Environmental Exposure and Health Effects: TCE and PCE

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Objectives

After this presentation, the participant should be able to discuss:
1) taking an exposure history
2) human health effects related to trichloroethylene (TCE) and tetrachloroethylene (PCE) exposure
3) the evaluation of patients with possible exposure to TCE and PCE.

Dupont Pompton Lakes Works Site History

- Explosives manufacturing plant, 1886-1994
  - Dupont acquired in 1902
  - Significant contamination of surface water, soil sediment and groundwater
- VOC Groundwater contamination
  - PCE, TCE, DCE, VC
  - Migration off-site towards Pompton Lake
  - Contamination of private drinking water wells
  - Residential vapor intrusion exposure investigation initiated 2008
    - PCE concentration in indoor air: non-detect to 10 ppb
    - TCE concentration in indoor air: non-detect to 1 ppb

Vapor Intrusion

- Migration of volatile compounds from contaminated groundwater through the soil into buildings
- Health implications
  - Acute health effects
  - Chronic health effects, increased cancer risk
  - Fire and explosion hazards
Source of Exposure
- Environmental Media
  - Soil, groundwater, surface water, sediment, air, food
- Exposure Point
- Exposure Route
  - Ingestion, inhalation, dermal contact
- Potentially Exposed Population

**Exposure Pathway**

**Exposure Dose**
- Dose is determined by the:
  - Chemical concentration
  - Route of exposure
  - Frequency of exposure
  - Duration of exposure
  - Body weight

**Association of Chemical Exposure with Health Impacts**
- Health effect has biologically plausible association with known toxicity of chemical
- Level of exposure is consistent with dose known to cause health effects
  - Complete exposure pathway
  - Frequency and duration of exposure
  - Concentration

**Pompton Lakes Residents' Exposure concerns**
- Health implications
  - Acute health effects
  - Chronic health effects
  - Increased cancer risk
  - Immediate hazards
- Past, present, future exposures
- Residential, occupational exposures

**Medical Exam: Exposure History**
- Present and previous home locations
- Jobs of household members
  - Personal protective equipment worn
  - Job tasks, materials and agents used
  - Medical and industrial hygiene surveillance
  - Personal habits—eating, smoking in workplace, change of clothes
- Military service
- Home cleaning agents, pesticide exposure
- Water supply
- Diet—wild game, fish consumption; alternative medicine
- Hobbies (e.g., painting, photography, sculpting, welding, woodworking, piloting, restoring automobiles, Shooting Firearms, creating stained glass, and gardening)
- Hazardous wastes/spill exposure

**Trichloroethylene (TCE)**
- Volatile chlorinated hydrocarbon
- Industrial degreaser/solvent
- Consumer products:
  - Adhesives
  - Spot removers
  - Cleaning fluids for rugs
  - Paint removers/strippers
  - Typewriter correction fluids
- Historical uses:
  - Extractant
  - Medical:
    - Anesthetic (Tri-lene)
    - Analgesic: trigeminal neuralgia, migraine

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**TCE Toxicokinetics**

- **TCE**—uncharged, nonpolar, highly lipophilic

- **Absorption**—readily and extensively absorbed across membranes
  - Ingestion: 90-95%
  - Passive diffusion limited by absorption vehicle
  - Inhalation: 75%
  - High blood/gas partition coefficient
  - Dermal: negligible from vapors; high from liquids

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**TCE Metabolism**

- Trichloroethylene (TCE) is metabolized by hydroxylation, oxidative dehalogenation, and dechlorination pathways.

- Metabolites include dichloroacetic acid (DCA) and trichloroacetaldehyde (TCA).

- These metabolites are then further metabolized by the liver.

- From: Pastino et al. EHP 108(Suppl 2):201-214

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**TCE Health Effects**

- **Neurologic**
  - 81-110 ppm threshold for mild CNS depression
  - >500 ppm: excitation, light-headedness, headache, nausea, incoordination, impaired ability to concentrate
  - >2000 ppm: anesthesia

- **Cardiovascular**
  - High concentrations: cardiac arrhythmia

- **Hepatic**
  - Liver toxicity at high concentrations
    - Increased ALT, AST
  - Alcohol consumption increases risk

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**TCE Elimination**

- **Urine**
- **Exhaled breath**

- From Droz 1978 Br J Ind Med
TCE: Chronic human health effects
(inhalation)

- Neurologic
  - Damage to the cranial nerves
    - Impaired trigeminal nerve function (blink and masseter reflexes)
  - Memory loss, impaired cognitive function
- Renal
  - High repetitive exposures—renal proximal tubule damage
- Reproductive and developmental
  - Crosses the placenta
  - Congenital cardiac anomalies (ingestion exposure)

TCE: Other health effects

- Respiratory
  - Minimal irritant
  - RADS or irritant induced asthma at very high concentrations
- Dermal
  - Contact dermatitis, rashes, burns
  - Degreaser’s flush (alcohol plus inhaled TCE)
- Immunological
  - Exacerbate underlying autoimmune disease or trigger the onset of a syndrome
- Genetic susceptibility
  - TCE metabolism
  - Association with systemic scleroderma

TCE: Cancer

- International Agency for Research on Cancer – Group 2A (probably carcinogenic to humans)
  - Kidney: RR = 1.7 (1.1-2.7)
  - Liver: RR = 1.9 (1.0-3.4)
- Other cancers
  - Non-Hodgkin’s lymphoma: RR = 1.5 (0.9-2.3)
  - Hodgkin’s lymphoma
  - Cervical cancer
  - Confounded by exposure to other solvents, quantifying exposures, risk factors


Tetrachloroethylene (PCE, PERC)

- Volatile chlorinated hydrocarbon
- Industrial degreaser/solvent
- Chemical intermediate
- Dry cleaning
- Consumer products:
  - Spot removers
  - Fabric water repellants
  - Paint removers/strippers
  - Typewriter correction fluids
- Historic Medical/Veterinary Use
  - Treatment of parasitic intestinal worms
  - Anesthesia

PCE Toxicokinetics

Absorption
- Highly lipophilic
- Readily absorbed by inhalation
- Proportional to ventilation rate

Distribution
- Richly perfused (12-16 hrs)
- Poorly perfused (30-40 hrs)
- Adipose (55 hours)
- Crosses the placenta
**PCE: Health effects**

No clinical effects at exposures below 50,000 ppb

Major Target Organs:
- Brain
- Liver
- Kidney

International Agency for Research on Cancer — Group 2A (probably carcinogenic to humans)
- Liver and kidney tumors in animals

**Medical Testing**

**Occupational settings:**

<table>
<thead>
<tr>
<th></th>
<th>TCE</th>
<th>PCE</th>
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<tbody>
<tr>
<td>Blood</td>
<td>trichloroethylene, free trichloroethanol</td>
<td>tetrachloroethylene</td>
</tr>
<tr>
<td>Urine</td>
<td>trichloroacetic acid, trichloroethanol</td>
<td>trichloroacetic acid</td>
</tr>
<tr>
<td>End-exhaled air</td>
<td>trichloroethylene</td>
<td>tetrachloroethylene</td>
</tr>
</tbody>
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**TCE, PCE: Medical Management**

(Inhalational vapor intrusion exposure)

- Exposure history
  - Proximity of home to known waste sites
    - Environmental sampling results, if available
  - Past and present occupational duties
  - Special laboratory tests not indicated
  - Usual preventive screening, medical management
  - Avoidance of exposure
    - No antidote for TCE or PCE

**Challenges in assessing health risks from exposure to TCE & PCE**

- Susceptibility issues
  - Sex, age, ethnicity
  - Medical conditions
    - Alcoholism, obesity, diabetes
  - Genetic variability
- Mixtures
  - Interaction between ethanol and TCE
  - Presence of other solvents

**NJ DOH Cancer Assessment**

**New Jersey State Cancer Registry**
- SIR—Pompton Lakes neighborhood
  - Year | Type | M/F | SIR | 95% CI |
  - 79-06 | Kidney | F | 3.15 | 1.26-6.48 |
  - 94-06 | NHL | M | 2.67 | 1.07-5.50 |
- SIR—entire Pompton Lakes
  - Year | Type | M/F | SIR | 95% CI |
  - 79-07 | Lung | F | 1.29 | 1.06-1.55 |
  - 79-89 | Lung | F | 1.69 | 1.23-2.27 |
  - 90-07 | Colon | M | 1.28 | 1.01-1.60 |

**Medical Testing**

**TCE PCE**

4 hours 100 ppm TCE

20 hours, pure air


4 hours 100 ppm TCE

20 hours, pure air

TCE Inhalational Health Effects & Guidelines (ppb)

More Information

- ATSDR (www.atsdr.cdc.gov)
  - Case Studies in Environmental Medicine
  - Taking an Exposure History
  - Pediatric Environmental Health
  - Trichloroethylene
  - Tetrachloroethylene
  - Toxicological Profiles
  - Medical Management Guidelines

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