

PCBs in Schools



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Presentation Topics

About PCBs

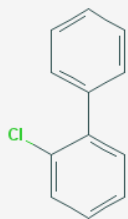
Research highlights for:

- Sources of PCBs in school buildings
- Environmental levels of PCBs in schools
- Potential exposures to PCBs in schools

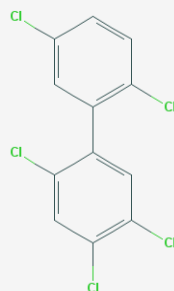
About PCBs

Polychlorinated Biphenyls (PCBs)

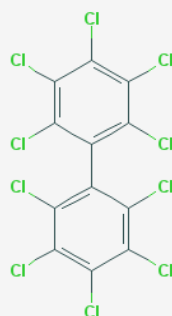
209 possible PCB congeners



PCB 1



PCB 101

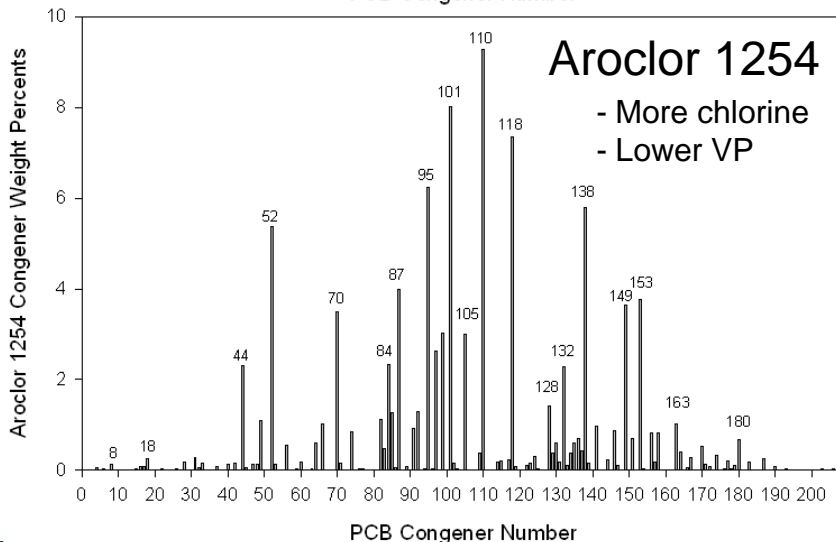
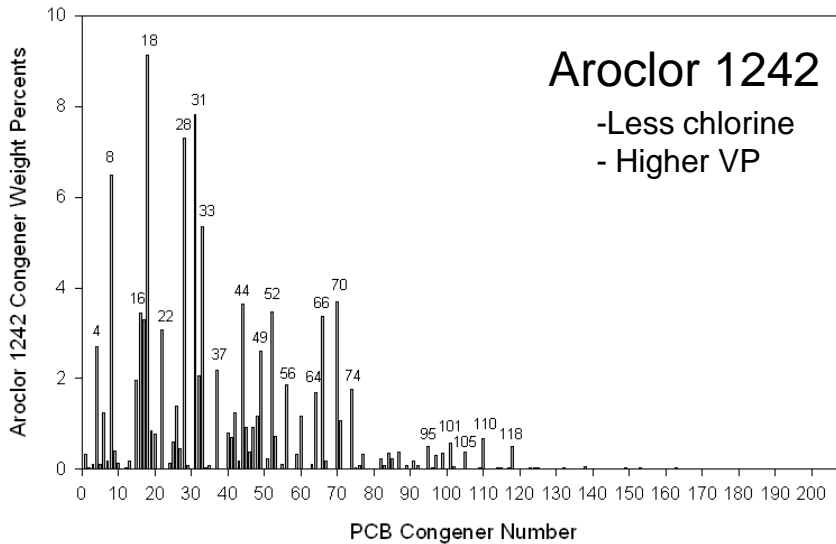


PCB 209

- PCBs are comprised of many similar semi-volatile organic chemicals called “**congeners**”
- PCBs were manufactured in the U.S. as mixtures of congeners from approx. 1929 to 1977
- “**Aroclor**” mixtures had the highest U.S. production

| Common Aroclors | Chlorine Weight % | Number of Congeners |
|---------------------|-------------------|---------------------|
| Aroclor 1221 | 21% | 60+ |
| Aroclor 1232 | 32% | 90+ |
| Aroclor 1016 | 41% | 70+ |
| Aroclor 1242 | 42% | 90+ |
| Aroclor 1248 | 48% | 95+ |
| Aroclor 1254 | 54% | 95+ |
| Aroclor 1260 | 60% | 90+ |
| Aroclor 1262 | 62% | 90+ |

PCB Congeners in Aroclor Mixtures



- >90 PCB congeners in these Aroclor mixtures
- Aroclor 1242 (or similar Aroclor 1016) often found in light ballast capacitors
- Aroclor 1254 often found in caulk
- Differences in amount of chlorine and vapor pressures

PCB Properties

- Electrical insulation
- Flame-resistance
- Plasticizer
- Chemical stability
- Durability

Useful for
many
applications

- Persistent in the environment
- Can vaporize and migrate
- Persistent in people
- Toxic effects

Implications
for human
exposure

PCBs in School Buildings

Possible Uses/Sources

**For schools built or renovated from about 1950 to 1979
(potentially >50% of U.S. public school buildings)**

Could be or have been in buildings

- Motor and hydraulic oil
- Electrical device capacitors
- Adhesives and tapes
- Carbonless copy paper
- Paints, coatings and inks
- Floor finish
- Microscope oil

Have been found in schools

- Fluorescent light ballasts
- Caulk
- Window glazing
- Joint sealant
- Ceiling tile coatings
- Spray-on fireproofing material
- Paints

Research Highlights

- Primary Sources of PCBs in Schools
- Secondary Sources of PCBs
- PCB Levels in School Environment
- PCB Exposure Estimation from Models

Research Objectives



Characterize primary and secondary sources of PCBs in school buildings

Characterize levels of PCBs in air, dust, soil and on surfaces; investigate relationships between sources and environmental levels

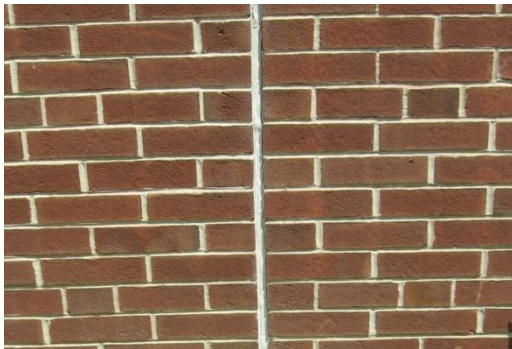
Apply an exposure model for estimating children's exposures to PCBs in schools

Evaluate which routes of exposure are likely to be the most important

Research Approach

- Source assessment
 - Primary sources – caulk and light ballasts (6 schools)
 - Secondary sources – paint, tile, furnishings, etc. (3 schools)
 - Emission rate estimation
- Environmental levels (6 schools except dust)
 - Air, surface, dust, soil PCB concentrations
 - Within and between-school variability
- Congener and homolog measurements for one school
- Exposure modeling
 - Estimate PCB exposure distributions for different age groups
 - Assess relative importance of different exposure pathways

PCB Sources – Caulk and Other Sealants



- U.S. Production of Aroclors as a plasticizer ingredient
 - 1958 - 4 million lbs.
 - 1969 - 19 million lbs.
 - 1971 – 0 lbs.
- PCBs were sometimes added to caulk during construction
- Used for
 - Exterior and interior windows and doors
 - Exterior and interior joints
 - Window glazing
 - Other locations/seams (plumbing, casework, etc.)
- Caulk with PCBs \geq 50 parts per million (ppm) is not an allowed use

PCB Sources – Caulk and Other Sealants



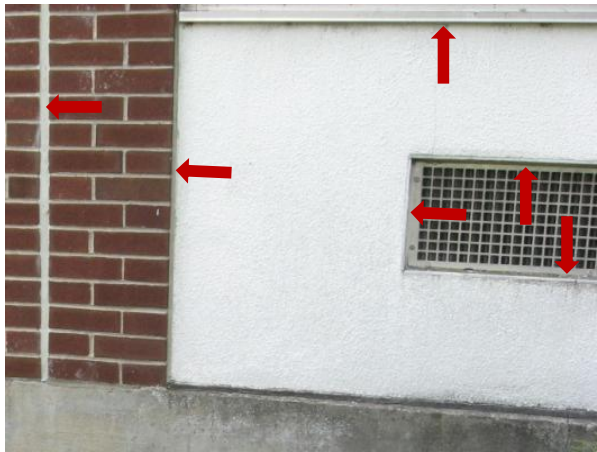
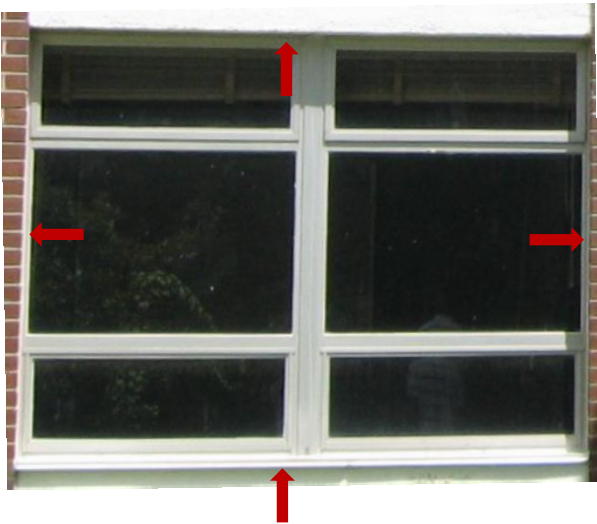
➤ School caulk measurements:

- 18% of 427 interior caulk/sealant samples >50 ppm PCBs
- 6% of interior samples >100,000 ppm (10% by weight)
- 63% of 73 exterior caulk/sealant samples >50 ppm PCBs
- 34% of exterior samples >100,000 ppm
- Highest level was 440,000 ppm PCBs (44% by weight)

➤ We have found that caulk with high PCB levels is usually still flexible and often largely intact

➤ Visual identification of caulk with PCBs is not reliable

PCB Sources – Caulk and Other Sealants



- PCBs in caulk/sealants move over time into:
 - Adjoining wood, cement, brick
 - Air and dust inside schools
 - Soil near school buildings
 - Other materials/furnishings
- Emissions of PCBs into the air can be quite substantial
 - Emissions can create indoor air levels above recommended concentrations
 - As the temperature increases, emissions increase
 - Ventilation is an important factor
- Although installed 40 – 60 years ago, high PCB levels remain and emissions will continue far into the future
- Other PCB sources, like coatings and paints, will act much like caulk in releasing PCBs into the environment

PCB Sources – Fluorescent Light Ballasts



- Fluorescent and high intensity light ballast capacitors
 - Prior to 1977 - Most contained PCBs
 - 1977 – 1978 - Some new ballasts contained PCBs
 - After 1978 - No new ballasts manufactured w PCBs
- Some PCB-containing ballasts remain in place
 - In several schools, 24% - 95% of the light ballasts likely contained PCBs
- Most PCB-containing ballasts have exceeded their expected lifetimes
- Failure and release of PCBs will continue and may increase

PCB Sources – Fluorescent Light Ballasts



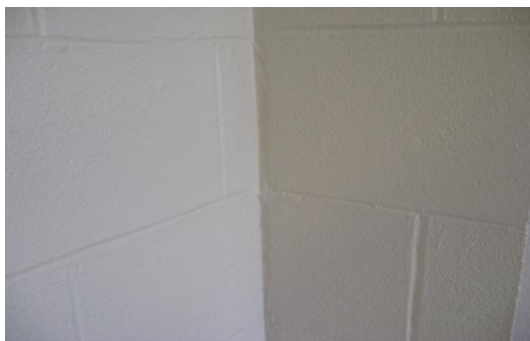
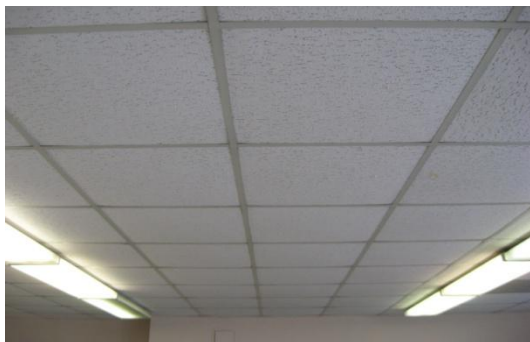
- PCBs are continuously released into the air from intact, functioning light ballasts
 - When lights are off, emissions are low
 - When lights are on, the ballast heats up, and emissions increase several-fold
- PCB ballasts can fail, releasing PCB vapors into the air and liquid PCBs onto surfaces
 - Air levels of PCBs can become quite large
 - Surfaces can be contaminated
 - Significant impact/costs to remediate
- Residues from previously failed ballasts can remain in light fixtures even if the ballast is replaced

PCB Sources – Secondary Sources/Sinks



- PCBs released from primary sources are absorbed into other materials in the school environment over time
- Following removal of primary sources, PCBs in secondary sources may be released into the school environment and result in continuing exposures
- In some cases, secondary sources may need to be considered for additional remedial actions following removal/remediation of primary sources

PCB Sources – Secondary Sources/Sinks



- In three schools with caulk and fluorescent light ballast PCB sources, 93% of 411 building material samples had measurable levels of PCBs
- Examples of some median and maximum PCB levels in different materials:

| | | |
|----------------|---------|----------------|
| ▪ Paint | 39 ppm | (max. 720 ppm) |
| ▪ Fiberboard | 31 ppm | (max. 55 ppm) |
| ▪ Dust | 22 ppm | (max. 87 ppm) |
| ▪ Varnish | 11 ppm | (max. 62 ppm) |
| ▪ Ceiling tile | 7.6 ppm | (max. 14 ppm) |
| ▪ Laminate | 5.4 ppm | (max. 200 ppm) |
| ▪ Floor tile | 4.4 ppm | (max. 57 ppm) |
- Paint may be an important secondary source due to its high surface area
- Dust is important as a source of ingestion and inhalation exposures

PCB Levels in the School Environment

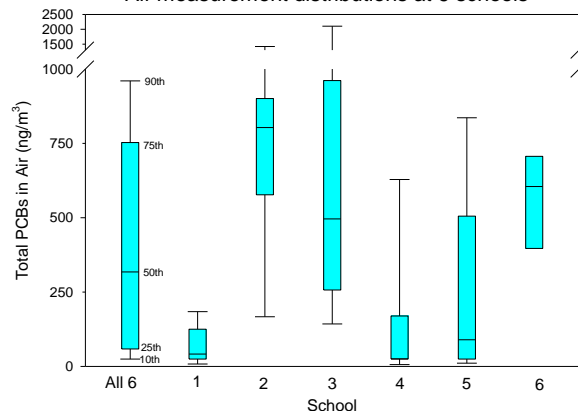
Summary of measurements from six schools

| Environmental Medium (units) | Total PCB Levels | | |
|---|------------------|-----------------------------|-------------|
| | Median | 75 th Percentile | Maximum |
| Indoor Air (ng/m ³) | 318 | 730 | 2920 |
| Indoor Surface Wipes (µg/100cm ²) | | | |
| High-contact surfaces (tables/desks) | 0.15 | 0.33 | 2.8 |
| Low-contact surfaces (floors/walls) | 0.20 | 0.42 | 2.3 |
| Indoor dust at one school (ppm) | 22 | 53 | 87 |
| Outdoor Soil (ppm) | | | |
| 0.5' from building; 0 – 2" soil depth | <QL | 2.1 | 210 |
| 3' from building; 0 – 2" soil depth | <QL | 0.55 | 21 |
| 8' from building; 0 – 2" soil depth | <QL | <QL | 5.3 |
| Outdoor Air (ng/m ³) | <QL | <QL | <QL |

QL = Quantifiable Limit

PCB Levels in the School Environment

Air measurement distributions at 6 schools



➤ Indoor Air

- PCB concentrations in air exceeded EPA-recommended levels in many school rooms
- There was considerable within- and between-school variability in indoor air concentrations

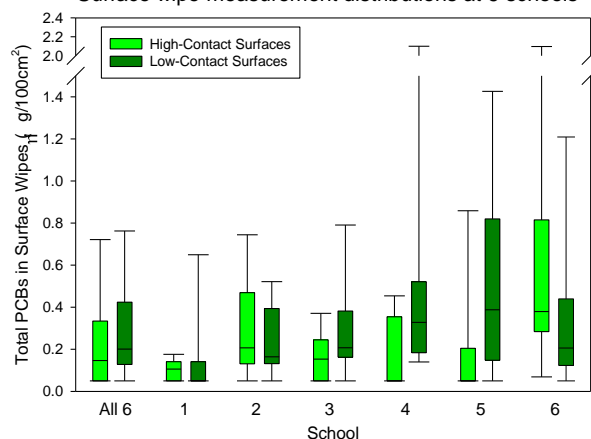
➤ Surface Wipes

- Most surface wipes were less than 1 $\mu\text{g}/100\text{cm}^2$
- There was considerable within- and between school variability in surface wipe levels

➤ Soil

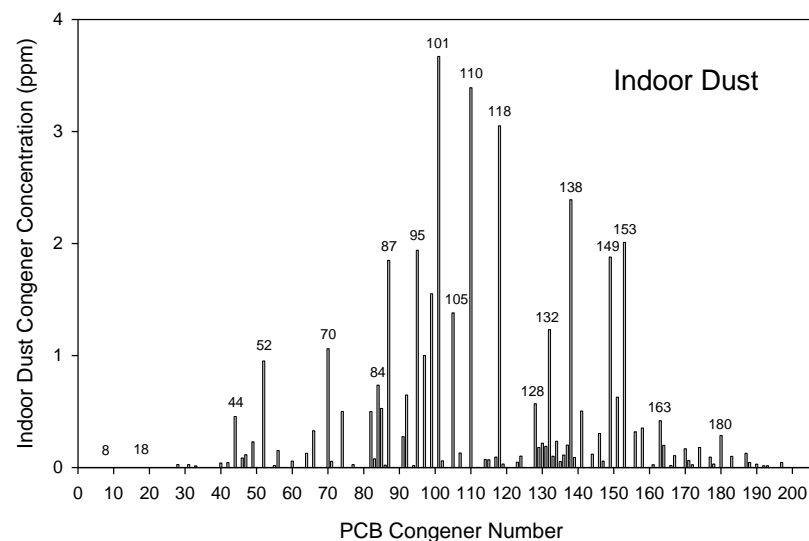
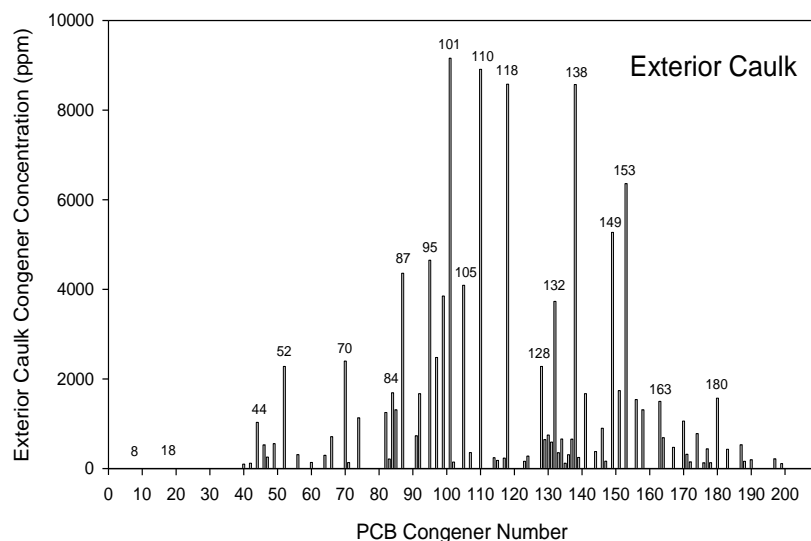
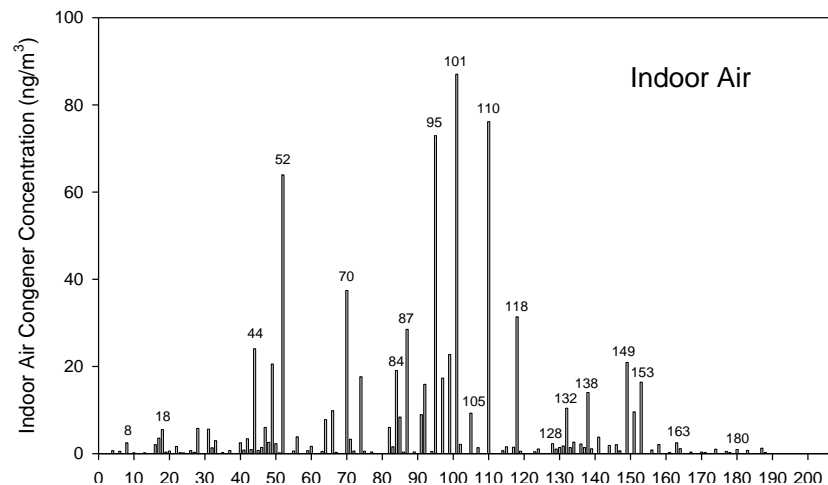
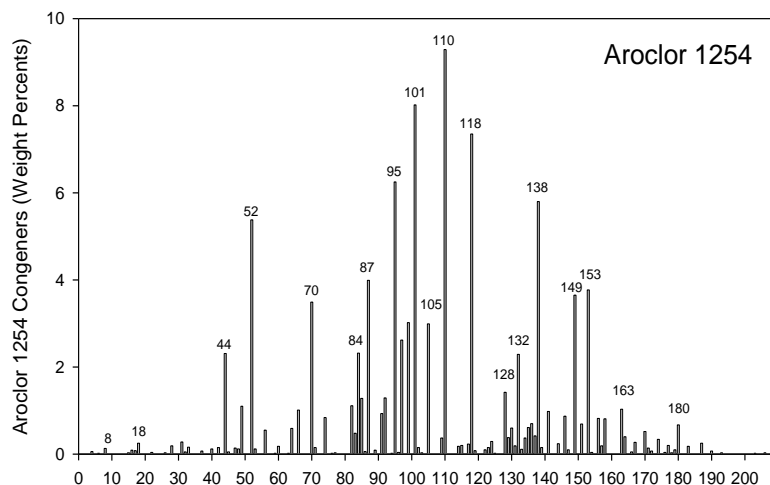
- Soil concentrations varied greatly between schools
- Some levels were greater than 1 ppm
- In general, levels decreased with increasing distance from buildings

Surface wipe measurement distributions at 6 schools



PCB Congener Concentrations & Patterns

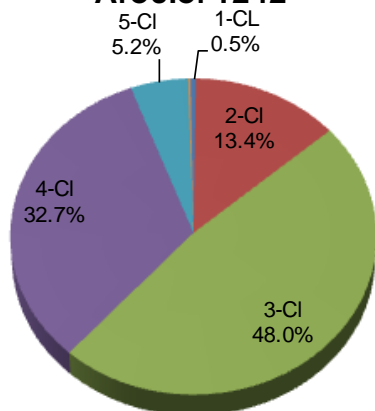
In One School with Congener Measurements



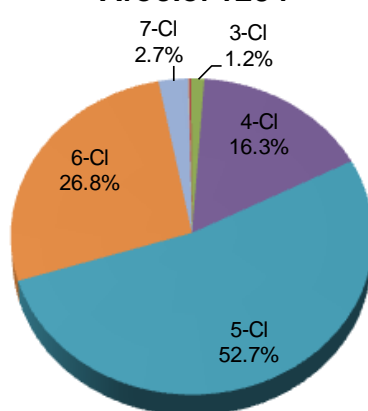
Homolog Patterns – Aroclors, Indoor Air, Caulk

In One School with Congener Measurements

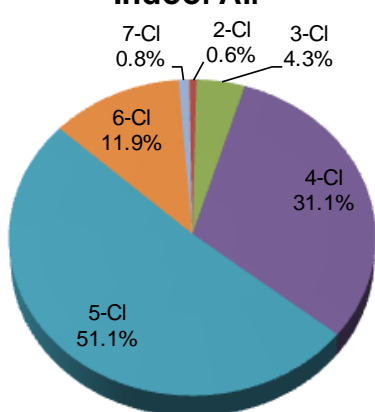
Aroclor 1242



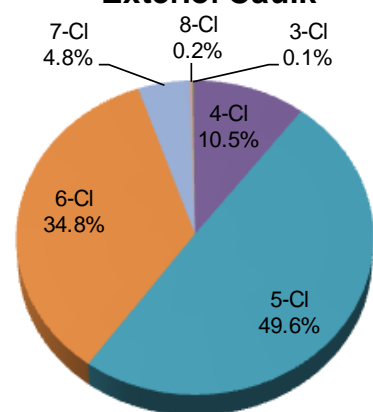
Aroclor 1254



Indoor Air



Exterior Caulk



Compared to A1254, air is weighted towards more volatile congeners

Compared to A1254, caulk is weighted towards less volatile congeners

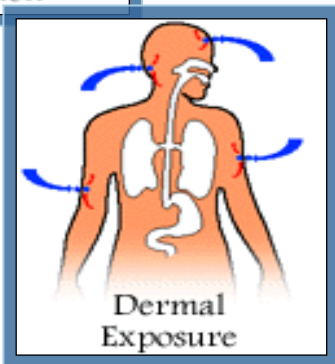
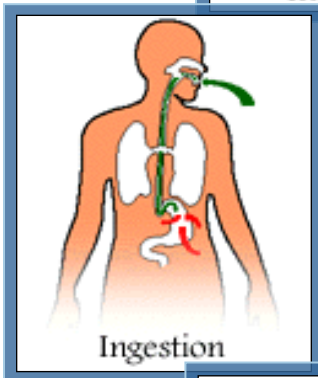
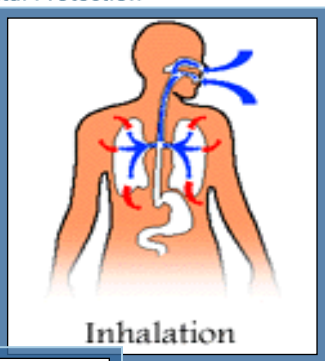
Air has higher levels of less volatile congeners than might be expected based on vapor emissions alone

May reflect air vapor + particle phase congeners

A1242 pattern is not reflected in these air samples

Aroclor measurements over-predicted concentrations

Exposures to PCBs in the School Environment



- Occupants in schools with interior PCB sources can be exposed to PCBs in the indoor air, dust, and on surfaces through their normal activities
- In school buildings with exterior PCB sources, exposures may occur through contact with contaminated soil
- Exposures can occur through inhalation, ingestion, and dermal contact



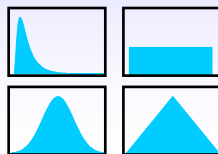
Figure from 2009 NIEHS L. Birnbaum presentation

Stochastic Human Exposure and Dose Simulation Model

Input Databases

- Human Activity
- Ambient Conc.
- Food Residues
- Recipe/Food Diary

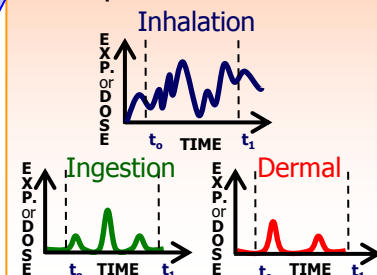
Exposure Factor Distributions



Algorithms

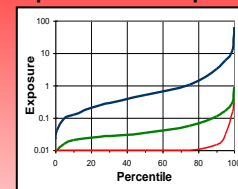


- Calculate Individual Exposure/Dose Profile

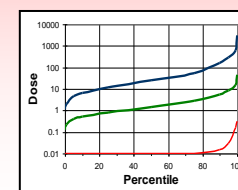


Output

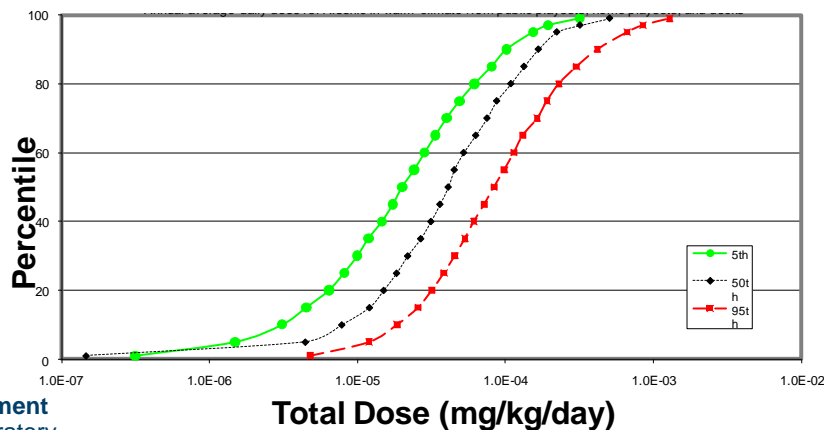
- Population Exposure



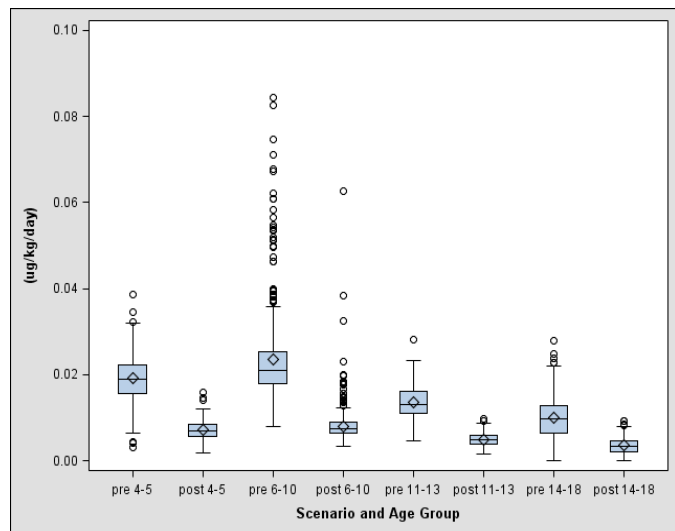
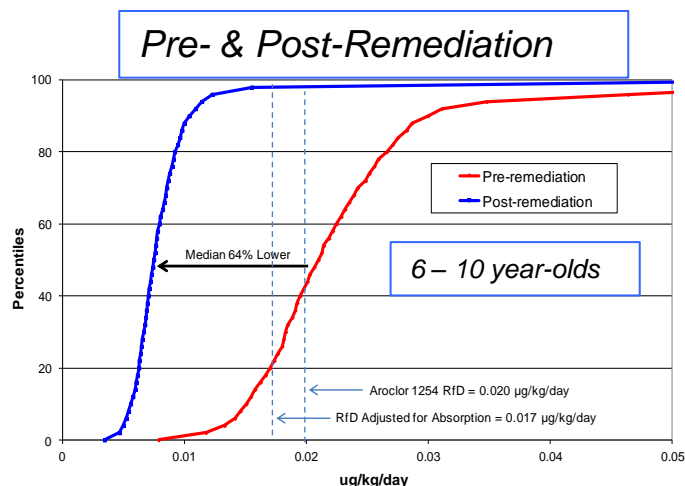
- Population Dose



Example Distributions of Estimated Doses



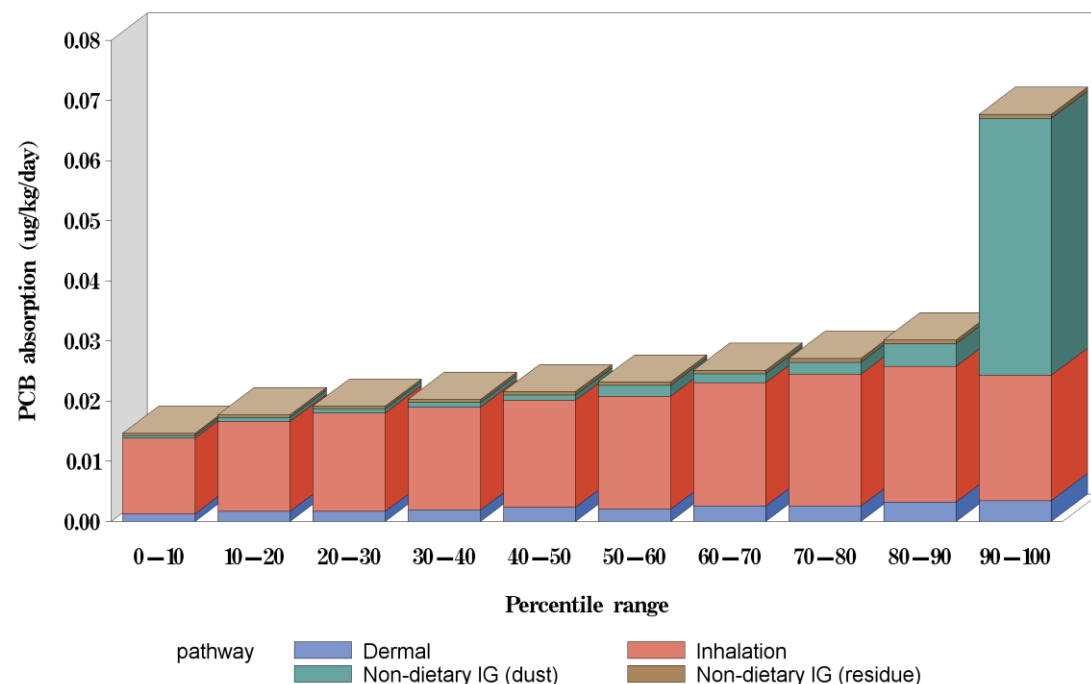
Exposures to PCBs in the School Environment



- An exposure model was used to estimate what exposures children might experience, using PCB levels measured across six schools
- Many children would be predicted to receive exposures above the EPA IRIS Reference Dose for Aroclor 1254
- With PCB levels measured following remediation efforts at several schools, most children would be predicted to receive exposures below the RfD
- *These exposure estimates do not include PCB exposures from diet or other sources away from school*

Exposures to PCBs in the School Environment

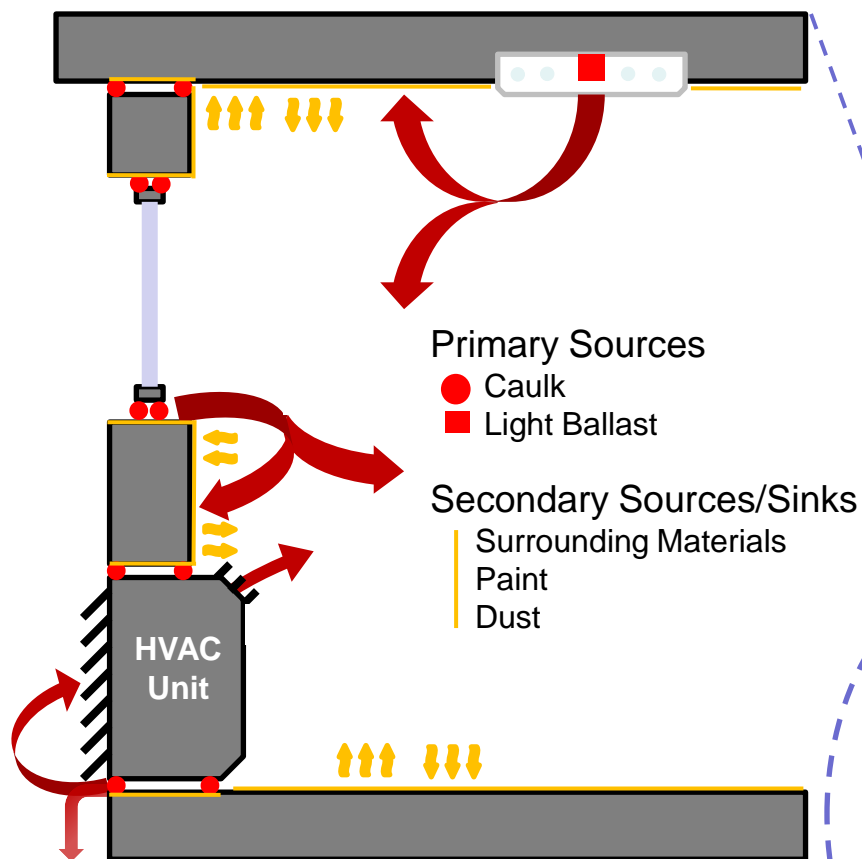
Estimation of PCB Dose From Different Pathways
(6 - 10 year olds; units: $\mu\text{g}/\text{kg day}^{-1}$)



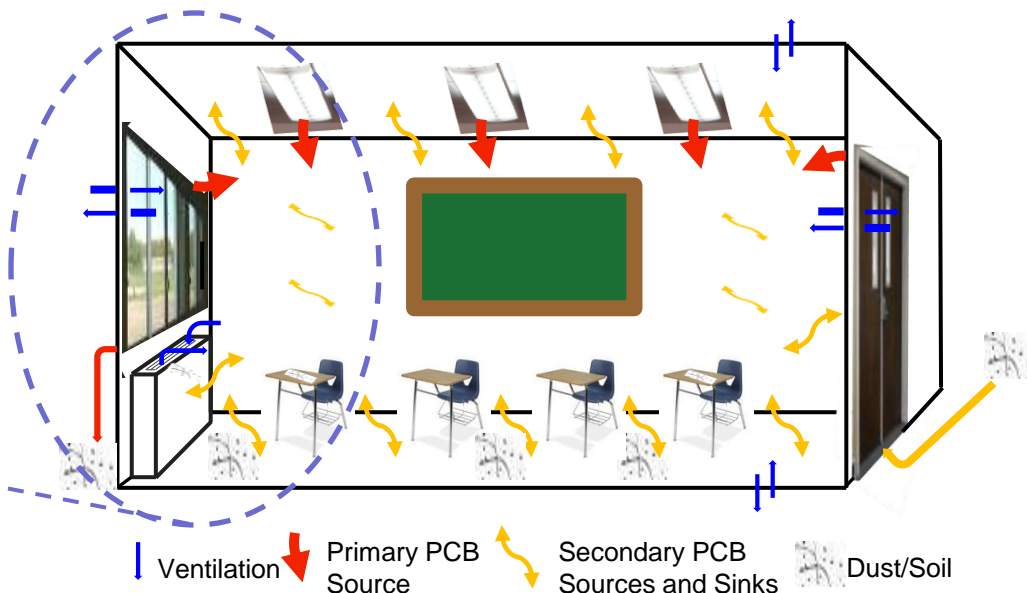
- For the environmental levels found in the six schools, >70% of the exposure would be predicted to result from inhalation of PCBs in the school air
- Dust ingestion may also be an important route of exposure in some situations

PCBs - A Complex Problem in Buildings

Example Scenario



- Over 100 PCB chemicals
- Multiple primary sources possible
- PCBs move from sources to air, surfaces, dust, soil
- Secondary sources are created
- Exposures through multiple pathways
- Ventilation and temperature effects



Research Limitations and Uncertainties

- Representativeness of schools tested is not known
- It is not known if results for schools apply to other types of buildings
- Relative importance of caulk and light ballasts as primary sources has been difficult to determine
- Impact of contaminated light fixtures has not been determined
- Other primary sources may be present in other school buildings
- There are uncertainties in modeled emission, exposure, and dose estimates

Additional Research Information



EPA/ORD research reports on PCBs in schools are available at:

<http://www.epa.gov/pcbsincaulk/caulkresearch.htm>

- Laboratory studies of PCB emission, transport and absorption
- Laboratory study of encapsulant effectiveness
- Laboratory study of in-situ treatment method
- Study of sources, environmental levels and exposures in school buildings
- Literature review of remediation methods