EMERGING CONTAMINANTS AT LANDFILLS: OCCURRENCE, MIGRATION, AND REMEDIATION

Fritz Krembs for Colorado SWANA Annual Conference, Steamboat Springs, CO, September 14, 2017
Presentation Road Map

INTRODUCTION
- What's an Emerging Contaminant?
- Why should I care?
- What's this have to do with landfills?

1,2,3-TRICHLOROPROPANE
- Uses
- Chemical properties
- Federal / WY regulations
- Relevance for landfills

PFAS

1,4-DIOXANE

CONCLUSIONS
Introduction:

What are Emerging Contaminants?

- “An emerging contaminant is a chemical or material characterized by a perceived, potential, or real threat to human health or the environment or by a lack of published health standards.” - USEPA

- Contaminant with “risk that is not yet fully understood.”
  Water Quality Association
Introduction:

Why should I care about Emerging Contaminants?

- USEPA or CDPHE may promulgate standard
- Groundwater sampling
- Detection / exceedance
- Possible follow-on actions
Introduction:

Occurrence at Landfills

- Historical uses / waste streams
- Empirical evidence
- Inference based on experience
1,2,3-Trichloropropane: Historical Uses

- Impurity in historical pesticides and fumigants in 1950s through 1970s
1,2,3-Trichloropropane: Chemical Properties

- Soluble in water
- Moderately volatile to air
- Moderate tendency to stick to soil
- Not readily biodegradable
- **BOTTOM LINE** – This compound has potential to form groundwater plumes
1,2,3-Trichloropropane: Regulations

- On Appendix I Detection Monitoring List
- No USEPA MCL
- CDPHE 5 CCR 1002-41 Standard of 0.00037 ug/L
- Other guidance
  - USEPA Tap Water Regional Screening Level = 0.00075 ug/L
  - CA public health goal = 0.0007 ug/L
  - NJ MCL = 0.03 ug/L

1 ug/L = ½ tsp salt in olympic swimming pool
1,2,3-Trichloropropane: Remediation

- Granular Activated Carbon (GAC)
- In-situ chemical reduction
- In-situ chemical oxidation
- In-situ bioremediation (?)
“Last week **5.2 million Americans** learned that their drinking water is contaminated with man-made chemicals linked to cancer.”
PFAS: Introduction

- Molecule with lots of fluorine
- Many molecules, many acronyms
- PFAS: Per- (and Poly-) Fluoro Alkyl Substances
- PFCs: Per- (and Poly-) Fluorinated Compounds (also perfluorocarbons)
- PFOA: Perfluorooctanoic Acid
- PFOS: Perfluorooctane Sulfonate
- PFHxA, PFHxS, PFBA, PFBS, ... 100s more
- AFFF: Aqueous Film-Forming Foams
PFAS: Historical Uses

- **Consumer products – Teflon®, Scotch guard®**
  - Personal care products (shampoo, dental floss)
  - Grease resistant food packaging (microwave popcorn bags and pizza boxes)
- **Industrial applications:**
  - Mist suppressants
  - Aerospace / Electronics
- **Aqueous Film-Forming Foam (AFFF)**
- In production since 1950s

http://www.foamtechantifire.com/foamer-ar-afff-3-6-510371.html
PFAS: Physical Properties

- Moderately soluble in water
- Doesn’t volatilize into air
- Sticks to soil / organic carbon
- BOTTOM LINE – This compound has potential to form groundwater plumes
PFAS: Regulations

- Not on Appendix I or II lists
- 2016 USEPA Health Advisory levels
  - PFOA = 0.070 ug/L
  - PFOS = 0.070 ug/L
- No USEPA MCL
- No CDPHE standards

Public water supply results for
PFOS (top)
PFOA (bottom)
PFAS: Remediation

- Pump & Treat w/ GAC
- Wellhead treatment w/ GAC
- In-situ methods being developed
Dartmouth Says Well Wasn’t Contaminated by Rennie Farm

Dartmouth Settles With Hanover Family Over Rennie Farm

A sign posted at the property of Rennie Farm in Hanover, N.H., October 25, 2015. Over 20,000 pounds of rodents and other small critters used for lab experiments were exhumed from Rennie Farm in 2012 and sample tests of nine private wells showed at least one contaminated well located at the property of 9 Rennie Road in Hanover, N.H. (Valley News - Kristen Zeis) Copyright Valley News. May not be reprinted or used online without permission. Send requests to permission@vnews.com. Purchase a reprint »
1,4-Dioxane: Historical (& Current) Uses

- Stabilizer used in 1,1,1-TCA
- Impurity in surfactants
- Used in paint strippers, dyes, greases, varnishes and waxes
1,4-Dioxane: Physical Properties

- Very soluble in water
- Doesn’t volatilize to air
- Doesn’t stick to soil / organic carbon
- BOTTOM LINE – 1,4-Dioxane has high potential to spread in groundwater
1,4-Dioxane: Regulatory Standards

- Not on Appendix I Detection Monitoring list
- No USEPA MCL
- CDPHE Groundwater Standard of 0.35 ug/L
- USEPA RSL of 0.46 ug/L
- FDA allows 10,000 ug/L in consumer products
1,4-Dioxane: Occurrence

When 1,4-dioxane detected, other solvents present 95% of time

6.9% of PWSs > 0.35 μg/L; Adamson et al., STOTEN, in press
### 1,4-Dioxane: Occurrence Cont.

- **1,4-Dioxane used as 1,1,1-TCA stabilizer**
- **At sites with 1,1,1-TCA impacts**
  - 1,4-dioxane typically detected IF it was sampled for
  - **BUT** most sites with 1,1,1-TCA didn’t analyze for 1,4-dioxane

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<thead>
<tr>
<th>76% Detection When Sampled</th>
<th>24% Non-Detect</th>
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<tr>
<td>1,4-Dioxane Not Analyzed at 67% of TCA Sites</td>
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<tr>
<th>76% Detection When Sampled</th>
<th>Hypothetical 76% Detection at Unsampled Sites</th>
<th>Hypothetical 24% ND</th>
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1,4-Dioxane: Occurrence at Landfills

- “When we look for 1,4-dioxane we find it” Landfill Portfolio Mgr.
- CDPHE is compelling landfills with other detections to analyze for 1,4-dioxane
1,4-Dioxane: Remediation

**Ex-Situ**
- P&T with GAC, RO
- Pump & Treat (P&T) with synthetic resins
- P&T with advanced oxidation

**In-Situ**
- Physical
  - Air sparging / SVE
- Chemical
  - In-Situ Chem. Oxid. (ISCO)
  - Chemical reduction (ISCR)
- Biological
  - Aerobic bio
  - Anaerobic bio
  - Co-metabolic processes
- Phytoremediation
- Monitored Natural Attenuation
1,4-Dioxane: Phytoremediation

- Phytoremediation = use of plants to remediate COCs
  - Use trees due to groundwater depth
- For 1,4-dioxane treatment
  - 1,4-dioxane pulled into tree roots, passes through trunk and leaves
  - Released to atmosphere and destroyed by UV light
- Trees can also transpire enough water to create cone of depression
1,4-Dioxane: Monitored Natural Attenuation

- Natural attenuation mechanisms
  - Sorption (-)
  - Advection/dispersion (+/-)
  - Diffusion into low permeability soil zones (+/-)
  - Biodegradation (+/-)
- Microbial testing is now commercially available to confirm biological degradation

\[\text{Attenuation trend analysis: 1,4-dioxane compared to TCA, TCE, and DCE}\]

\[\text{Concentration Trends at Individual Sites}\]

\[\text{Non-Increasing Trends}\]

\[\text{Increasing/Probably Increasing} \quad \text{Stable} \quad \text{No Trend} \quad \text{Decreasing/Probably Decreasing}\]

1 Adamson et al., 2015, Evidence of 1,4-Dioxane Attenuation at Groundwater Sites Contaminated with Chlorinated Solvents and 1,4-Dioxane, Environmental Science & Technology.
1,4-Dioxane: Recap

- Commonly associated with solvents (1,1,1-TCA)
- Can spread in groundwater
- Has been commonly detected at solvent sites including landfills
Conclusions

- Emerging Contaminants have likely environmental risk but no regulatory standards (YET)
- Presence at / beneath landfills depends on historical waste streams
  - 1,4-Dioxane could be present
  - Trichloropropane, PFAS, and others more uncertain
- Assessment and cleanup options exist, but need depends on future regulations (or lack thereof)
Questions?
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