Oil and Gas Wastewater Reuse in California: Considerations and Risks

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Disclaimer

The ideas in this presentation are my own and do not necessarily reflect those of the Central Valley Regional Water Quality Control Board, The State Water Board, or the Food Safety Expert Panel.
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We...
Generate
Translate
Disseminate

Scientific resources and put them into the places where they are used to ensure responsible energy policy decisionmaking.
Food Safety Expert Panel

- Convened by the Central Valley Regional Water Quality Control Board
- To provide technical expertise on the range of topics associated with the reuse of oilfield produced water for irrigation of food crops
- Convened in 2016
- Composed of representatives and experts in oil and gas, public health, agriculture and aquatic ecology
Hydraulic Fracturing in CA is Different
- Shallower, Vertical Wells
Produced water management

• California’s oil and gas fields *on average* produce more than 10-times as much water as oil

• Produced water from wells contain naturally occurring and added chemicals
Current produced water reuse in California

- Predominantly in the San Joaquin Valley
- Irrigation of food crops
  - Treatment:
    - Oil-water separation and walnut shells (San Joaquin Valley)
    - Only one operation uses reverse osmosis (Central Coast)
- Aquifer recharge via percolation
  - Often no treatment beyond oil-water separation
  - Confirmed contamination of groundwater > 2 miles away (CVRWQCB 2018)
  - Observed intermixing with nearby USDWs – even those previously thought to be zonally isolated (USGS, forthcoming)
  - Widespread mixing with groundwater <10,000 mg/l TDS at least within two fields (USGS, forthcoming)
Chemical Use in Hydraulic Fracturing (CCST SB 4 Study)

- Identified ~300 chemical or chemical mixtures used for hydraulic fracturing
  - Many chemicals were reported infrequently
- Identified ~80 chemical or chemical mixtures used for matrix acidizing
  - ~1/3 were not on hydraulic fracturing list
- Information needed for complete hazard or risk assessment was often not available

CCST (2015); Shonkoff et al. (2015)
Hydraulic fracturing chemicals: information gaps inhibit our ability to evaluate health risks

Table 6.3-1. Available and unavailable information for characterizing the hazard of stimulation chemicals used in hydraulic fracturing.

<table>
<thead>
<tr>
<th>Number of chemicals</th>
<th>Proportion of all chemicals</th>
<th>Identified by unique CASRN</th>
<th>Impact or toxicity</th>
<th>Quantity of use or emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>176</td>
<td>55%</td>
<td>Available</td>
<td>Available</td>
<td>Available</td>
</tr>
<tr>
<td>17</td>
<td>5%</td>
<td>Available</td>
<td>Available</td>
<td>Unavailable</td>
</tr>
<tr>
<td>6</td>
<td>2%</td>
<td>Available</td>
<td>Unavailable</td>
<td>Available</td>
</tr>
<tr>
<td>121</td>
<td>38%</td>
<td>Unavailable</td>
<td>Unavailable</td>
<td>Available</td>
</tr>
</tbody>
</table>

Shonkoff et al. (2015)
Critical Data Gap for chemicals used in HF: Basic Information on Toxicity Missing

**Acute Aquatic Toxicity (Daphnia magna)**
- Non-Toxic: 16%
- GHS 3: 7.2%
- GHS 2: 6.8%
- GHS 1: 5.6%
- Insufficient Data: 65%

**Acute Aquatic Toxicity (Fathead Minnow)**
- Non-Toxic: 12%
- GHS 3: 6.4%
- GHS 2: 3.6%
- GHS 1: 2%
- Insufficient Data: 76%

*Stringfellow et al. (2015)*
Produced water used for food crop irrigation in the San Joaquin Valley

Current practice could allow flowback water to be mixed with produced water for use in irrigation and for the disposal of oil and gas wastewater into unlined pits.

“BUT WE DON’T FRAC” (so there’s no chemical risk)

Lauren Sommer
RESEARCH ARTICLE

Comparison of chemical-use between hydraulic fracturing, acidizing, and routine oil and gas development

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Abstract

The potential hazards and risks associated with well-stimulation in unconventional oil and gas development (hydraulic fracturing, acid fracturing, and matrix acidizing) have been investigated and evaluated and federal and state regulations requiring chemical disclosure for well-stimulation have been implemented as part of an overall risk management strategy for unconventional oil and gas development. Similar evaluations for chemicals used in other routine oil and gas development activities, such as maintenance acidizing, gravel packing, and well drilling, have not been previously conducted, in part due to a lack of reliable information concerning on-field chemical-use. In this study, we compare chemical-use between routine activities and the more closely regulated well-stimulation activities using data collected by the South Coast Air Quality Monitoring District (SCAQMD), which mandates the reporting of both unconventional and routine on-field chemical-use for parts of Southern California. Analysis of this data shows that there is significant overlap in chemical-use between so-called unconventional activities and routine activities conducted for well maintenance, well-completion, or rework. A comparison within the SCAQMD shows a significant overlap between both types and amounts of chemicals used for well-stimulation treatments included under State mandatory-disclosure regulations and routine treatments that are not included under State regulations. A comparison between SCAQMD chemical-use for routine treatments and state-wide chemical-use for hydraulic fracturing also showed close similarity in chemical-use between activities covered under chemical disclosure requirements (e.g., hydraulic fracturing) and many other oil and gas field activities. The results of this study indicate regulations and risk assessments focused exclusively on chemicals used in well-stimulation activities may underestimate potential hazard or risk from overall oil field chemical-use.
Overlap of all chemical usage according to activity (SCAQMD)

Note: This figure only includes chemicals WITHOUT available CASRN data

Stringfellow, Shonkoff, et al. (2017)
Summary of available chemical data for non-hydraulic fracturing events (SCAQMD)

<table>
<thead>
<tr>
<th>Number of chemicals</th>
<th>Proportion of all Chemicals</th>
<th>Identified by unique CASRN</th>
<th>Toxicity</th>
<th>Quantity of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>151</td>
<td>30%</td>
<td>Available</td>
<td>Available</td>
<td>Available</td>
</tr>
<tr>
<td>1</td>
<td>0%</td>
<td>Available</td>
<td>Available</td>
<td>Unavailable</td>
</tr>
<tr>
<td>97</td>
<td>18%</td>
<td>Available</td>
<td>Unavailable</td>
<td>Available</td>
</tr>
<tr>
<td>43</td>
<td>8%</td>
<td>Unavailable</td>
<td>Unavailable</td>
<td>Available</td>
</tr>
<tr>
<td>233</td>
<td>44%</td>
<td>Unavailable</td>
<td>Unavailable</td>
<td>Unavailable</td>
</tr>
</tbody>
</table>

Stringfellow, Shonkoff, et al. (2017)
Hazard Assessment of Chemical Additives Used in Oil Fields that Reuse Produced Water for Agricultural Irrigation, Livestock Watering, and Groundwater Recharge in The San Joaquin Valley of California: Preliminary Results

Authors:

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Technical Report
September 2016
Dataset Summary

- Data collected under authority of California Water Code section 13267
- Chemical additive data from 7 operators that provide produced water for reuse in California
  - Chevron, Valley Water Management Company, California Resources Production Corporations, Bellaire Oil Company, Hathaway, Modus, and Little Creek Properties/Daybreak Oil and Gas
- Period of January 2014 – June 2016
- Operations span 5 oil fields
  - Deer Creek, Mount Poso, Jasmine, Kern Front, and Kern River oil fields

Shonkoff, et al. (2016)
Methods

- **Chemical toxicity** was rated according to United Nations Globally Harmonized System (GHS) of Classification and Labelling of Chemicals
  - Lower numbers indicate higher toxicity
  - Designation of “1” is the most toxic

- **Carcinogenicity and other health hazards** were determined by if the chemical was on a regulatory/hazard list

- **Biodegradability** was categorized according to OECD criteria for biodegradability

- **Bioconcentration** was calculated using U.S. EPA EPISuite Software and categorized according to U.S. EPA criteria for bioaccumulation

*Shonkoff, et al. (2016)*
Chemical disclosures

<table>
<thead>
<tr>
<th>Total Chemicals</th>
<th>Chemicals without CASRN</th>
<th>Chemicals with CASRN</th>
</tr>
</thead>
<tbody>
<tr>
<td>173</td>
<td>66 (38%)</td>
<td>107 (62%)</td>
</tr>
</tbody>
</table>

Chemicals without Chemical Abstract Services Registry Numbers (CASRN) could not be definitively identified and no further chemical analysis could be done on these chemicals.

*Shonkoff, et al. (2016)*
## Additional Considerations

<table>
<thead>
<tr>
<th># of Chemicals</th>
<th>Health and Environmental Hazards</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>California Prop 65</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>USEPA National Primary Drinking Water Standard and Health Advisory Chemicals</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>International Agency for Research on Cancer (IARC)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Bioaccumulative</td>
<td>Only available for 86 chemicals</td>
</tr>
<tr>
<td>5</td>
<td>“Category 1 and 2” for Mammalian Toxicity</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>“Category 1 and 2: for Ecotoxicity</td>
<td></td>
</tr>
</tbody>
</table>

*Shonkoff, et al. (2016)*
Results summary

- Non-hazardous chemicals: 61 (35%)
- Trade secrets: 66 (38%)
- Potential chemicals of concern: 46 (27%)

Shonkoff, et al. (2016)
Location of percolation pits used for produced water disposal and the location of groundwater of varying quality

Legend
Minimum Total Dissolved Solids (mg/L)
- <=500
- >500 to <=1,000
- >1,000 to <=1,500
- >1,500 to <=3,000
- >3,000 to <10,000

Percolation ponds by status
- Active
- Unknown
- Inactive
- Basin with a new oil or gas well since 2001

CCST (2015)
Disposal of Produced Water in Percolation Pits (CCST Conclusion and Recommendation)

**Conclusion:** Produced water disposed in percolation pits likely contains hydraulic fracturing chemicals, associated breakdown products, and health-damaging naturally occurring constituents…and “Unregulated percolation pits present an unjustified risk to water supply, wildlife, vegetation, and human health.”

**CCST Recommendation:** “Ensure safe disposal of produced water in percolation pits with appropriate testing and treatment or phase out this practice.”
Clovis is conserving our water resources by irrigating with recycled water.

RECYCLED WATER - DO NOT DRINK
AGUA DE DESPERDICIO RECLAMADA - NO TOME
Science and Policy Updates

- **AB 1328**: Enables the water boards to order O&G operators and their chemical suppliers to disclose chemical use in operations that discharge their produced water to land.

- **Forthcoming Independent Scientific Study**: Evaluation of oilfield, water and other datasets to investigate key resource, health and environmental considerations for the reuse of produced water in California (CCST, PSE, LBNL).

- **Ongoing Food Safety Expert Panel**

- **Ongoing oil industry and water district crop testing**
Take home messages

- Chemical risks are not specific to hydraulic fracturing and unconventional OGD; chemical additives are used across all oil and gas development practices.

- OPW can meet drinking water standards and MCLs and still pose health and environmental risks.

- O&G fields are very dynamic systems; OPW is extremely variable between and within oilfields.

- Significant knowledge gaps persist including:
  - Chemical composition of OPW within and between O&G fields
  - Disclosure of chemical use in O&G development
  - Environmental, toxicological and health profiles of OPW
  - Appropriate monitoring approaches and associated limits of detection for OPW
  - Appropriate treatment approaches for OPW
Thank you

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Sources Cited

• Central Valley Regional Water Quality Control Board Food Safety Expert Panel. https://www.waterboards.ca.gov/centralvalley/water_issues/oil_fields/food_safety/

• DiGiulio DC, Shonkoff SBC, Jackson RB. 2018. The Need to Protect Fresh and Brackish Groundwater Resources During Unconventional Oil and Gas Development. Current Opinion in Environmental Science & Health. 3:1-7. https://authors.elsevier.com/c/1Wf1I8nlePle~Z


Produced Water Disposal: Fractured Wells

- Percolation pits
- Class II injection wells
- “Other” & “not reported”
  - Data gap

CCST 2015