Investigations into the Temporal and Source Dependent Chemical Composition and Reactivity of Natural Dissolved Organic Matter

In this project, the interactions (sorption, covalent and non-covalent bonding) between aquatic dissolved natural organic matter (DOM) and representative small molecules will be studied using a combination of (1) ultrafiltration, size-exclusion chromatography, wet-chemical sorption studies, NMR, and isotope-ratio monitoring mass spectrometry and (2) extensive molecular-level characterization of the DOM.

Intellectual Merit

This project will integrate the determination of molecular-level chemical characteristics of natural dissolved organic matter (DOM) with investigations that quantitatively explore the reactivity of DOM with model compounds. Our preliminary work shows that compositional differences in DOM attributed to both season and source can influence the bulk chemical properties of natural waters so as to induce changes in, for example, the solubility of specific compounds. We will investigate changes in composition and reactivity of DOM as a function of season (over 2.3 years), organic matter source (6 sites from upstream blackwater rivers to the coastal ocean) and water chemistry (pH, salinity, etc.). A rigorous sampling regime, combined with laboratory work designed to detail both the bulk chemical composition and reactivity of the DOM will allow for more comprehensive quantitative models of DOM chemistry and interactions with anthropogenic compounds. As part of this work, we plan to use NMR, IR, HLPC and several mass spectral approaches to fully characterize the DOM and use NMR and IRMS to quantitatively follow its chemical interactions with isotopically labeled model compounds.

Broader Impacts

This study will provide significant advancements in the areas of aquatic/marine and analytical chemistry, contaminant transport and the impact of anthropogenic compounds in aqueous systems and organic matter sequestration and preservation. As an initial attempt to quantitatively probe the reactivity of DOM at the molecular-level, this project will monitor the interactions of both bulk DOM and selected molecular-weight fractions of DOM with test substrates (two aromatic compounds, a hydrocarbon, an aliphatic alcohol and a small peptide). This quantitative approach will provide significant insights into both the molecular composition and specific reactivity of the DOM pool. Old Dominion University is strongly committed to the training of graduates, undergraduates and K-12 students. This work will provide direct support for three graduate students whose dissertation topics will be centered in DOM characterization, variability and molecular interactions. In addition, Old Dominion University guarantees every undergraduate who so desires an internship or research experience with the faculty. Students interested in working with either Dias, Minor or Hatcher will be trained in advanced analytical and instrumental techniques as well as in the interpretation of their results. This project will provide a unique opportunity for our undergraduate majors in chemical oceanography, chemistry and perhaps environmental engineering to gain valuable research experience in the field of environmental chemistry and advanced analytical techniques. Much of ODU's organic geochemical research is incorporated into the ODU Honors General Chemistry Laboratory, which has been taught by both Dias and Minor. This provides approximately 40 enterprising freshmen with an early introduction to aquatic chemistry research and allows them to see real-world, local applications of chemical principles. Research is perhaps, the most valuable teaching tool in our pedagogical arsenal. Finally, this study will be augmented by our continued association with the NSF-sponsored REUMUST program in ocean science at ODU. We will continue our collaboration with the ongoing REU and outreach programs at ODU and will use aspects of this project to provide a meaningful research experience in aquatic organic geochemistry and advanced analytical techniques to qualified underrepresented students.