Remediation Research on Combination of Reduction and Sequestration Treatment

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FIU Applied Research Center

Remediation Research on Combination of Reduction and Sequestration Treatment

Overall Needs:

- Research evaluates the re-oxidation behavior of Tc and U in the presence of nitrate (NO_3^-) after application of strong reductants coupled with ammonia gas injections for potential vadose zone remediation.
- A limitation of strong reductants technology is these reduced forms of U(IV) and Tc(IV) may re-oxidize over time, dissolving back into the aqueous phase after reductive capacity is consumed and conditions return to natural conditions.
  - To achieve more permanent immobilization, additional strategies are being explored that involve incorporating Tc and U into other low solubility phases or coating them.
- This is the first attempt to couple strong reductants with ammonia gas treatment to prolong the effectiveness of contaminant immobilization.

Objectives:

Quantify the immobilization of Tc(VII) using a combined treatment such as ZVI/SMI in the presence of co-contaminants, U(VI) and nitrate, followed by ammonia gas injection and investigate potential immobilization of reduced Tc(IV), U(IV) and other targeted contaminants throughout the process.

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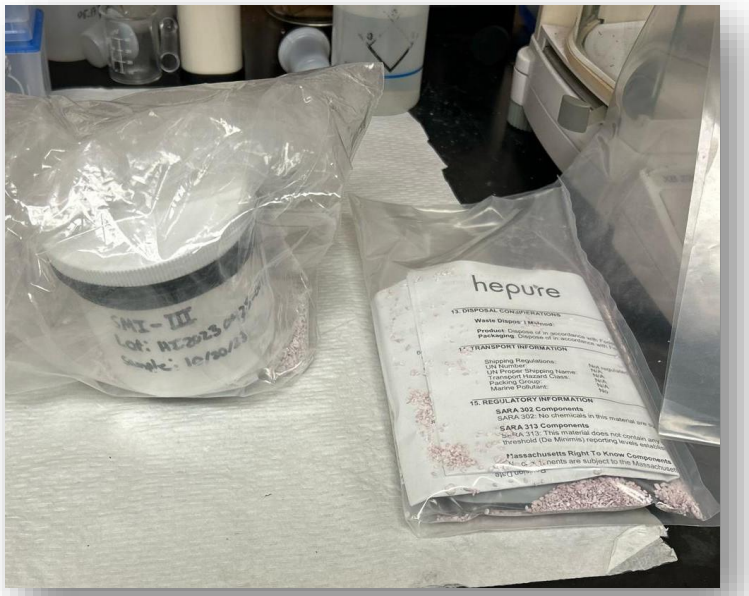
FIU Year 4 Highlights & Accomplishments:

- Test matrix:
  - Prepared synthetic solutions of PW
  - Purged with N_2; pH adjusted; spiked with ^{99}Tc, U(VI) & NO_3^-
  - PW (pH 8.2): 100 µg/L Tc + 150 mg/L U + 204 mg/L NO_3^- (from $NaNO_3$ in PW simulant solution).
  - 10 g sediment + 100 mL solution + 100 mg of ZVI or SMI (1.0 wt.% of sediment)
  - 1.0 wt% ZVI and 1.0 wt% SMI
  - 15 samples total Ringold Formation sediment <2 mm in triplicate samples
- Monitored for change in pH, ORP, DO, Tc, U, NO_3^-, SO_4^{2-} concentrations at each sampling point
- Studied re-oxidation behavior of ^{99}Tc, U(VI), and NO_3^- after treatment with strong reductants



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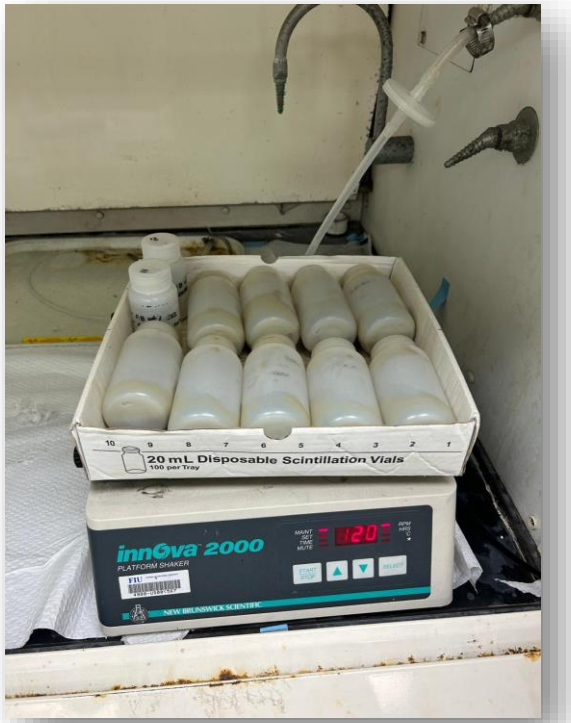
FIU Year 4 Highlights & Accomplishments:

- Two phases of experiments for reduction of ^{99}Tc, U(VI), and NO_3^-:
  - **Phase 1:** In presence of 1.0 % wt of ZVI and SMI under anaerobic conditions for up to **37 days**
  - **Phase 2:** In aerobic conditions after the addition of ammonia hydroxide for up to **49 days**.
    - Total testing = 86 days.
- Results:
  - **Phase 1:**
    - DO: ~0.03-0.05 mg/L
    - ORP: -300 mV -350 mV indicative of reducing conditions
  - **Phase 2:** DO and ORP increased:
    - DO: 5-6 mg/L
    - ORP: +150 to +400 mV consistent with oxidative conditions.



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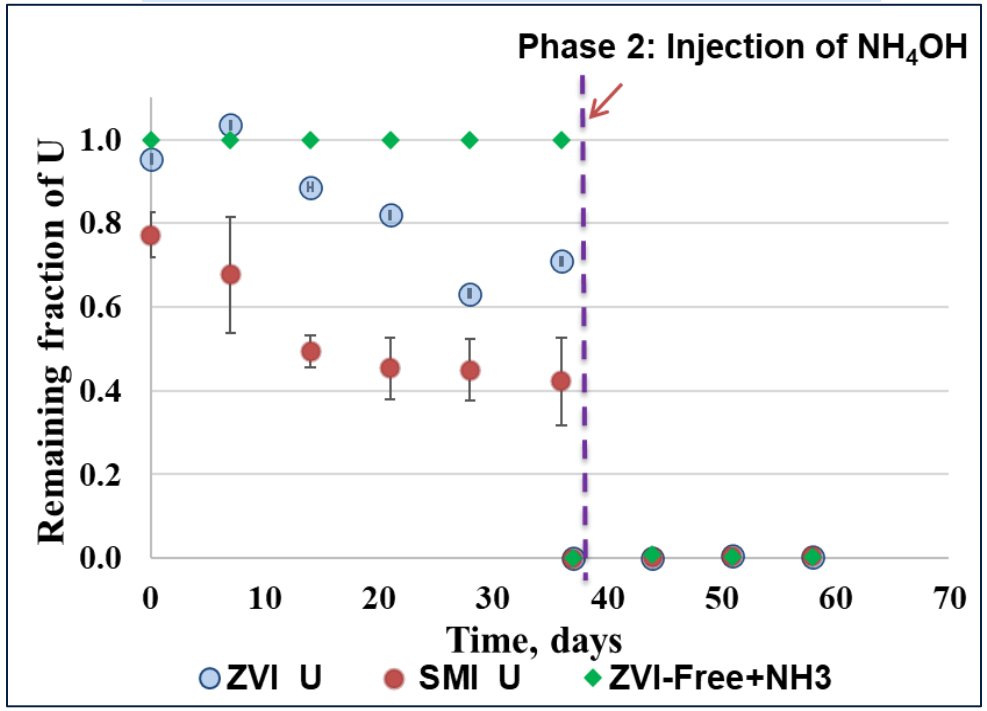
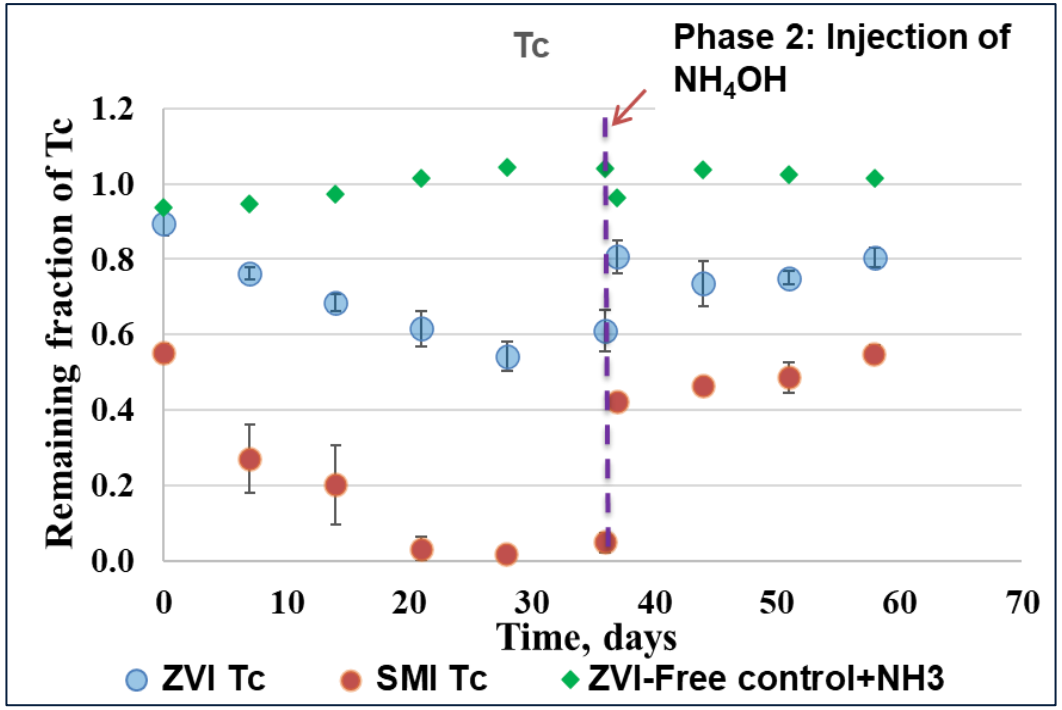
FIU Year 4 Highlights & Accomplishments: Results for U and Tc

Remaining U Fraction in PW, 1%



- SMI more efficient to reduce U in anaerobic conditions.
- U concentration dropped after addition of NH_4OH in aerobic conditions, probably due to formation of U hydroxide at pH ~11.

Remaining Tc Fraction in PW, 1%



- SMI more efficient to reduce Tc in anaerobic conditions.
- Concentration of Tc rebounded after addition of NH_4OH under aerobic conditions.
- In reductant-free control, Tc has not changed.

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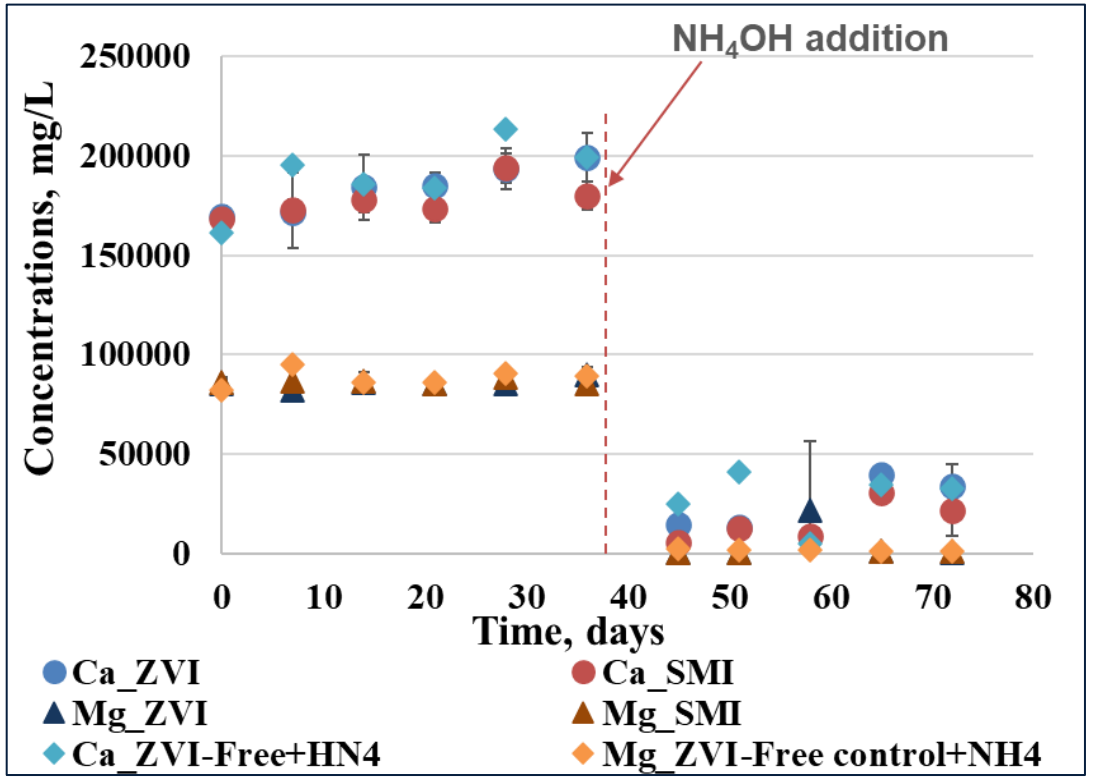
FIU Year 4 Highlights & Accomplishments: Changes in Ca, Mg, & Si



- In Phase 2, after NH_4OH addition, system traps CO_2, which precipitates as $CaCO_3$ and $MgCO_3$. Consequently, aqueous concentrations of Ca and Mg become much lower.
- Behavior of ZVI-Free control + NH_4 samples identical to samples amended with ZVI/SMI.

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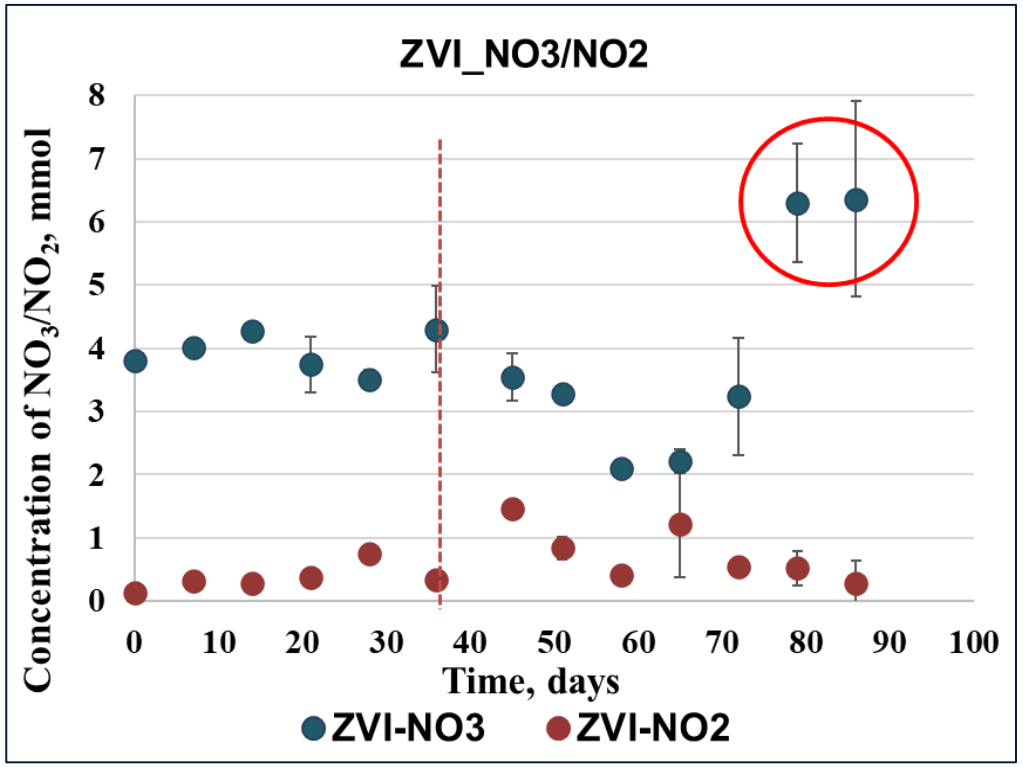
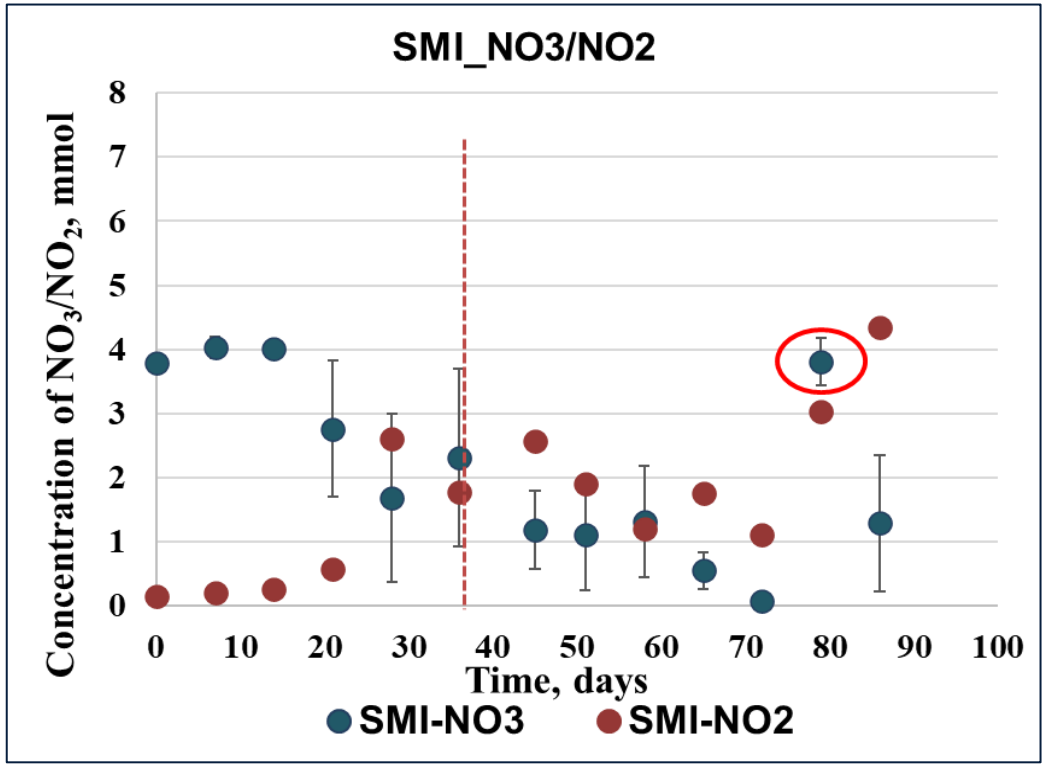
FIU Year 4 Research Highlights & Accomplishments: Changes in NO_3/ NO_2





NO_2 concentration higher in presence of ZVI

SMI more effective in NO_3 removal

Submitted abstract to WM 2025 on project results.

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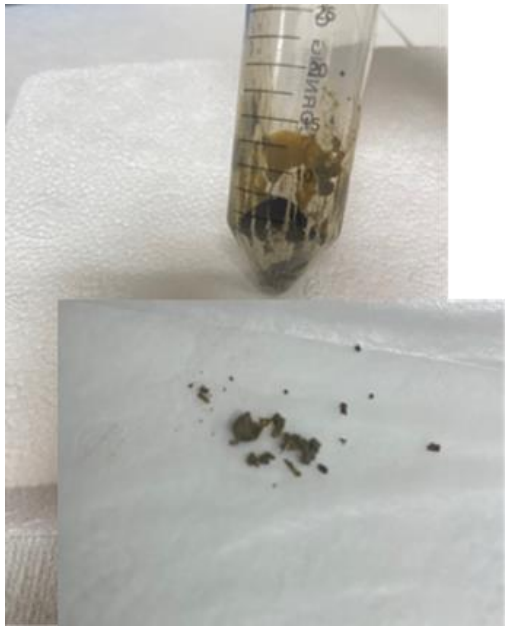
FIU Year 4 Research Highlights & Accomplishments: Solid Characterization

- Prepared samples for solids characterization
  - Separated precipitate from liquid sample
  - Centrifuged and dried sediment

Top layer



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Summer Internship

- Cyanide mobilization task
  - Analyzing behavior of cyanide in relation to various remediation technologies currently being studied
  - Abiotic and biological
  - Mentor: Dr. Alex Kugler
    - Worked with: Andrew Plymale & Hilary Emerson

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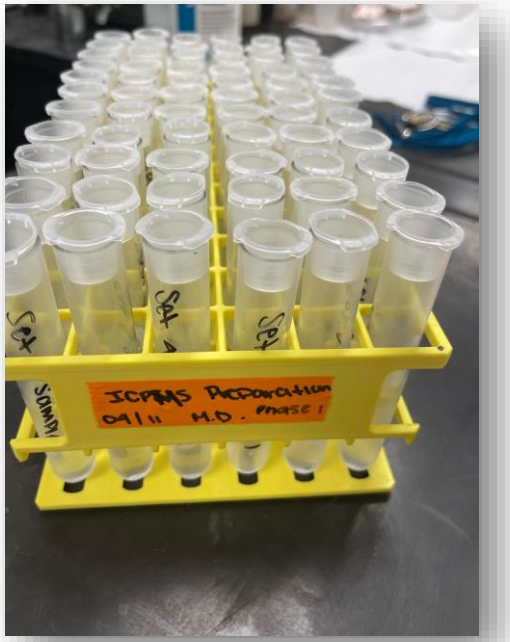
Future work

- Run last samples via ICP-OES
- Finalize Solids Characterization



- **Transitioning to new position at PNNL:**
  - Undergraduate Technical Intern – level IV

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PNNL

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Thank You. Questions?