# Sorption characteristics of inorganic and organic compounds found in hydraulic fracturing flowback and produced water: Implications for fate and transport

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In recent years, due to increasing energy demands, hydraulic fracturing operation for unconventional hydrocarbon resources has increased. Wastewater recovered is referred to as flowback and produced water (FPW), and is often saline, contains numerous organic and inorganic constituents, and may pose threats to groundwater resources. Hundreds of spills of FPW have been reported to the Alberta Energy Regulator each year. As such, the environmental risk that FPW may pose to shallow groundwater environments and surface water bodies has emerged as a major concern in several jurisdictions. Contaminants within this complex fluid may interact with other compounds, either synergistically or antagonistically, resulting in different sorption behavior. To assess this behavior, batch and column experiments were conducted using FPW collected from hydraulic fracturing operations in the Duvernay play with soils collected from Fox Creek, AB. In our batch experiments, we found that for many of the dissolved inorganics (e.g. Sr, Cu, Ni), sorption was supressed, likely a result of the high total dissolved solids (TDS) of the fluid and competition with other constituents within the FPW. Differential sorption of organic compounds (polyethylene glycols; PEGs) were found to sorb more strongly, increasing with increasing ethylene oxide numbers.

Column experiments were also conducted to address how groundwater flow may influence sorption. Sorption of some dissolved inorganic constituents (e.g. Sr, Li, B) and PEGs were observed to be further suppressed compared to our batch experiments. We argue that sorption is non-instantaneous, characterized by two stages: a fast adsorption phase onto external sorption sites, followed by a slow absorption phase into internal sorption sites. Flow likely negated the latter process, explaining the decrease in sorption. Heavy metals (e.g. Ni, Cu) were observed to exhibit enhanced sorption in the presence of flow. We argue that because the column experiments were conducted under anaerobic conditions, precipitation of heavy metal-bearing sulphides may have acted to additionally sequester these elements, resulting in higher heavy metal retention. Coupled with the known toxicity FPW poses to aquatic ecosystems, we argue that FPW may pose a serious threat to groundwater aquifers and aquatic ecosystems in the event of a surface spill.

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