Opportunity Title: Characterization of Microbial Species for Bioremediation of Uranium in Groundwater
Opportunity Reference Code: IC-16-05

Organization Office of the Director of National Intelligence (ODNI)

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How to Apply

Create and release your Profile on Zintellect – Postdoctoral applicants must create an account and complete a profile in the on-line application system. **Please note: your resume/CV may not exceed 2 pages.**

Complete your application – Enter the rest of the information required for the IC Postdoc Program Research Opportunity. The application itself contains detailed instructions for each one of these components: availability, citizenship, transcripts, dissertation abstract, publication and presentation plan, and information about your Research Advisor co-applicant.

Application Deadline 4/15/2016 6:00:00 PM Eastern Time Zone

Description

Nuclear activities can result in the release of highly toxic radionuclides and heavy metals into localized environments through controlled and uncontrolled discharge of effluents. Radioactive and mixed wastes can negatively impact ecosystems through contamination of surface and groundwater, soil, and sediments. The release of such materials is of intense public concern and has prompted extensive study both to characterize contaminated sites and to devise methods for remediation.

Of particular concern is uranium due to its toxicity and long half-life. The U.S. alone houses approximately 6.4 trillion liters of uranium-contaminated waste in over 120 Department of Energy sites. Strategies for remediation have recently focused on minimizing uranium migration into groundwater to prevent infiltration into drinking water, although current methods which rely on chemical/physical techniques are expensive and ineffective at low metal concentrations. Further, remediation efforts are hampered by lack of knowledge on environmental fate and chemistries predicated upon the prevailing biotic and abiotic forces that dictate the presence of various uranium valence states.

Bioremediation provides promise as a viable alternative to present techniques, offering the advantages of low cost and high efficiency even where contaminants are present in very low concentrations. Multiple strains of microorganisms from genera such as Geobacter, Citrobacter, Metallosphaera, and Pseudomonas already have been identified in areas characterized by high levels of uranium, and a number of tactics, including extracellular binding and intracellular sequestration of offensive materials, can be used to retain cell viability in the presence of otherwise toxic contaminants. However, thorough

understanding of underlying mechanisms that allow species to cope with the presence of the metallic toxicant is lacking. If such microorganisms are to be useful for the purpose of environmental remediation, further investigation into microbe-metal interactions is merited. Research to assess speciation and chemical nature of uranium in real-world conditions combined with studies on cellular localization and means of sequestering or eliminating uranium will allow identification of key pathways and structures. Information derived from these studies could be leveraged to develop practical microbe-based bioremediation strategies.

Pseudomonas aeruginosa J007 was found to accumulate and biomineralize uranium, thus sequestering the heavy metal to an innocuous state (see Choudhary and Sar, 2015 for review). While this strain is under investigation for use in bioremediation, many research questions still remain about specific genetics and mechanisms behind its remarkable uranium biomineraliztion capabilities. Increased characterization of this strain (or other uranium accumulating species) would allow us to better assess its potential use in varied uranium contaminated environments, and making targeted recommendations for ongoing applied research.

Example Approaches

Research could focus on the potential use of uranium accumulation by Pseudomonas aeruginosa strain J007 in the context of bioremediation. Consider both in silico and in vivo (or combinations) of research that forward our understanding of how P. aeruginosa and its capabilities could be used to create better means of accumulating and sequestering uranium.

These are a few examples, but creative approaches are encouraged.

- Microbial biofilms typically are more resistant to metal toxicity, oxidative stress, radiation, and drying than their planktonic counterparts. Quantify the effects of abiotic stressors (pH, temperature, chemical oxidants, chronic and acute forms of ionizing radiation, UV-ABC, and desiccation) associated with targeted environments on the viability of J007 cells, and their ability to form biofilms and immobilize/reduce U and/or other metals (e.g., Cu, Ni).
- Development of methods for increased uranium accumulation or transfer of accumulation capability are encouraged. Whole genome sequencing and comparative analysis of the wild-type J007 and a representative J007 mutant with enhanced U(VI) resistance could be applied to the construction of shuttle plasmids suitable for expression of U-resistance functions in environmentally-robust species (e.g., Deinococcus radiodurans).Reduction of soluble U(VI) to insoluble U(IV) species has been proposed as a microbial

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defense strategy. Apply directed evolution towards the selection of P. aeruginosa J007 mutants with increased metal resistance.
- Characterizing the effects of nutrient growth conditions on the formation and stability of J007 biofilms, U(VI) resistance/reduction, and U(IV) sorption/accumulation under aerobic and anaerobic conditions. Studies could include determining any bias in concentration of U-235 versus U-238, and the extent to which accumulation of U is competitively inhibited by other environmentally-relevant metals (Cr, Cu, Ni, Hg, Mn, Fe) and anions. As U-235 is a radionuclide, the development and viability of U-accumulating J007 biofilms (hydrated and desiccated) could be facilitated by the presence of radio-protectants (e.g., trehalose, Deinococcus Mn-antioxidants). This could facilitate in situ bioremediation, and for biomonitoring and enrichment purposes.

Eligibility Requirements

- **Citizenship:** U.S. Citizen Only
- **Degree:** Doctoral Degree.
- **Discipline(s):**
  - **Business** (11 👁)
  - **Chemistry and Materials Sciences** (12 👁)
  - **Communications and Graphics Design** (6 👁)
  - **Computer, Information, and Data Sciences** (16 👁)
  - **Earth and Geosciences** (21 👁)
  - **Engineering** (27 👁)
  - **Environmental and Marine Sciences** (14 👁)
  - **Life Health and Medical Sciences** (45 👁)
  - **Mathematics and Statistics** (10 👁)
  - **Other Non-Science & Engineering** (13 👁)
  - **Physics** (16 👁)
  - **Science & Engineering-related** (1 👁)
  - **Social and Behavioral Sciences** (28 👁)