Hydrogeochemical Controls of Arsenic and Uranium Mobility in Groundwater of the Pine Ridge Reservation, South Dakota

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This study integrates geochemical modeling, spatial analysis and several statistical methods including principal component analysis, multivariate regression and cluster analysis to investigate hydrogeochemical controls of arsenic and uranium contamination within groundwater of the Arikaree aquifer on the Pine Ridge Reservation (PRR) on a regional scale. Located in southwestern South Dakota, the Pine Ridge Reservation is largely rural and thousands of people rely on domestic wells tapped into the Arikaree aquifer as their primary drinking water source. Locally, the White River Group, which unconformably underlies the Arikaree Group, is enriched in U and As related to volcanic ash deposits.

Geochemical data from over 250 groundwater samples were obtained through collaboration with the Oglala Sioux Tribe. 48% of the groundwater samples failed an EPA MCL for arsenic, uranium, and/or gross alpha, a measure of radioactive elements. Cluster spatial statistics analyses delineated four regions of statistically significant variations in groundwater chemistry that represent upgradient, intermediate, and downgradient portions of the Arikaree aquifer.

Groundwater evolves as it flows through the Arikaree aquifer with increasing alkalinity, sodium, and pH along flow paths. These chemical changes are likely due to dissolution of carbonate minerals and volcanic ash. Elevated alkalinity and pH levels were found to be the driving factors of arsenic and uranium mobility, and downgradient sections of the aquifer in the northern portions of the PRR are most likely to be impacted by metal(loid) contamination. Thermodynamic calculations suggest increasing supersaturation of the groundwater with respect to calcite, thus, volcanic ash dissolution may be an important source of alkalinity.

Developing a conceptual model to assess contaminant pathways in groundwater on the PRR is critical to identify controls of heavy metal dissolution, and has implications in developing effective planning, treatment and remediation strategies.