HEI STATEMENT

Synopsis of Research Report 233

Potential Exposures to Groundwater Contamination Related to Oil and Gas Development in Pennsylvania

BACKGROUND

Unconventional oil and gas development (UOGD) involves injecting millions of gallons of water, sand, and chemicals at high pressure deep into the ground to release oil or gas. This mixture of injected water mixes with naturally occurring formation water, which is returned to the surface as wastewater (known as produced water). In addition to chemical additives, produced water may contain compounds that come from deep under the ground, including some radioactive materials, trace elements, or petroleum hydrocarbons. Produced water composition can change over time and is generated throughout the life of the well. UOGD targets oil and gas in sandstone or shale formations and often occurs in areas with a history of conventional oil and gas production or coal mining. A key challenge in understanding UOGD exposure in regions with historical energy development is that many contaminants are the same.

This Statement highlights a study led by Baka, Brantley, and Xue (The Pennsylvania State University) and colleagues. HEI Energy's released Request for Applications *E20-2*: Community Exposures Associated with Unconventional Oil and Natural Gas Development to fund research that would assess exposures to chemicals in surface or groundwater originating from UOGD and distinguish potential UOGD exposures from other background sources. The investigators proposed to use a large database of existing groundwater samples to try to distinguish the chemicals from UOGD from historical hydrocarbon development. Additionally, the team proposed hosting focus groups to gauge community concerns about UOGD, water contamination, and public health to help guide their study.

APPROACH

The investigators used an existing groundwater chemistry database for Pennsylvania known as the Shale Network Database. The database includes chemicals found in oil, gas, and coal, those that may indicate hydraulic fracturing or drilling fluids, salts, and inorganic species that are common to the deep underground waters that make up produced water. For their study, the team focused on southwestern Pennsylvania because it has one of the highest densities of UOGD wells in the world and over a century of energy extraction history, including coal mining and conventional methods of extracting oil and gas. At the time of the study, the database included more than 28,000 groundwater analyses collected between April 2008 and April 2020. Approximately 7,000 of the analyses were from southwestern Pennsylvania.

What This Study Adds

- This study used a publicly available database to develop and apply a modeling approach designed to isolate the effects of unconventional oil and gas development on groundwater in regions with long histories of energy development.
- Baka, Brantley, Xue, and colleagues hosted focus groups to learn community concerns regarding unconventional oil and gas development, water contamination, and public health.
- They found small increases in barium and strontium in a few hotspot areas, mainly linked to oil and gas wastewater spills or leaks from storage areas.
- Community focus groups expressed concerns about potential radiation exposure from spills and leaks specifically, which helped to inform the study design and highlighted the value of community knowledge in exposure studies.
- This study improves our understanding of UOGD-related groundwater contamination and potential exposures through water and provides an approach to predict possible contamination hotspots.

This Statement, prepared by HEI Energy, summarizes a research project funded by HEI Energy and conducted by Dr. Jennifer Baka, Susan L. Brantley, Lingzhou Xue (The Pennsylvania State University) and colleagues. Research Report 233 contains the detailed Investigators' Report and a Commentary on the study prepared by the HEI Energy Review Committee.

The investigators used statistical methods to identify patterns in the concentrations of chemicals in the groundwater database to link them to specific types of energy extraction activities or determine if the compounds were from other sources. By combining these methods, they mapped potential hotspots where energy extraction may have led to groundwater contamination.

Concurrently, the team hosted focus groups to engage with community members in the study areas and learn about their concerns regarding UOGD, water contamination, and public health. These concerns were then incorporated into the research design and used to interpret the results of the assessment of potential community exposures associated with UOGD. The research team conducted a total of six meetings in three counties in southwestern Pennsylvania. The objective of the first meeting in each county was to gather community input on the relationship between UOGD, water contamination, and public health. A second meeting was held to share preliminary findings and to continue gathering information on any concerns that may have changed since the initial meeting.

KEY RESULTS

Overall, the investigators noted small but significant increases in the concentrations of two chemical elements that are common in produced water — barium and strontium — near UOGD, particularly in the regions of Pennsylvania where UOGD overlaps with historical energy development. While these chemicals are not toxic at the levels observed, they indicate that UOGD has influenced the groundwater in these areas and may point to where contamination may have occurred. The research team observed that concentrations of these chemicals were more affected by additional spills than the presence of additional wells. This indicates that spills contribute more strongly to UOGD-related groundwater impacts than the presence of wells alone in these regions. Additionally, the investigators found that there were higher concentrations of barium near areas used to store produced water (also known as impoundments) in southwestern Pennsylvania, particularly near impoundments that were reprimanded by the Pennsylvania Department of Environmental Protection in 2014 for suspected leaks of produced water.

These areas of potential contamination, as suggested by their analysis of the groundwater dataset, are illustrated in a map in one of the counties in southwestern Pennsylvania (**Statement Figure**). The team defined potential contaminant hotspot locations as areas within 1 km of impoundments and higher densities of UOGD wells where their model predicted signatures of UOGD in groundwater. Regions for comparison that were not likely to be affected by UOGD were defined as areas more than 3 km from UOGD impoundments or wells.

The focus groups in southwestern Pennsylvania were most concerned about potential radiation exposure from spilled or leaked produced water. They expressed frustration about not knowing whether there might be a link between UOGD and cancer. While extensive testing for radioactive or other hazardous trace elements for the groundwater database has not been done, in response to focus group concerns, the team sought to estimate potential chemical concentrations based on known ratios of chemical compounds in produced water in southwestern Pennsylvania. Thus, the investigators used existing data and identified several areas where a hazardous trace element, thallium, which is naturally present in formation water and can be found in produced water, could exceed EPA limits.

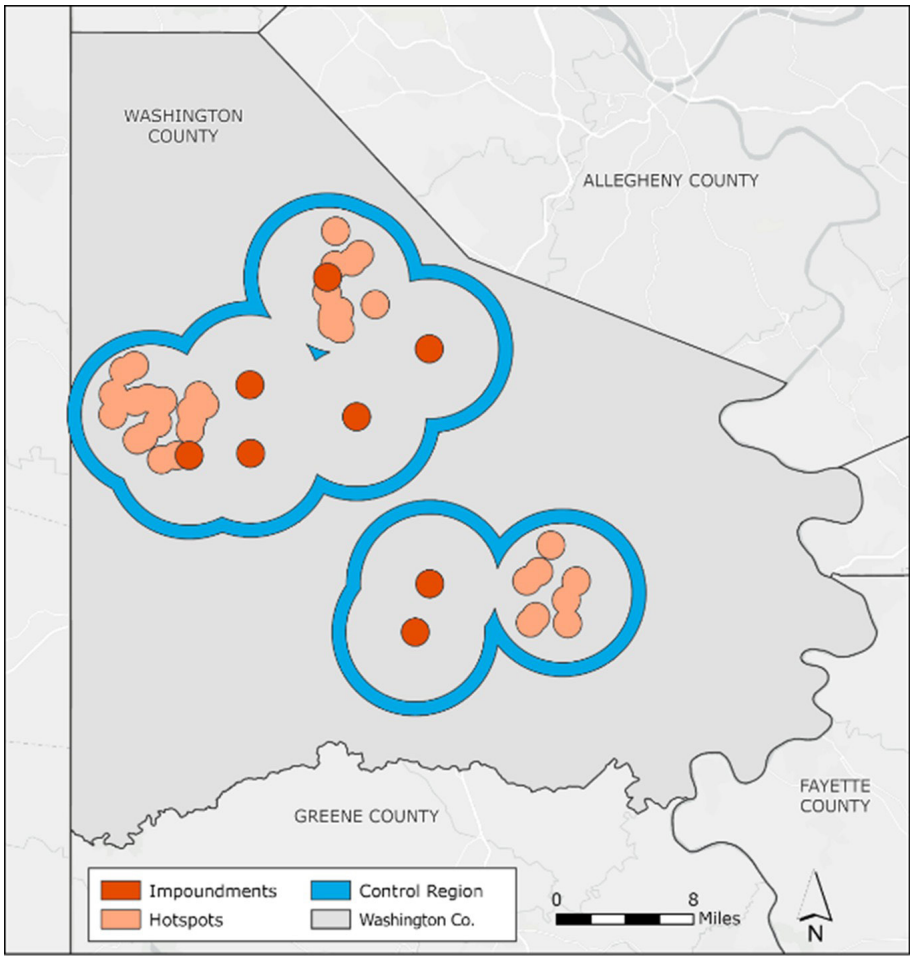
The focus group also reported on obstacles to learning more about UOGD-related water contamination and any potential public health impacts. These obstacles included a lack of transparency of industry practices, low trust in regulatory agencies, and a hesitancy for open conversation with neighbors due to tensions regarding whether UOGD is helping (employment, financial gain for landowners) or hurting (health issues, environmental degradation) communities.

Based on the focus group participant feedback, researchers developed recommendations for creating productive dialogue with communities on topics of contentious environmental issues. In particular, the recommendations include engaging with the community early and continuing throughout the process, improving communication, and increasing transparency. The team also recommends conducting regular radiation testing in drinking water sources.

INTERPRETATION AND CONCLUSIONS

The investigators performed a large-scale investigation using a publicly available groundwater database to highlight relevant UOGD processes in this area that may lead to groundwater contamination. They found that spills and leaks of produced water were likely sources of groundwater contamination. Their data-mining approach was able to isolate the effects of UOGD from historical energy development and other sources of chemicals (such as coal mining or road salting), which represents a novel and important contribution to understanding the influence of UOGD on groundwater sources. These findings may be relevant for other major oil and gas producing areas as well. However, many oil and gas regions don't have enough data to analyze the impact of UOGD on groundwater using data-mining techniques, which require large databases.

Additionally, the team collected a rich set of public opinion on the intersection of UOGD, groundwater contamination, and public health that helped shape some of the analyses and interpretations of the research. The focus groups identified spills and potential radiation



Statement Figure. Locations of potential UOGD-related groundwater contamination in Washington County, PA, based on proximity (within 1 km) to UOGD operations and impoundments. The surrounding regions in Washington County, PA (blue circles, areas more than 3 km from wells) are likely not affected by UOGD. No spills were identified in this region. (Source: Investigators' Report Figure 3.)

effects as concerns. The concern about spills was corroborated by the team's analysis, which found that barium and strontium in groundwater likely came from wastewater spills and leaks. The concern about radiation was more difficult to address due to a lack of data, indicating that additional testing of water sources for radiation might be useful to address community concerns about a potential link between UOGD and health effects. Overall, the focus groups highlight the success of two-way communication between researchers and communities and the importance of local knowledge in exposure studies.

In summary, the team used statistical techniques to separate the effects of UOGD on groundwater from those of other land uses and historical energy production in southwestern Pennsylvania, a complex task due to overlapping and similar impacts. They found small increases in barium and strontium, mainly linked to UOGD wastewater spills or leaks from storage areas. Community focus groups highlighted concerns about potential radiation exposure from these spills and leaks; however, extensive testing for radioactive or other hazardous trace elements has not been conducted for the groundwater database. This study improves our understanding of UOGD-related groundwater contamination and exposures through water and provides an approach to predict potential contamination hotspots. These findings could inform other regions with similar UOGD development and practices. However, data-mining techniques require large databases, indicating more testing would be needed to reproduce this model in other UOGD areas.