Study of an Unrefined Humate Solution as a Possible Remediation Method for Groundwater Contamination

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Background

Savannah River Site (SRS) was one of the major nuclear processing facilities in the U.S. where plutonium was produced during the Cold War.

Approximately 1.8 billion gallons of low level acidic waste solution containing radionuclides and dissolved metals were discharged to a series of unlined seepage basins at the F/H Area.

Uranium is a key contaminant of concern in the basin's groundwater. It is migrating into the groundwater creating an acidic plume with a pH between 3-5.5.

Groundwater Actions:

- The pump-and-treat water treatment unit was designed and built in 1997 to remove metals and radionuclides.
- In 2004 a hybrid funnel-and-gate system was constructed to create a treatment zone in which the acidic nature of the contaminated sediments could be reversed.

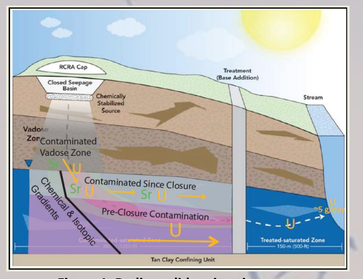

Figure 1. Radionuclide migration

Huma-K

Huma-K is an organic fertilizer that comes from the alkaline extraction of leonardite (a low-rank coal).

Huma-K has a high content of humic substances which consist of complex organic compounds formed by the decomposition of plant and animal tissue.

Figure 2. Huma-K

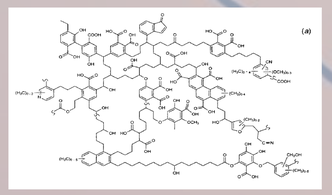

Figure 3. Soil humic acid structure proposed by Schulten and Schnitzer

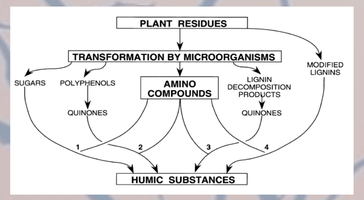

Figure 4. Humic substances formation

Project Objective

The objective of this study is to determine if a low cost unrefined humate solution (Huma-K) can be used to facilitate uranium adsorption to control its mobility in acidic groundwater.

This study can assist in evaluating whether Huma-K can be used as an in situ amendment for the remediation of groundwater contaminated with uranium.

Experimental Procedure

Sorption Experiment of Huma-K Using Savannah River Site Sediment

Sediments from FAW-1 70-90ft were used in this experiment.

Experimental Design

- Sediments were disaggregated and sieved to a particle size of ≤ 2 mm.
- Concentrations in the range 10-500ppm were tested.
- Once all the components were added, pH was adjusted to 4.
- Samples were vortex mixed and placed on a shaker table at 100 RPM for a period of 24 hours in order to reach the adsorption equilibrium (Figure 6).
- Once the adsorption equilibrate was reached, samples were centrifuged at 2700 RPM (Figure 7) to separate the liquid and the solid phase.
- The liquid fraction was analyzed using a Thermo Scientific Genesys 10S UV-Vis spectrophotometer (Figure 8).

Figure 5. Centrifuge tube with sediment and humate solution

Figure 6. Shaker table with samples

Figure 7. Centrifuge

Figure 8. UV-Vis spectrophotometer

Sorption at Different pH Values

The same experimental design was used as explained above.

A known concentration of Huma-K was used to study the pH effect on the sorption process.

pH values were measured at the beginning and at the end of the experiment.

Results and Discussion

Spectra of Huma-K show a featureless character (Figure 9).

Absorbance of light increases as the wavelength is decreased.

Measurements were done at 254nm due to the presence of aromatic rings.

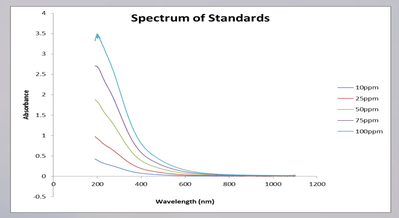

Figure 9. Spectra of standards

Apparently there are two sorption processes (Figure 10).

The first one follows the same trend as the Langmuir isotherm up to 250ppm.

The second sorption process occurs after all the binding sites in the sediments have been occupied.

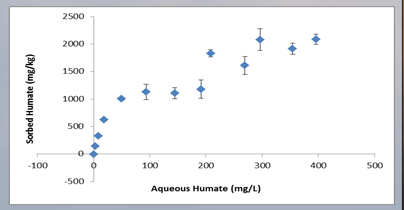

Figure 10. Sorption isotherm

In Figure 11 it can be seen that sorption is decreased as the pH is increased.

Precipitation decreases as the pH is increased.

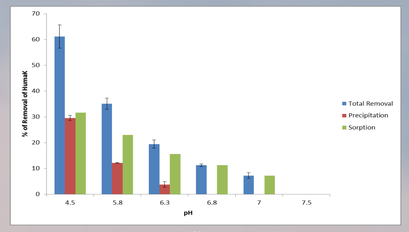

Figure 11. Different pH values

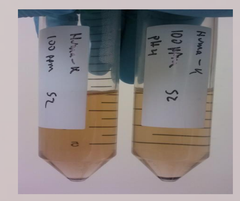

Figure 12. Precipitation of Huma-K

In Figure 12 it can be seen that precipitation forms at the bottom of the centrifuge tube at low pH values.

Conclusion

Based on the sorption isotherm, humic substances apparently bind first to the binding sites of the sediments particles.

Once all the binding sites have been occupied, other sorption processes may start to dominate.

Sorption is affected by pH. Higher sorption is seen at low pH values.

Increased precipitation at low pH values is probably due to the neutralization of surface charges of humic molecules making them agglomerate.

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