humankind is facing substantial global challenges in sustainable, responsible energy production; access to clean air and water resources; changes to our climate; management of the Earth’s nutrients; and control of infectious diseases. The stakes have never been higher, and our population has never relied so heavily on the expertise and guidance of environmental scientists and engineers.

Colorado State University is a leading institution in the United States in the research and development of new remediation strategies and practical solutions to some of our greatest global development challenges. Our mission and goal is to educate future leaders in the field of environmental science and engineering, so that they will have the tools they will need to address future energy and environmental challenges.

The Borch Laboratory’s Strengths Run Deep

Increasingly, industry leaders, environmental groups, and communities are looking to the Borch lab to provide credible, nonpartisan solutions to the complexities facing the energy-producing industry and the general public, including issues related to the fate and transport of chemicals in complex environmental systems, treatment of water and soil contaminants, risk assessment, and technology development. The Borch lab is known internationally for its work with uranium mining; unconventional gas and hydraulic fracturing; iron and carbon cycling; and the fate, transport, and treatment of pharmaceuticals and other emerging contaminants. The Borch lab is committed to working with industry to tackle environmental and industrial challenges and to serve as good environmental stewards at the local, national, and international levels.

The goal of the Borch lab’s research is to help develop new knowledge and solutions to benefit efforts to increase energy production cleanly and affordably; to educate and build tomorrow’s industry workforce; and to create partnerships between CSU and industry to continue to find new and better ways to produce the energy and waste-management technology the United States needs.

“\nMy concern three years ago was whether the United States and its people could reach self-sufficient energy production and consumption without contaminating the soil and water that feeds and sustains us. Now that concern is being materially alleviated by research using synchrotron light sources and isotopes to identify and map potential toxic chemicals in surface and groundwater. This has been made possible, in part, by the research of Dr. Borch and the people at Colorado State University by finding and then determining that the ultimate expansion of energy sources derived from the Earth are expandable through continually evolving methods that either prevent pollution or safely recover those two most important sources of life, thus creating a viable partnership between ecology and energy production. As a litigator, I never knew nor dreamed of such possibilities. As a financial participant over these past three years with CSU, I have been joyously allowed to watch and then revel in this work and these discoveries.”

—Karl Hoppess, B.S., ’60 agricultural sciences

Advancing Energy Production and Waste Management

Developing Technology; Creating Partnerships; Educating the Energy and Environmental Workforce of Tomorrow

Dr. Thomas Borch, Professor of Environmental Chemistry in the Department of Soil and Crop Sciences & Department of Chemistry

Colorado State University
Dr. Thomas Borch is a professor of environmental and analytical chemistry at Colorado State University. Dr. Borch is engaging in groundbreaking research related to (1) determining the fate and down-hole chemistry of hydraulic fracturing fluids used for oil and gas production; (2) optimizing restoration strategies for ISR uranium mines; (3) developing technologies to treat groundwater and soil; and (4) improving our fundamental understanding of the molecular mechanisms controlling the environmental fate and transport of emerging contaminants, nutrients, and soil organic matter. In 2012, the prestigious Journal of Environmental Monitoring recognized Dr. Borch as an “Emerging Investigator” – one of just 15 international researchers commended for their work. The Emerging Investigators represent “the best and brightest young minds in environmental sciences and engineering” – and the field’s future “is in good hands” with the work of this vanguard, the journal’s editors wrote.

In 2008, Dr. Borch received the Faculty Early Career Development, or CAREER, Award from the National Science Foundation. The honor is considered one of the most prestigious for up-and-coming researchers in science and engineering. Dr. Borch is also an associate editor for the Journal of Environmental Quality, and he serves as the Soils and Environmental Quality Chair for the Soil Science Society of America.
ISR Uranium Mining: Improving Groundwater Restoration

Dr. Borch’s lab focuses on understanding and optimizing the restoration process used for uranium mining sites to minimize cost and health risks. One of our projects is conducted in collaboration with Cameco Resources at their uranium mines. The sites are mined using an *in situ* recovery mining process in which the uranium is produced through well fields, rather than open pits or underground shafts. There are no tailings or waste rock being produced, however, the potential for increased human health risk after mining, down-gradient transport, and contamination must still be fully understood. Thus, the main objective is to compare the human health risks (if any) associated with the sites before and after mining. Synchrotron radiation-based spectroscopy and reactive transport modeling are being used for hydro-biogeochemical characterization of pre- and post-mining conditions, resulting in data for risk analysis. This project will help regulators assess the actual risk associated with ISR uranium mining and will help companies to improve current restoration strategies in order to assure effectiveness and efficiency.

“Private funding sources would aid us in doing more applied environmental-oriented research involving state-of-the-art technologies leading to creative innovation, which is the key to scientific progress.”

— Amrita Bhattacharyya, Ph.D., postdoctoral fellow

Emerging Contaminants

Pharmaceuticals: Degradation in Environmental and Engineered Systems

Pharmaceuticals, pesticides, household products, and other chemicals are detected in surface waters at low concentrations with increasing frequency, and there is concern that these compounds will impair drinking and irrigation water quality, and negatively impact human health and natural environments. In particular, the presence of antibiotics in surface water and wastewater has been linked to the threat of antibiotic resistance among infectious bacteria. These chemicals reach surface waters through various sources, including discharge from wastewater treatment plants and runoff from agricultural fields. The Borch lab uses state-of-the-art technology to detect these “contaminants of emerging concern” in surface water and soil samples, and to study their fate and transport in complex environments.

“The goal of the Borch lab’s emerging contaminant research is to improve water treatment processes and agricultural practices in a cost-effective manner that safeguards water quality, human health, and the environment. In our case, private donations for equipment, supplies, and expenses have made this work possible.”

— Robert Young, Ph.D. student

For more information please contact:

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Disinfection Byproducts: The Impact of Headwater Chemistry on Drinking Water Quality

Subalpine forests of the Colorado Rockies provide water to approximately 25 million people in seven states. The Rocky Mountain forests have been struck by a massive outbreak of mountain pine beetle infestation, responsible for the death of millions of acres of trees. The impact of dissolved organic carbon from dead and new tree species is having an unknown effect on the chemical composition of the headwaters, which are distributed into drinking water treatment plants. Some of the chemicals exported from the forests can react during water treatment with chlorine to form highly toxic disinfection byproducts. The Borch lab seeks to identify the compounds resulting in the formation of disinfection byproducts in order to help optimize the drinking water treatment process.

“The generous donation of Karl Hoppeess enabled me to join the Borch group in 2011, and gave me the time to apply and be successful in the USDA postdoctoral fellowship program. Donations such as this one, allow Dr. Borch more flexibility in hiring new students and postdocs, so that they can create their own successful research projects.”

– Gina McKee, Ph.D., postdoctoral USDA NIFA AFRI Fellow

Remediation Technology

Groundwater Remediation: Electrolytic Degradation of Organic Pollutants

The Borch lab also focuses on cleaning up vital water sources that have been contaminated with toxic and/or carcinogenic pollutants. We have developed reactors containing electrodes for the treatment of contaminated water. Electrolytic degradation of the organic contaminants proceed through a combination of direct electron transfer at the electrode surface, by reactive radical species, and novel catalytic titanium dioxide pellets. We are currently optimizing this system for the removal of 1,4-dioxane, and treatment of flowback water from hydraulic fracturing operations, but this treatment technology has promise for many other organic pollutants as well.

“Private funding sources can be the catalyst that allows us to explore innovative treatment technologies for some of the most difficult organic contaminants of concern.”

– Jeramy Jasmann, Ph.D. student

Carbon Sequestration

Controls on Carbon Cycling in Wetlands

Wetland soils are biogeochemical hotspots that influence the storage and release of nutrients, carbon, iron, and contaminants in headwater drainages. Thus, changes in climate such as temperature and precipitation patterns in these ecosystems may also have a significant effect on surface water quality. The Borch lab investigates the role of iron and bacteria on the fate and transport of dissolved organic carbon under different temperature, moisture, and redox conditions. This project is being conducted in close collaboration with the University of California, Berkeley, and the USDA Forest Service and includes investigations from the molecular to the field scale.

“With private research funding, I have had the intellectual freedom to pursue questions on the frontiers of science and to perform cutting-edge experiments with researchers at the top of my field.”

– Ellen Daugherty, Ph.D. student