DETERMINING ARSENIC MOBILITY AND SPECIATION: AN ANALYSIS OF SOIL CONTAMINATED BY WATER FILTRATION TECHNIQUES IN COSTA RICA

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Introduction

- Access to clean water is a fundamental aspect of survival. In areas with contaminated water, filtration systems are used to provide local communities with access to clean potable water.
- In Costa Rica, local water filtration plants remove contaminants, such as arsenic, from drinking water sources. The filters are composed of anatase (TiO₂).
- The arsenic-enriched filter waste is then partially deposited on soil surfaces and affected by runoff.
- The implications of the arsenic contaminated soil with respect to toxicity and transport are still unknown.
- Understanding the physical properties of the arsenic, such as speciation and mobility, are the first steps to determining the risk to nearby communities and the environment.

Objectives

- To determine the physicochemical properties of the contaminated soils and drinking water filter waste containing arsenic.
- Physicochemical properties such as mobility, speciation, and mineralogy will be determined.

Materials and Methods

- The hydrometer method for particle size analysis was conducted to find the distribution percentages of sand, silt and clay in the sediment samples.
- X-Ray Diffraction (XRD) measured diffraction values of samples when hit with X-rays to determine the identity of crystalline structures in the sediments. Instrument: Rigaku Ultima III XRD, TTU Department of Chemistry.
- X-ray absorption spectroscopy of sediment samples were prepared and sent to the synchrotron light source in France, where arsenic speciation and elemental trends in the samples were measured. Instrument: Samba Beamline, Soleil Synchrotron, France.
- Portable X-ray fluorescence (XRF) detected the elemental concentrations in the sediments. Instrument: Vanta Portable XRF analyzer (Olympus).
- Scanning Electron Microscope (SEM) images visualized the surface morphology of the sediments. Instrument: Hitachi S-4300 E/N (FESEM), TTU Department of Experimental Sciences.

Results

Table 1: PXRF values taken at sediment collection site. The values are listed in ppm or part per million.

<table>
<thead>
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<th>Sediment</th>
<th>As ppm</th>
<th>Ti ppm</th>
<th>Al ppm</th>
<th>Fe ppm</th>
<th>V ppm</th>
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<td>339711</td>
<td>2163</td>
<td>8085</td>
<td>518</td>
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</table>

Figure 2: X-ray absorption near edge spectra (XANES) of As(III) vs. As(V).

Figure 4: SEM image of Worm Accretion sample from Don Miguel Site shows suspected TiO₂ on sand grain.

Discussion

- The PXRF data revealed the sediments contain 157-517 ppm of As and 106101-339711 ppm of Ti. Titanium (Ti) is the most prominent element in each of the samples because the filters are composed of TiO₂ particles.
- X-Ray Absorption Data from the synchrotron helped speciate the arsenic to be As V. The data shows the arsenic in the sediments aligns with the arsenic V standard peak but not with the arsenic III standard peak.
- The particle size data analysis shows the sediments are loam texture with high silt values up to 48%. The high percentage of small particles enriched with arsenic increases the mobility of the contaminant through the air, which increases the inhalation risk of nearby residents.
- XRD analysis data indicate the sediments are primarily composed of anatase (TiO₂).

Conclusion and Future Work

- Arsenic is most likely bound to anatase, a compound containing Ti. The sediments are predominantly Ti with up to about 34% Ti.
- The arsenic was successfully speciated using the X-ray absorption spectroscopy and found to be Arsenic V (pentavalent).
- The particle sizes of the samples, which is predominantly silt, suggests the soil is susceptible to wind and dust formation. The high percentage of small particles increases the mobility of the contaminant through the air, which increases the inhalation risk of nearby residents.
- Additionally, the small particle size increases the mobility of the arsenic-enriched particles due to enhanced transport during water erosion and moves them towards potential sources of groundwater and irrigation water.
- Future work will explore the risk of contaminant on the environment and the people in local communities.

Acknowledgments

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References


Figure 6: Photograph taken during sediment sample collection in Costa Rica near water filtration plant.