Science of the Total Environment 748 (2020) 142236

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Endocrine disrupting activities and geochemistry of water resources associated with unconventional oil and gas activity

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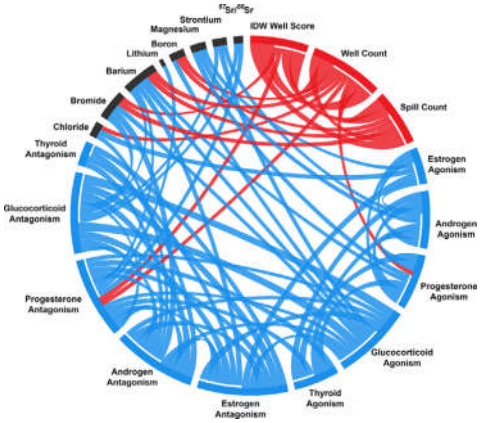
HIGHLIGHTS

- Tested endocrine bioactivities in water near unconventional oil/gas (UOG) operations
- Antagonist activities increased near and correlated with density of UOG operations.
- Geochemistry supports UOG produced water contamination at some sites.
- Organic chemistry analysis suggests UOG contamination at other sites.
- UOG-impacted samples disrupted nuclear receptors at environmentally relevant concentrations.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 6 April 2020
Received in revised form 1 September 2020
Accepted 3 September 2020
Available online 8 September 2020

Editor: Thomas Kevin V

Keywords:
Endocrine disrupting chemicals
Water contamination
Hydraulic fracturing
Unconventional oil and gas operations
Hormonal activity

ABSTRACT

The rise of hydraulic fracturing and unconventional oil and gas (UOG) exploration in the United States has increased public concerns for water contamination induced from hydraulic fracturing fluids and associated wastewater spills. Herein, we collected surface and groundwater samples across Garfield County, Colorado, a drilling-dense region, and measured endocrine bioactivities, geochemical tracers of UOG wastewater, UOG-related organic contaminants in surface water, and evaluated UOG drilling production (weighted well scores, nearby well count, reported spills) surrounding sites. Elevated antagonist activities for the estrogen, androgen, progesterone, and glucocorticoid receptors were detected in surface water and associated with nearby shale gas well counts and density. The elevated endocrine activities were observed in surface water associated with medium and high UOG production (weighted UOG well score-based groups). These bioactivities were generally not associated with reported spills nearby, and often did not exhibit geochemical profiles associated with UOG wastewater from this region. Our results suggest the potential for releases of low-saline hydraulic fracturing fluids or chemicals used in other aspects of UOG production, similar to the chemistry of the local water, and dissimilar from defined spills of post-injection wastewater. Notably, water collected from certain medium and

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https://doi.org/10.1016/j.scitotenv.2020.142236
0048-9697/