Frontiers in Contaminant Speciation and Reactivity in Terrestrial Environments: The Role of Synchrotron Radiation

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Environmental quality and sustainability is a concern worldwide. Contamination of soils and waters with metals, oxyanions, radionuclides, nutrients, and organic chemicals is the focus of research in a variety of fields including soil and environmental sciences and engineering. Ideally, one wants to understand environmentally important reactions and processes in natural systems at multiple scales to accurately predict the fate, transport, toxicity, and bioavailability of contaminants. In the past, most studies were conducted at larger scales such as the field and macroscopic scales. However, in the past decade, there have been major advances in the development and use of state-of-the-art in-situ analytical techniques that enable one to study an array of important reactions and processes at the molecular scale. In fact, a new interdisciplinary science has evolved based on the use of molecular scale approaches - molecular environmental science.

To delineate reaction mechanisms of contaminant reactions on soil minerals and in soils, it is advisable to couple macroscopic investigations with molecular scale studies. In recent years, synchrotron-based, in-situ micro-focused X-ray absorption and fluorescence spectroscopic techniques, infrared spectroscopy, and microtomography have significantly advanced research frontiers in the soil and environmental sciences. Applications of these techniques to assess metal and metalloid sorption/release, natural attenuation processes, speciation of metal(loid)s in heterogeneous soils/biosolids/plants, and mineral/microbe/contaminant reactions will be addressed. Future research needs and directions will also be assessed.