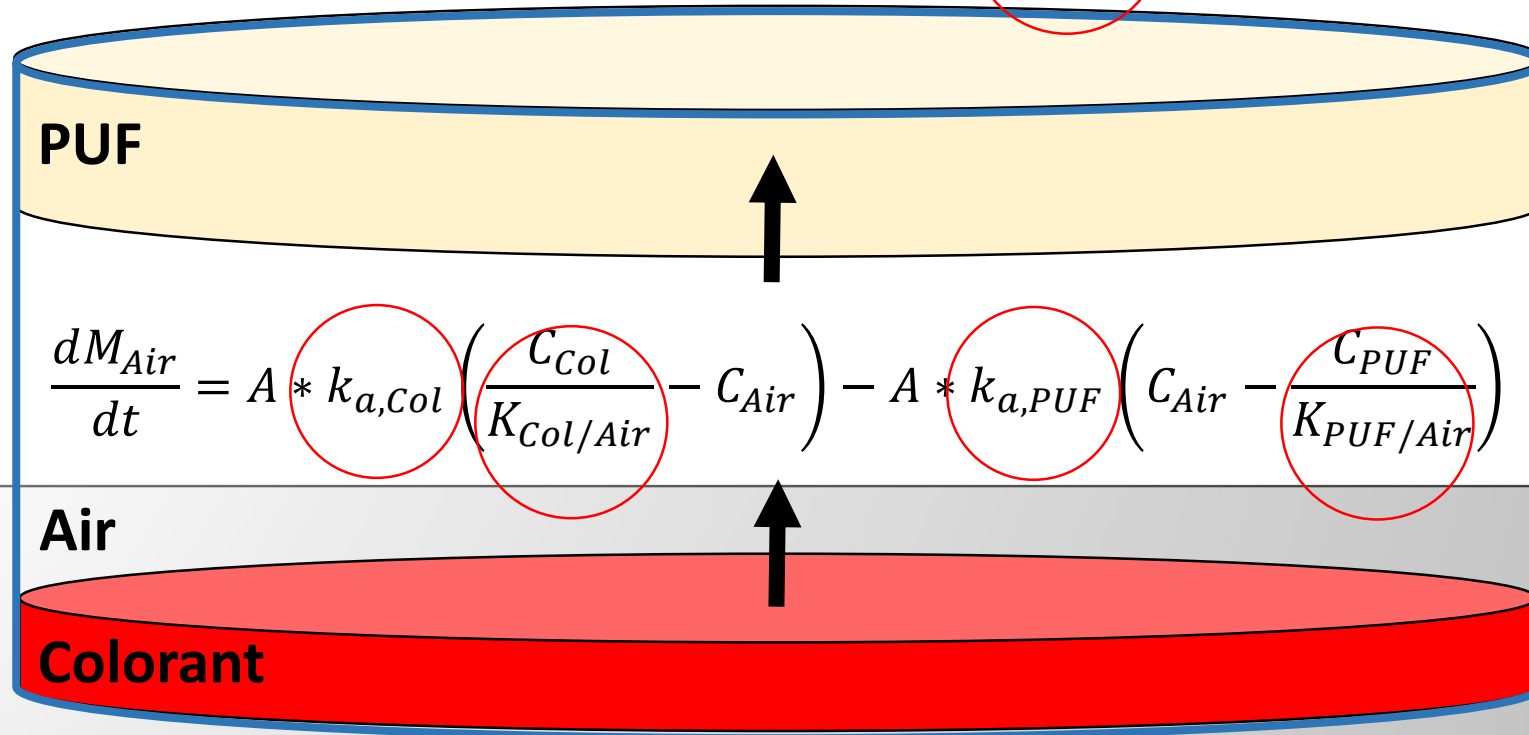
PCBs Accumulate in the PUF Over Time



PCBs Emissions are a Function of Congener Properties



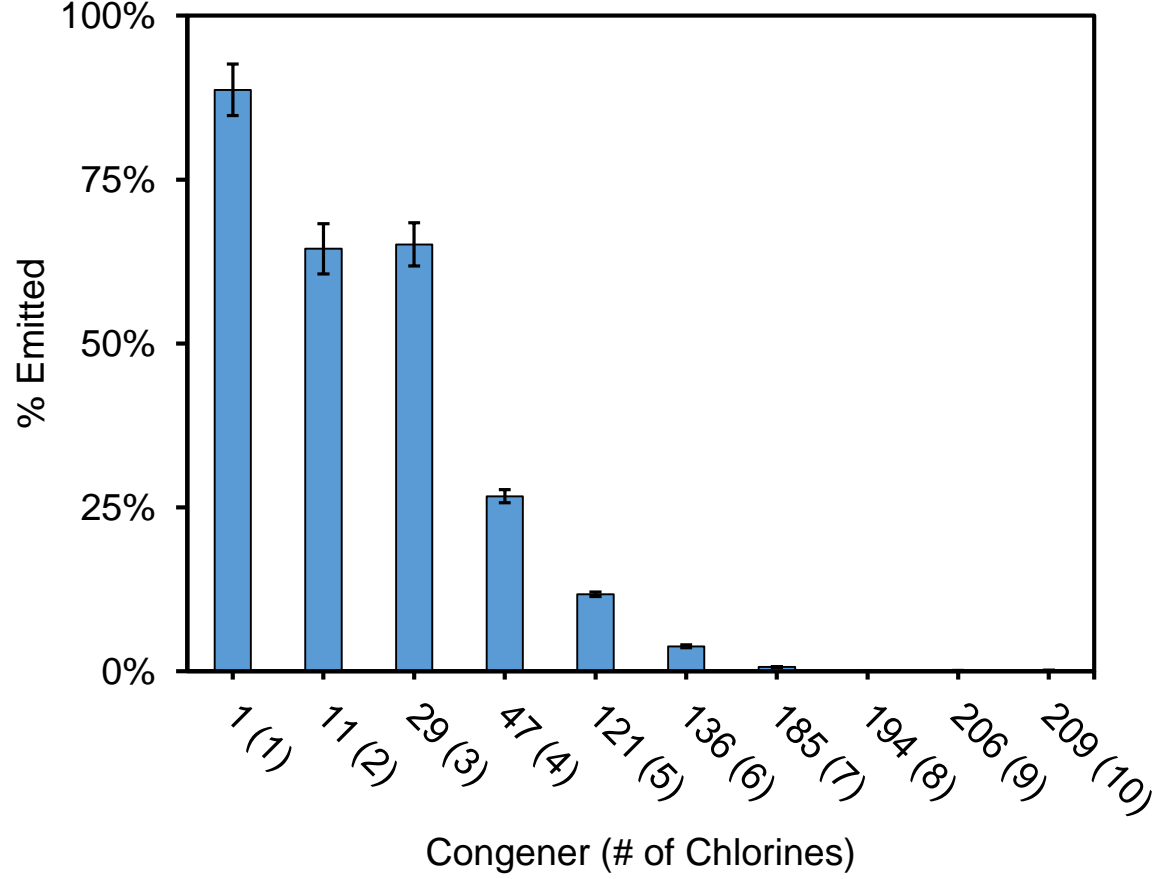
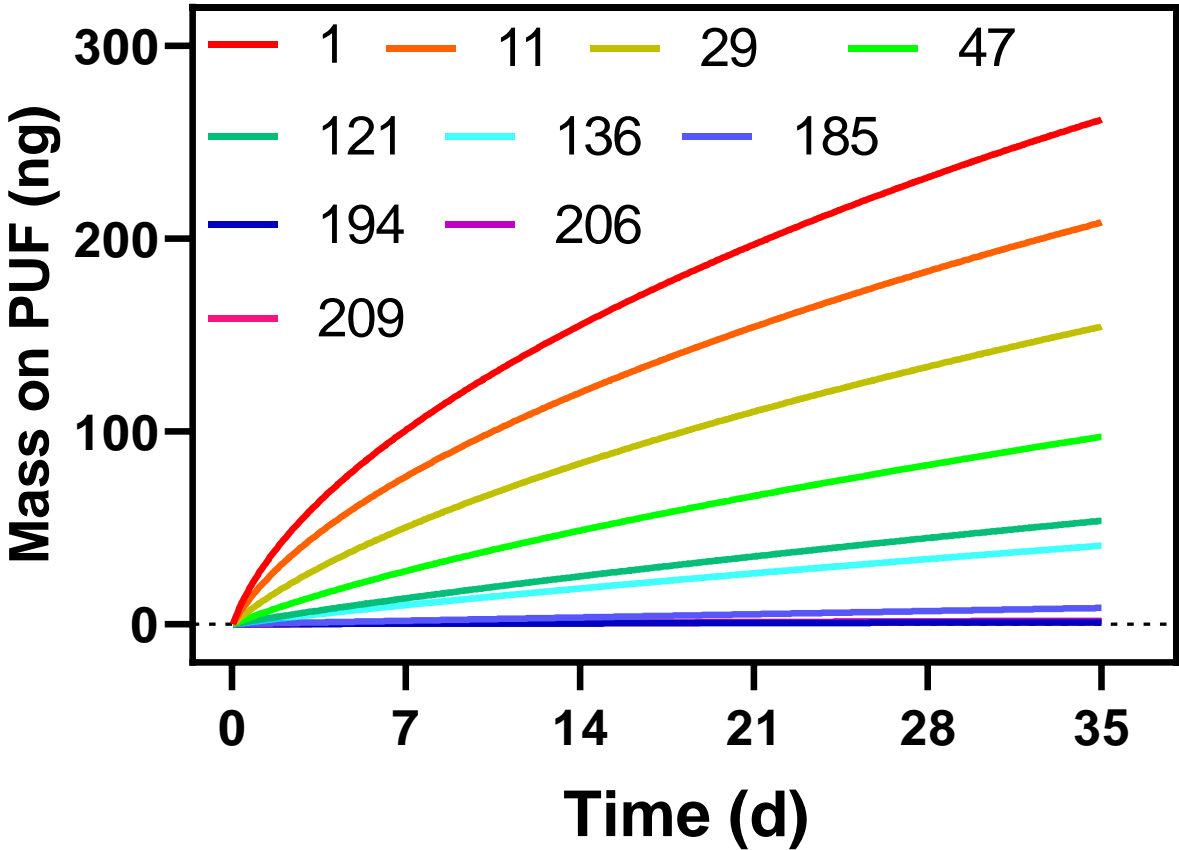
$$\frac{dM_{PUF}}{dt} = A * k_{a,PUF} \left(C_{Air} - \frac{C_{PUF}}{K_{PUF/Air}} \right)$$



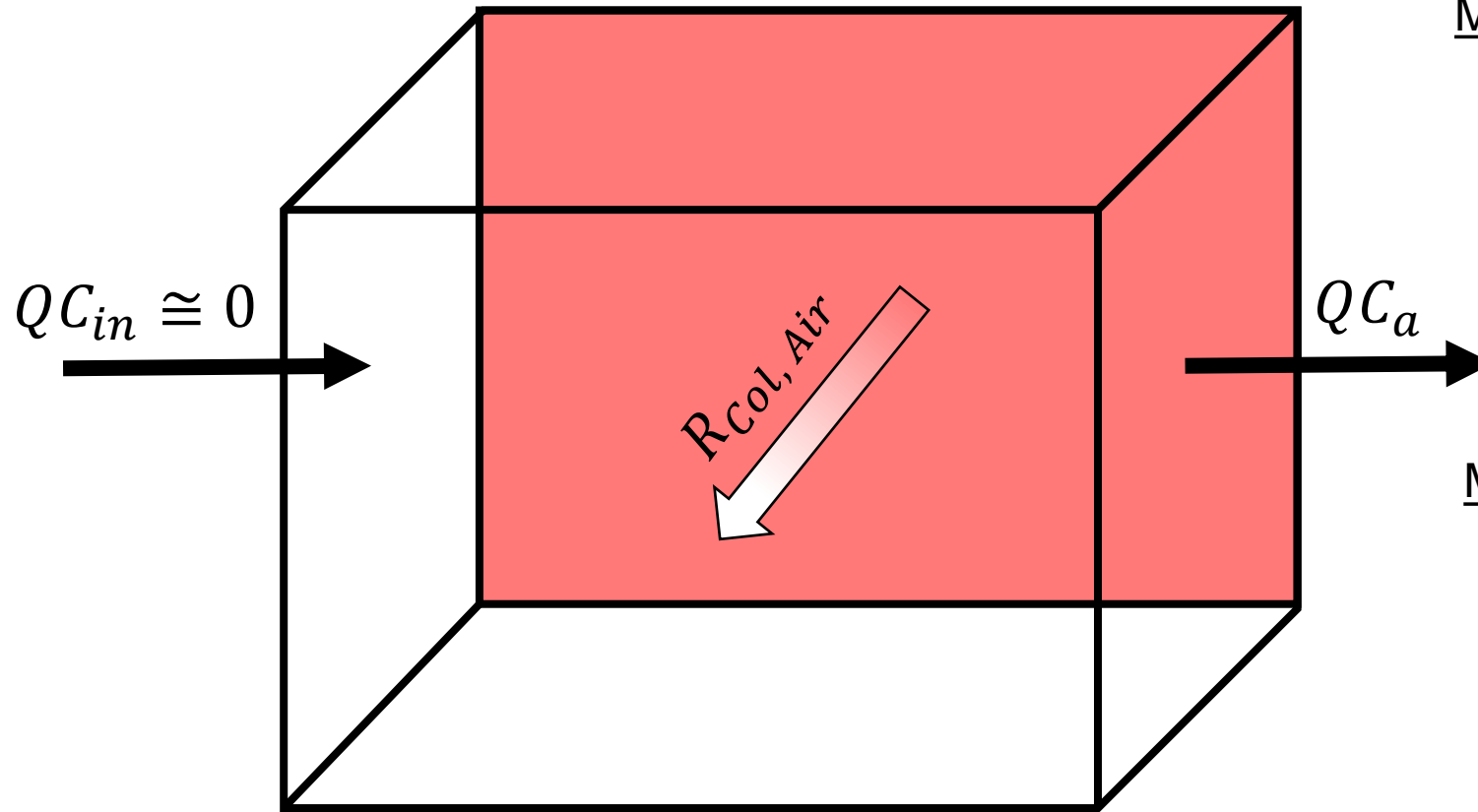
$$\frac{dM_{Air}}{dt} = A * k_{a,col} \left(\frac{C_{col}}{K_{Col/Air}} - C_{Air} \right) - A * k_{a,PUF} \left(C_{Air} - \frac{C_{PUF}}{K_{PUF/Air}} \right)$$

$$\frac{dM_{col}}{dt} = -A * k_{a,col} \left(\frac{C_{col}}{K_{Col/Air}} - C_{Air} \right)$$

Predicted PCB Emissions Match Experimental



Modeling the Emissions of PCBs to Indoor Air



Mass transfer of PCBs from source to air

$$V_0 \frac{dC_{Air}}{dt} = R_{Col, Air} - QC_{Air}$$

$$R_{Col, Air} = Ah_{a, Col} \left(\frac{C_{Col}}{K_{Col, Air}} - C_{Air} \right)$$

Mass transfer of PCBs within the source

$$V_j \frac{dC_{mj}}{dt} = -R_{ji} + R_{kj}$$

$$R_{ij} = Ah_m (C_{mi} - C_{mj})$$

A Framework for Modelling Non-Steady-State Concentrations of Semivolatile Organic Compounds Indoors – I: Emissions from Diffusional Sources and Sorption by Interior Surfaces

Zhishi Guo

Indoor and Built Environment, 2013

Review of indoor emission source models. Part 2. Parameter estimation

Zhishi Guo

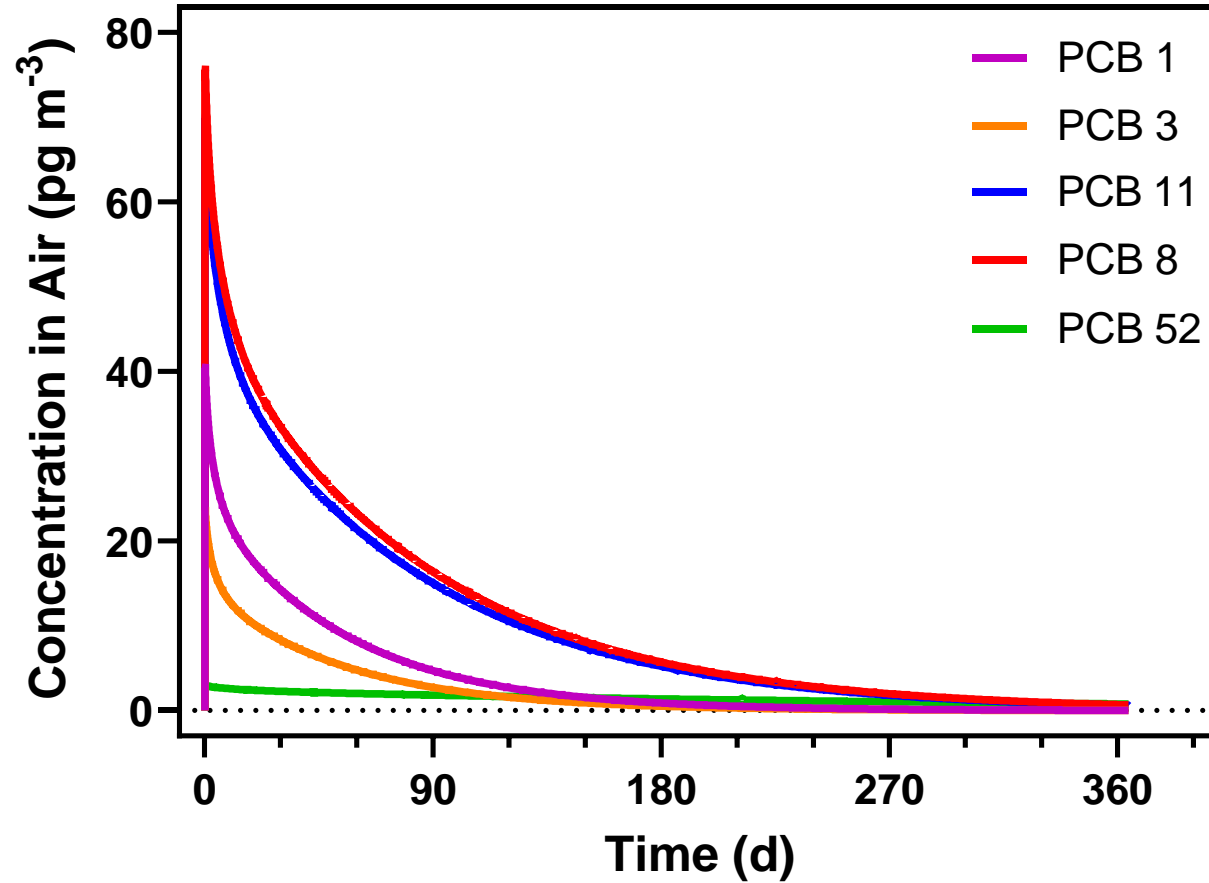
Environmental Pollution, 2002

A quantitative property-property relationship for the internal diffusion coefficients of organic compounds in solid materials

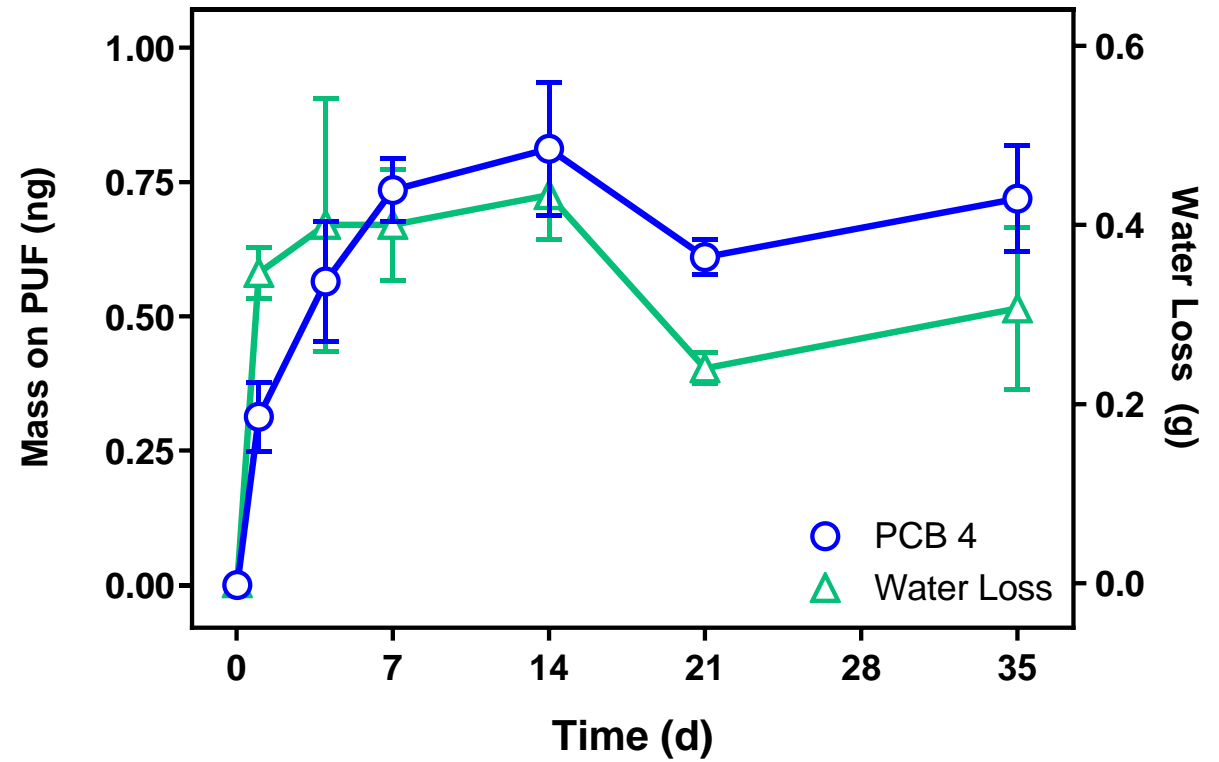
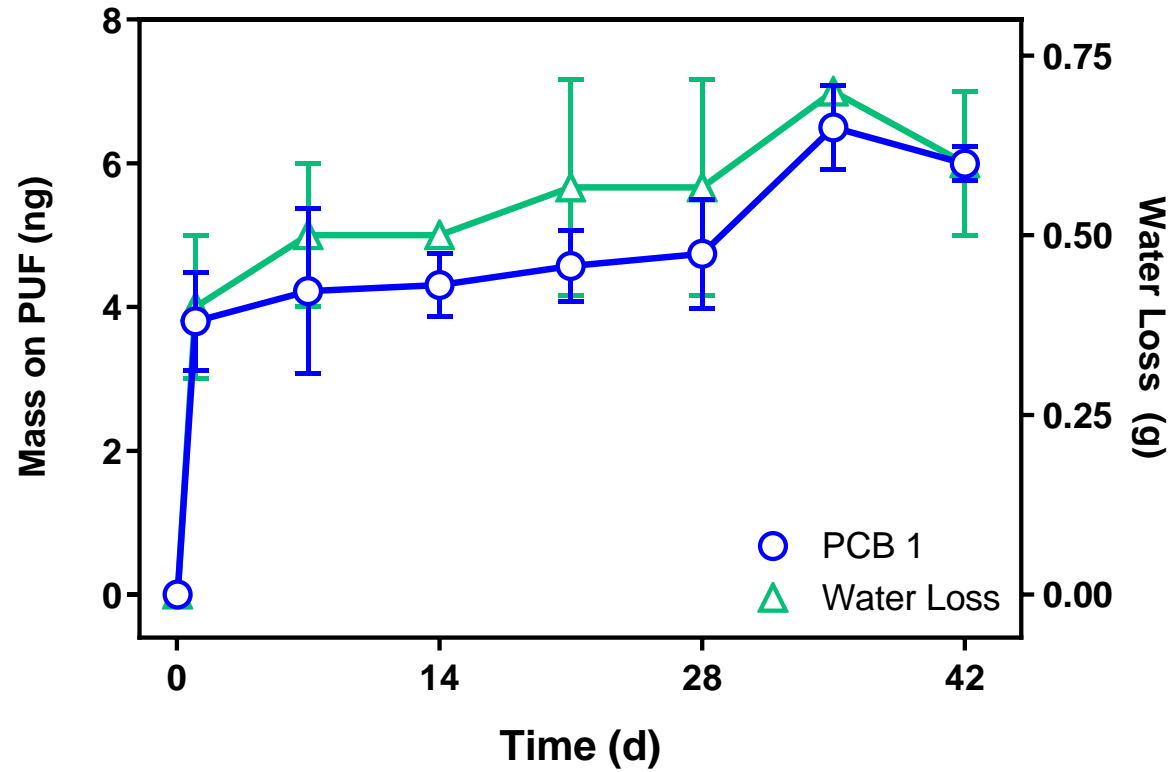
L. Huang, P. Fantke, A. Ernstoff, O. Jolliet

Indoor Air, 2017

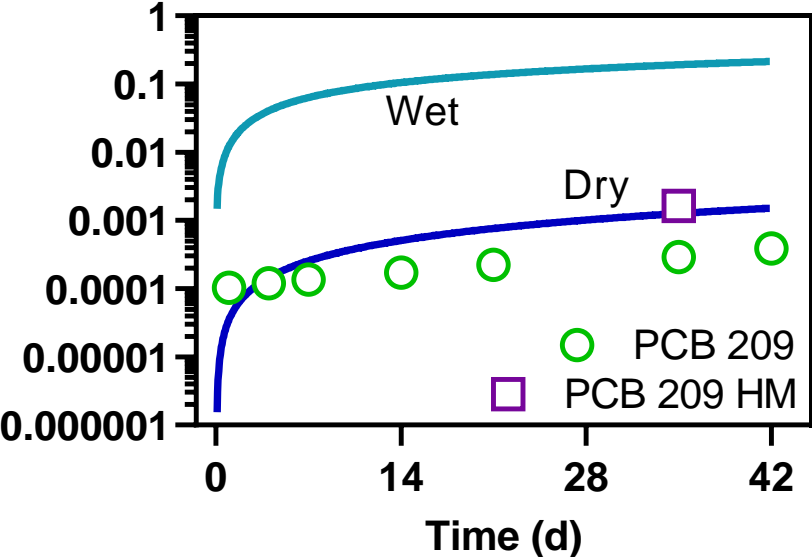
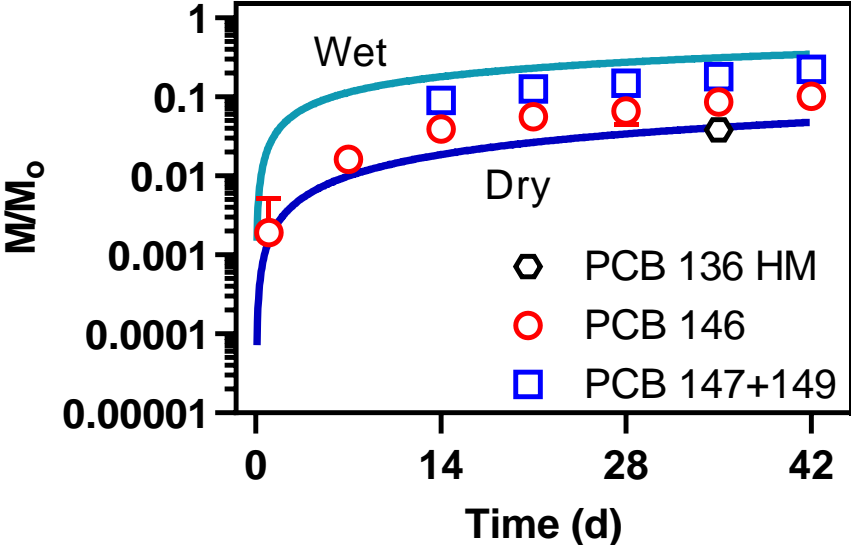
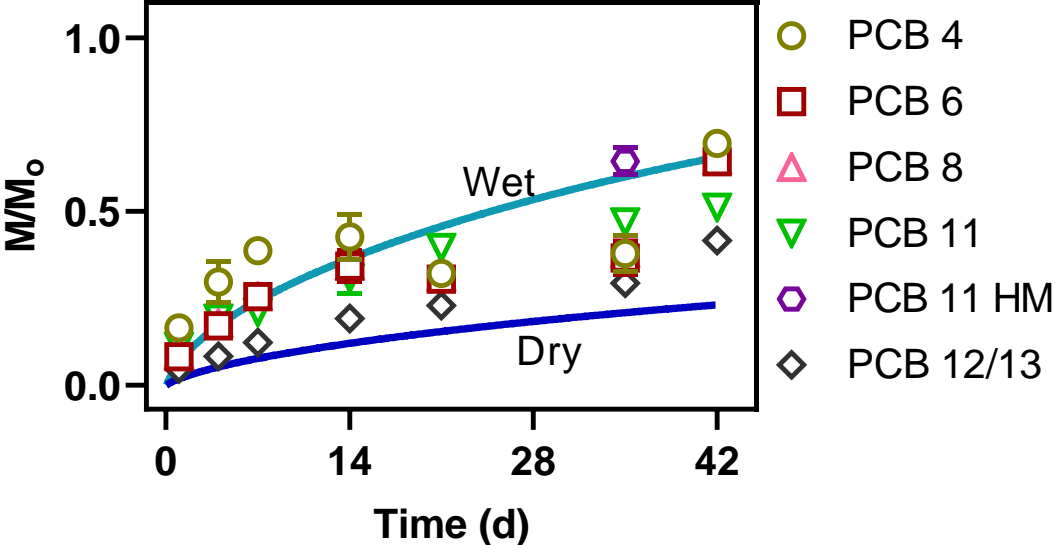
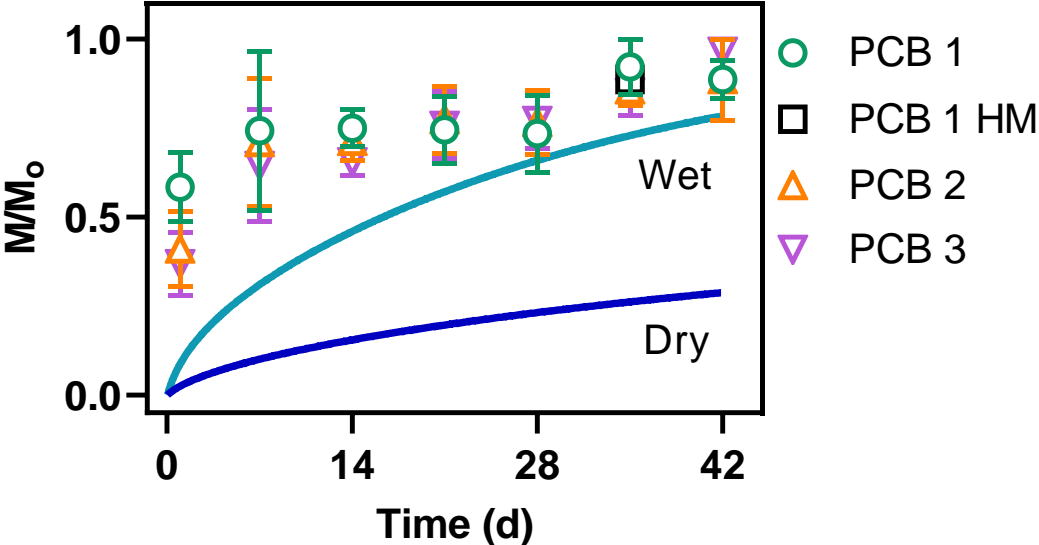
Highest PCB Concentrations Occur Right After Painting



Water Content Could Affect PCB Emissions



Predicted PCB Emissions from 'Wet' or 'Dry' Paint





rose home hope used tube cute
joke spoke broke role hole dove
cube tube nose hose stove none
come cone mile mule those these
chun chone catch patch whole white

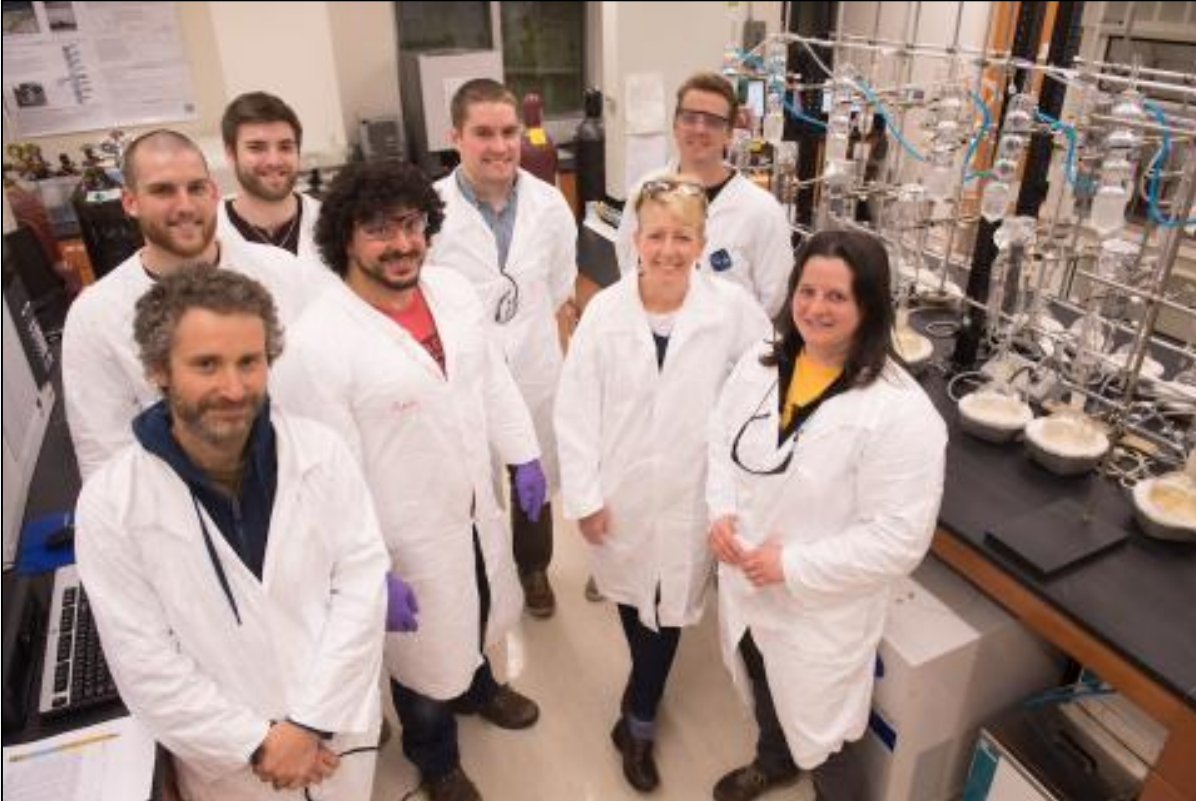
Rose uses tubes and rope at her job.
A cute white rat ran down the hole.

- Early Finishers**
1. Check your work.
 2. Finish work in your red folder.
 3. Plead from your book bin.
 4. Start a new piece of writing.
 5. Shop for books.



Acknowledgements

Keri Hornbuckle and Staff



Thanks for
Listening

Questions?

