



## WATER RESOURCES RESEARCH GRANT PROPOSAL

1. **Title:** Multi-Faceted Investigation of Arsenic Biogeochemistry
2. **Focus Categories:** G&G, TS
3. **Keywords:** Arsenic, Geochemistry, Biotransformation, Oxidation, Reduction
4. **Duration:** 9/98 to 8/00
5. **Federal Funds Requested:** \$73,061.00
6. **Non-Federal Funds:** \$149,633.00
7. **Principal Investigators:**

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8. **Congressional District:** 5th District of Maryland

9. **Statement of Critical Regional or State Water Problems:**

Arsenic concerns range from local to international. The many historic uses of arsenic, especially in pesticides and wood preservatives, have produced significant environmental contamination. Arsenic contamination has been identified at 781 of the 1300 National Priorities list sites through out the U.S. In the Mid-Atlantic region high arsenic levels have been detected in soils, groundwater, and surface water near facilities for wood treatment, military ordnance testing and pesticide manufacturing and testing, in addition to numerous landfills. Arsenic is also released during mining operations in the Western areas of the regions. The health risks due to arsenic are highlighted by the 1996 Amendments to the Safe Drinking Water Act which aim to set revised U.S. drinking water standards for AS by January 1, 2000.

For many contaminants, such as arsenic, sediment/water exchange reactions play an important role in its aqueous environmental chemistry. The problems of arsenic in water supplies and its removal remain as some of the top current issues in environmental health. Furthermore, elevated arsenic concentrations in different environments associated with arsenic wastes have demonstrated the importance of microbially mediated arsenic transformations. Concern over the impacts of arsenic in water bodies emphasizes the need for information on the factors controlling the types, amounts, and speciation of arsenic exported. An important goal of environmental geochemistry is to understand how

reactions of various minerals affiliated with arsenic compounds as well as biological activity influence the migration of arsenic metalloids. Since comprehensive information on physical, chemical and biological interactions between arsenic and the surrounding environment is rather limited, the overall goal of this project is to quantify and develop a mechanistic understanding of the key geochemical and biological processes controlling the fate of arsenic. Such understanding is necessary not only to assess arsenic exposure from polluted areas, but also for the selection of a soil decontamination or water treatment technology for a specific site. Ultimately, site-specific factors will control the efficiency of any treatment technology.

Critical to evaluating the various risks associated with arsenic is a thorough understanding of the reactions of arsenic in the environment. Transport and partitioning of arsenic depend upon its chemical form (oxidation state and speciation) as well as the chemical/biological characteristics of the surrounding environments. Soluble forms move with available water and may be transported long distances. However, some aqueous arsenic species may be adsorbed and immobilized onto the geochemical components of sediments and soils, i.e., clays, iron oxides, aluminum hydroxides, manganese compounds and organic material. Microbial transformation of different arsenic contaminants species is often responsible for the distribution and concentration of various arsenic species present in lake, ocean, stream and soil environments. For example, mining activities and microbially facilitated disturbances greatly increase the amount of arsenic releases into both surface and ground waters, producing levels significantly over background. When coupled with deposition of iron oxyhydroxides due to acid mine drainage impacts, the biogeochemistry of this trace element becomes enormously complex. Both the iron mineral and other surfaces will concentrate arsenic and act as a storage reservoir.

Redox gradients in soils and sediments, which are also important in controlling the type and speciation of arsenic, depend on the organic carbon content, sedimentation, and oxygen diffusion. As oxic environments become reduced,  $MnO_2$  (with adsorbed As) will reductively dissolve, releasing the sorbed arsenic that could be re-adsorbed into Fe-oxides. Furthermore, biologically mediated activities involve transformation of various arsenic species (e.g., reduction of As(V) to As(III) and/or inorganic arsenic to organoarsenic). Thus, sediment-bound arsenic may be released back into the overlying water directly by chemical or biological transformations of other compounds that bind arsenic. Values of partitioning coefficients for arsenic that are employed in contaminant transport modeling range over several orders of magnitude due to the complexity of arsenic biogeochemistry.

## **10. Statement of Results or Benefits:**

While adsorption of arsenic onto single oxides has extensively been studied, it is reasonable to assume that intermixing or coating of various chemical species onto minerals would greatly alter this sorption/desorption and redox behavior. Nevertheless, more research is needed on As adsorption onto mixed oxides in the presence of naturally occurring inorganic and organic ions, and on speciation and solubility changes as a result

of microbial activity. By completing a multi-faceted experimentation on the chemical and biological transformations of various As species, we can add greatly to the knowledge base on arsenic fate and transport through the determination of equilibrium and rate parameters. The results will contribute to the body of information needed towards better decision making tools for minimizing arsenic health risks in the Mid-Atlantic area. Overall results from this study will provide a more integrated understanding of arsenic biogeochemistry.