

Environmental Exposure and Health Effects: TCE and PCE

Michelle Watters, MD, PhD, MPH
 Medical Officer
 Agency for Toxic Substances and Disease Registry
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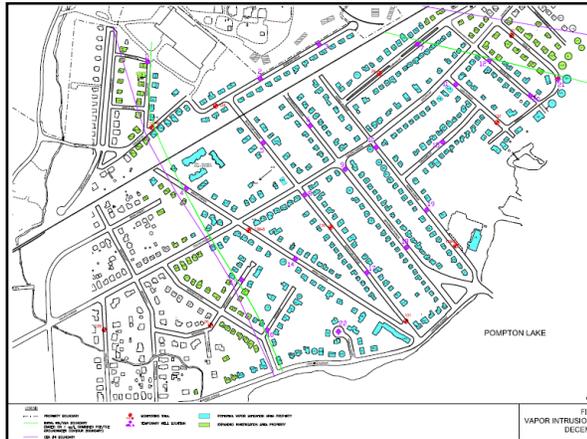
Objectives

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.

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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

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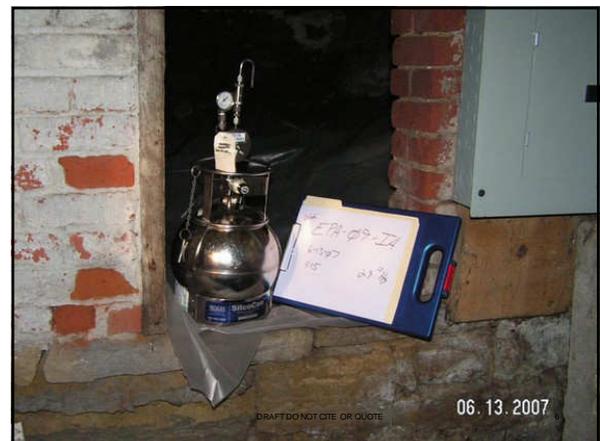
Vapor Intrusion

- 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



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EXPOSURE PATHWAY

- Source of Exposure
- Environmental Media
 - Soil, groundwater, surface water, sediment, air, food
- Exposure Point
- Exposure Route
 - Ingestion, inhalation, dermal contact
- Potentially Exposed Population

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Exposure Dose

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

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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

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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

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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 clother
- 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

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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

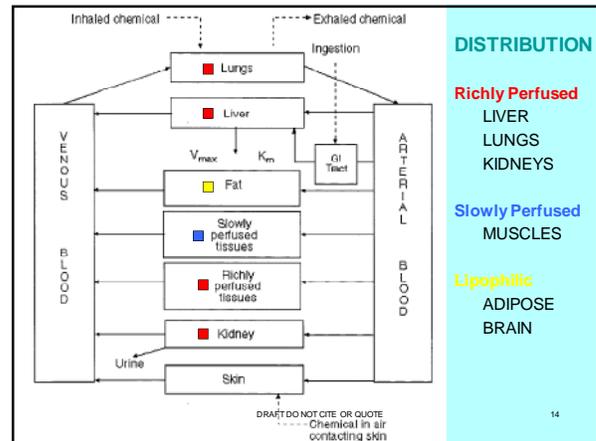
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TCE Toxicokinetics

- 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

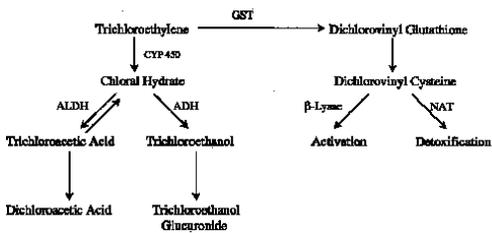
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TCE Metabolism



From: Bastino et al. 2000; EHP 108(Suppl 2):201-214

TCE Elimination

- Urine
- Exhaled breath

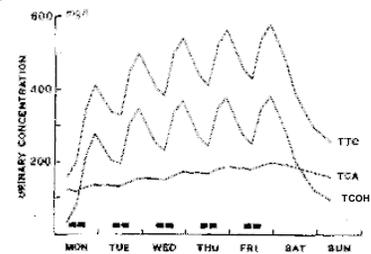


Fig. 1 Urinary concentrations TCOH, TCA and TCE during a steady-state week of exposure at 100 ppm. The urine samples are taken at 7 am, 12 am, 5 pm and 10 pm.
 From Droz 1978 Br J Ind Med

From Droz 1978 Br J Ind Med

TCE Health Effects

FIGURE 2-5. Existing Information on Health Effects of Trichloroethylene

	SYSTEMIC									
	Leath	Acute	Intermediate	Chronic	Immunological/lymphoproliferative	Neurological	Reproductive	Developmental	Genotoxic	Cancer
Inhalation	•	•	•	•	•	•	•	•	•	•
Oral	•	•	•	•	•	•	•	•	•	•
Dermal	•	•	•	•	•	•	•	•	•	•

Human

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TCE: Acute human health effects (inhalation)

- 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: 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)

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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

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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

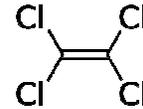
Wartenberg et al. 2000. *EHP* 108(Suppl 2):161-176.

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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



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PCE Toxicokinetics

Absorption

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

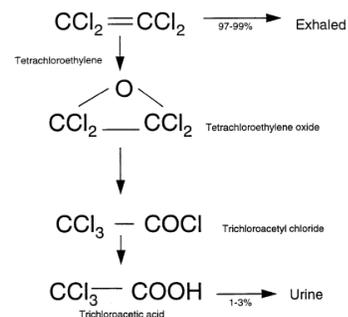
Distribution

- Richly perfused (12-16 hrs)
- Poorly perfused (30-40 hrs)
- Adipose (55 hours)
- Crosses the placenta

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FIGURE 2-3. Metabolism of Tetrachloroethylene by Humans*



Modified from ACGIH 1991

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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

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NJ DOH Cancer Assessment

- New Jersey State Cancer Registry
- SIR—Pompton Lakes neighborhood

Years	Type	M/F	SIR	95% CI
79-06	Kidney	F	3.15	1.26-6.49
94-06	NHL	M	2.67	1.07-5.50

- SIR- entire Pompton Lakes

Years	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

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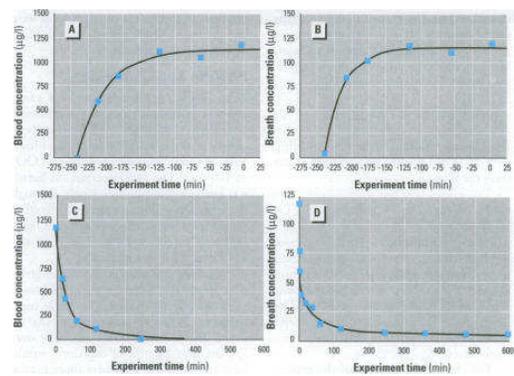
Medical Testing

- Occupational settings:

	TCE	PCE
Blood	trichloroethylene, free trichloroethanol	tetrachloroethylene
Urine	trichloroacetic acid, trichloroethanol	trichloroacetic acid
End-exhaled air	trichloroethylene	tetrachloroethylene

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Pleil et al. 1998. *EHP* 106(9):573-580
4 hours 100 ppm TCE
20 hours, pure air

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TCE, PCE: Medical Management (Inhalational vapor intrusion exposure)

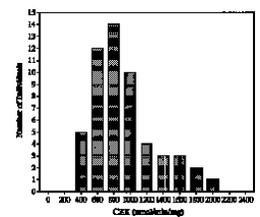
- Exposure history
 - Proximity of home to known waste sites
 - Environmental sampling results, if available
 - Past and present occupational duties
- Special laboratory tests not indicated
- Usual preventive screening, medical management
- Avoidance of exposure
 - No antidote for TCE or PCE

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Challenges in assessing health risks from exposure to TCE & PCE

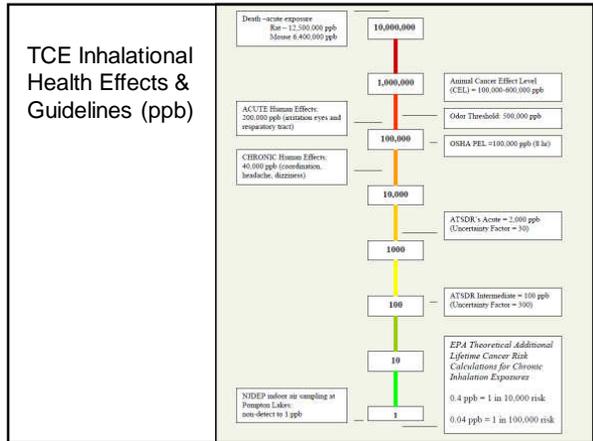
- Susceptibility issues
 - Sex, age, ethnicity
 - Medical conditions
 - Alcoholism, obesity, diabetes
 - Genetic variability
- Mixtures
 - Interaction between ethanol and TCE
 - Presence of other solvents



Lash et al. 2000 *EHP* v108 s2 p177

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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

Michelle Watters, MD, PhD, MPH; Medical Officer, ATSDR
aax6@cdc.gov; 312-866-0840

Leah Graziano, Senior Regional Representative, ATSDR
lge2@cdc.gov; 732-906-6932

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