Biocides in Hydraulic Fracturing Fluids: A Critical Review of Their Usage, Mobility, Degradation, and Toxicity - Environmental Science & Technology (ACS Publications)

**Type**  Web Page  
**URL**  http://pubs.acs.org/doi/abs/10.1021/es503724k  
**Accessed**  9/4/2016, 1:06:19 AM  
**Abstract**  Biocides are critical components of hydraulic fracturing (“fracking”) fluids used for unconventional shale gas development. Bacteria may cause bioclogging and inhibit gas extraction, produce toxic hydrogen sulfide, and induce corrosion leading to downhole equipment failure. The use of biocides such as glutaraldehyde and quaternary ammonium compounds has spurred a public concern and debate among regulators regarding the impact of inadvertent releases into the environment on ecosystem and human health. This work provides a critical review of the potential fate and toxicity of biocides used in hydraulic fracturing operations. We identified the following physicochemical and toxicological aspects as well as knowledge gaps that should be considered when selecting biocides: (1) uncharged species will dominate in the aqueous phase and be subject to degradation and transport whereas charged species will sorb to soils and be less bioavailable; (2) many biocides are short-lived or degradable through abiotic and biotic processes, but some may transform into more toxic or persistent compounds; (3) understanding of biocides’ fate under downhole conditions (high pressure, temperature, and salt and organic matter concentrations) is limited; (4) several biocidal alternatives exist, but high cost, high energy demands, and/or formation of disinfection byproducts limits their use. This review may serve as a guide for environmental risk assessment and identification of microbial control strategies to help develop a sustainable path for managing hydraulic fracturing fluids.  
**Date Added**  9/4/2016, 1:06:19 AM  
**Modified**  9/4/2016, 1:07:10 AM  

**Attachments**

- Biocides in Hydraulic Fracturing Fluids: A Critical Review of Their Usage, Mobility, Degradation, and Toxicity - Environmental Science & Technology (ACS Publications)

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Spills of Hydraulic Fracturing Chemicals on Agricultural Topsoil: Biodegradation, Sorption, and Co-contaminant Interactions - Environmental Science & Technology (ACS Publications)

**Type**  Web Page  
**URL**  http://pubs.acs.org/doi/abs/10.1021/acs.est.6b00240  
**Accessed**  9/4/2016, 1:07:28 AM
Abstract  Hydraulic fracturing frequently occurs on agricultural land. Yet the extent of sorption, transformation, and interactions among the numerous organic frac fluid and oil and gas wastewater constituents upon environmental release is hardly known. Thus, this study aims to advance our current understanding of processes that control the environmental fate and toxicity of commonly used hydraulic fracturing chemicals. Poly(ethylene glycol) surfactants were completely biodegraded in agricultural topsoil within 42–71 days, but their transformation was impeded in the presence of the biocide glutaraldehyde and was completely inhibited by salt at concentrations typical for oil and gas wastewater. At the same time, aqueous glutaraldehyde concentrations decreased due to sorption to soil and were completely biodegraded within 33–57 days. While no aqueous removal of polyacrylamide friction reducer was observed over a period of 6 months, it cross-linked with glutaraldehyde, further lowering the biocide’s aqueous concentration. These findings highlight the necessity to consider co-contaminant effects when we evaluate the risk of frac fluid additives and oil and gas wastewater constituents in agricultural soils in order to fully understand their human health impacts, likelihood for crop uptake, and potential for groundwater contamination.

Date Added  9/4/2016, 1:07:28 AM
Modified  9/4/2016, 1:07:44 AM

Attachments

- Spills of Hydraulic Fracturing Chemicals on Agricultural Topsoil: Biodegradation, Sorption, and Co-contaminant Interactions - Environmental Science & Technology (ACS Publications)

Overview of Chronic Oral Toxicity Values for Chemicals Present in Hydraulic Fracturing Fluids, Flowback, and Produced Waters - Environmental Science & Technology (ACS Publications)

Type  Web Page
URL  http://pubs.acs.org/doi/abs/10.1021/acs.est.5b04645
Abstract  Concerns have been raised about potential public health effects that may arise if hydraulic fracturing-related chemicals were to impact drinking water resources. This study presents an overview of the chronic oral toxicity values—specifically, chronic oral reference values (RfVs) for noncancer effects, and oral slope factors (OSFs) for cancer—that are available for a list of 1173 chemicals that the United States (U.S.) Environmental Protection Agency (EPA) identified as being associated with hydraulic fracturing, including 1076 chemicals used in hydraulic fracturing fluids and 134 chemicals detected in flowback or produced waters from hydraulically fractured wells. The EPA compiled RfVs and OSFs using six governmental and intergovernmental data sources. Ninety (8%) of the 1076 chemicals reported in hydraulic fracturing fluids and 83 (62%) of the 134 chemicals reported in flowback/produced water had a chronic oral RfV or OSF available from one or more of the six sources. Furthermore, of the 36 chemicals reported in hydraulic fracturing fluids in at least 10% of wells nationwide (identified from EPA's analysis of the FracFocus Chemical Disclosure Registry 1.0), 8 chemicals (22%) had an available chronic oral RfV. The lack of chronic oral RfVs and...
OSFs for the majority of these chemicals highlights the significant knowledge gap that exists to assess the potential human health hazards associated with hydraulic fracturing.

**Date Added** 9/4/2016, 1:08:09 AM  
**Modified** 9/4/2016, 1:08:22 AM

**Attachments**

- Overview of Chronic Oral Toxicity Values for Chemicals Present in Hydraulic Fracturing Fluids, Flowback, and Produced Waters - Environmental Science & Technology (ACS Publications)

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**FracFocus Chemical Disclosure Registry**

**Type** Web Page  
**URL** http://fracfocus.org/  
**Accessed** 9/14/2016, 11:58:14 PM  
**Date Added** 9/14/2016, 11:58:14 PM  
**Modified** 9/14/2016, 11:58:14 PM

**Attachments**

- FracFocus Chemical Disclosure Registry

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**Frackwire — Hydraulic fracturing news and information**

**Type** Web Page  
**URL** http://frackwire.com/  
**Accessed** 9/14/2016, 11:58:38 PM  
**Date Added** 9/14/2016, 11:58:38 PM  
**Modified** 9/14/2016, 11:58:38 PM

**Attachments**

- Frackwire — Hydraulic fracturing news and information

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**DMME - Division of Gas and Oil - Regulatory Advisory Panel**

**Type** Web Page  
**Accessed** 9/14/2016, 11:59:31 PM  
**Date Added** 9/14/2016, 11:59:31 PM  
**Modified** 9/14/2016, 11:59:31 PM
Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources

**Type** Attachment  
**Accessed** 9/15/2016, 12:00:38 AM  
**Date Added** 9/15/2016, 12:00:38 AM  
**Modified** 9/15/2016, 12:03:20 AM

EHP – Radionuclides in Fracking Wastewater: Managing a Toxic Blend

**Type** Web Page  
**URL** http://ehp.niehs.nih.gov/122-a50/  
**Accessed** 9/15/2016, 12:02:20 AM  
**Date Added** 9/15/2016, 12:02:20 AM  
**Modified** 9/15/2016, 12:02:20 AM

**Attachments**

○ EHP – Radionuclides in Fracking Wastewater: Managing a Toxic Blend

Increased stray gas abundance in a subset of drinking water wells near Marcellus shale gas extraction

**Type** Web Page  
**URL** http://www.pnas.org/content/110/28/11250  
**Accessed** 9/15/2016, 12:04:14 AM  
**Abstract** Horizontal drilling and hydraulic fracturing are transforming energy production, but their potential environmental effects remain controversial. We analyzed 141 drinking water wells across the Appalachian Plateaus physiographic province of northeastern Pennsylvania, examining natural gas concentrations and isotopic signatures with proximity to shale gas wells. Methane was detected in 82% of drinking water samples, with average concentrations six times higher for homes <1 km from natural gas wells (P = 0.0006). Ethane was 23 times higher in homes <1 km from gas wells (P = 0.0013); propane was detected in 10 water wells, all within approximately 1 km distance (P = 0.01). Of three factors previously proposed to influence gas concentrations in shallow groundwater (distances to gas wells, valley bottoms, and the Appalachian Structural...
Front, a proxy for tectonic deformation), distance to gas wells was highly significant for methane concentrations (P = 0.007; multiple regression), whereas distances to valley bottoms and the Appalachian Structural Front were not significant (P = 0.27 and P = 0.11, respectively). Distance to gas wells was also the most significant factor for Pearson and Spearman correlation analyses (P < 0.01). For ethane concentrations, distance to gas wells was the only statistically significant factor (P < 0.005). Isotopic signatures (δ13C-CH4, δ13C-C2H6, and δ2H-CH4), hydrocarbon ratios (methane to ethane and propane), and the ratio of the noble gas 4He to CH4 in groundwater were characteristic of a thermally postmature Marcellus-like source in some cases. Overall, our data suggest that some homeowners living <1 km from gas wells have drinking water contaminated with stray gases.

**Date Added** 9/15/2016, 12:04:14 AM  
**Modified** 9/15/2016, 12:04:50 AM

**Attachments**

- Increased stray gas abundance in a subset of drinking water wells near Marcellus shale gas extraction

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**Fluid Systems Energized Optimize Frac Effectiveness**

**Type** Web Page  
**Accessed** 9/15/2016, 12:08:15 AM  
**Date Added** 9/15/2016, 12:08:15 AM  
**Modified** 9/15/2016, 12:08:15 AM

**Attachments**

- Fluid Systems Energized Optimize Frac Effectiveness

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**Shale Gas International | Shale Gas News | Unconventional Gas and Oil News**

**Type** Web Page  
**URL** http://www.shalegas.international/  
**Accessed** 9/15/2016, 12:14:04 AM  
**Date Added** 9/15/2016, 12:14:04 AM  
**Modified** 9/15/2016, 12:14:04 AM

**Attachments**

- Shale Gas International | Shale Gas News | Unconventional Gas and Oil News
Hydraulic Fracturing Can Potentially Contaminate Drinking Water Sources - Fact Sheet

**Type**: Attachment  
**Accessed**: 9/15/2016, 12:16:15 AM  
**Date Added**: 9/15/2016, 12:16:15 AM  
**Modified**: 9/15/2016, 12:17:25 AM

In Fracking’s Wake: New Rules are Needed to Protect Our Health and Environment from Contaminated Wastewater | NRDC

**Type**: Web Page  
**Accessed**: 9/15/2016, 12:26:05 AM  
**Abstract**: This paper analyzes the problem of wastewater generated from the hydraulic fracturing process of producing natural gas, particularly with regard to production in the Marcellus Shale.* It shows that, while hydraulic fracturing (often called "hydrofracking" or "fracking") generates massive amounts of polluted wastewater that threaten the health of our drinking water supplies, rivers, streams, and groundwater, federal and state regulations have not kept up with the dramatic growth in the practice and must be significantly strengthened to reduce the risks of fracking throughout the Marcellus region and elsewhere.**  
**Date Added**: 9/15/2016, 12:26:05 AM  
**Modified**: 9/15/2016, 12:26:15 AM

**Attachments**

- In Fracking’s Wake: New Rules are Needed to Protect Our Health and Environment from Contaminated Wastewater | NRDC

List of 78 Chemicals Used in Hydraulic Fracturing Fluid in Pennsylvania | Marcellus Drilling News

**Type**: Web Page  
**Accessed**: 9/15/2016, 12:27:46 AM  
**Date Added**: 9/15/2016, 12:27:46 AM  
**Modified**: 9/15/2016, 12:27:46 AM
The U.S. Environmental Protection Agency (EPA) is conducting a Study of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources. The study is based upon an extensive review of the literature; results from EPA research projects; and technical input from state, industry, and non-governmental organizations, as well as the public and other stakeholders. A series of technical roundtables and in-depth technical workshops were held to help address specific research questions and to inform the work of the study.

EPA Report Finds Nearly 700 Chemicals Used in Fracking - EcoWatch

Hydraulic Fracturing Fluids - Composition and Additives
Attachments

- Hydraulic Fracturing Fluids - Composition and Additives

The Science and Technology of Hydraulic Fracturing - American Chemical Society

- **Type**: Web Page
- **URL**: https://www.acs.org/content/acs/en/policy/publicpolicies/promote/hydraulic-fracturing-statement.html
- **Accessed**: 9/15/2016, 12:37:33 AM
- **Date Added**: 9/15/2016, 12:37:33 AM
- **Modified**: 9/15/2016, 12:37:33 AM

Attachments

- The Science and Technology of Hydraulic Fracturing - American Chemical Society