Inadvertent PCBs in Consumer Products

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Center for Environmental Measurement and Modeling

The Collaborative on Health and the Environment – Washington Partnership

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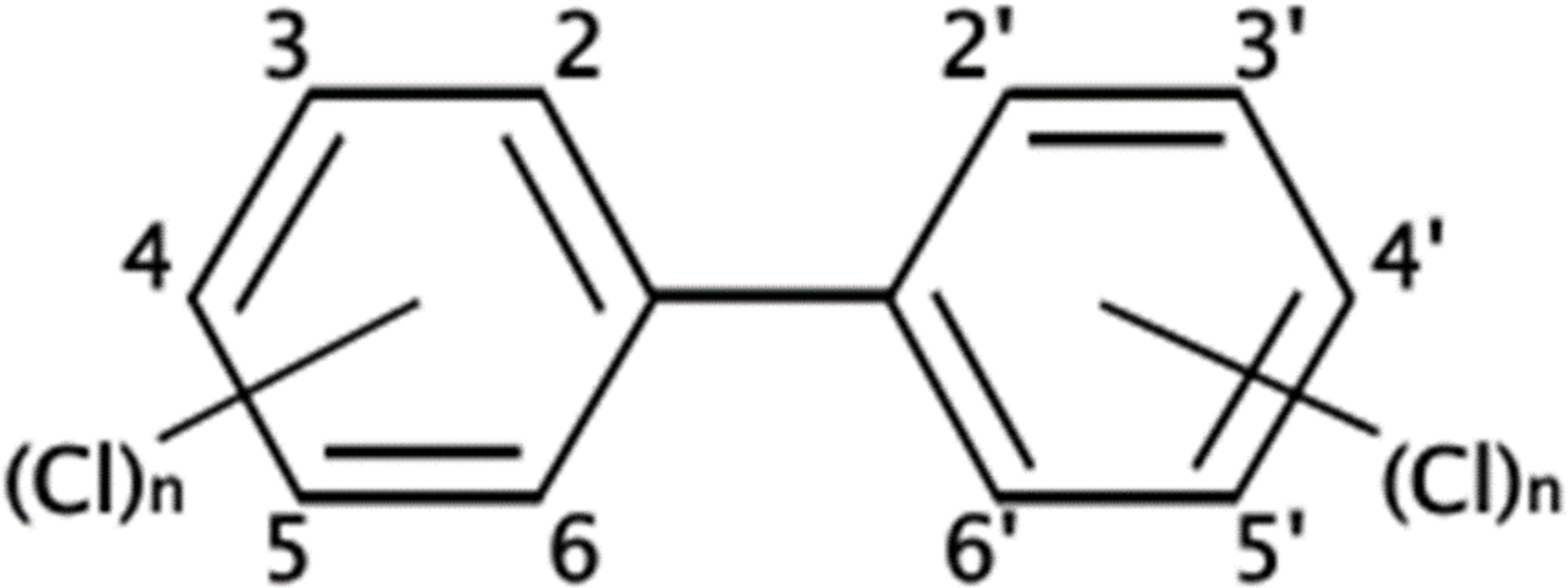
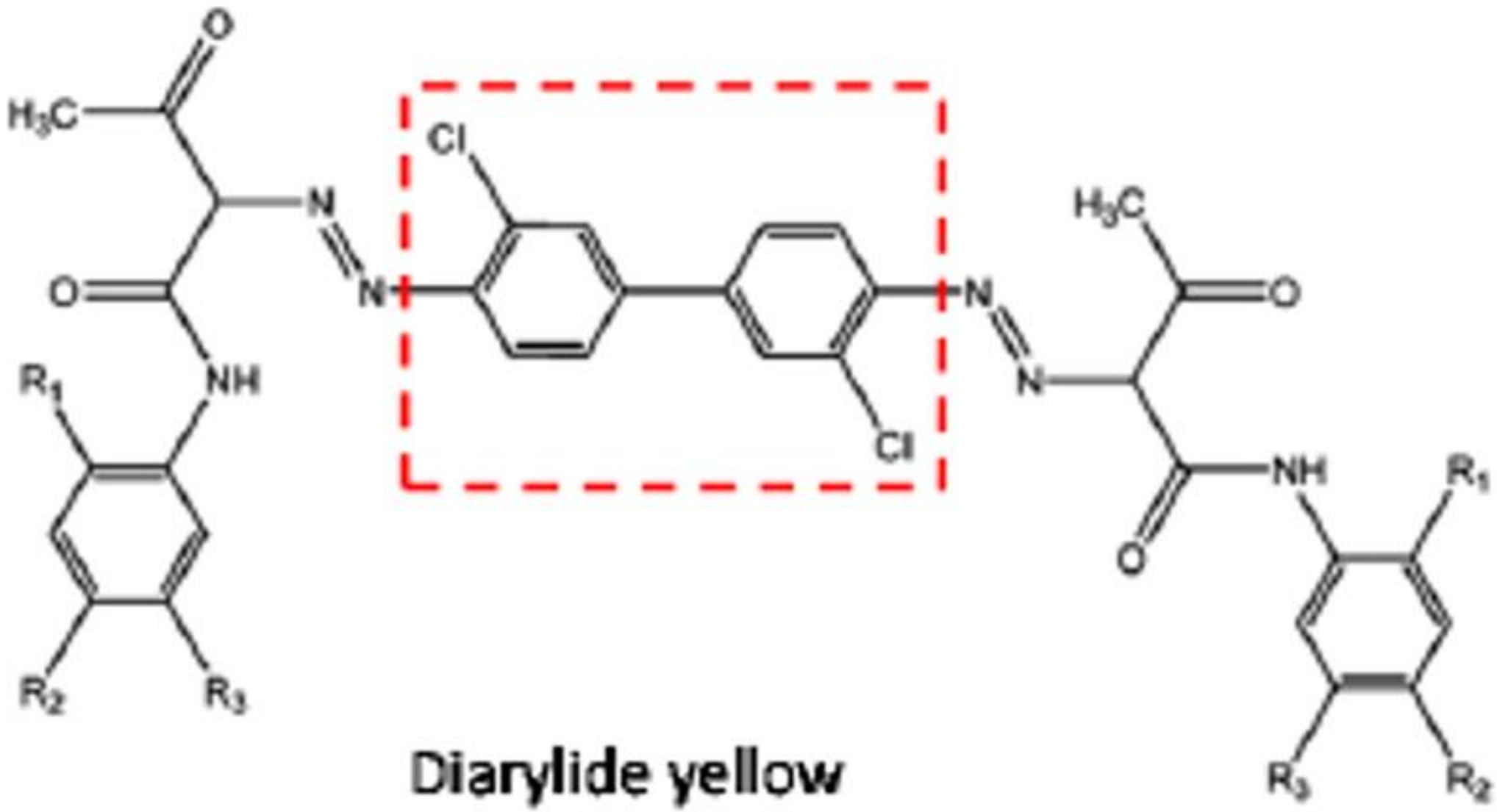
What are PCBs?



What are inadvertent PCBs (iPCBs)?

Chemical or process	Number of reports
Pigments and dyes	53
GE silicones	8
Vinyl chloride production	3
Unique	6
Unknown	7
Total	77

Yellow Pigment- Diarylide Yellow



Diarylide yellow

Adapted from Nicolaou and Da Rocha (1995)

PCB-11

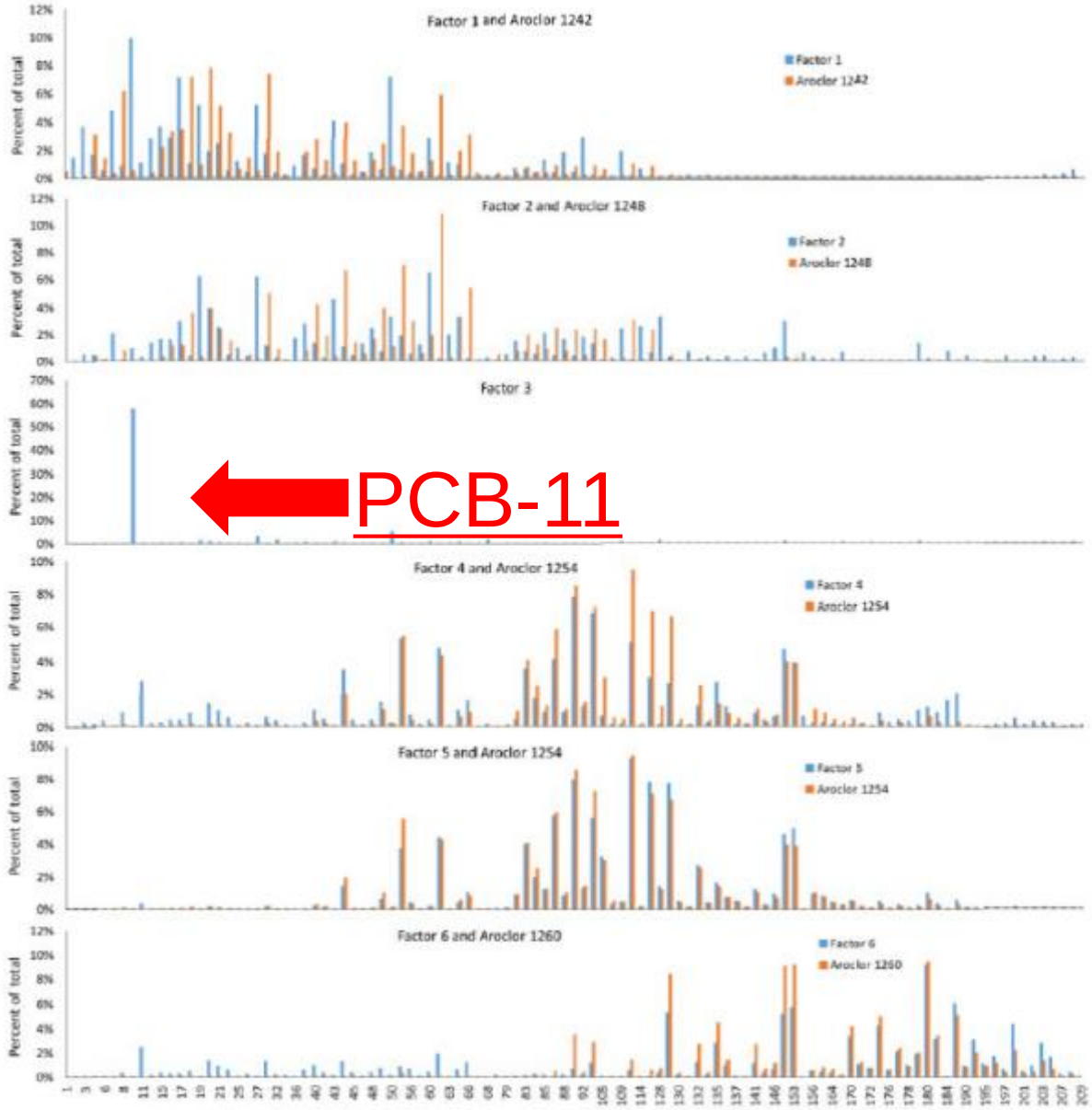


Figure 2-19. Fingerprints of the six factors compared to Aroclors

Figure shows each congener as percent of total mass in the data set.

Image Source: See PDF page 47. http://srrttf.org/wp-content/uploads/2016/05/2016-Annual-Toxics-Management-Report_04142016.pdf

Health Effects of PCBs

- Carcinogenic in animals, probably human carcinogen
- Non-cancer health effects on:
  - Immune system
  - Reproductive system
  - Nervous system
  - Endocrine system
  - and other health effects
- The different health effects of PCBs may be interrelated. Alterations in one system may have significant implications for the other systems of the body.

Routes of Exposure

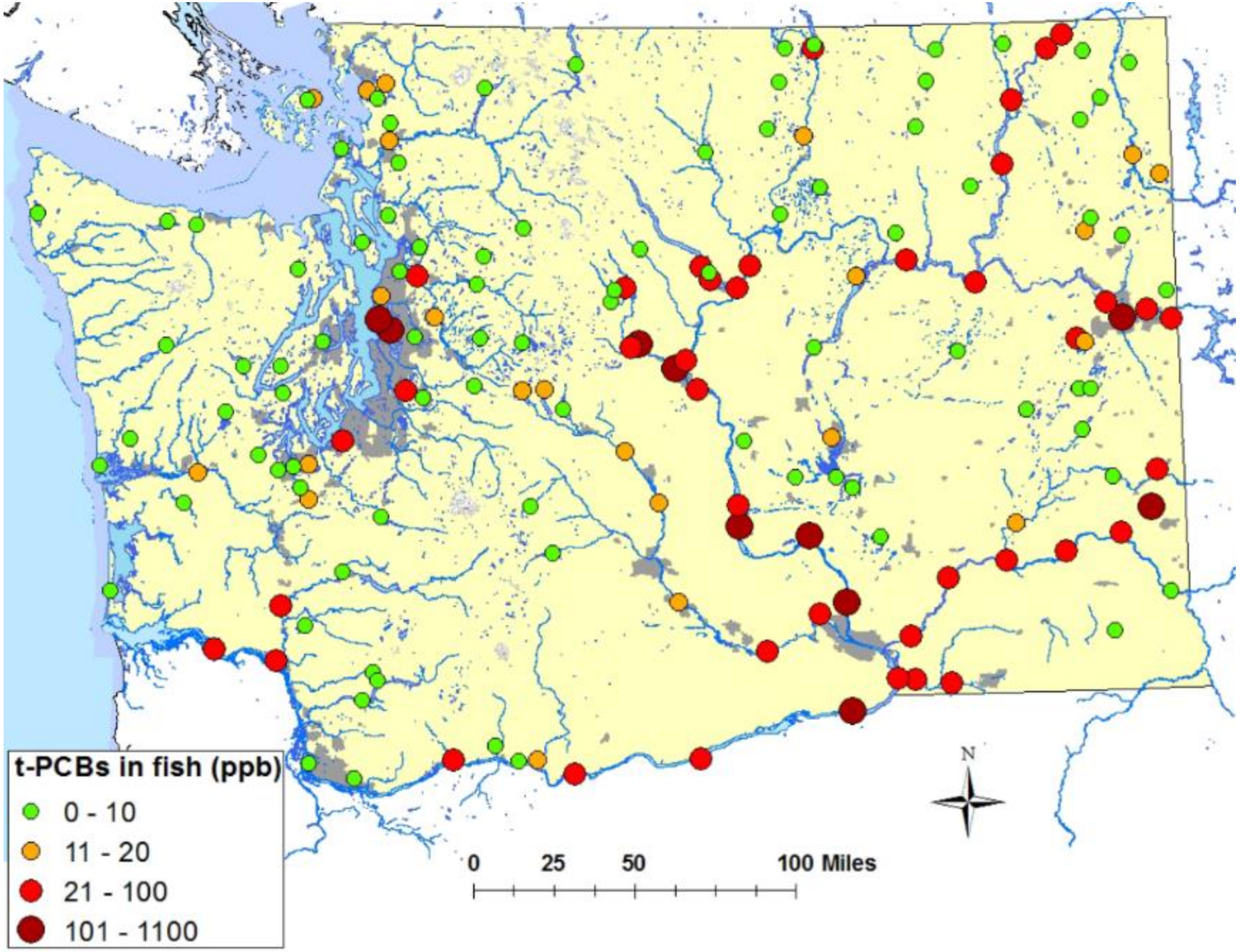


Image source: Ecology's PCB Chemical Action Plan. See PDF page 93. https://apps.ecology.wa.gov/publications/documents/1507002.pdf

Figure 14. Total PCBs and PCB-11 in Container/Box Samples

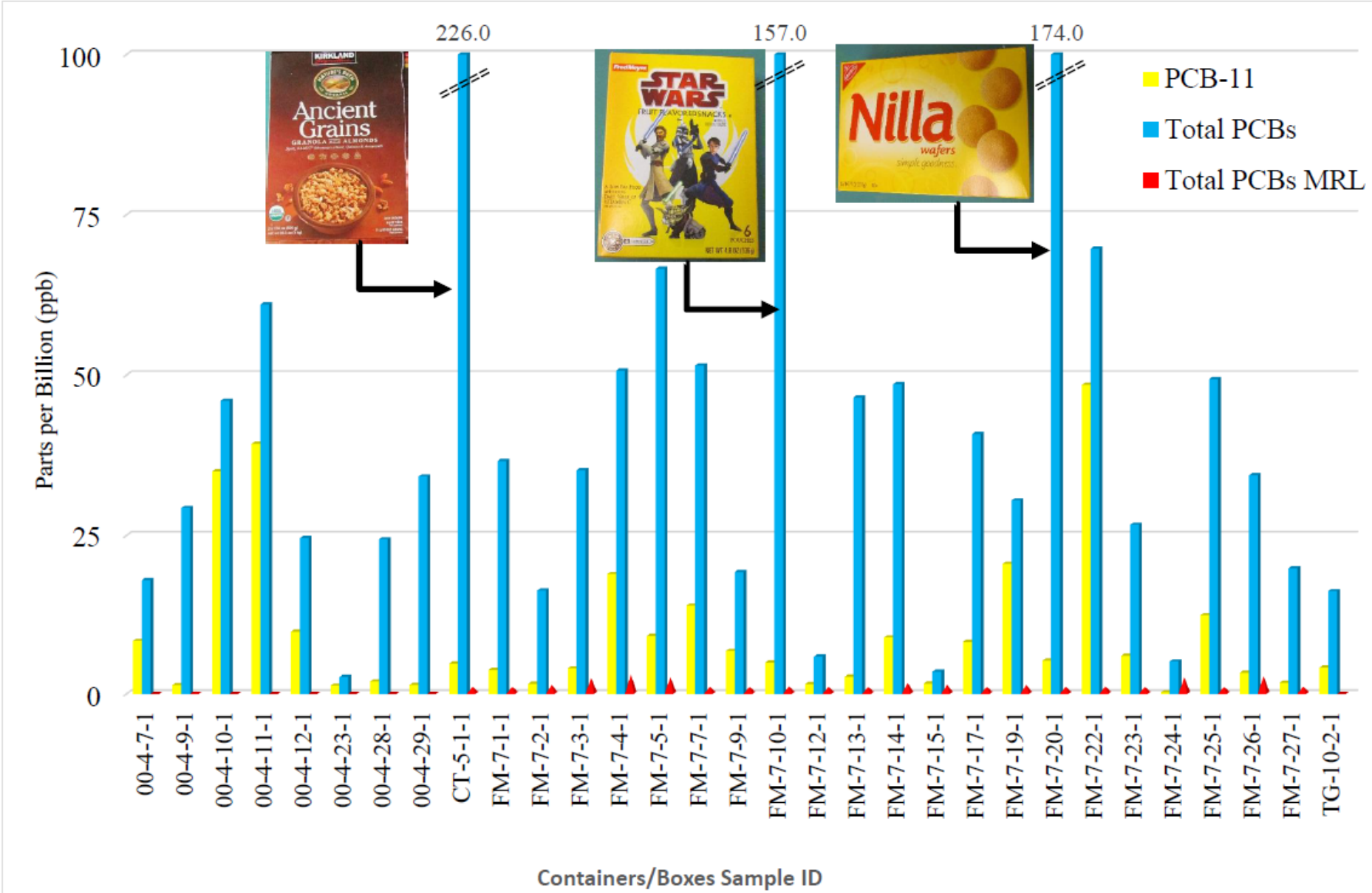
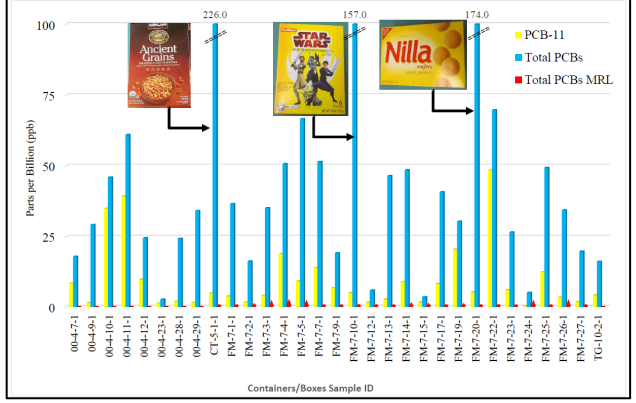


Image source: Ecology Publication No. 16-04-014 “Polychlorinated Biphenyls in Consumer Products” November 2016.

United States Environmental Protection Agency

Figure 14. Total PCBs and PCB-11 in Container/Box Samples



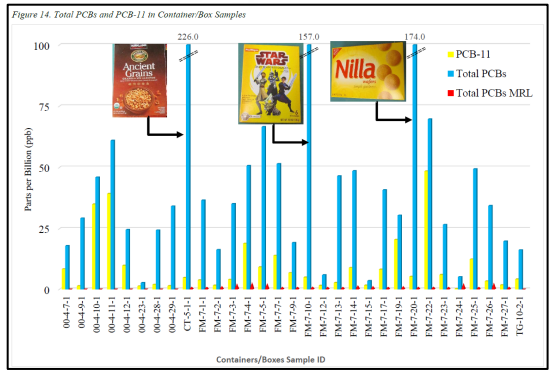
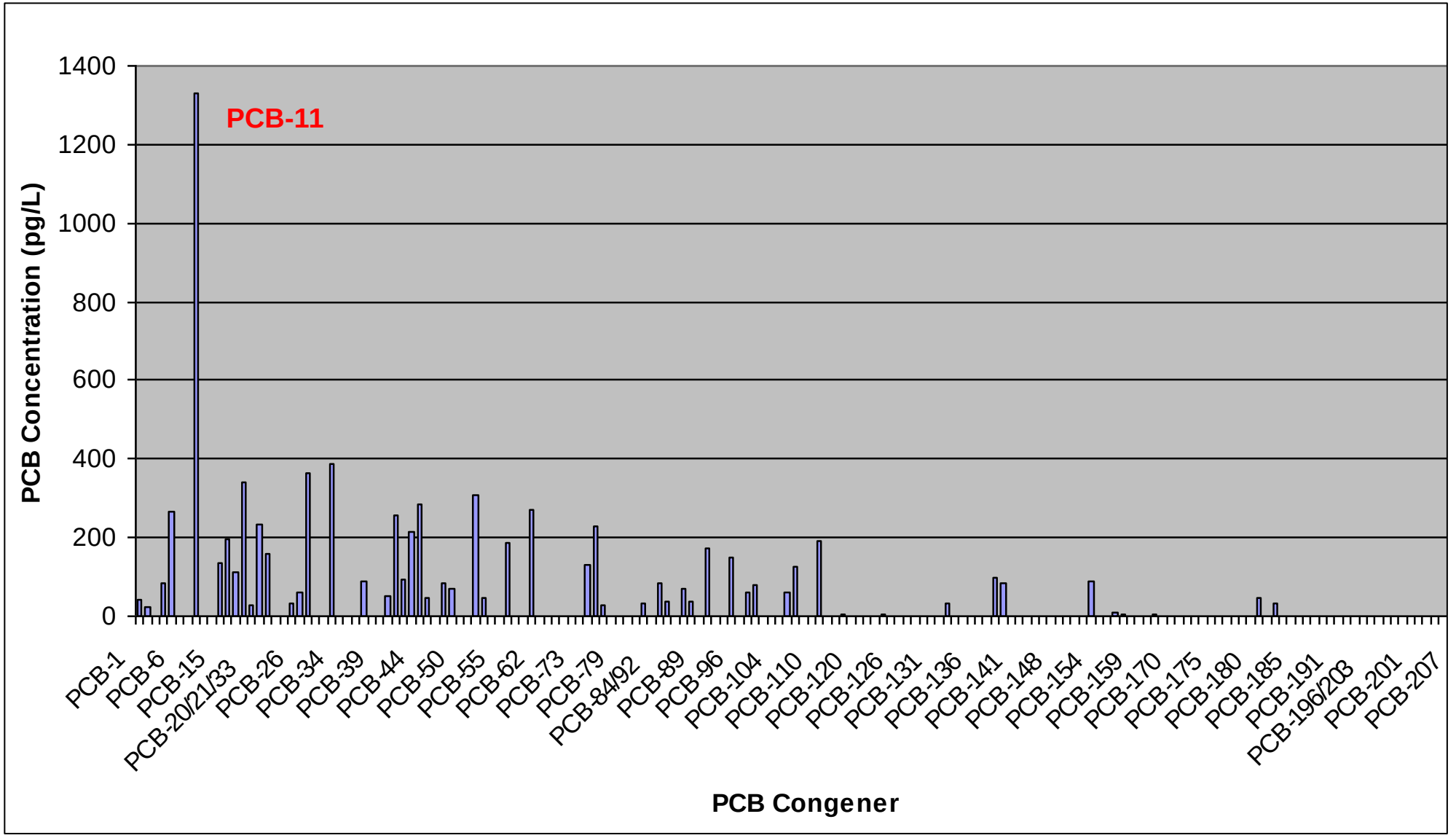
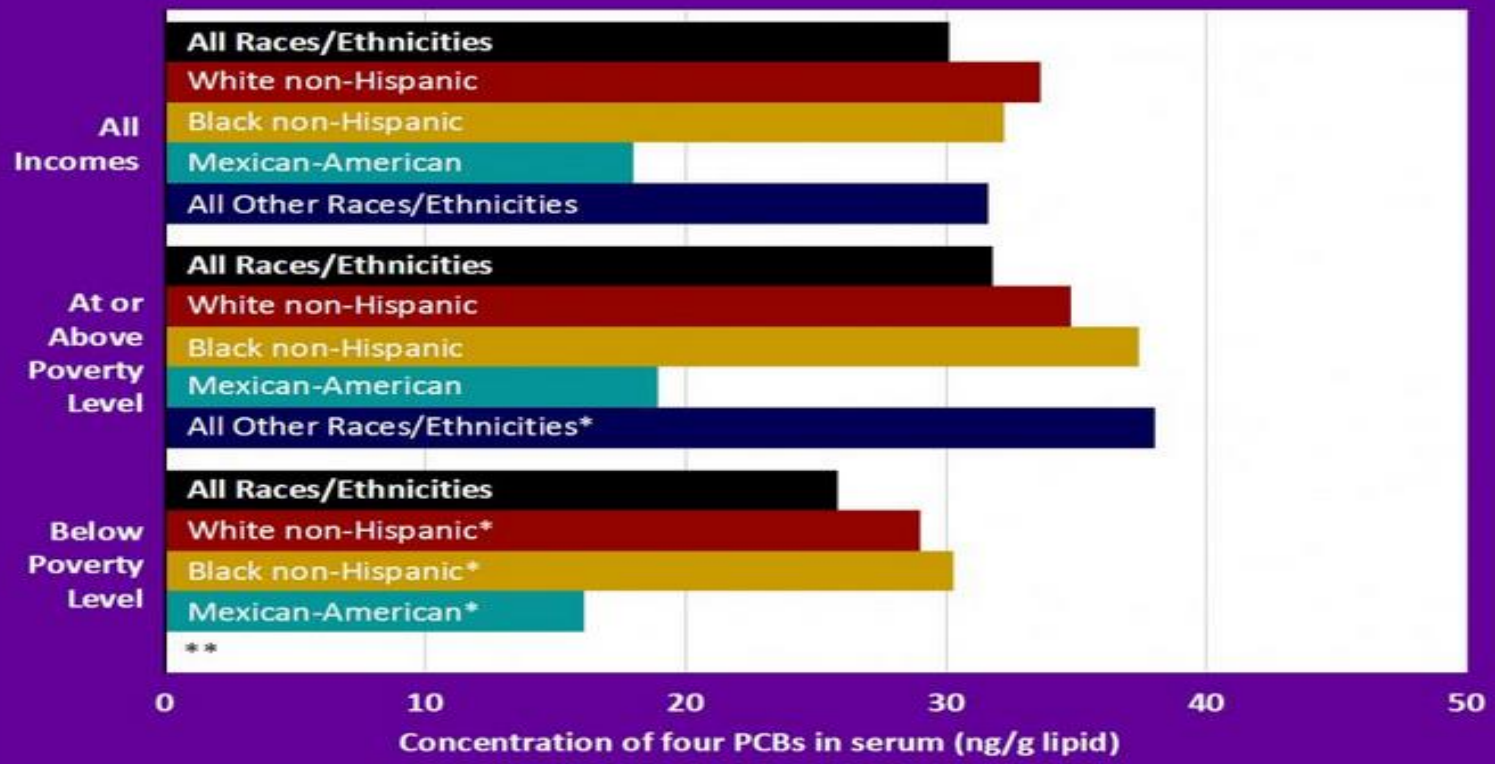


Figure 14. Total PCBs and PCB-11 in Container/Box Samples
226.0
157.0
174.0
PCB-11
Total PCBs
Total PCBs MRL
Parts per Billion (ppb)
Containers/Boxes Sample ID


PCB-11
PCB Concentration (pg/L)
PCB Congener
PCB-1
PCB-6
PCB-15
PCB-20/21/33
PCB-26
PCB-34
PCB-39
PCB-44
PCB-50
PCB-55
PCB-62
PCB-73
PCB-79
PCB-84/92
PCB-89
PCB-96
PCB-104
PCB-110
PCB-120
PCB-126
PCB-131
PCB-136
PCB-141
PCB-148
PCB-154
PCB-159
PCB-170
PCB-175
PCB-180
PCB-185
PCB-191
PCB-196/203
PCB-201
PCB-207

Indicator B7

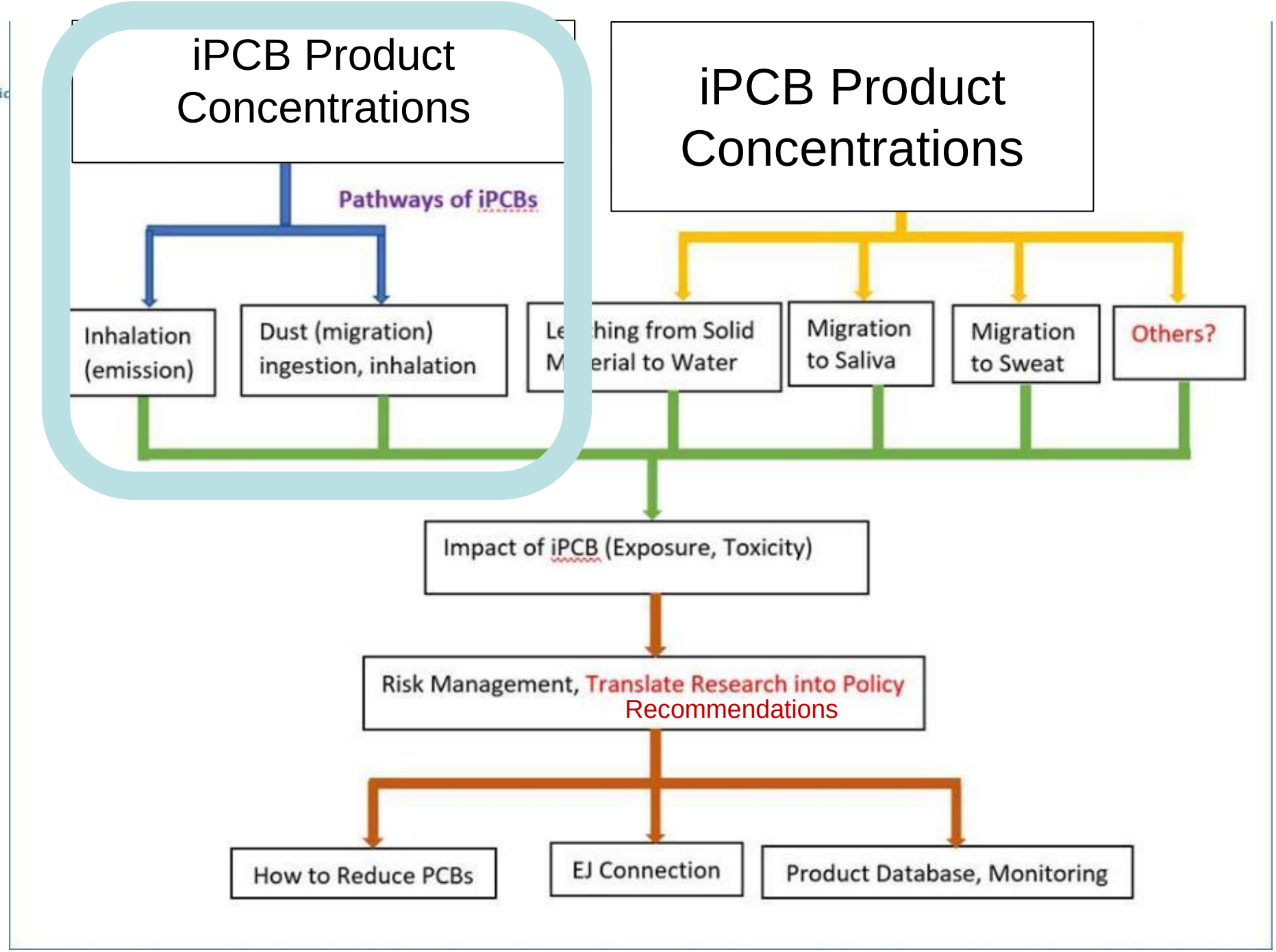
PCBs in women ages 16 to 49 years: Median concentrations in blood serum, by race/ethnicity and family income, 2001-2004



Data: Centers for Disease Control and Prevention, National Center for Health Statistics and National Center for Environmental Health, National Health and Nutrition Examination Survey

Note: To reflect exposures to women who are pregnant or may become pregnant, the estimates are adjusted for the probability (by age and race/ethnicity) that a woman gives birth.

Photo Credit: Saskia VanBergen, WA Ecology.


iPCB Product Concentrations
Pathways of iPCBs
Inhalation (emission)
Dust (migration) ingestion, inhalation
Leaching from Solid Material to Water
iPCB Product Concentrations
Migration to Saliva
Migration to Sweat
Others?
Impact of iPCB (Exposure, Toxicity)
Risk Management, Translate Research into Policy Recommendations
How to Reduce PCBs
EJ Connection
Product Database, Monitoring

Questions to Be Answered

- Which consumer products contain iPCBs?
- Are existing product testing results replicable?
- How do iPCBs transport from sources to the environment and human body?
- What are the risk management options?

EPA Region 10: Addressing iPCBs

- R10 PCB Program and P2 Program supporting WA efforts, with support from R10 Children's Health and R10 OW.
- Joined by R1, R2, R6, R9, ORCR, OCSPP and ORD for national effort

ORD	Work Groups	WA Ecology/City of Spokane	WA DOT	WA DES
• Source characterization • Fate and transport • Modeling • Exposure assessment	• National iPCBs • National P2 • R10 PCBs • Spokane River Task Force • Columbia River Working Group	• PCB Chemical Action Plan • PCB congener identification in products • Presentations for paper recyclers to meet WQS • iPCB Workshop	• New purchasing specifications for yellow road paints with lower levels of iPCBs	• Preferred purchasing rules in WA

EPA ORD CEMM's Research

- Identify iPCB concentrations in consumer products mainly used by children, or commonly found in school or daycare settings
- Determine iPCB emissions from a product to air
- Investigate iPCB migration from a product to house dust

Source Characterization

- Tested 39 Products
  - Agilent GC/MS
  - 5 sets of calibration mixtures covering all 209 congeners
  - Analytical recovery, method precision and instrument detection limit
- Compared Extraction Methods
  - Sonication vs. soxhlet extraction
  - Hexane vs. methylene chloride ($MeCl_2$)
  - Extraction recovery check
- Evaluated Variability of PCBs across one sample type – yellow glitter foam sheets

Products Tested

Modeling Dough

Art Paint

Finger Paint

Crayons

Art Chalk

Wafers Box

Sidewalk Chalk

Chalk Paint

Glue Sticks

Foam Sheet

Glitter Foam Sheet

Sidewalk Paint Powder

Cereal Box

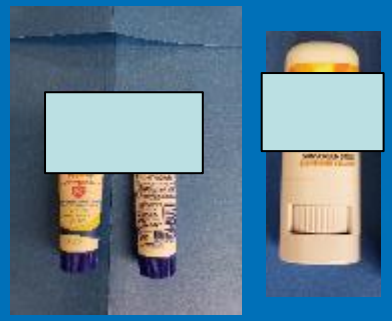
Cereal Box

Protein Bar Box

Cereal Bag

Glitter Foam Sheet

Products Tested



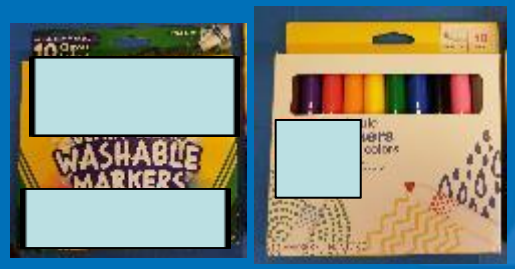
Sunscreen

Baby Lotion

Fabric Dye

Egg Dye

Bubble Bath



Washable Marker

Bath Drop/Tablets

Construction Paper

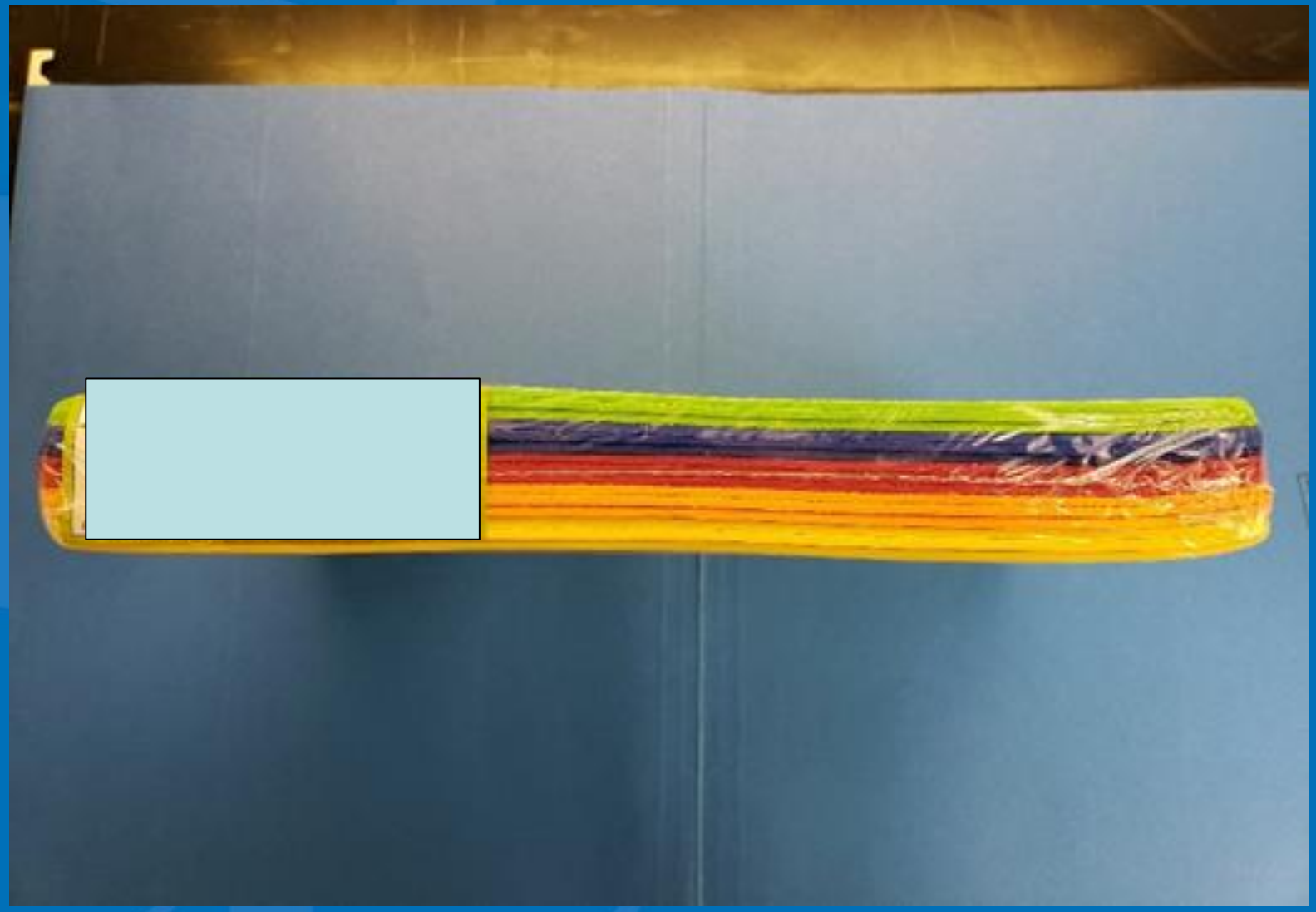
Pencils

Dry Eraser Marker

Finger Paint

Variability Evaluation

- Yellow Glitter Foam Sheets
- 5 packages tested
- 3 yellow sheets per package
- Samples 1-3, 4-6, 7-9 from different sheets in the same package, respectively
- Samples 10 to 13 from sheet #2 of each package



iPCB Emissions from a Product to Air

Micro Chamber Emission Tests

- Yellow Glitter Foam Sheets
- Duplicate tests
  - Micro chamber size 114 mL
  - 40° C/104º F;
  - %RH = 27.8;
  - Air flow 102 mL/min,
  - Air change rate 53 h^{-1}

iPCB Migration from a Product to House Dust

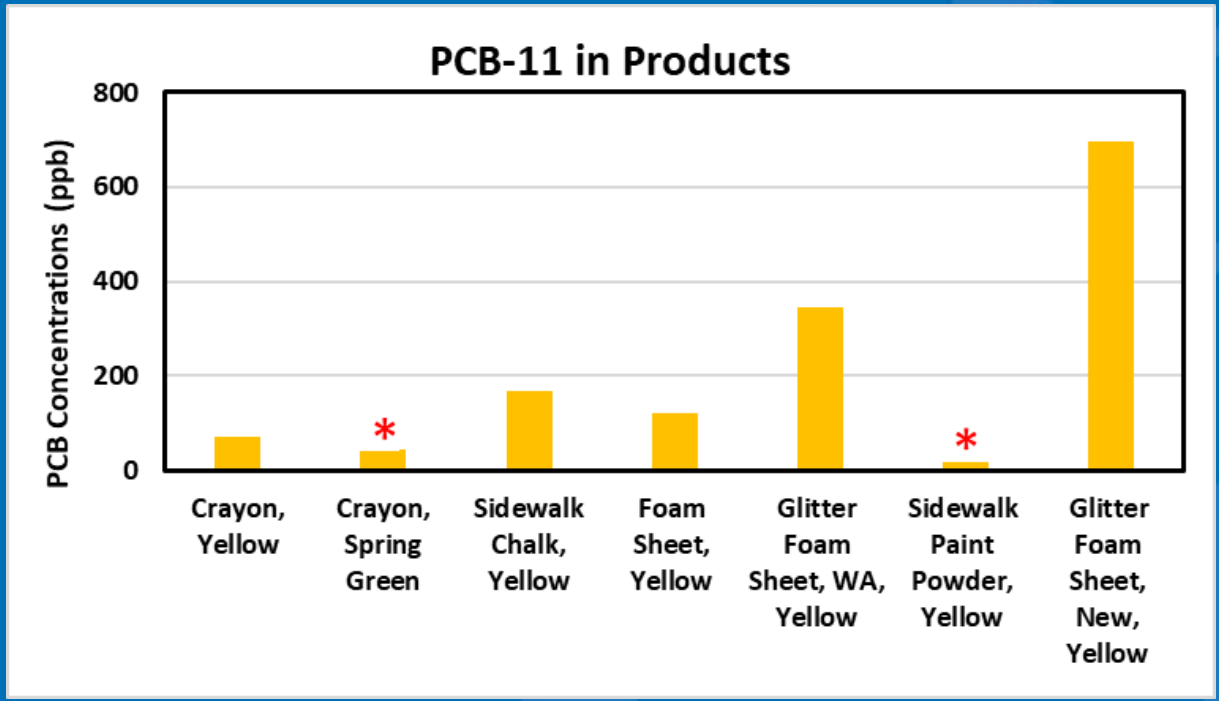
- Tested both sides and PCB-free release paper
- Small chamber size 53 L
- Typical indoor air conditions
  - 23˚ C/ 73.4ºF
  - 47.6 %RH
  - air change rate 1 h^{-1}

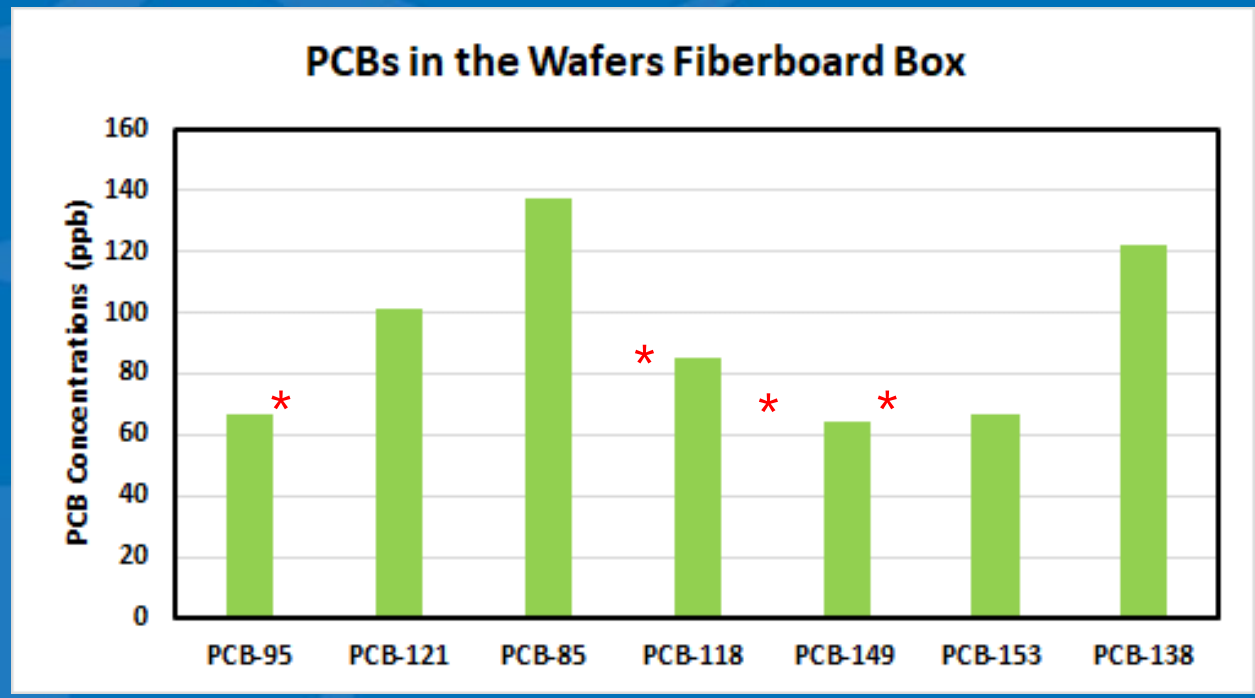
iPCB Migration from Product to House Dust

- 6+1 samples loaded with ~0.17 g of dust each
  - Collected one sample at each sampling time with one duplicate at 576 hours
- 3 samples were loaded with different amounts of dust: 0.2, 0.3, and 0.4 g, respectively
  - Collected at the end of the test along with the last of the 6+1 samples
  - 4 samples together to investigate how the dust loading affects the migration

Results – iPCB in Products

Concentrations (Average of duplicates)

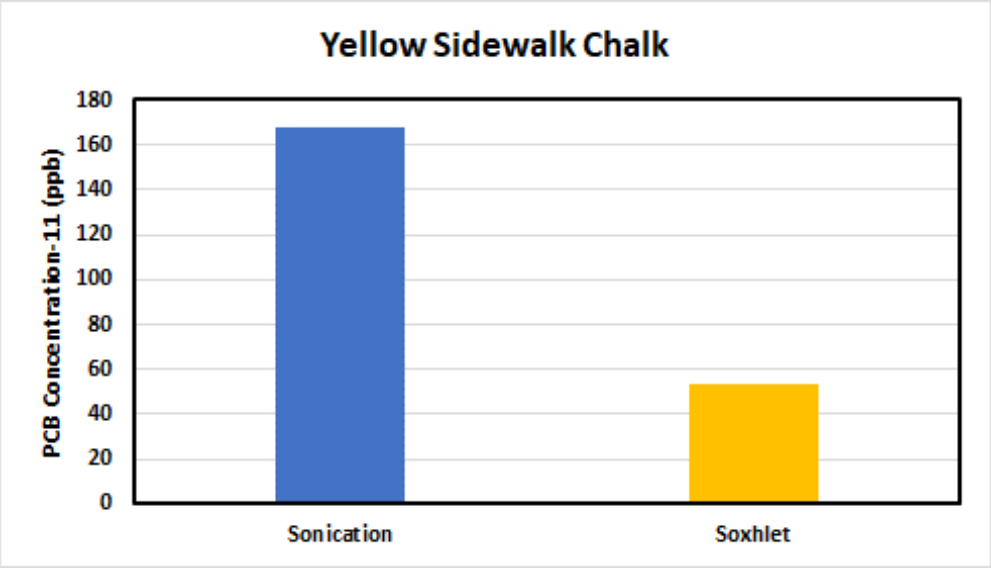


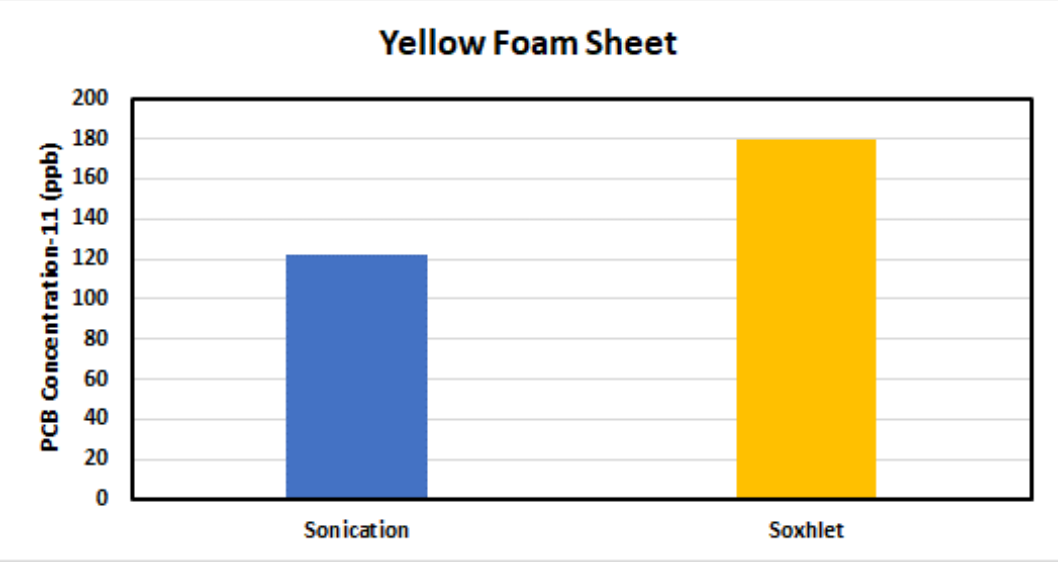


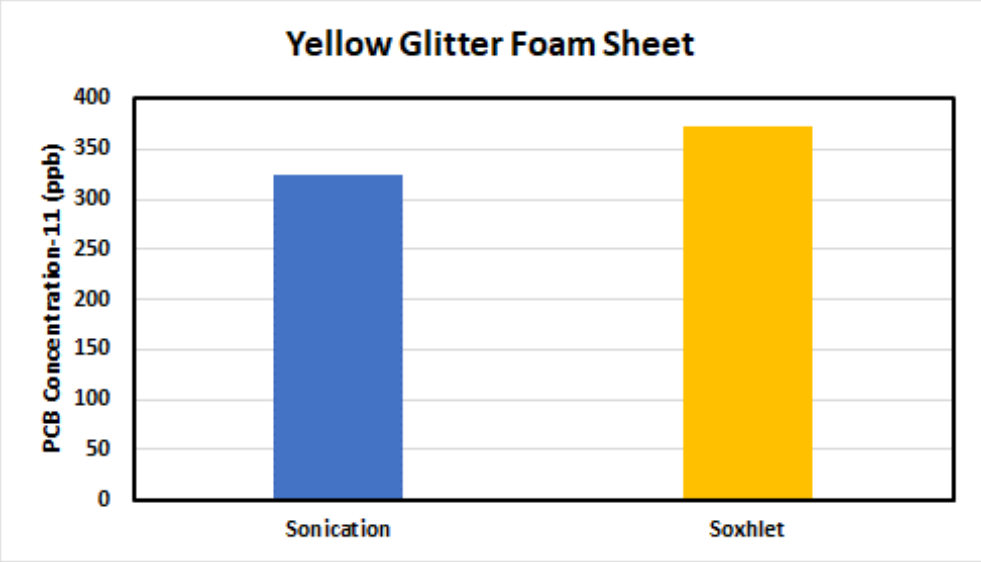
* Concentration below the lowest calibration but above the instrument detection limit

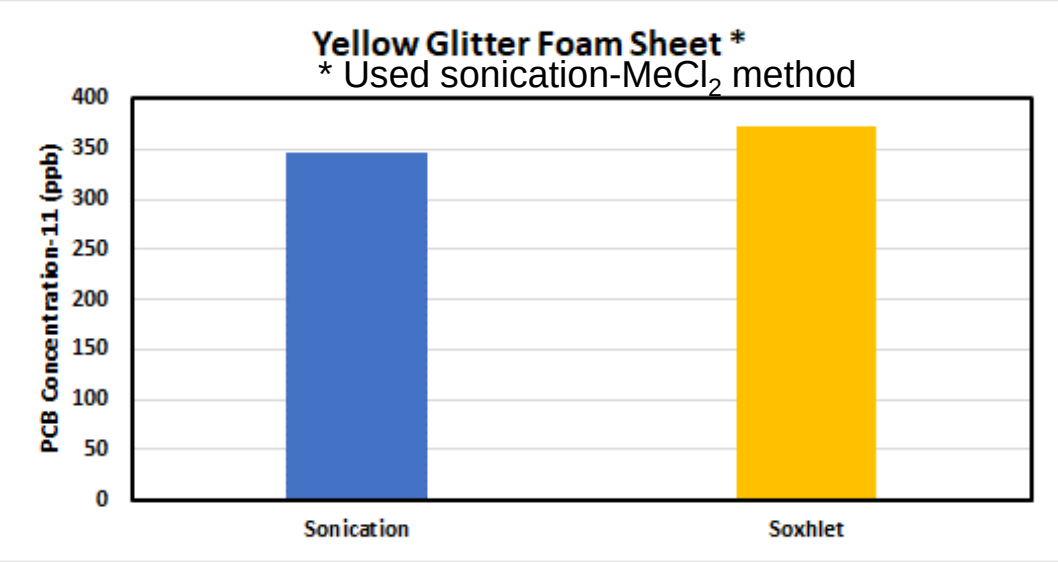
Results – Extraction Evaluation

Soxhlet-$MeCl_2$ vs. Sonication-Hexane



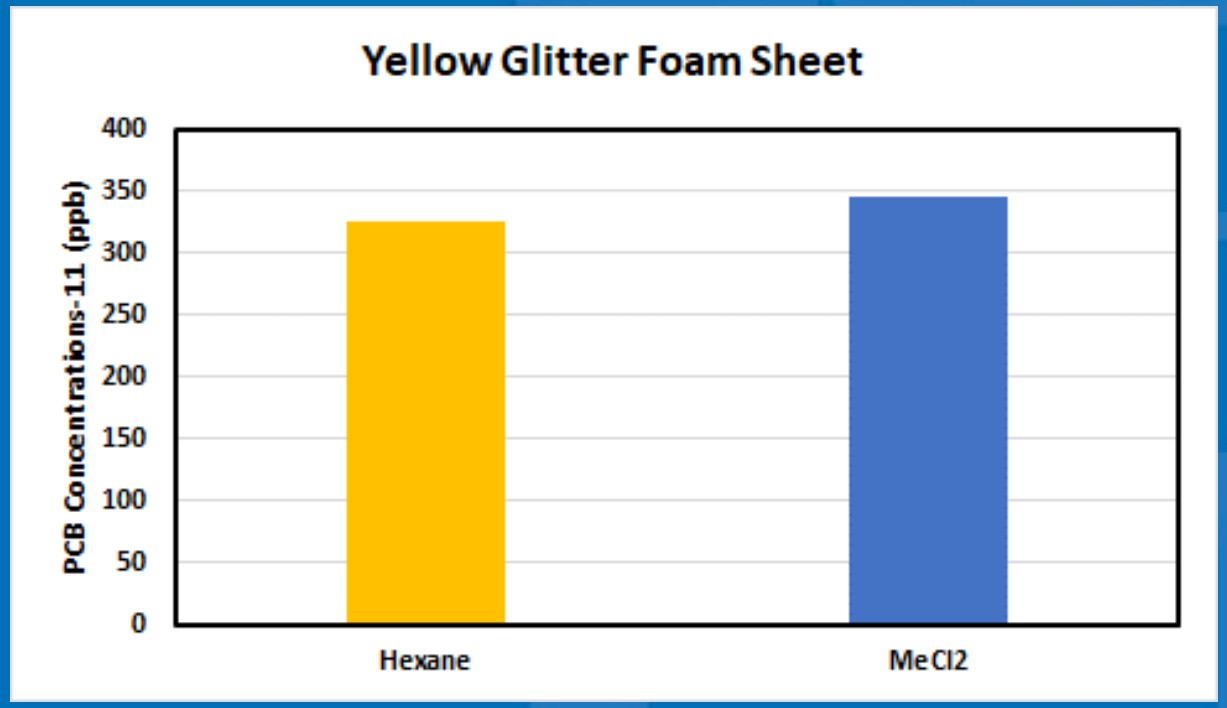


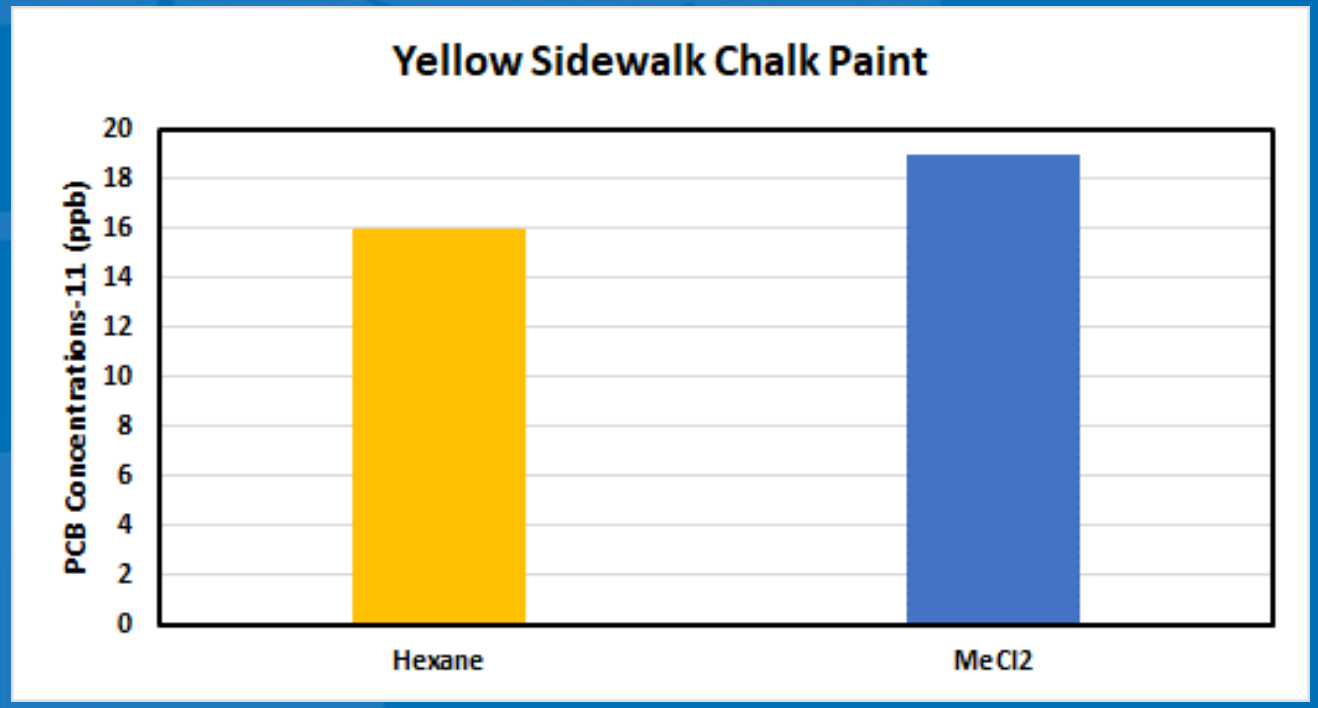




Results – Extraction Evaluation

Sonication (Hexane vs. $MeCl_2$)





Results – Variability

- Tested 13 yellow glitter foam sheets from 5 packages

  662 ppb ± 116 (SD), %RSD= 18

- Within packages (3 sheets in a package, tested 3 packages)

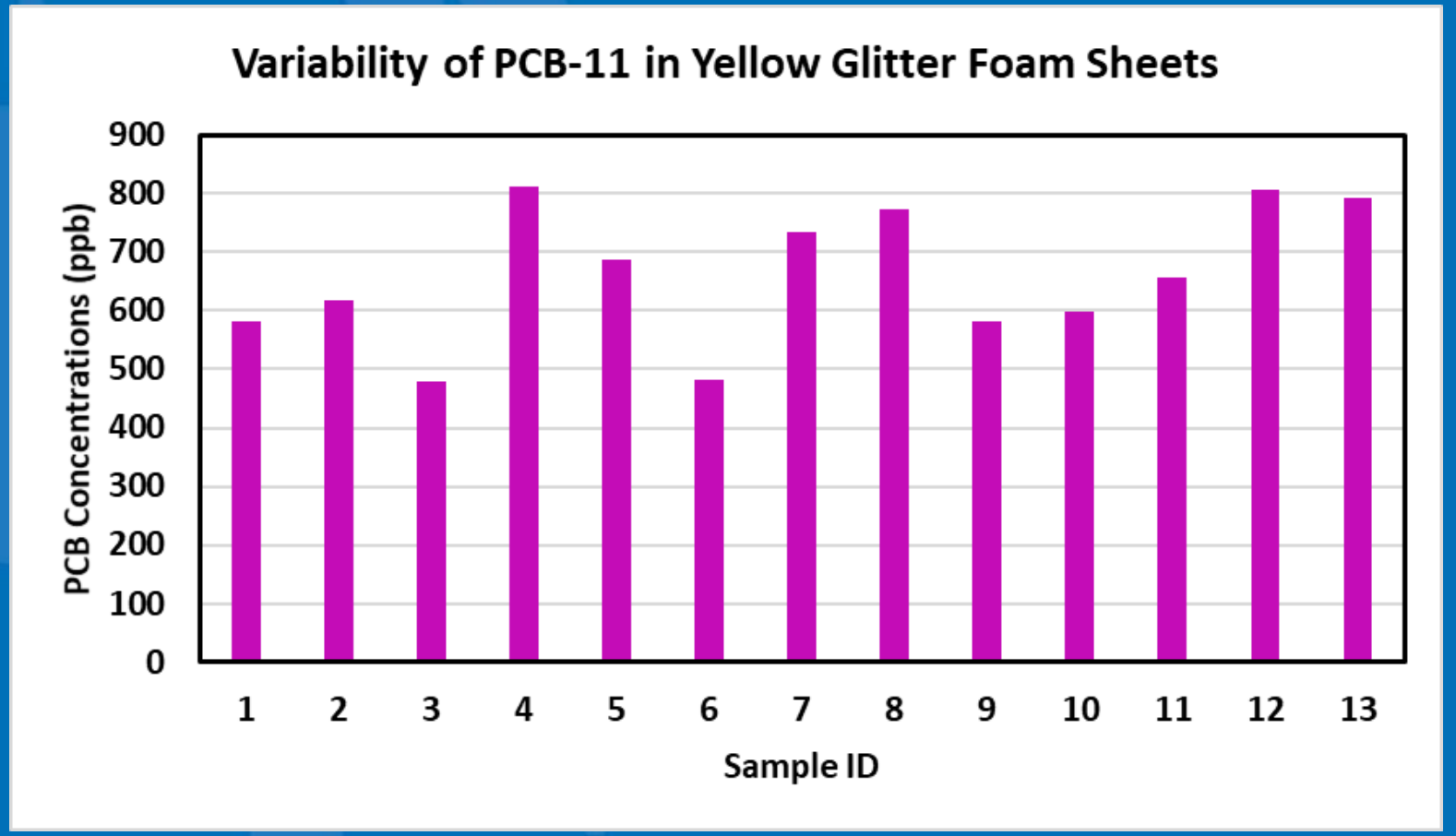
  560 ppb ± 72 (SD), %RSD= 13

  660 ppb ± 166 (SD), %RSD = 25

  751 ppb ± 83 (SD), %RSD = 12

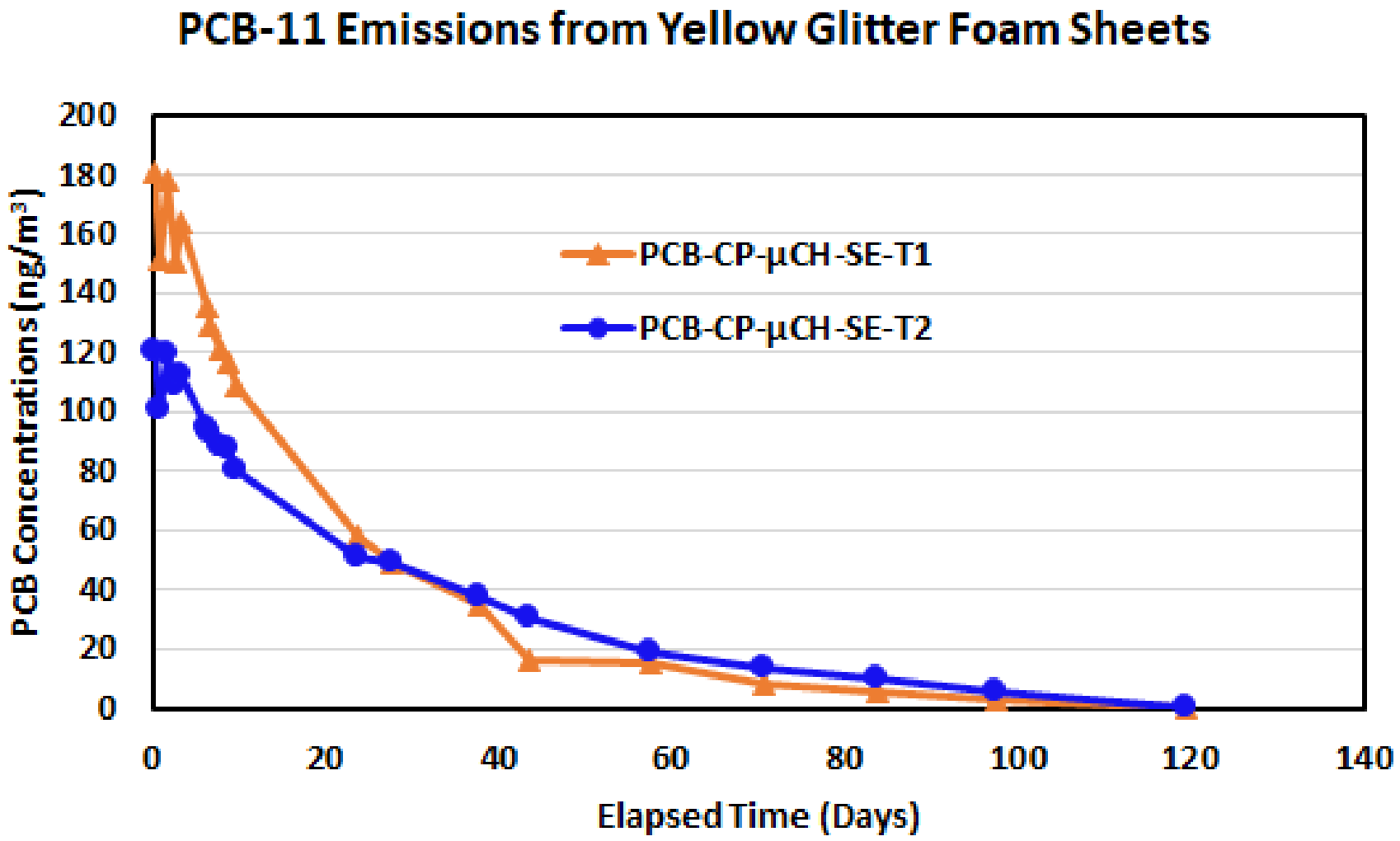
- All #2 sheets in 7 different packages

  704 ppb ± 86 (SD), %RSD = 12



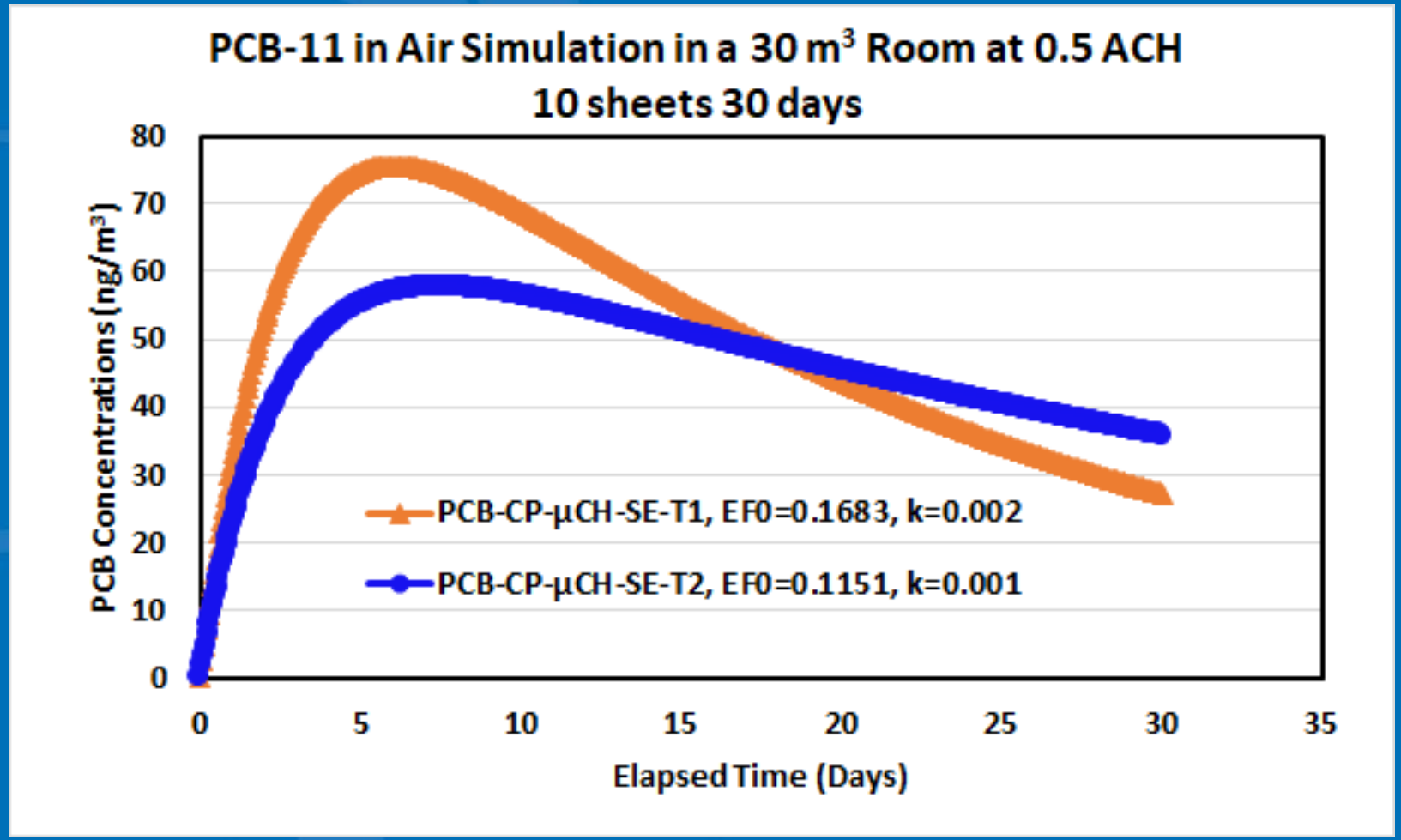
Results – Emissions from a Product to Air

- Concentration reached peak within the first 2 days
- After ~20 days the decay rate slowed.
- Emissions continued for ~120 days or just over 4 months. EPA estimates children are in school 180-185 school days over ~9 months



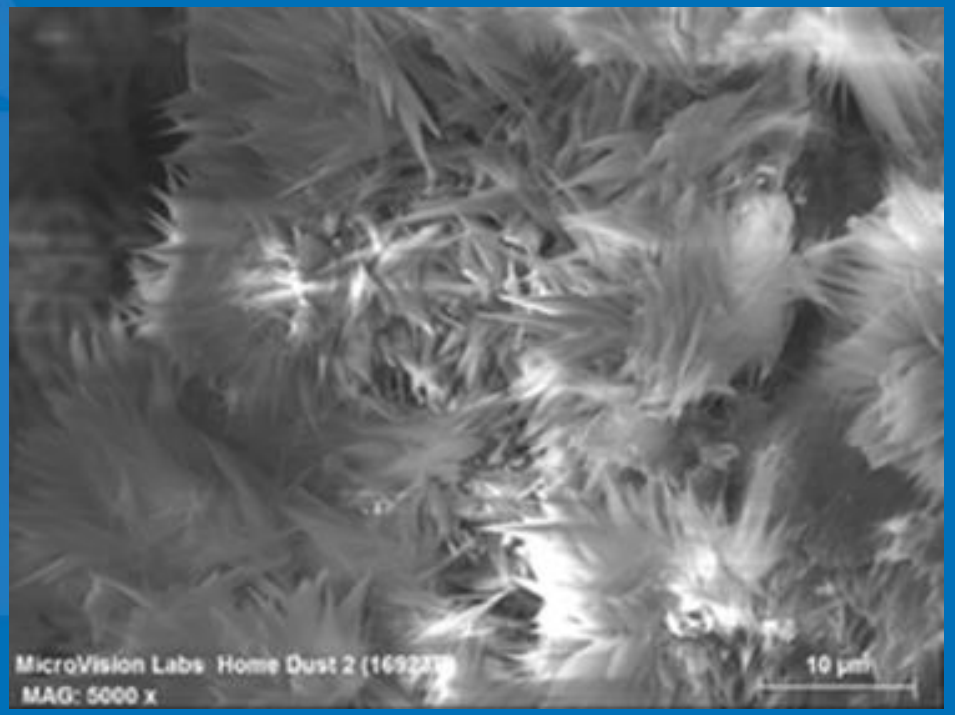
Emissions Simulation Update

- IAQX (Simulation Tool Kit For Indoor Air Quality And Inhalation Exposure, EPA ORD)
- First order decay at 40° C/ 104° F (ASTMD5116-17 Equation (15) $EF=(EF_0)e^{-kt}$)
- No sink effect in the room
- Room size, 30 m^3
- 1 full sheet 13.9 cm x 21.5 cm, 10 sheets
- Air concentration Co = 0
- Source remove time, 1000 hours
- Simulation time, 30 days, 720 hours



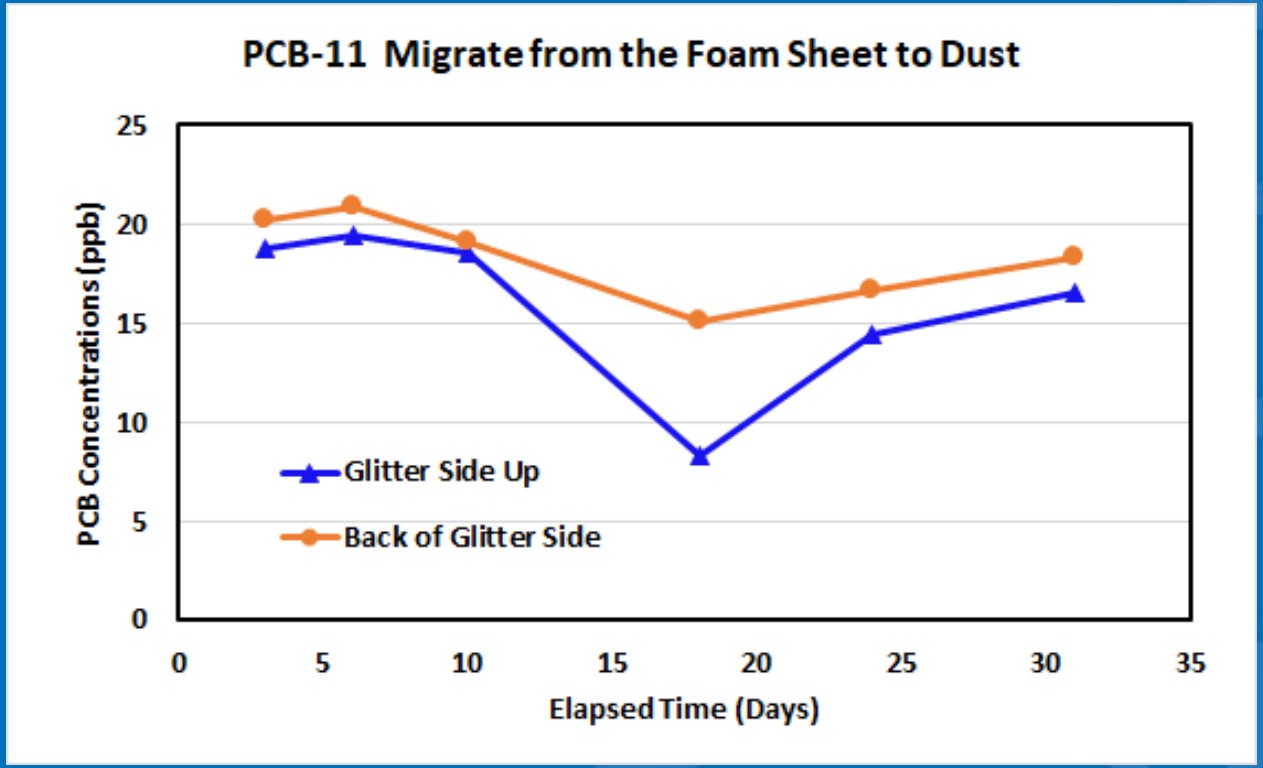
Results – Dust Properties

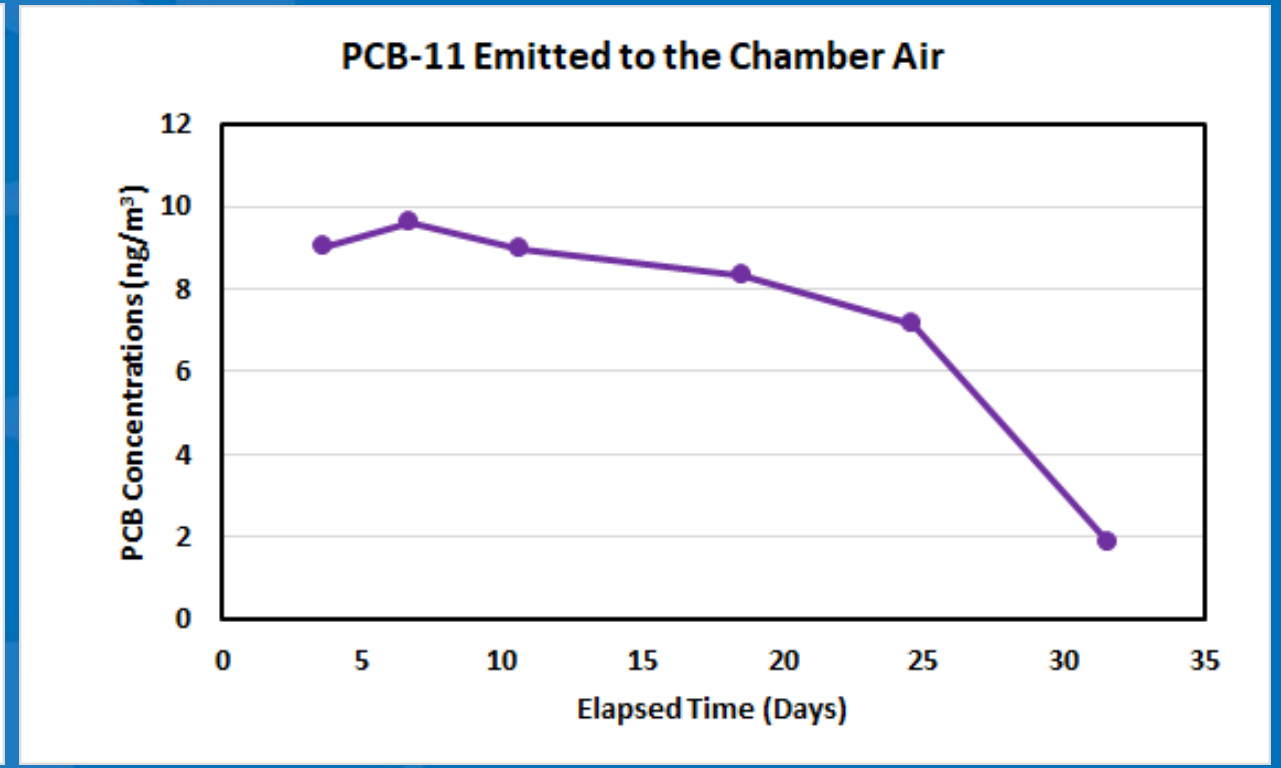
Property	HD2
Weight by volume, g/mL [a]	0.938 ± 0.008
Surface area, m^2/g [b, c]	3.599 ± 0.017
Particle size — mean, µm [b, d]	67.882 ± 0.209
Particle size — range, µm [b, e]	0.922 to 260
Total carbon, % (w/w) [f]	20.83 ± 0.48 [f]
Organic carbon, % (w/w) [f]	20.11 ± 0.56 [f]



a Arithmetic mean ± standard deviation (SD) (n = 2); measured at room temperature by gravimetric method.
b Analyzed by Micromeritics Analytical Services.
c Arithmetic mean ± SD (n = 2); method: Brunauer-Emmett-Teller (BET) method with N2.
d Weighted mean value ± SD (n = 2); method: light scattering (ISO 13320).
e Method: light scattering (ISO 13320).
f Arithmetic mean ± SD (n = 4); method: NIOSH 5040.

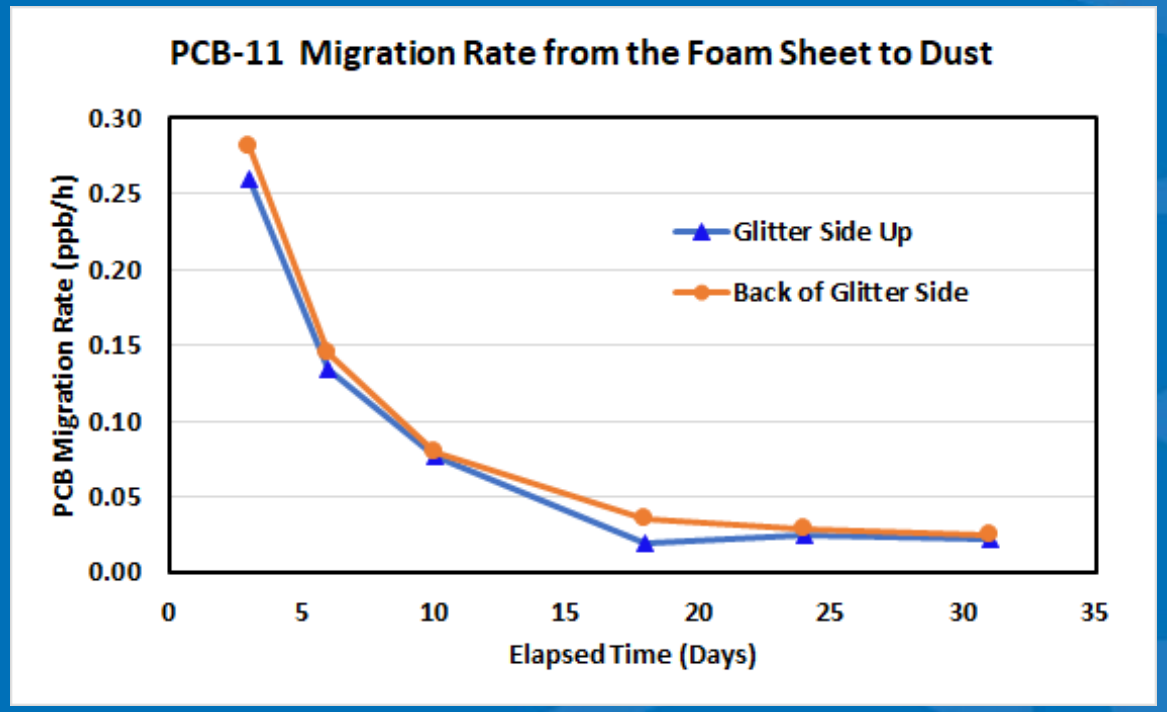
Results – Migration from a Product to House Dust

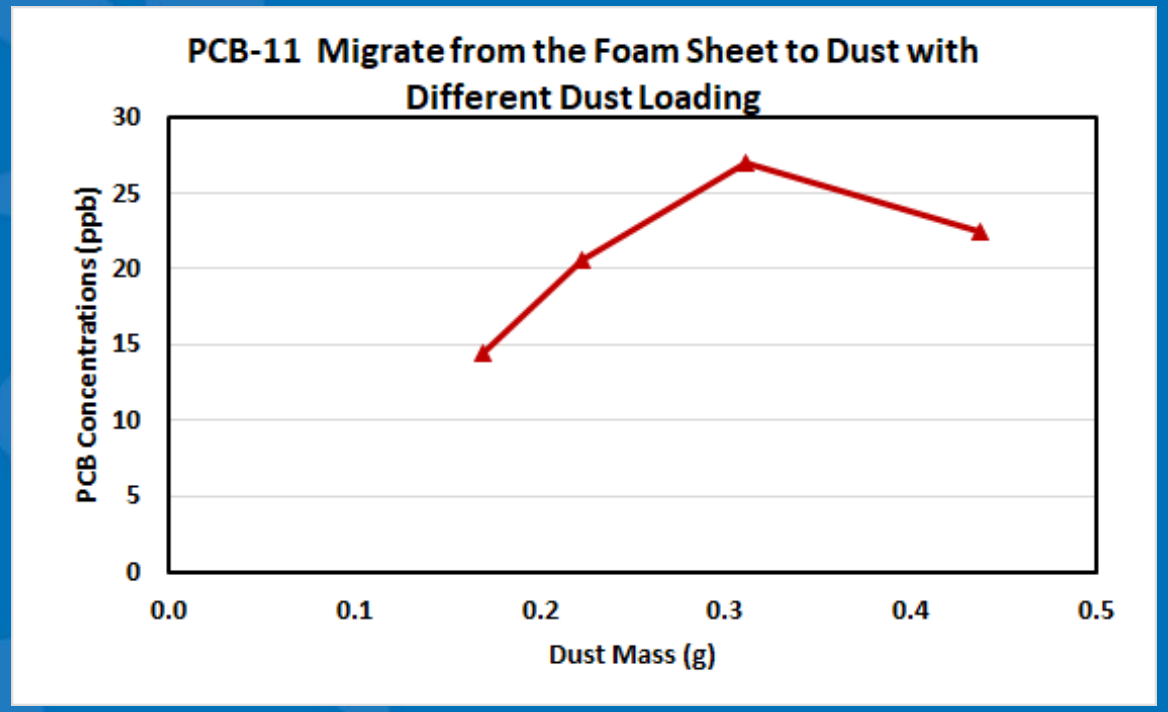




- iPCBs migrated from both sides of the foam to dust ~20-15 ppb
- iPCBs emitted from foam to air ~9 ng/m^3 at the beginning and then dropped because the iPCB source foam sheets were removed

Results – Migration from Product to House Dust





- The rate of migration quickly decreased over the first ~17 days and then stabilized
- The amount of dust appears to have a direct correlation to the concentration of PCBs in the dust.

Major Findings

- 8 out of 39 products detected iPCBs up to ~660 ppb
- PCB-11 was the most frequently detected congener across products
- Sonication-$MeCl_2$ extraction method is better in practice
- **There is variation** of iPCB concentrations in a single product within the same package and between different packages
- **iPCB emits from the source to the air,** and the air concentration in a room can be estimated
- **iPCBs migrate from the source into the dust**
- Dust adsorbs iPCBs at a much faster rate through direct contact with a source than its emission to the air from the source
- Air emissions continued from the product **for about 120 days or just about 4 months.** EPA estimates children are in school 180-185 school days over ~9 months

New Research Questions

- What is the cumulative emissions to air and migration to dust from multiple products?
- What is the cumulative exposure from breathing air with emissions from multiple products and dust, and from other exposure routes on multiple products such as hand-to-mouth activities, breathing suspended particles, etc.)
- What are the appropriate inputs to simulate indoor air quality and inhalation exposure?
- Is there an opportunity to refine Best Management Practices for reducing exposure to PCBs in schools?

Future Research Needed

- Continue testing additional products with the potential to impact children's health
- Evaluate other potential human exposure pathways
  - Dermal exposure
  - Oral exposure
  - Leaching to water
  - Migration to saliva
  - Sweat
- Conduct exposure and risk assessments
- Conduct toxicity assessments of individual congeners

Reducing iPCBs through Pollution Prevention

- Inclusion of safe colorants without iPCBs in Small Business Innovation Research Program 2021 and 2022 solicitations.
  - NanoSonic, Inc won Phase I funding in 2021 for their research on PCB-free colorants for textiles
- An EPA P2 grant funded a roundtable of state, local, industry, and non-profit representatives from various parts of the supply chain to discuss opportunities to reduce iPCBs in printed paper and packaging through innovation.
- P2 30th Anniversary Case Study: "Reducing Inadvertently Generated PCBs Through Pollution Prevention"

Outreach

- Presented research findings
  - Internationally at the ISES-ISIAQ 2019
  - Nationally to the EPA Children's Health Program
  - Locally to the SRRTTF

- New EPA Inadvertent PCB Webpage

Best Management Practices to Reduce Exposure

https://www.epa.gov/sites/default/files/2016-03/documents/practical_actions_for_reducing_exposure_to_pcbs_in_schools_and_other_buildings.pdf

- ✓Ensure that ventilation systems are operating properly and are regularly inspected and maintained according to system manufacturer instructions and guidelines or ANSI/ ASHRAE/ACCA Standard 180-2012.
- ✓If system cleaning is needed, follow ANSI/ACCA Standard 6.
- ✓Clean inside schools and other buildings frequently to reduce dust and residue.
- ✓Use a wet or damp cloth or mop to clean surfaces.
- ✓Use vacuums with high efficiency particulate air (HEPA) filters.
- ✓Do not sweep with dry brooms or use dry cloths for dusting.
- ✓Wash hands with soap and water, particularly before eating.
- ✓Wash children's toys.
- ✓For EPA's general school cleaning recommendations, visit: http://www.epa.gov/iaq/schools/ clean_maintenance.html.

Disclaimer

This presentation has been reviewed in accordance with U.S. EPA policy and approved for presentation. The views expressed are those of the author and do not necessarily represent the views and policies of the agency. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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We also thank the Region 10 RCRA Program, Region 10 Children's Health Program, Region 10 RARE Program, and EPA HQ ORCR for funding.

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Thank You !

Images from the U.S. EPA Facility in Research Triangle Park, NC