



Inadvertent PCB production and its impact on water quality

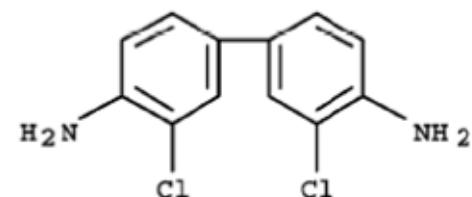
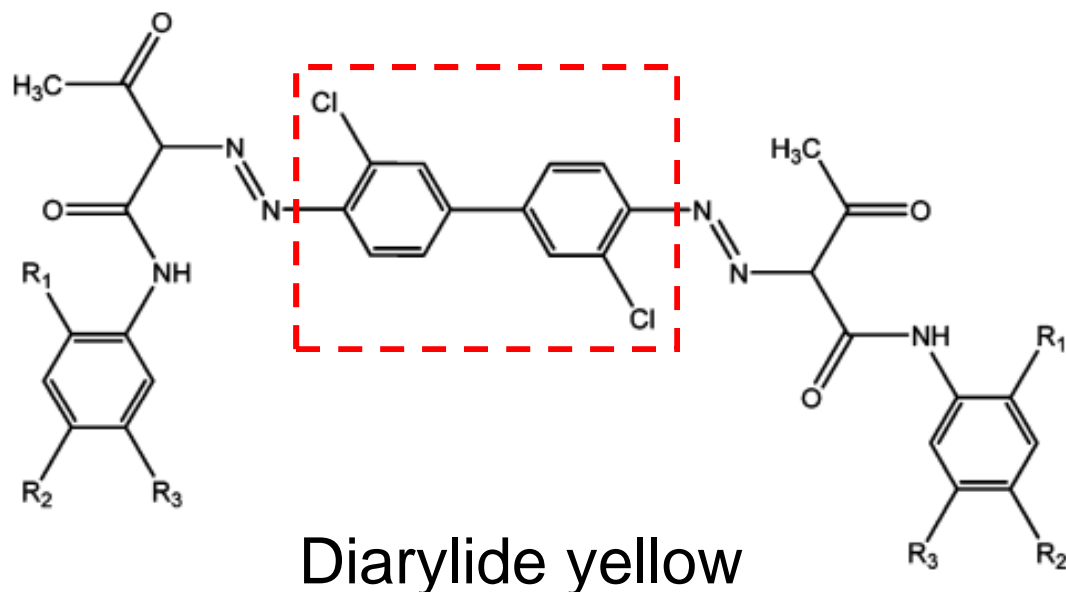
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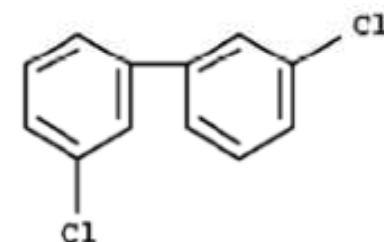
Several known inadvertent PCB sources

- Pigments, especially diarylide yellow, produce primarily PCB 11, among others
- Titanium dioxide (white pigment) produces PCBs 206, 208, and 209
- Silicone rubber tubing produces PCBs 44 and 45 (among others)

PCB 11 from Diarylide Yellow



3,3'-dichlorobenzidine



PCB 11

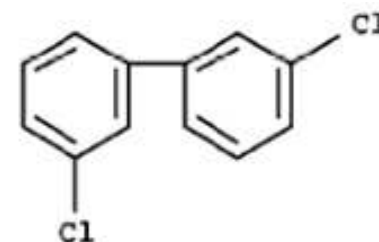
$R_1, R_2, R_3 = H$	Pigment yellow 12
$R_1, R_2 = CH_3, R_3 = H$	Pigment yellow 13
$R_1 = OCH_3, R_2, R_3 = H$	Pigment yellow 17
$R_1, R_3 = OCH_3, R_2 = Cl$	Pigment yellow 83



All listed in EPA's Toxic Substances Control Act (ToSCA) inventory

(Basu et al. 2009)

Production of PCB 11

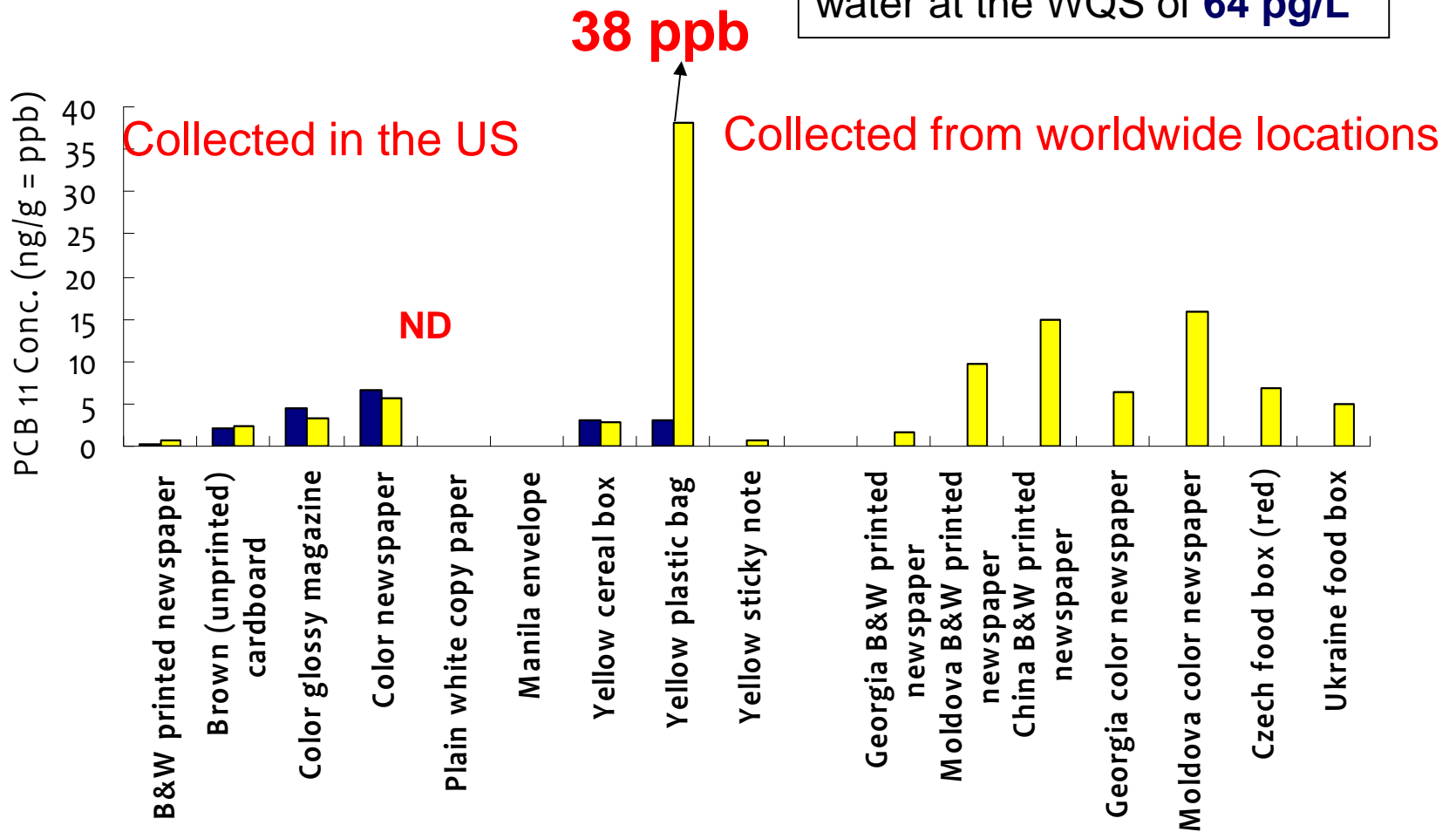


- 2006 worldwide production of color organic pigments ~ **250M** t
- 25% of this production is diarylide yellow, containing a few **ppb** of PCB 11
- 65% of all diarylide yellow is used in printing
- We estimate worldwide production of PCB 11 ~ **1.5 metric tons** in 2006 (Rodenburg et al. 2009, ES&T)

PCB 11 Concentration in Consumer Goods

PCB 11 mostly associated with materials printed with yellow ink

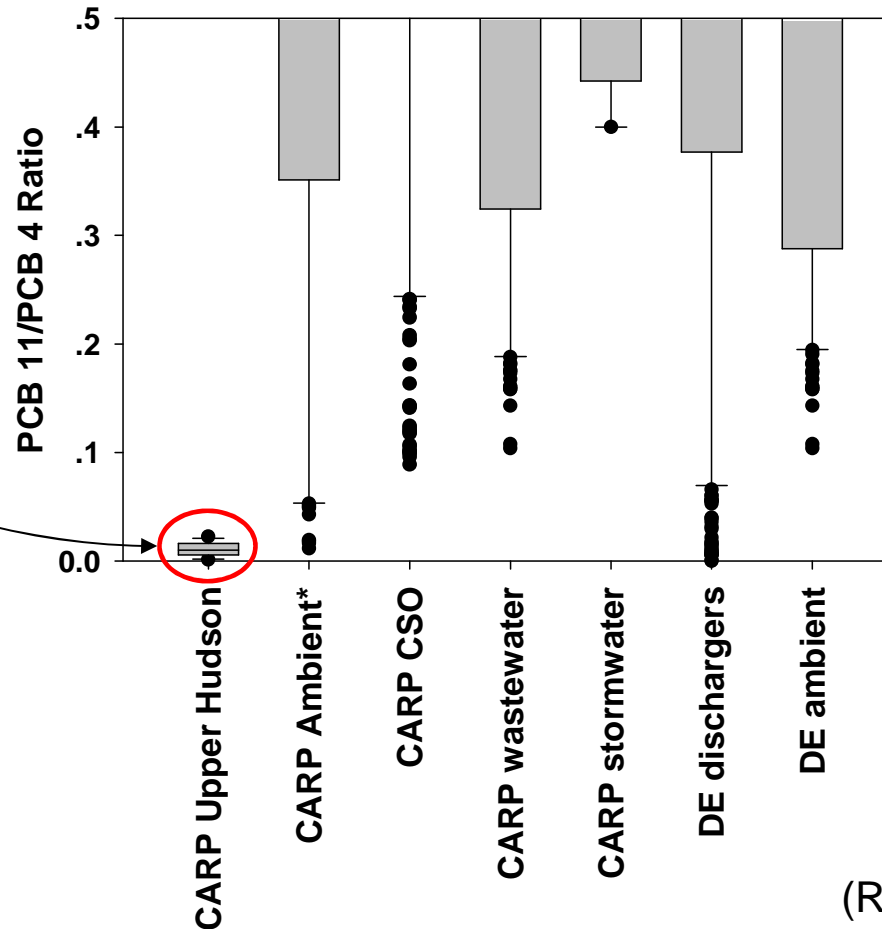
One cereal box can contaminate ~ **2,000 L** of water at the WQS of **64 pg/L**



Ratio of PCB 11 to PCB 4 (a dechlorination product)

Ratio is low and constant in Upper Hudson, where dechlorination occurs

Ratio is much larger and more variable everywhere else!



PCB 11 not associated with dechlorination

Other PCBs in pigments

From Hu and Hornbuckle 2010

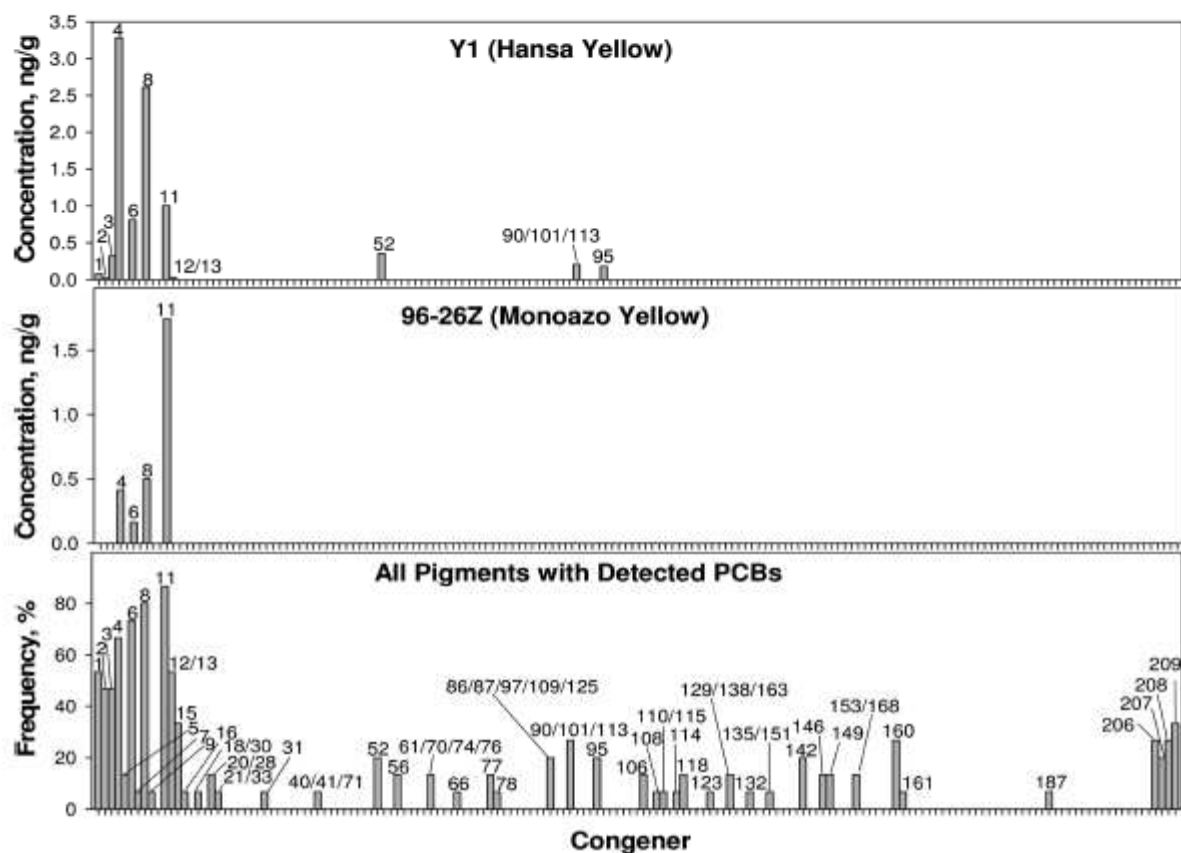
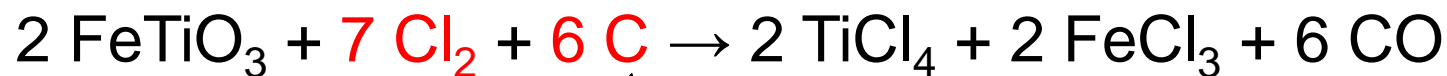
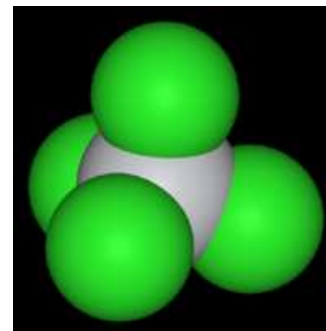


FIGURE 2. Examples of PCB profiles in paint pigments (top two plots) and the frequency of congener detection in the 15 pigments with detected PCBs (bottom plot).

PCBs 206, 208, 209

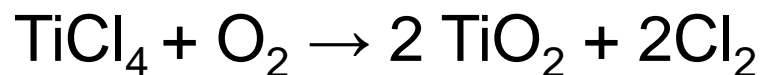
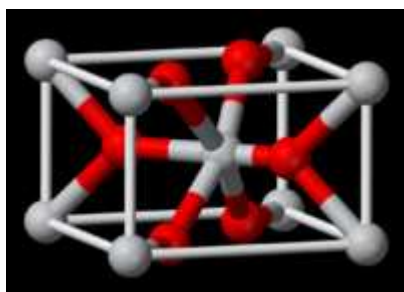
Produced inadvertently during the making of titanium tetrachloride



This carbon is chlorinated to form PCBs

Often sold to water treatment plants as a flocculant

Most TiCl_4 is then used to make titanium dioxide (white pigment)



Inadvertent PCBs detected above Federal Water Quality Standard of **64 pg/L (ppq)**

PCB 11

- Halifax Harbor (40-126 pg/L)
- New York/New Jersey Harbor (over 100 pg/L)
- Delaware River (~20 pg/L- above local criterion)
- Houston Ship Channel (~200 pg/L)
- San Francisco Bay (~100 pg/L)

PCB 206+208+209

- Delaware River (~230 pg/L)
- Houston Ship Channel (~130 pg/L)

Conclusions

- Inadvertent PCB production is a significant obstacle to meeting WQS.
- The main source of PCB 11 in two typical urban watersheds is not dechlorination of heavier PCB congeners.
- PCB 11 is present in paper and cardboard materials that may be easily shredded and can contribute to the particle-phase PCB 11 burden in ambient waters. PCB 11 can also be released from these materials to the dissolved phase.
- Monitoring programs should measure all 209 PCB congeners in at least some samples, and should measure PCB 11 in all samples.

Acknowledgements



Delaware River Basin Commission

