Doctoral Thesis Proposal

Abstract

Introduction

In the past 100 years, radionuclides have become intimately tied with human society, serving as fuel sources, weapons, and tracers for both medical and environmental processes. Despite their ever increasing ubiquity, there is a strained relationship with these compounds, one often characterized by distrust and fear \cite{Hohenemser1977}. As one example, the 2011 Fukushima Dai-ichi Power Plant accident has driven many countries to abandon nuclear energy programs all together in attempt to avoid releases of nuclear material that could occur due to unforeseen circumstances \cite{CITE SOURCE}. Despite this, nuclear energy and medicine are still used globally\cite{SOURCE}, and their waste products require careful treatment and disposal. One subject area requiring significant more understanding is the transport of these waste products in groundwater systems. As seen by the continuing work at the **Savannah River,** poor management of waste can lead to persistent contamination of groundwater \cite{Emerson2014}. Groundwater transport also plays an important role in the fate of contaminants at Fukushima, though many radioisotopes require further study \cite{Steinhauser2014}.

Among these radioisotopes, two elements stand out: Radium and Iodine. Radium has multiple isotopes that are naturally occurring in the environment, with a range of half-lives from a few weeks to thousands of years. While it has seen usage in the past in as a dubiously safe popular medicine, and as a luminescent compound, it currently sees little commercial usage \cite{???}. Radium’s societal relevance comes not from its commercial usage, but from natural settings. Brines produced from shales, which are sources for hydrocarbons used in hydraulic fracturing operations can contain up to 0.7 nCi/L of Radium \cite{Barbot2013}, and must be carefully managed. Radium also has been identified as a key tracer for groundwater discharge into the ocean \cite{Moore2000}, but little attention has been given to how it interacts with aquifer solids.

Iodine is a more complicated element, with multiple oxidation states, and strong interactions with organic matter. Its most abundant natural form is the stable isotope 127I, with the less abundant forms, 129I and 131I, being primarily derived from nuclear operations \cite{SOURCES}. 127I is a crucial micronutrient for human life, but radioactive Iodine isotopes can displace non-radioactive forms, presenting a health risk during nuclear accidents. Understanding its transport in soils and groundwater is also crucial for human health. Additionally, the long half-life of 129I and its low natural abundance mean that 129I can be used as a tracer for nuclear material release. However, efforts to understand its transport are complicated by Iodine’s multiple oxidation states and incorporation into organic compounds.

LITERATURE REVIEW?

Objectives/Hypothesis

Characterize the interactions of Radium and Iodine with specific minerals and model organic compounds, so that I can understand its groundwater transport. Aquifer conditions and mineralogy will play a serious role in the transport of both compounds, and I intend to explore those interactions.

Proposed research

\subsection{Radium}

\subsubsection{Sorption Studies}

The first step to understanding

1. Radium
   1. Sorption Studies: Mineral specific interactions
      1. Ideal conditions (batch experiments)
      2. Aquifer/Brine Conditions (batch experiments)
      3. Time studies (batch experiments)
      4. Coordination environment and surface behavior (synchrotron work)(
   2. Transport Studies: Retention and release of radium under variable conditions
      1. Column experiments: constant condition
      2. Column experiments: Induced mineral transformations to enhance sorption
      3. Field studies?
      4. Modeling?
2. Iodine
   1. Sorption Studies of Inorganic Iodine: Mineral specific interactions
      1. Ideal conditions
      2. Mineralogy impacts on speciation
      3. Time studies
      4. Coordination environment and surface behavior
   2. Transport studies
      1. Column experiments: Speciation
      2. Speciation control?
      3. Field study?
   3. Organic compound-Iodine interactions: Competing incorporation of iodine into organic matter
      1. Need a model organic compound
      2. Competing sorption to organic compound and mineral?
      3. Mechanisms for Iodine incorporations?

Expected Results

I expect to characterize the transport of Radium and Iodine in controlled systems. I’ll be able to predict what minerals dominate the sorption processes, and characterize how the sorption varies depending on the solution composition. Furthermore, I expect to be able to characterize “ideal” sorption scenarios when transport is most retarded. Lastly, I hope to enhance existing data on these compounds’ behavior in the environment, enabling their usage as tracers.