Occurrence of BTEX from oil- and gas-related incidents in groundwater above the Denver-Julesburg Basin

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Introduction
Public concern about water quality related to oil and gas development has grown in recent years. There is a need to better understand the exposure potential in groundwater for organic compounds associated with oil and gas development.

Various organic compounds, including BTEX, are found in hydraulic fracturing fluids, flowback/produced waters, and petroleum products. Possible groundwater impacts were confirmed, in part, by Hildenbrand et al. (2011) in studies focusing on the Barnett shale. The most likely pathway for groundwater contamination is thought to be isolated, accidental surface spills. An example of this type of spill is shown in the image below.

Objectives & Methods
1. How many spills impacted groundwater?
   • The Colorado Oil and Gas Conservation Commission (COGCC) maintains incident reports in an online database.
   • Oil and gas operators report incidents and indicate impacted media.
   • Possible groundwater impacts were confirmed by manually reviewing reports.

2. How frequently did spills impact groundwater?
   • The number of spills was normalized to indicators of development in the study area.

3. What was the character of spills that impacted groundwater?
   • Spill and remediation reports were reviewed to determine spill causes, facility types, and materials released, among other information.

Analysis was conducted for the years 2010–2012, since extensive unconventional oil and gas development began in this region in 2010.

Results

<table>
<thead>
<tr>
<th>Year</th>
<th>All</th>
<th>Groundwater</th>
<th>Groundwater (BTEX)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>192</td>
<td>102</td>
<td>93</td>
</tr>
<tr>
<td>2011</td>
<td>183</td>
<td>61</td>
<td>52</td>
</tr>
<tr>
<td>2012</td>
<td>215</td>
<td>86</td>
<td>73</td>
</tr>
<tr>
<td>Total</td>
<td>589</td>
<td>249</td>
<td>218</td>
</tr>
</tbody>
</table>

Rates of spills compared to number of producing wells

<table>
<thead>
<tr>
<th>Year</th>
<th>Producing wells</th>
<th>All incidents*</th>
<th>Groundwater impact</th>
<th>Groundwater impact (BTEX)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>17,855</td>
<td>1.07%</td>
<td>0.57%</td>
<td>0.52%</td>
</tr>
<tr>
<td>2011</td>
<td>19,348</td>
<td>0.94%</td>
<td>0.32%</td>
<td>0.27%</td>
</tr>
<tr>
<td>2012</td>
<td>20,775</td>
<td>1.03%</td>
<td>0.41%</td>
<td>0.35%</td>
</tr>
</tbody>
</table>

*Predicted based on the expected overlap among spill and remediation files submitted to the COGCC in 2010-2012. An “overlap ratio” was developed as part of the manual review of spill and remediation files.

Spills impacting groundwater occurred most often at tank batteries and flow lines. These spills were most often due to equipment failure or were historical releases, and the materials released most frequently were produced water, condensate, and oil.

We estimate that the number of spills overall is ~1% of the number of producing wells. About 40% of spills resulted in impacts to groundwater. About 90% of groundwater-impacting spills involved one or more of the BTEX compounds.

Conclusions
Spills impacting groundwater occurred most often at tank batteries and flow lines. These spills were most often due to equipment failure or were historical releases, and the materials released most frequently were produced water, condensate, and oil.

We estimate that the number of spills overall is ~1% of the number of producing wells. About 40% of spills resulted in impacts to groundwater. About 90% of groundwater-impacting spills involved one or more of the BTEX compounds.

These occurrence rates and spill characteristics are a foundation for future exposure assessments of organic compounds of concern (including the BTEX compounds) that are associated with oil and gas development. This research could also be applied to inform improved regulations for the oil and gas industry.

Future work is planned for this project: we will evaluate spills from 2004 to 2014 in the study area in order to tell a “story” of oil and gas development in the Denver-Julesburg Basin, which experienced a boom in 2010 thanks to advances in unconventional drilling technology.

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References

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The AirWaterGas Sustainability Research Network is an NSF-funded project based at CU Boulder. Research teams from 10 different institutions are working to develop a science-based framework for understanding the environmental, economic, and social tradeoffs of oil and gas development.

http://airwatergas.org/