Research Topics Directed by Dr. Matthew Alexander
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Microalgae Growth in Wastewaters for Biodiesel Production: Microalgae represent an excellent vehicle for high concentration triglyceride production, which can subsequently be transformed chemically into biodiesel fuel. However, large volumes of water are necessary for successful microalgae cultivation. With ever increasing demands for clean potable water, it makes sense to investigate use of non-potable waters, such as wastewater and brackish waters, for microalgae culturing. Experimental work is conducted to investigate algae growth and oil production in these water sources.

Process Modeling of Environmental Treatment Operations: The performance of environmental treatment processes (wastewater treatment) such as adsorption, volatilization, oxidative degradation, or other chemical degradation reactions may be conducted using a chemical process simulator such as Aspen Plus. This modeling can assist in determining consumption of media, treatment chemicals, or energy for a given amount of treatment achieved. The process simulation environment allows for time-efficient treatment analysis of complex mixtures of contaminants not readily possible in a laboratory environment. Analyses of breakthrough curves and media consumption are important results for planning the operation of full scale systems employing these treatment technologies.

Biowall or Permeable Reactive Barrier Water Quality Evaluation: Organic degradable materials installed in a subsurface permeable reactive barrier (PRB) or biowall for groundwater contaminant treatment can affect the quality of water emanating from the barrier. This water quality may have a negative impact on surface waters if there is a groundwater discharge point close to the biowall. Modeling and experimental work is conducted to assess the degree of impact on groundwater as a function of initial groundwater conditions, degradable organic loading, and distance downgradient from the biowall. Groundwater quality is assessed by measuring total organic carbon (TOC), sulfate and sulfide levels from laboratory columns mimicking a biowall loaded with wood mulch for the carbon source.

Enhancing Oily Sludge Waste Biodegradation in Water: The purpose of this research is to look at different ideas / approaches to remediate or treat historic wastewaters impounded in lagoons from historic refinery operations. The presence of untreated historic oily sludge in wastewater ponds represents a long-term liability at older petroleum refineries. The oil component of this sludge is typically difficult to biodegrade because of its long-chain or polyaromatic nature. Biodegradation treatment enhanced by dispersion of the oily material to increase interfacial area and by addition of petroleum-degrading microbial consortia is being investigated through laboratory studies and modeling, with a goal of achieving significant to nearly complete biodegradation in a couple of years.

Simulation Modeling for Process Sustainability Improvements: In a resource constrained world, chemical process economic performance can be enhanced by applying sustainability concepts. Aspen modeling of chemical processes is performed with an emphasis on extensive use of heat integration, feed material recycling, and water recovery and reuse.

Groundwater Fate and Transport Modeling of Natural Causes of Concentration Fluctuations: Fluctuations in contaminant concentration as groundwater levels approach cleanup levels represents a technical and programmatic challenge for environmental remediation project managers. Transient groundwater fate and transport modeling is used to assess the degree to which events such as fluctuating water table and periodic contaminant input from smear zones may be responsible for contaminant concentration fluctuations that preclude achievement of groundwater cleanup goals.