Oil and Gas Wastewater Reuse in California: Considerations and Risks

Seth B.C. Shonkoff, PhD, MPH

PSE Healthy Energy / University of California, Berkeley /

Lawrence Berkeley National Lab

Collaborative on Health and the Environment Webinar

May 31, 2018

PSE Bringing science to energy policy

BERKELEY LAB

PSE Bringing science to energy policy

PSE Healthy Energy is an energy research and policy institute that brings scientific transparency to energy policy issues.

We…

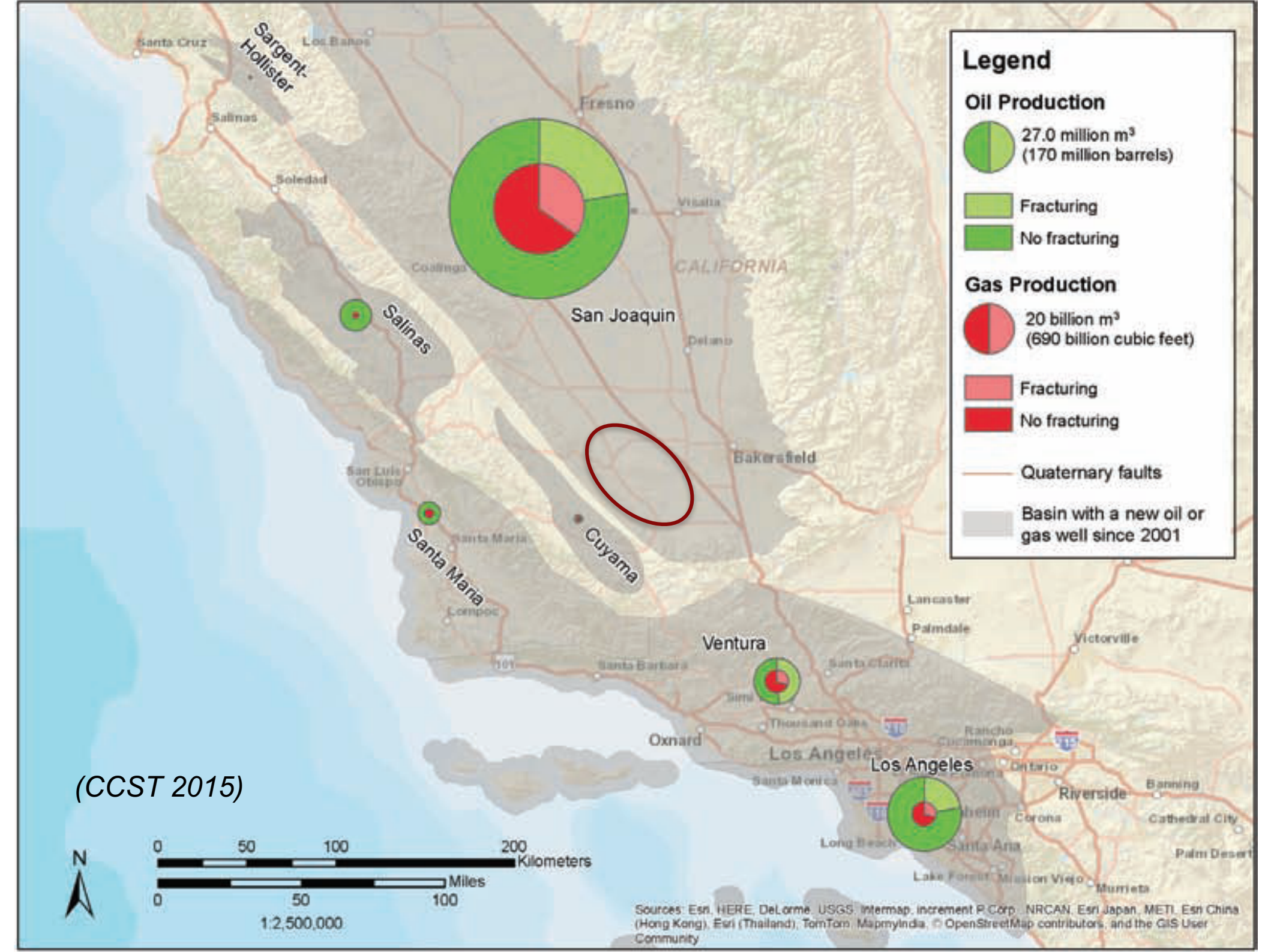
Generate

Translate

Disseminate

Scientific resources and put them into the places where they are used to ensure responsible energy policy decisionmaking

PSE Bringing science to energy policy


Legend
Oil Production
27.0 million m³
(170 million barrels)
Fracturing
No fracturing
Gas Production
20 billion m³
(690 billion cubic feet)
Fracturing
No fracturing
Quaternary faults
Basin with a new oil or gas well since 2001
Sargent-Hollister
Salinas
San Joaquin
Cuyama
Santa Maria
Ventura
Los Angeles
Riverside
Bakersfield
Fresno
CALIFORNIA
(CCST 2015)
N
0 50 100 200 Kilometers
0 50 100 Miles
1:2,500,000
Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Produced water management

- California's oil and gas fields on average produce **more than ten 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
- Aquifer recharge via percolation
  - No treatment
  - Known contamination of groundwater > 2 miles away
- Irrigation of food crops for >20 years in the Cawelo Water District and recently expanding
  - Treatment: oil-water separation and walnut shells

Produced water used for food crop irrigation in the San Joaquin Valley

"BUT WE DON'T FRAC"
(so there's no chemical risk)

Lauren Sommer

PLOS ONE

RESEARCH ARTICLE

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

William T. Stringfellow[1,2], Mary Kay Camarillo[1,2], Jeremy K. Domen[1,2], Seth B. C. Shonkoff[3,4]*

1 Earth & Environmental Sciences Area, Lawrence Berkeley National Lab, Berkeley, CA, United States of America, **2** Ecological Engineering Research Program, School of Engineering & Computer Science, University of the Pacific, 3601 Pacific Avenue, Stockton, CA, United States of America, **3** PSE Healthy Energy, 1440 Broadway, Suite 205, Oakland CA, United States of America, **4** Department of Environmental Science, Policy and Management, University of California, Berkeley, Berkeley, CA, United States of America

* sshonkoff@psehealthyenergy.org

OPEN ACCESS

Citation: Stringfellow WT, Camarillo MK, Domen JK, Shonkoff SBC (2017) Comparison of chemical-use between hydraulic fracturing, acidizing, and routine oil and gas development. PLoS ONE 12(4): e0175344. https://doi.org/10.1371/journal.pone.0175344

Editor: John M. Senko, The University of Akron, UNITED STATES

Received: January 28, 2017

Accepted: March 26, 2017

Published: April 19, 2017

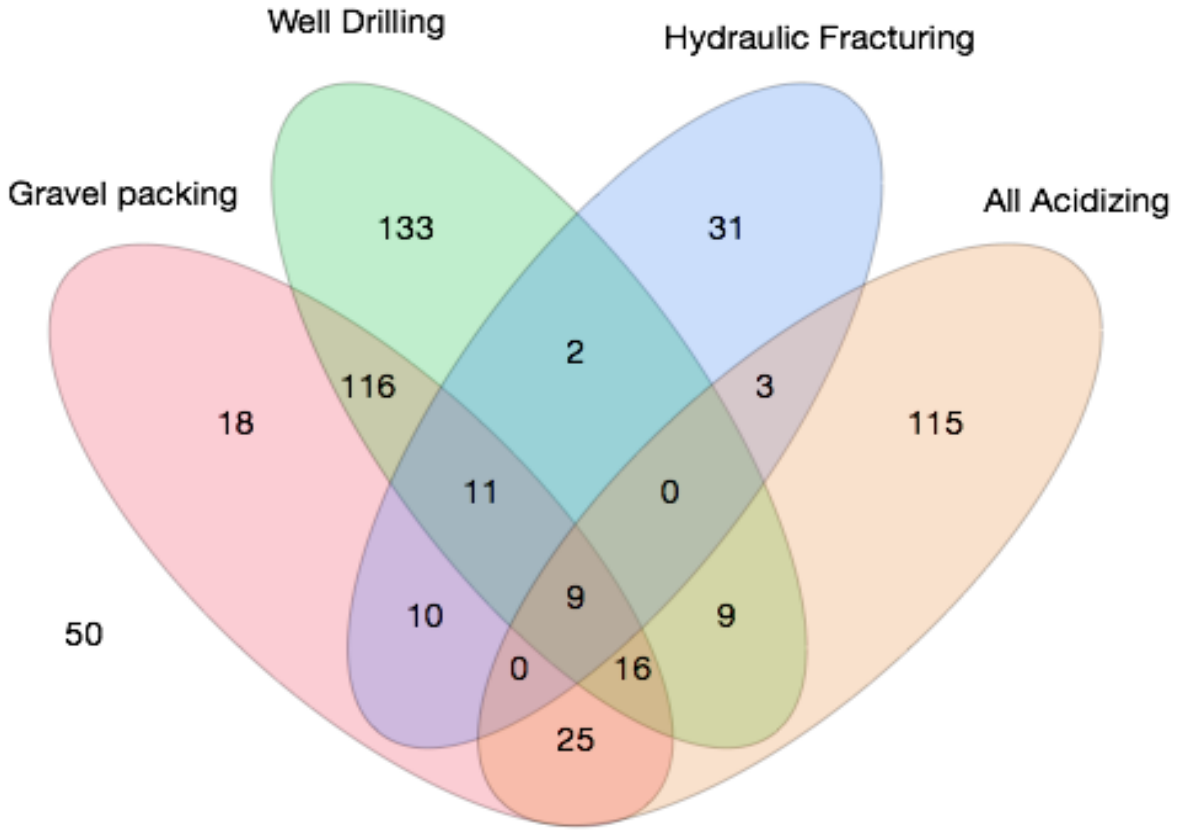
Data Availability Statement: Data are available from the South Coast Air Quality Monitoring District (http://www.aqmd.gov/). Additional data in Research Gate: DOI: 10.13140/RG.2.2.19128.55041.

Funding: This material is based upon work supported by the Department of Energy under Award Number DE-IA0000018. This study was supported in part by grants from The Broad Reach Fund and Laboratory Directed Research and Development (LDRD) funding from Berkeley Lab,

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 <u>WITHOUT</u> available CASRN data

Stringfellow, Shonkoff, et al. (2017)

Summary of available chemical data for non-hydraulic fracturing events (SCAQMD)

Number of chemicals	Proportion of all Chemicals	Identified by unique CASRN	Toxicity	Quantity of use
151	30%	Available	Available	Available
1	0%	Available	Available	Unavailable
97	18%	Available	Unavailable	Available
43	8%	Unavailable	Unavailable	Available
233	44%	Unavailable	Unavailable	Unavailable

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:

Seth B.C. Shonkoff, PhD, MPH[1,2,3]

William T. Stringfellow, PhD[3,4]

Jeremy K. Domen, MS[3,4]

[1] PSE Healthy Energy, Inc., Oakland, CA

[2] Department of Environmental Science, Policy, and Management, University of California, Berkeley

[3] Earth & Environmental Sciences Area, Lawrence Berkeley National Laboratory

[4] Ecological Engineering Research Program, University of the Pacific

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

Total Chemicals	Chemicals without CASRN	Chemicals with CASRN
173	66 (38%)	107 (62%)

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

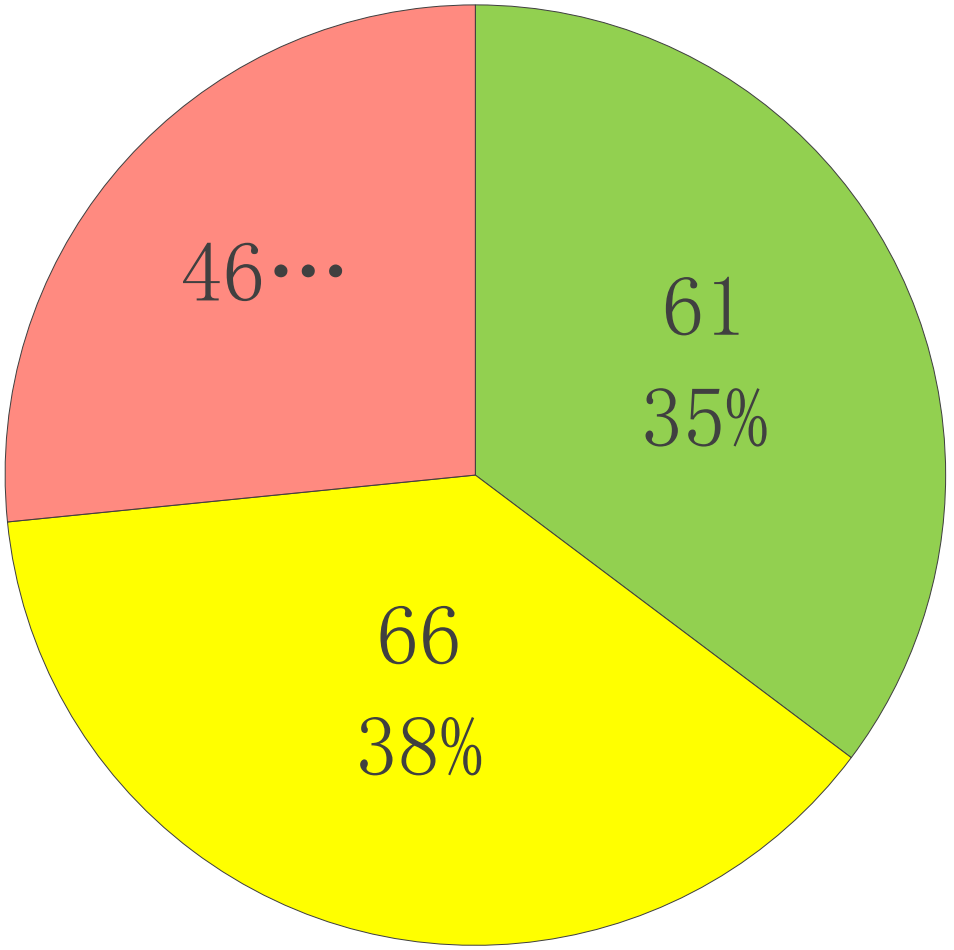
Shonkoff, et al. (2016)

Additional Considerations

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

Shonkoff, et al. (2016)

Results summary



Non-hazardous chemicals

Trade secrets

Potential chemicals of concern

Shonkoff, et al. (2016)


Clovis is conserving
our water resources
by irrigating with
recycled water
RECYCLED WATER - DO NOT DRINK
AGUA DE DESPERDICIO RECLAMADA - NO TOME

Take home messages

- OPW can meet drinking water standards and MCLs and still pose health and environmental risks
- Chemical risks are not specific to hydraulic fracturing and/or unconventional OGD
- O&G fields are very dynamic systems; OPW is extremely variable between and within oilfields.
- Significant knowledge gaps persist:
  - Chemical composition of OPW
  - Disclosure of chemical use in O&G development
  - Environmental and health profiles of OPW
  - Appropriate monitoring approaches and associated limits of detection for OPW
  - Appropriate treatment approaches for OPW

Contact

Seth B.C. Shonkoff, PhD, MPH

sshonkoff@psehealthyenergy.org
sshonkoff@berkeley.edu

www.psehealthyenergy.org

PSE Bringing science to energy policy

BERKELEY LAB

PSE Bringing science to energy policy

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/1Wf1I8nIePIe~Z
- DiGiulio D, Shonkoff SBC. 2017. Is Reuse of Produced Water Safe? First, Let's Find out What's in It. August 2017. EM Magazine, a copyrighted publication of the Air & Waste Management Association.
- Stringfellow WT, Camarillo MK, Domen JK, Shonkoff SBC. 2017. Comparison of Chemical-Use Between Hydraulic Fracturing, Acidizing, and Routine Oil and Gas Development. PLoS ONE. 12(4): e0175344. https://doi.org/10.1371/journal.pone.0175344
- Shonkoff SBC, Domen JK, Stringfellow WT. 2016. 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. PSE Healthy Energy. September 2016. https://www.psehealthyenergy.org/our-work/publications/archive/hazard-assessment-of-chemical-additives-used-in-oil-fields-that-reuse-produced-water-for-agricultural-irrigation-2/
- Shonkoff SBC, Maddalena RL, Hays J, Stringfellow W, Wettstein ZS, Harrison, R, Sandelin W, McKone, TE. 2015. Potential Impacts of Well Stimulation on Human Health in California. In: An Independent Scientific Assessment of Well Stimulation in California. California Council on Science and Technology, Sacramento, CA. http://ccst.us/publications/2015/vol-II-chapter-6.pdf