Advancing Research on Oil and Gas Produced Water

Data Aggregation and Democratization

Cloelle Danforth, PhD
Central Valley, California: 30 year program – currently over 90K acres approved to use oilfield wastewater for food crop irrigation

Pecos, Texas: 2015 pilot to irrigate cotton with produced water

Oklahoma: Governor task force examines alternatives to oil and gas wastewater disposal wells in 2016

West of 98th Meridian: EPA rules allow discharges if “good enough quality” for ag and livestock

Pennsylvania: Discharges to surface waters via centralized treatment facilities (PA rules, in effect, require thermal distillation)

Total produced: 900 billion gallons annually

*1 barrel = 42 gallons
What are the gaps?

**DETECTION**
We struggle with finding chemicals that may be present in oil & gas wastewater…

**AWARENESS**
…which means we don’t know exactly which chemicals or what amounts may be present because we can’t find what we aren’t looking for…

**EXPOSURE**
…which means we aren’t researching who/what may come in contact with those chemicals…

**HAZARDS**
…so we can’t determine whether chemicals are present at dangerous levels…

**PROTECTION**
…which means we don’t have the information needed to treat or regulate unsafe chemicals and advance detection efforts….
Data Gaps & Produced Water

![Bar chart showing number of potential chemicals for detection gap, hazard gap, and protection gap in approved analytical methods, toxicity data, and CWT ELGs & permits.]

- Detection Gap
- Hazard Gap
- Protection Gap
EDF Science Partners

- Karl Linden, Mike Thurman, University of Colorado/Boulder
  - Biological treatment, chemical characterization
- Thomas Borch, Jens Blotevogal, J. Lucas Argueso, Colorado State University
  - Toxicity bioassay, soil health study
- Motoko Mukai, Cornell University
  - Toxicity bioassay (Zebrafish)
- Kartik Chandran, Columbia University
  - Microbial characterization for biological treatment
- Damian Helbling, Cornell University
  - Chemical Characterization
- April Gu, Cornell University
  - Toxicity bioassay
- Chris Higgins, Colorado School of Mines
  - Chemical characterization
- Nancy Denslow, University of Florida
  - Toxicity bioassay
- Bryan Brooks, Baylor University
  - Chemical characterization, toxicity identification evaluation
- Robert Tanguay, Oregon State University
  - Toxicity bioassay
- Mark Engle, Aaron Jubb, USGS
  - Chemical characterization (inorganic)
- Joe Ryan, Colorado State University
  - Database development/expansion
- Ivan Rusyn, Weihsueh Chiu, Texas A&M
  - QSAR, toxicity profiling of database
Exploring matrix effects and quantitative additive determination in hydraulic fracturing using liquid chromatography-electrospray ionisation mass spectrometry

Markia Neill and Darran F. Heiling

Hydraulic fracturing (HF) operations utilize millions of gallons of water and various chemicals to create large, continuous fractures in the subsurface where hydrocarbons may be present. As a result of these efforts, water quality problems have been reported in the vicinity of HF operations. The present study validates that the environmental and human health impacts of HF operations can be assessed via quantitative matrix effects (ME) determination via LC-ESI-MS/MS. A ME validation method was developed using the National Institute of Standards and Technology oilfield suite and a suite of environmentally relevant standards. The method was validated for a matrix matrix with a recovery of 92%, and an ME qualitative and quantitative additivity additivity determined for 220 days in the Denver-Julesburg Basin. Technical include were between EPM toxicity and microbial commensalism, the potential for environmental and human health impacts of HF operations, and the need for long-term monitoring of industrial impacts.

Introduction
The use of hydraulic fracturing (HF), coupled with horizontal drilling, has led to a boom in unconventional shale gas production over the course of the past decade. For example, as the United States (US) sought to become a natural gas exporter, environmental and public health concerns have been raised. The presence of unconventional resources in the form of shale gas has led to increased interest in the potential for environmental and human health impacts, as well as the need for long-term monitoring of industrial impacts.
Ongoing work - toxicity

• Toxicity identification evaluation of produced waters of different production ages

• Toxicity of produced water before/after various benchtop treatment schemes

• Toxicological characterization of surface water impacted by discharge of minimally treated produced water
Literature Review Objectives

• Identify chemicals detected in wastewater from on-shore oil and gas operations

• Prioritize based on known/unknown toxicity hazards

• Search logic:
Records identified through database searching
  Web of Science (n = 11996)
  PubMed (n = 3665)
  Records screened (n = 15661)
  Records excluded (n = 15391)
  Studies identified from hand searching reviews (n = 21)
  Full-text articles assessed for eligibility (n = 291)
  Full-text articles excluded (n = 191)
  Studies included (n = 100)

Includes relevant studies to March 8, 2018 (including advance online publications)
Distribution of Basins

- Appalachian Basin: 38
- Denver-Julesburg Basin: 16
- Powder River Basin: 9
- Western Canadian Sedimentary Basin: 7
- Bend Arch-Fort Worth Basin: 7
- Permian Basin: 6
- Arkoma Basin: 5
- East Texas Basin: 4
- Piceance Basin: 4
- Williston Basin: 3
- Green River Basin: 3
- Raton Basin: 3
- San Juan Basin: 2
- Black Warrior Basin: 2
- Gulf Coast Basin: 2
- Illinois Basin: 1
- Uintah Basin: 1
- Central Basin: 1
- Cherokee Basin: 1
- Tongue River Basin: 1
- N.S.: 1
## Chemicals x-walk list

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<thead>
<tr>
<th>Chemical</th>
<th>Source</th>
<th>Regulated</th>
<th>Methods</th>
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<td>40 CFR 136 SW846</td>
<td>CWT permit</td>
<td>Priority Pollutant</td>
<td>TRI, RCRA</td>
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<td>NPDWR or CC4</td>
<td>FracFocus (count, date)</td>
<td>Literature (concentration, number of times sampled)</td>
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**Chemical**
- CAS
- Chemical Name

**Methods**
- 40 CFR 136 SW846
- CWT permit
- Priority Pollutant
- TRI, RCRA
- NPDWR or CC4
Comptox Dashboard x-walk

- Search 761 K chemicals by CAS/Name
- Returns data or modeling on
  - Chemical properties
  - Environmental Fate/Transport
  - Hazard
  - Exposure
  - Bioassays
- Links to literature
- Presence on Lists:
  - ToxVal Data availability: 18 different databases, including ToxCast, Aggregated Computational Toxicology Online Resource (ACToR), TRI
  - National Environment Methods Index (NEMI)
  - Provisional Peer-Reviewed Toxicity Values (PPRTVs)
Chemicals x-walk list + Comptox

- Chemical, Source, Regulated, Methods
- Comptox & other Tox data
- ToxVal Availability
- TEDX List
- TOPKAT (Yost et. al.)
Data Gaps & Produced Water

Updated: FF review, PW from literature review, ToxVal Data
## Cross-walks

### CHEMICALS DETECTED IN PW (1180)

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Source: TOXCAST Data

BARC FracFocus (2013-2017)

BARC FracFocus (2013-2017) with Regulated Data
## Cross-walks

**UNREGULATED, WITH TOXVAL DATA IN PW (358)**

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