Geochemical and Microbiological Indicators of Oil and Gas Wastewater Releases

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Background/Objectives. Liquid and solid wastes produced during development of oil and gas (OG) resources pose potential, but largely unquantified, risks to the quality of the Nation's environmental resources and the health of organisms, from microbes to humans. Wastes that contain naturally-occurring toxic/radioactive elements or chemical additives may enter the environment from spills or other accidents. Analysis of data from spills reports from 2008-2015 for North Dakota, for example, revealed that volumes and composition of materials spilled are often not reported. The more than 8,000 spills that were recorded constituted over 20-million gallons of waste fluids. Researchers from the USGS and other collaborators are conducting interdisciplinary environmental studies at laboratory to site to regional scales to enable a national scale understanding of the environmental impacts of OG wastewater releases. We are 1) characterizing the geochemical composition of OG wastes; 2) studying the geochemical alterations of water, soil, and sediments from OG wastewater-impacted sites, and 3) targeting contaminants of aquatic and human health concern or those compounds that could serve as useful tracers of waste materials in the event of a release to the environment.

Approach/Activities. Our approach includes analysis of spills across the United States, characterization of reactive and potentially toxic components of OG waste materials, and examination of field sites where releases have occurred. To track materials from releases, we developed analytical methods for trace levels of hydrocarbons, utilized stable and radioactive isotopes, and characterized microbial communities as a proxy for ecological disturbance. Our site-based studies include watershed-scale investigations of impacts from drilling activities in Pennsylvania, a large wastewater spill in North Dakota, historical wastewater disposal activity in Montana, and a wastewater disposal facility in West Virginia.

Results/Lessons Learned. Investigations at sites across the United States identified a suite of analytes that can be used as OG-wastewater markers, with elevated concentrations of Na, Cl, Ba, Sr, Li, and trace hydrocarbons being key markers when combined with Sr isotopic analysis. The combination of these analytes has allowed us to identify, and track over time, the impacts of OG wastes on the environment. In particular, at the West Virginia site the combination of Sr isotopic signatures with elevated Na, Cl, Ba, Sr, and Li concentrations, as well as the identification of organic compounds associated with OG wastes, allowed us to trace environmental alterations due to activities associated with wastewater disposal. Further, we distinguished between multiple sources of OG wastewater using Sr isotopic analysis. Ecological impacts were also observed via shifts in microbial community composition at locations with altered geochemistry. In North Dakota, the presence of OG-wastewater markers and shifts in microbial communities persisted at least six months post spill. In addition, labile Ba, Ra and Sr concentrations extracted from sediments collected six months post spill were higher downstream from the spill site. Effects of contaminants released to the environment during OG waste management activities remain poorly understood; however, analyses of Ra concentrations and Sr isotopes, as well as trace inorganic and organic compounds and microbial communities at these sites are beginning to provide insights into potentials for human exposures.