Multimedia Transport of Poly- and Perfluorinated Alkyl Substances (PFAS): Air Emissions to Groundwater—A Case Study

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Eric R. Edwalds
Evan G. Christianson
David J. Dahlstrom
Adam K. Janzen
Barr Engineering Co., Minneapolis, MN
 Jonathon T. Carter
   Rav W. Wuolo
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Poly- and perfluoroalkyl substances (PFAS) including perfluorooctanoic acid (PFOA) have been manufactured and used since the 1940s, although have only recently come under enhanced regulatory evaluations. The fate and transport of these fluorinated hydrocarbon compounds is highly complex, with several pathways for multimedia transport. The carbon-fluorine bond is one of the strongest molecular bonds and results in characteristics that are useful in the production of chemical, electrical, and heat resistant materials, yet also allows PFAS compounds to more readily move through the environment. In some manufacturing processes, PFAS compounds may be released to the environment through air emissions. This presentation will focus on the air emissions pathway including air emissions stack testing, air emissions characterization and air deposition modeling using AERMOD, and subsequent transport to groundwater for both active and decommissioned facilities. Air emissions deposition is shown to be highly sensitive to the assumed particle characteristics of the air emissions as well as to the selected deposition algorithm within AERMOD. The discussion will include identification of issues encountered as part of technical evaluations and approaches to address these technical issues.
PFAS and Barr

- headquartered in Minneapolis, Minnesota
  - 10 offices, primarily in Upper Midwest
  - 1 Canadian office (Calgary)
- working on PFAS sites since early 2000s
- Barr developed stack test methods for PFOA
- leader in water treatment technology applications
outline

• PFAS / PFOA properties
• sources of PFAS to groundwater
• modeling case study—air deposition pathway
characteristics of PFOA

- surfactant – fluoropolymer manufacturing
- high solubility, low volatility
- resistant to degradation
- low sorption - “non-stick” properties
- reduce surface tension
- PFOA and PFOS phased out
sources of PFAS to groundwater
PFAS – what are the sources?

- industrial sources:
  - primary manufacturers
  - glass cloth makers
  - non-stick cookware
  - coated papers
  - waterproofing
  - plating
  - fire fighting foams
soil & groundwater contamination pathways
unsaturated zone transport
case study: air deposition pathway

• **setting:** PFOA detected in 100s of wells
• **site:** fabric coating facility since mid-1980s
• **goal:** combined air-soil-water transport model to:
  - define contamination extent
  - forecast future groundwater concentrations
  - inform future site investigations
site map
conceptual site model (CSM)
CSM objectives

• understand deposition mechanisms
• mechanistic explanation of groundwater concentrations
• determine deposition extent
• identify other possible sources
air emissions from fabric coating
air model

- AERMOD v.15181
- 18,285 receptors
- 13 stacks
- annual emissions (1986 – 2015)
- annual PFOA deposition
air emission estimates

• facility data – dispersions usage
• air permits
• stack testing
• Dispersion Processors Material Balance Report
air model challenges

- stack/building configuration
- meteorological data
- AERMOD deposition algorithms
AERMOD deposition parameters

Method 1

<table>
<thead>
<tr>
<th>Particle Diameter, µm</th>
<th>Mass Fraction, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;0.0</td>
<td>5.6</td>
</tr>
<tr>
<td>1.7</td>
<td>12.9</td>
</tr>
<tr>
<td>0.5</td>
<td>9.2</td>
</tr>
<tr>
<td>0.3</td>
<td>7.2</td>
</tr>
<tr>
<td>&lt;0.28</td>
<td>5.3</td>
</tr>
<tr>
<td></td>
<td>59.8</td>
</tr>
</tbody>
</table>

Method 2

- fine particle fraction (< 2.5 µm) of 0.61
- Method 2 deposition 10 x > Method 1

Barton et al., 2006. Characterizing Perfluorooctanoate in Ambient Air near the Fence Line Of a Manufacturing Facility Comparing Modeled and Monitored Values. JAWMA 56:48-55

Barton et al., 2010. A Site-Specific Screening Comparison of Modeled and Monitored Air Dispersion and Deposition for Perfluorooctanoate, JAWMA, 60:4 402-411
simulated vs. measured groundwater concentration
modeled groundwater concentrations: present
modeled groundwater concentrations: 10 years later
modeled groundwater concentrations: 25 years later
Summary

• case study of PFOA air deposition
• CSM a useful tool
• AERMOD performance
questions?

• Eric Edwalds, Barr Engineering Co.
  eedwalds@barr.com
  952–832–2627