CLEMSON UNIVERSITY

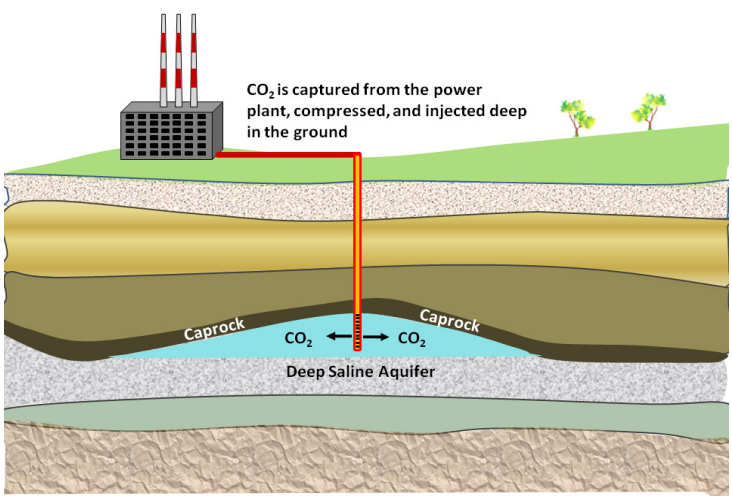
Inside E3S

Department of Environmental Engineering and Earth Sciences

Geologic Carbon Dioxide Sequestration

Geologic storage of CO_2 is one of the most promising alternatives for reducing CO_2 emissions using current technology. With this method, CO_2 is captured from coal, gas or oil-fired power plants, compressed, and then injected into deep geologic formations. Suitable CO_2 storage formations include depleted oil and gas reservoirs, and saline aquifers. Storage formations are confined by impermeable caprocks, and they are thousands of feet below the ground surface.

The EEES department is becoming actively involved in research and training related to geologic CO_2 sequestration. **Ron Falta** and **Larry Murdoch**, professors in EEES, have received an $891,000 Environmental Protection Agency (EPA) Science to Achieve Results (STAR) grant to study the safe storage of CO_2 in geological formations. They will focus on the behavior of CO_2 dissolved in salt water at high pressure. Geologic storage is considered to be a secure way to isolate the CO_2 from the atmosphere for thousands of years. However, there is a slight chance that some of the CO_2 could start to leak from some formations. One route for CO_2 escape involves the flow of CO_2 saturated brines from the storage formation, to a shallower formation where the hydrostatic pressure is lower. Under these conditions, the dissolved CO_2 will come out of solution (exsolve), forming a separate supercritical CO_2 phase. This phenomenon has not been studied previously, and the mobility of the exsolved supercritical CO_2 phase is not known. This project will use laboratory experiments to examine this CO_2 exsolution process, and numerical modeling to help to identify the broader geologic conditions that may lead to CO_2 leakage. The EEES researchers will work with Stanford University professor Sally Benson. Benson is the director of Stanford's Global Climate & Energy Project, and she previously was a visiting professor in the Earth Sciences Department at Clemson.



EEES professors **Jim Castle** and **John Wagner** have received a three-year award from the U.S. Department of Energy to develop technology training related to carbon capture and sequestration in collaboration with other members of the Southeast Regional Sequestration Partnership (SECARB), including the Southern States Energy Board as lead organization. SECARB represents 11 southeastern states in efforts to develop carbon sequestration projects in the region. Clemson's part of the technology training will focus on water management for CO_2 capture and sequestration.

Faculty Profile

Dr. Elizabeth Carraway, Associate Professor, has been at Clemson University since 1999, initially in the Department of Environmental Toxicology and since 2003 in the Department of Engineering and Earth Sciences. She received her PhD in physical chemistry from the University of Virginia in 1989. She completed post-doctoral work on photocatalysis using nanoparticles at Caltech and on dechlorination of dioxins at the University of Michigan. Dr. Carraway's primary teaching and research interests are environmental chemistry applied to engineered and natural systems. She regularly teaches courses in environmental analytical chemistry and introductory environmental science and periodically teaches courses on photochemistry and on environmental effects of nanomaterials. Dr. Carraway divides her time and her work with students between EEES and the graduate program in Environmental Toxicology. In 1999, she received an NSF CAREER Award for work on nano-sized zero-valent iron applied to dechlorination of contaminants such as PCE and TCE. She received the Clemson University Board of Trustees Award of Excellence in 2006. She is married, has one child, and enjoys hiking and swimming.

Chair's Corner

Dear EEES alumni and friends:

First, I would like take this opportunity to wish you a happy and safe Holiday Season and a prosperous New Year. We had a historical year with several unusual and unfamiliar economic challenges. Unfortunately, economy forecasts do not indicate a fast recovery; as a result, in the Department and the University, we are adjusting to function at a new normal or a new equilibrium. This requires significantly more effort and careful considerations in planning, but we have been successful so far. I anticipate the same is true, to some extent, in your personal lives. Despite these challenges, our faculty, staff and students have shown amazing and exemplary professionalism, productivity, and citizenship throughout the past year. This is a testament for the strong core that exists in the department that we all should be proud of.

Here are some data about the department: We currently have 16 tenure-track faculty, and a total of 6 lecturers, research faculty and post-doctoral research associates. There are 72 graduate students (48 M.Sc. and 24 Ph.D), and about 40 undergraduate geology majors. The direct research expenditures (i.e., without overhead or indirect) during the 2008-2009 fiscal year was about $2M. The new research awards during the same period reached approximately $2.2M. We graduated 4 Ph.D. and 12 M.Sc. students during the past year. Overall, these are strong numbers, especially considering the fact that the Department has been changing its shell with many retirements in recent years, and joining of new faculty members.

The Department has also been expanding its expertise and coverage of wide range of environmental issues and challenges. As introduced in the first newsletter, sustainability is now one of the focus areas in the Department with a curriculum and research active faculty. In this issue, we present the recent research and educational activities on CO_2 sequestration. Our graduate students and faculty continue to explore interesting and challenging research problems, winning awards and recognitions, and successfully representing the Department at national and state meetings. This newsletter documents some samples from those activities. Please visit our web page for additional information.

Finally, alumni support cannot be more critical and important to us at such challenging times. We greatly appreciate your contributions and we are thankful for your continued and most generous support. THANK YOU!

Tanju Karanfil, Ph.D., P.E., BCEE
Professor and Chair

Student Awards

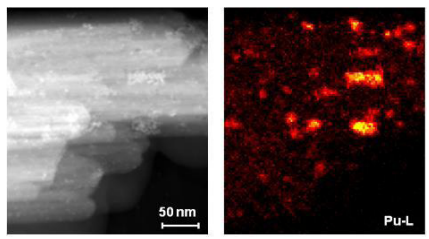
Ting Shao's paper entitled "Factors Influencing the Adsorption of Synthetic Organic Compounds by Carbon Nanotubes in Aquatic Environments" was selected as the winner of the 2009 Water Environment Federation Student Paper Competition in the Masters Division. As the winner, she received a $500 award, presented her paper at the Annual WEFTEC Meeting in the Poster Symposium, and received additional recognition at the WEF Annual Awards and Presidential Reception and Celebration.

Peng Luo received a Trainee Grant and was one of four students to receive the Valentin T. Jordanov Radiation Instrumentation Travel Grant so that he could attend and present his research at the 2009 IEEE Nuclear Science Symposium. The title of Peng's presentation was, "Sequential Probability Ratio Test Using Scaled Time-Intervals for Environmental Radiation Monitoring."

Amer Kanan was elected into the PHI KAPPA PHI Honors Society.

Faculty News

Dr. Brian Powell will collaborate on a proposal ($6 million over five-years) funded by the Department of Energy's Office of Science, Biological and Environmental Research (BER). The project will be lead by Dr. Annie Kersting and Dr. Mavrik Zavarin at the Lawrence Livermore National Laboratory and focus on understanding the dominant geochemical processes that control plutonium transport in the environment. Plutonium geochemical behavior is influenced by complex chemical, physical, and biological processes. For example, plutonium associated with groundwater colloids (such as nanoscale mineral particles) has been shown to facilitate accelerated transport of plutonium in groundwater. The figure demonstrates strong association of plutonium colloids associated with the iron oxyhydroxide mineral goethite. This project will provide the DOE with models which provide a scientific basis to support decisions for the remediation and long-term stewardship of contaminated legacy sites.



A proposal entitled "Subsurface Thermal Energy Storage for Improved Heating and Air Conditioning Efficiency" submitted to Department of Defense (DoD) by **Drs. Ron Falta** and **Fred Molz** along with Chuck Newell (GSI Environmental, Inc.; Houston, TX) was selected for funding. This four year project funded at $971K will build a new generation of a geothermal heat pump system that is assisted by subsurface thermal energy storage. The project team will build this system to heat and cool a 10,000 to 20,000 ft^2 building at a DoD facility somewhere in the US (location to be determined).

Dr. David Freedman was approved as a Board Certified Environmental Engineer by the American Academy of Environmental Engineers. **Dr. Freedman** was also awarded patent no. 7,615, 153 B1, entitled "Microbial Based Chloroethene Destruction" with Christopher Bagwell, Robin Brigmon, **William Bratt,** and **Elizabeth Wood** (both MS, EE&S).

Research by Professors **Jim Castle** and **John Rodgers** was reported worldwide after they proposed a new hypothesis for mass extinctions at the national Geological Society of America meeting in October. Their research, which included examining occurrences of modern algal toxins and the distribution of algal structures through geologic time, suggests that toxin-producing algae may have played an important role in the major mass extinction events during the past one-half billion years. The research findings by **Castle** and **Rodgers** were reported in newspapers around the world and announced by numerous organizations including National Geographic Society, NASA, MSNBC, Science Daily, UPI, USNews and World Report, the Society of Environmental Journalists, Europa Press, and Yahoo. **Castle** and **Rodgers** were interviewed on national public radio shows, but they say that the most fun they have had through this publicity is reading the blogs on their hypothesis. Contact **Jim Castle (jcastle@clemson.edu)** or **John Rodgers (jrodger@clemson.edu)** if you would like a copy of their paper.

Dr. Leslie Grady and **Dr. Bill Hiatt** (Ph.D., EE&S) received the 2009 Rudolf Industrial Waste Management Medal from Water Environment Federation for their publications in the Water Environment Research journal:

- **Hiatt, W. C.** and **Grady, C. P. L. Jr.**, "An updated process model for carbon oxidation, nitrification, and denitrification", Water Environment Research, 80, 2145-2156, 2008.
- **Hiatt, W. C.** and **Grady, C. P. L. Jr.**, "Application of the activated sludge model for nitrogen to elevated nitrogen conditions", Water Environment Research, 80, 2134-2144, 2008.

Dr. Glen Daigger, former chair in our department, was elected President of the International Water Association (IWA). **Dr. Daigger** will assume his term in September, 2010 and will be inducted at the Montreal Congress.

Selected Student Presentations

Arika Bridhikitti and Dr. Tom Overcamp, "Comparison of MODIS Aerosol Products and AERONET and Their Dependences on Land Surface Brightness and Aerosol Type: The Study in Southeast Asia," and "Understanding Optical Characteristics of the Southeast Asia's Regional Aerosol," Annual Meeting of the Air & Waste Management Association, Detroit, MI, June 16-19, 2009.

Shannon Thompson, Dr. Robert Fjeld, Dr. Fred Molz, and Dr. Dan Kaplan "Plutonium Transport in Plants: Experimental Determination of Transport Velocity in Live Plants and Sorption to Plant Xylem," Health Physics Society Annual Meeting Minneapolis, MN July 12-16, 2009.

Shujuan Zhang, Ting Shao, Sule Kaplan, and Dr. Tanju Karanfil. "Comparing Adsorption of Organic Contaminants by Carbon Nanotubes, Activated Carbon and Activated Carbon Fiber." 2009 Water Quality Technology Conference in Seattle, Nov 15-19, 2009.

Tony Reid and Dr. David Freedman presented a poster at the SERDP and ESTCP Technical Symposium, Washington, DC (December 1-3, 2009). The title of the poster was "Observations of Ethene and Vinyl Chloride Bio-Oxidation under Anaerobic Conditions."

CLEMSON UNIVERSITY

Department of Environmental Engineering and Earth Sciences
342 Computer Court
L.G. Rich Environmental Laboratory
Anderson, SC 29625

www.clemson.edu/ces/departments/eees

Nonprofit
Organization
U.S. Postage
PAID
Clemson, SC
Permit No. 10

Address Service Requested

Student Projects

Ph.D. candidate Shannon Thompson and Dr. Fred Molz have been performing plutonium uptake experiments on corn grown at the L. G. Rich Laboratory. The experiments are showing that the plant water uptake system, which supplies water for transpiration and plant growth, can result in the rapid transfer of plutonium from the soil to the plant tops. When plants are cut or die naturally, such plutonium may be deposited on the soil surface. This is of potential concern, because small amounts of ingested or inhaled radioactive plutonium can be dangerous. Given the chemical nature of ionic plutonium, this rapid transfer was unexpected, and it may due to the corn mistaking plutonium for iron, a mineral necessary for plant growth. Many plants, particularly grasses, have evolved a specialized chemical transport system for obtaining iron from soil. Since iron is similar in a molecular sense to plutonium, plants may absorb plutonium by mistake when it is present in soil due to radioactive accidents or waste disposal.

Dan Matz, a MS student working with Dr. Stephen Moysey, has returned home from India after spending five months living and working in Madhya Pradesh. While there he was conducting research on water resource management in collaboration with the Foundation for Ecological Security (FES). To accomplish this goal, Dan used geophysics, mainly electromagnetic induction, to look at soil variability in agricultural fields to try and help farmers with more water efficient irrigation practices. Furthermore, traditional hydrologic approaches were used to study the watershed, such as stream measurements, well measurements, and monitoring the weather in the watershed. Overall, the experience was fantastic for Dan, and hopefully a lot of the outcomes will help decrease the water stress faced by so many in this region each year. For more information about the field work that was conducted, go and visit Dan's online field blog that was updated often while he was in India: www.dansindiablog2009.blogspot.com