1,4-DIOXANE:
EMERGING CONTAMINANT ISSUE

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WHAT IS IT?

• Solvent stabilizer and corrosion inhibitor often found with TCA
• By-product of manufacturing
• Also used alone as a solvent
• Wide variety of applications

USES OF 1,4-DIOXANE

• As the Main Ingredient
  – Cellulose Acetate Membrane Production
  – Scintillation Counting Cocktails/Bray’s Solution
• Synthesis of other products
  – Brominated flame retardants
  – Pharmaceutical industry
  – Paper industry (coated paper)

USES OF 1,4-DIOXANE (cont.)

• As a Minor Ingredient
  – Magnetic Tape Production
  – Tissue Preservative in Histology
  – Inks and printing operations
  – Painting, coating and stripping
  – Polyurethane medical devices
  – Brake cleaning sprays and fluids
  – Wood glue and contact cement
  – Loosening agent for hardware


USES OF 1,4-DIOXANE (cont.)

• Produced as By-Product
  – Photographic film recycling (dimethyl terephthalate, DMT)
  – Aircraft deicing fluid
  – Ethoxylated surfactant production
  – Resin production
  – PET plastic production
  – Antifreeze Production

FACILITIES / OPERATIONS

Where 1,4-Dioxane Could Be Found

<table>
<thead>
<tr>
<th>Degreasing operations</th>
<th>Electroplating/polishing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paints, varnishes, lacquers, strippers</td>
<td>Inks, dyes, coatings, and adhesives</td>
</tr>
<tr>
<td>Pharmaceutical plants</td>
<td>Polymers, plastics, rubber manufacture</td>
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<tr>
<td>Semiconductors, electronic components</td>
<td>Commercial printing and photographic equipment</td>
</tr>
<tr>
<td>Pulp, paper, fiber manufacture</td>
<td>Explosives</td>
</tr>
<tr>
<td>Personal care products (cosmetics, detergents, shampoos)</td>
<td>University landfills</td>
</tr>
</tbody>
</table>

CHEMICAL PROPERTIES OF 1,4-DIOXANE

- Colorless, flammable liquid with faint pleasant odor
- Cyclic ether (C₄H₈O₂)
- Specific gravity 1.033
- Evaporates readily
- Boiling Point 101°C
- Mobile in soils (low Koc 1.23, log Kow -0.27)
- Completely soluble in water
- Relatively non-volatile in water (very low Henry’s Law Constant of 4.88 x 10⁻⁶ atm-m³/mol)
WHAT HAPPENS TO 1,4-DIOXANE when it’s released to...

Air

• Readily evaporates, moderate vapor pressure of 38.0 mm Hg at 25°C
• As a vapor, breaks down readily to form aldehydes and ketones

Soil

• Will tend to migrate through soil rather than adsorb to particles (except for moist clay/silt)

Water

• Completely soluble in water = travels ahead of other solvents in plume (similar to MTBE)
• Tends to stay dissolved, therefore low volatilization risk from groundwater
• Chemically stable, not expected to degrade once in groundwater or surface water
WHY DO WE CARE?

- EPA - Probable Human Carcinogen
  - Kidney and liver effects
  - Updated IRIS tox. data
- Widespread use
- Persistence - not expected to biodegrade
- Found in drinking water supply wells

EMERGING CONTAMINANT HISTORY

- 2001 - White Paper by Thomas Mohr
- 2003 - EPA Region 1 brings it to state’s attention, begin looking at NPL and RCRA CA sites
- 2004 - CT DPH establishes private drinking water well Comparison Value of 20 µg/L
- Oct. 2011 – CT DPH establishes new action levels for ingestion & dermal contact based on IRIS updates
- Feb. 2012 – CT DPH Private Well Fact Sheet
- May 2012 – CT DEEP presentation to LEPs, regulated community at Remediation Roundtable meeting
ANALYTICAL METHODS

• Initially, lab methods had high reporting limits
• Newer methods have lower detection limits
  – Modified EPA Method 8260 SIM
  – Modified EPA Method 8270 SIM (good if high conc. of other chlorinated VOCs, no need to dilute sample) (1 µg/L)
  – EPA Method 8261A (vacuum distillation with cryogenic trapping – rec. by T. Mohr)
  – EPA Method 522

REGULATORY STANDARDS

<table>
<thead>
<tr>
<th>State</th>
<th>Groundwater Standards</th>
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<tbody>
<tr>
<td>Connecticut</td>
<td>3 µg/L – Private wells - drinking water</td>
</tr>
<tr>
<td></td>
<td>50 µg/L – bathing/showering</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>Not established; tested at Superfund sites</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>0.3 µg/L - Drinking water supplies</td>
</tr>
<tr>
<td></td>
<td>3 µg/L - GW-1 areas (water supply zones)</td>
</tr>
<tr>
<td></td>
<td>6,000 µg/L - GW-2 areas (vol. risk near bldgs)</td>
</tr>
<tr>
<td></td>
<td>50,000 µg/L - GW-3 areas</td>
</tr>
<tr>
<td>Vermont</td>
<td>20 µg/L</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>3 µg/L → 0.35 µg/L</td>
</tr>
<tr>
<td>Maine</td>
<td>4 µg/L – drinking water</td>
</tr>
<tr>
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<td>72,000 µg/L – worker exposure</td>
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</table>
TREATMENT OPTIONS
FOR 1,4-DIOXANE

**Not Effective**
- Air stripping (unless soil is dry)
- Ion exchange

**Limited Effectiveness**
- GAC filters - Depends on influent water quality
- Reverse osmosis
- Biorem.

**Effective**
- Advanced Oxidation
- In-situ Thermal Treatment
- $$$

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TREATMENT OPTIONS
FOR POTABLE WELLS

- GAC filters with frequent monitoring & filter change-outs
- Bottled water
- Bisco Environmental residential ozone/peroxidation treatment system (to be tested)
- WATER MAIN EXTENSION
CT CASE STUDIES

• Sites with Polluted Potable Wells
  – Durham Meadows NPL site – 16 wells with max. 14DX 58 µg/L, TCE 110 µg/L; GAC filters; bottled water provided to 7 houses; water main extension planned.
  – Tylerville State Superfund Site, Haddam – 15 wells with max. 14DX 65 µg/L, TCE 330 µg/L; other wells without 14DX; GAC filters; bottled water provided to 5 houses; multiple potential source areas; water supply study in progress.

CT CASE STUDIES

• Sites with Polluted Groundwater
  – Solvents Recovery Service New England NPL site, Southington, (max. 4.3 mg/L) – in-situ thermal treatment
  – Upjohn/Pharmacia/Pfizer, North Haven – in-situ thermal
  – Susan Bates RCRA CA site, Chester – some detections following massive historic release from TCA tank

• Site with Polluted Soil
  – Henlopen, Danbury – 65 mg/kg under building, discovered in SVE effluent; max 220 µg/L in overburden GW, 31 µg/L in bedrock GW; permanganate injections into GW, soil removal
OTHER CONSIDERATIONS

• Collocation with TCE
• 1,4-Dioxane can penetrate mineral structure of clay liners (T. Mohr)
• Retained in unsaturated silts/clays at 10-100x concentration as in adjacent sands, diffuses into immobile pore spaces (T. Mohr)
• Other solvent stabilizers of concern?

1,4-DIOXANE RESOURCES

Mohr, Thomas K.G., 2010. Environmental Investigation and Remediation: 1,4-Dioxane and other Solvent Stabilizers.

EPA Technical Fact Sheet

CLU-IN http://cluin.org/contaminantfocus/default.focus/sec/1,4-Dioxane/cat/Overview/


CT DPH Fact Sheet: