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Geochemical and Biological Effects of Oil and Gas Wastewater Release to Surface Water

Liquid and solid wastes produced during development of oil and gas (OG) resources, including shale gas and tight oil, 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 more than 8,000 spills were recorded, that 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; 3) targeting potentially harmful compounds to aquatic and human health concern and constituents that could serve as useful tracers of waste materials in the event of a release to the environment 4) employing geophysical techniques to trace movement of potential contaminants and 5) conducting *in-situ* and site water investigations of biological responses to field spill conditions. 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, legacy wastewater disposal activity in Montana, and a wastewater disposal facility in West Virginia.

Our investigations at these sites identified a suite of analytes that can be used as OG-wastewater signatures; in our studies we found elevated concentrations of Na, Cl, Ba, Sr, Li, and trace hydrocarbons were key markers when combined with Sr and Ra isotopic ratios.These analytes combined with hydrologic and geophysical investigations has allowed us to identify contaminant discharges, and track them over time, to assess impacts of OG wastes on water quality. In one recent study in North Dakota, the presence of OG-wastewater markers and shifts in microbial communities persisted at least six months after a wastewater spill. In addition, labile Ba, Ra and Sr concentrations extracted from sediments collected six months post spill were higher downstream than upstream of the spill site. Biological effects *in situ* included mortality of resident and caged-fish. Application of these tools also demonstrated that one year after the spill the stream water no longer had a wastewater spill signal. 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.