McCormick

Northwestern Engineering

Environmental Engineering and Science

photo by Ian Britton

MS and PhD degree Studies

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... Program Overview

Sustainable Communities

The goals of our program are to ensure that modern civilizations coexist in synergy with nature and to promote sustainable communities where critical activities are ecologically sound, socially just, and economically viable now and far into the future.

Environmental engineers and scientists are the technical professionals who identify and design solutions for environmental problems. They seek to mediate and mitigate human impacts on the environment, protect human populations from adverse environmental events such as floods and disease, and restore environmental quality for ecological and human well-being.

photo by Ian Britton

Northwestern University's Environmental Engineering and Science (EES) program is organized to both provide a common core for all environmental engineers and to allow individual students to tailor the program to their interests. The core program features a mixture of fundamental classes and distinct integrative classes, which reflect our commitment to interdisciplinary approaches to environmental problems. The chosen specialization will allow you to develop a depth of expertise in a particular area within your interests. There is also the opportunity to take additional electives in a wide range of subjects, drawing on Northwestern's broad strength in science, engineering, and management.

We feel that our program will ensure that all of our graduate students gain a good general knowledge of environmental processes and also develop very strong skills that will enable them to make major contributions through the course of their careers.

The Northwestern University Approach

To meet today's demands, undergraduate and graduate education at Northwestern University begins by building a strong foundation in fundamental and applied environmental sciences. This foundation expands students' capabilities, providing state-of-the-art knowledge needed for finding and managing both natural and engineered solutions to environmental challenges. These two components—science and technology—prepare students for entering professional practice and performing independent research.

Research at Northwestern stresses the integration of applied science and engineering methods. It addresses current problems and generates new knowledge for dealing with the problems of the future. Although the scope of projects is large, the research is characterized by developing a fundamental scientific understanding in parallel with engineering solutions for prevention, restoration or management of natural and human systems.

Collaboration with faculty and students in other departments and centers augments the research resources available to students in environmental engineering. Examples of such collaborators include the Departments of Chemical and Biological Engineering (biotechnology, catalytic processes, and green manufacturing), Biochemistry, Molecular Biology, and Cell Biology (molecular biology and heavy-metal resistance), Chemistry (photocatalysis and surface science), Earth and Planetary Science (organic biogeochemistry), and Geological Sciences (stable isotope analysis and the global climate); the Center for Advanced Cement-based Materials (radionuclide immobilization and CO_2 fixation); the Institutes for Policy Research (environmental impact assessment and urban sustainability) and Environmental Catalysis (molecular chemistry and biology); the Medical School (environmental toxicology and pathogens); the J.L. Kellogg Graduate School of Management (environmental management); and Geotechnics (groundwater transport and geoenvironmental engineering).

EES Program Objectives

Environmental engineers and scientists take the technical lead for environmental assessment, protection, remediation, and scientific research. Traditionally, environmental engineers assumed responsibility for providing a safe water supply, treating wastewaters, mitigating air pollution, ensuring industrial hygiene and disposing of solid waste. While those traditional responsibilities grow more important every day, environmental engineers and scientist are being called upon increasingly to expand the scope of their efforts to include the protection, restoration and management of natural systems such as lakes, rivers, wetlands, the development of renewable energy, the characterization of physical, chemical and biological complexity in natural and engineered systems, the development of novel technologies to identify, monitor and remediate emerging contaminants, and the reduction of society's carbon and ecological footprints.

Although many people are concerned about the state of our environment, environmental engineers understand how complex environmental systems work. They develop molecular tools to measure contaminants at very low levels in complex mixtures and genomic tools to characterize microbial diversity in unknown communities. They devise sensitive techniques to track chemicals and particles under dynamic fluid flow conditions. They are not only involved in developing nanomaterials and nanotechnologies for new environmental applications, they also address the unintended ecological and toxicological consequences of nanomaterial use.

Environmental engineers are the vital link between scientific discovery, technological development and the societal need for protecting human health and ecological integrity. More and more the emphasis of their work is shifting from managing wastes after they are generated, to altering production processes so to recover, recycle and reuse resources.

The field of environmental engineering, as well as environmental engineering education, is highly interdisciplinary. It involves traditional components such as mathematics, physics, chemistry, and engineering design. But, environmental engineering education also includes a range of other disciplines, including biology, microbiology, ecology, public health, material science, geology, meteorology, economics, political science, and computer science. To address the spectrum of issues facing the environment, environmental engineers are broadly educated, as well as technically trained.

Eligibility and Background

The program looks for students whose academic preparation and work experience support their development in the environmental area. Superior students who hold a bachelor's or master's degree in Environmental Engineering, Civil Engineering, or Chemical Engineering normally are eligible for admission to the graduate program without remedial course work. Superior students with degrees in other engineering disciplines or Chemistry, Biological Sciences, Geology, and other scientific disciplines also are eligible for admission, but they may be required to take remedial courses that do not confer graduate credit.

The minimum course work background required for all students is:

- Full sequence in differential and integral calculus (Math 220, 224, and 230)
- Differential equations (Math 250)
- Classical physics (Physics 235-1 and 2)
- One year of chemistry (Chemistry 101, 102, and 103)
- Computer programming (Computer Science 101)
- Fluid mechanics (Mechanical Engineering 241)

The courses in parentheses are given at Northwestern University; they can be used to assess equivalency or can be taken on a remedial basis, thus not for credit.

… Master of Science (MS) — Environmental Engineering and Science

The Master of Science (MS) degree in Environmental Engineering and Science (EES) is highly valuable as preparation for professional practice and serves as a foundation for advancement to doctoral study. Listed here are the MS Degree Requirements in EES.

- Satisfy the university's residency requirement of 3 quarters *(a minimum of three units and a maximum of four units constitutes full-time residency for any quarter).*
- Complete at least 12 graduate-level units in this manner: *(9 units for a letter grade, and no more than 2 research units can be used for the 12 units) :*
  - **Completing EES Master's Degree Core Program courses** (6 units) plus the CIV_ENV 516 seminar each quarter — students who have already completed equivalent course work will not be required to repeat courses at Northwestern.
  - **Completing Specialization courses** (3 units) — to be approved by EES faculty
  - **Completing Graduate-level Elective courses** (3 units) — to be approved by EES faculty

Required EES Master's Degree Core Program

Units	*Course#*	*Course Title*
1	CIV_ENV 361-1	Environmental Microbiology
1	CIV_ENV 365	Environmental Laboratory
1	CIV_ENV 367	Aquatic Chemistry
1	CIV_ENV 440	Environmental Transport Processes
1	CIV_ENV 444	Physical/Chemical Processes in Environmental Control
1	CIV_ENV 448	Biophysicochemical Processes in Environmental Systems
0	CIV_ENV 516-1,2,3	Seminar in Environmental Engineering and Science

6 units *1-unit courses are for letter grade; 0-unit courses are for S/U (satisfactory/unsatisfactory)*

Specialization Themes

Student-designed three-course thematic specialization in some aspect of environmental engineering and science. EES faculty approval required.

Specialization Programs (Examples)

Environmental Chemistry

CIV_ENV 447	Biogeochemistry
CIV_ENV 468	Chemical Speciation in Environmental Systems
MAT_SCI 360	Introduction to Electron Microscopy

Environmental Microbiology

CIV_ENV 441	Methods in Microbial Complexity
CIV_ENV 442	Processes in Environmental Biotechnology
CIV_ENV 443	Microbial Ecology

Suggested Electives

Three graduate-level courses in Engineering, Science, Policy, Public Health, Kellogg Graduate School of Management, Research, or the environmental courses listed here (EES faculty approval required).

CIV_ENV 303	Environmental Law and Policy
CIV_ENV 355	Engineering Aspects of Groundwater Flow
CIV_ENV 356	Transport Processes in Porous Media
EARTH 314	Organic Geochemistry
CIV_ENV 395, 23	Environmental Justice: Environmental Protection and Social Equity
CIV_ENV 441	Methods in Microbial Complexity
CIV_ENV 442	Processes in Environmental Biotechnology
CIV_ENV 443	Microbial Ecology
CIV_ENV 468	Chemical Speciation in Environmental Systems

Full-time students who do not need remedial courses are able to complete the MS degree course work in three academic quarters, or nine months. The necessity for remedial courses may extend the program's duration beyond nine months. In addition, an independent research project (CIV_ENV 499) may also extend the program's duration beyond nine months.

The typical MS program does not require an MS thesis, although an independent study project can be arranged at the discretion of the student and a faculty adviser and may produce a written report. At the invitation of faculty, MS students may prepare an MS thesis and receive thesis-research credit. Normally, thesis research is reserved for the PhD student.

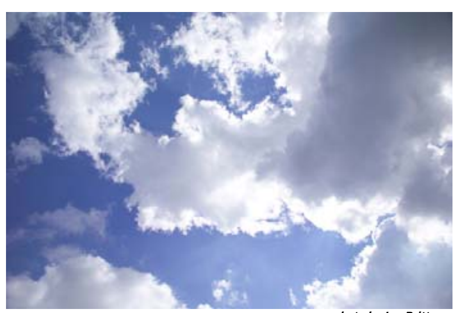

photo by Ian Britton

… Doctor of Philosophy (PhD) — Environmental Engineering and Science

The doctor of philosophy (Ph.D.) degree prepares students for advanced, independent research and teaching in academic, industrial, governmental, or other settings. Candidates for the Ph.D. degree may enter the program with a BS or an MS degree. Candidates for the Ph.D. must complete the following requirements:

- Satisfy The Graduate School's residency requirement of eight quarters of full-time registration (defined as registration for a minimum of three units or a maximum of four units during each of the eight quarters).
- Meet The Graduate School's requirement for a minimum of nine graduate-level courses for a letter grade even if entering with an MS degree. Students continuing for the Ph.D. degree after obtaining the MS degree at Northwestern generally are not required to take further courses for a grade, although most do take additional courses because further course work may be required by your advisor.
- Complete course work necessary to prepare for independent research in the student's research area; the course work is determined by the student and his/her adviser with advice from the student's preliminary examination committee.
- Demonstrate competency in the program's core courses and an appropriate research area by passing a preliminary qualifying examination (PQE); students normally take the PQE within one year after entering the graduate program.
- Pass an oral qualifying exam (QE) based on a defense of a written research proposal. Ideally, the QE is taken in the 6th quarter (end of the 2nd Academic Year) after the student passes the PQE. The QE must be completed by end of the 7th quarter (or Fall Quarter of the 3rd Academic Year). The student enters official Ph.D. candidacy after passing the qualifying examination.
- <u>Committees</u>: The PQE committee must be comprised of three EES faculty; The QE committee must have a minimum of four members, three of whom must be EES faculty. We encourage at least one member outside the department and students may have additional members beyond the minimum. Students will provide a yearly update of their progress to their committee in the form of a meeting, a two-page summary of progress and short presentation.
- Complete a program that provides a mentored teaching experience.
- All Ph.D. students must give at least one EES seminar prior to their formal defense (typically in 4th year).
- Successfully present, defend, and submit a Ph.D. dissertation that constitutes a significant and original research contribution.

Full-time students typically complete the Ph.D. requirements three to four years after completing the preliminary examination. Since many research fields are interdisciplinary, students usually take a significant number of their courses from areas outside the environmental engineering and science program, such as chemistry, biochemistry, applied mathematics, geology, geotechnics, and chemical engineering. Dissertation research is carried out under the supervision of the student's faculty adviser. Selection of faculty advisers takes place during the student's first year in the Ph.D. program. In some cases, having co-advisers is desirable to facilitate interdisciplinary research.

... Fields of Study and Research

Research areas at Northwestern University are diverse and reflect the wide ranging interests of the faculty and students. The following summaries describe the major research areas:

- Environmental Biotechnology
- Physical/Chemical Processes
- Natural Systems

Environmental Biotechnology

Environmental biotechnology at Northwestern combines the traditional tools of environmental engineering—kinetic modeling, reactor design, and lab- and pilot-scale experimentation—with approaches of modern biotechnology, such as molecular genetics, microbial ecology, and biochemistry. Research based on this combination is providing the next generation of biological treatment processes for contaminated waters, wastewaters, soils, and air. It also is creating the foundation for understanding the fate of biodegradable pollutants in the environment. Although individual projects might emphasize experimentation, modeling, or microbiological aspects, all research involves quantification, the key to making the research results useful in practice. Examples of current and recent environmental biotechnology projects are:

- Molecular and modeling techniques for studying mixed cultures including nitrifying bacteria
- Mechanisms of adaptation of anaerobic communities to chlorinated organic compounds
- Biofilm community structure and function in reaction to H_2 exchange
- Kinetic fundamentals of biofilm treatment of gas stream VOCs
- Biological reduction of perchlorate using a membrane-biofilm reactor
- Microbially driven water quality changes in drinking water distribution networks
- Modeling of complex biogeochemical systems involving metals
- Mechanisms of microbial resistance to metals
- Cell-to-cell signaling in biofilms

Physical/Chemical Processes

Physical and chemical phenomena can be used to separate or destroy contaminants in waters, wastewaters, sludges, soils, and sediments. The traditional physical/chemical processes—such as sedimentation, coagulation, filtration, and adsorption—remain critically important, and exciting new technologies are emerging. These include advanced oxidation, flotation, and membrane separations. Our research improves fundamental understanding of the governing mechanisms, which leads to more broadly useful bases for design, scale-up and operation. Examples of projects in physical/chemical processes are:

- Photocatalytic destruction of hazardous organic pollutants using TiO_2 with UV and visible light (reaction pathways, mechanistic and kinetic modeling)
- Identification of precursors to disinfection byproducts
- Characterization of natural organic matter in water and wastewater treatment by pyrolysis GC-MS
- Electrokinetic soil decontamination

Natural Systems

Research in this area at Northwestern focuses on interactions of natural system components—such as soils, sediments, water, and living organisms—with environmental contaminants and waste materials. Specific emphases range from the biophysical chemistry occurring at interfaces to cycling of elements to overall macrosystem fate and effects. Examples of natural systems projects are:

- Bacterially produced manganese oxide catalyst solids
- The role of particles in scavenging trace metals at the oxic/anoxic interface in aquatic systems
- The fate of PCBs in a perphytic bio-layer of an artificial stream system

- The fate of trace metals in freshwater sediments
- The fate of metals in artificial wetlands
- Studies in a reconstructed wetland: plant transpiration, phosphate fractionation in sediments, and modeling water flow
- Microbial ecology of Lake Michigan sediments
- The transport of particles and water at the groundwater/surface-water interface

… Facilities

The Environmental Engineering and Science Program occupies approximately 7,000 square feet of state-of-the-art laboratories in the A-wing of the Robert R. McCormick School of Engineering and Applied Science. Major instrumentation and facilities include:

MAJOR INSTRUMENTATION

• Gas chromatographs (GC's) with FID and ECD	• Electrophoresis systems
• Pyrolysis GC-MS	• DGGE system
• Reduced-gas chromatograph	• DNA sequencers
• High-performance liquid chromatograph (HPLC)	• General molecular biology instrumentation
• Ion chromatograph	• Incubators and refrigerators
• Total organic carbon (TOC) analyzer	• - 80°C Freezers
• Graphite furnace atomic absorption spectroscope	• Walk-in temperature control chamber
• UV/VIS spectrophotometer	• Anaerobic glove box
• Fluorescence spectrophotometer	• Autoclave
• Phase-contrast microscope with fluorescence and photographic capabilities	• Muffle furnace
• High quality CCD camera for microscopy	• Drying ovens
• Scanning laser confocal microscope	• Analytical balances
• Mercury intrusion porosimeter	• Water still
• Sub-micron particle sizers and zeta-potential analyzer	• Ultrapure water system
• Laser Doppler velocimeters	• Flume laboratories
• Microtitre plate fluorimeter	• Clean room for trace metal analysis
• Microtitre plate absorbance reader	• Radioactivity counting room
• Biofilm flow cell apparatus	• Scintillation counter
• PCR thermocycler	• Biosafety Level 2 laboratory
• Sorvall centrifuge	• Teaching laboratory
• Ultracentrifuges and mini centrifuges	• Access to shared facilities @ Facilities
• Computerized titrator	

These laboratories also are fully equipped for routine wet chemistry and have advanced safety features. The CEE Department has a full-time laboratory coordinator for the environmental engineering and science laboratories.

Northwestern University is connected to CIC Net and the worldwide Internet, allowing researchers to make full use of all Internet-connected resources, such as program archive sites and supercomputer centers. Furthermore, recent modifications to the network infrastructure within the Department of Civil and Environmental Engineering have brought this connection not only to a central location on campus but also to almost every room in the department, including faculty and student offices and research laboratories.

The department maintains a network of computer workstations for research use. These stations include Macintosh, IBM, Sun, Hewlett-Packard, and other microcomputers. The department also maintains its own graphics workstation laboratories used for research and instructional purposes. Fully networked, these computing systems have a wide variety of software installed, including source code compilers (C, C++, Fortran, and Pascal), Scientific Visualization Software (SGI Explorer and MovieSTAR.BYU), and Geographical Information Systems software (GRASS 4.1). The department has a full-time computer-network manager.

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Education

- B.A., Northwestern University, Biology
- M.S., University of Miami, Civil Engineering (Environmental)
- Ph.D., Johns Hopkins University, Environmental Engineering

Research

My areas of research are environmental catalysis and physicochemical processes in natural and engineered environmental systems. We are studying the synthesis, characterization, and performance of photocatalytic materials, principally TiO_2. Currently, we are collaborating with materials scientists at Northwestern to prepare highly active nano-structured mixed phase titania catalysts using a variety of techniques and with chemists at Argonne National Laboratory to detail charge transfer behavior in these materials using EPR. This fundamental understanding of structure and function is guiding the use of these photoactive materials for applications in renewable energy (CO_2 reduction, water splitting), water recycling (reactive membranes for chemical oxidation and disinfection, photoactive carbon nanotubes for reactions and separation) and air quality control (cabin air, building air handling). Work in my group also involves the investigation of chemical fate in natural systems. We are probing the role of periphyton (algal biofilms) in contaminant accumulation in stream sediments and in denitrification in wetlands. We are also studying the ways in which detailed understanding of ecological relationships (periphyton structure, dynamic food web descriptions) improves our ability to predict chemical transfer (bioaccumulation) in aquatic systems and ultimately human health risks. Application of this research is important in efforts to restore critical ecosystems (Great Lakes) and to employ ecosystem function for environmental protection (treatment wetlands).

Teaching

- ENVR-SCI 203 Energy and the Environment: The Automobile
- CIV_ENV 368 Sustainability: Issues and Actions, Near and Far
- CIV_ENV 398-1,2 Community-based Design
- CIV_ENV 444 Physical/Chemical Processes in Environmental Control

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Professional Activities and Honors

- Sigma Xi Distinguished Lecturer, 2008-2010
- Aldo Leopold Leadership Fellow, 2008
- Organizer and Speaker, The Green City: A Field Study in Chicago, Northwestern University Summer Institute, Aug. 2006-2007.
- Board of Directors, Chicagoland Redevelopment Initiative (REDI), 2002-2006.
- Association of Environmental Engineering Professors, Board of Directors, 1996-1999; Vice-President, 1997-98; President, 1998-1999.
- National Research Council Water Science and Technology Board, Member of Committee on USGS Water Resources Research, 1996-1999.
- Presidential Young Investigator, National Science Foundation, 1991-1996

Selected Publications

- G. Li, K.A. Gray (2007) "Visible Light Photocatalytic Properties of Anion-Doped TiO_2 Materials Prepared from a Molecular Titanium Precursor," Chemical Physics Letters, Vol 451/1-3 pp 75-79.
- G. Li, S.M. Ciston, N. Dimitrijevic, T. Rajh, K.A. Gray (2008). "Photooxidation and Photoreduction using Mixed-phase Titanium Dioxide," Journal of Catalysis, 253:105-110.
- C.K. Ishida, S. Arnon, C. Peterson, J.J. Kelly, K.A. Gray, (2007) "The influence of algal community structure on denitrification rates in periphyton cultivated on artificial substrates," Microbial Ecology, in press.
- S. Arnon, C.G. Peterson, K.A. Gray, A.I. Packman. (2007) "Influence of Flow Conditions and System Geometry on Nitrate Utilization by Benthic Biofilms: Implications for Nutrient Mitigation," Environmental Science & Technology, 41:8142-8148.
- G. Li, K.A. Gray, (2007) "The solid-solid interface: Explaining the high and unique photocatalytic reactivity of TiO2-based nanocomposite materials," Chemical Physics, 339:1-3:173-187 (doi:10.1016/j.chemphys.2007.05.023).
- G. Li, L. Chen, M. Graham, K.A. Gray, (2007) "A comparison of mixed phase titania photocatalysts prepared by physical and chemical methods: The importance of the solid-solid interface." Journal of Molecular Catalysis A: Chemical, 275:30-35.
- S. Arnon, K.A. Gray, A.I. Packman, (2007) "Biophysicochemical process coupling controls nitrogen use by benthic biofilms." Limnol. Oceanogr. 52: 1665-1671.
- G. Li, K.A. Gray (2007). "Preparation of Mixed-phase Titanium Dioxide Nanocomposites via Solvothermal Processing." Chemistry of Materials, 19:1143-1146.
- S. Ciston, K.A. Gray (2007). "Photocatalysis for Water Recovery: Importance of nanostructure in reactive membrane filtration," G.I.T. Laboratory Journal, 11:36-37.
- C. Liu, K. Nakano, E. Obuchi, T. Oike, N. Yukihira, D. Hurum, K.A. Gray (2007).

"Photocatalytic decomposition of formaldehyde using titania coated lime tile," Jour. of Advanced Oxidation Technologies 10 (1): 11-16.

- S. Arnon, A.I. Packman, C.G. Peterson, K.A. Gray (2006) "The effects of overlying velocity on periphyton structure and denitrification," Journal of Geophysical Research, 112, G01002, doi:10.1029/2006JG000235.

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Education

- B.S. (Chemistry) University of Maryland
- Ph.D. (Organic Chemistry) Stanford University

Research

The cycling of the element carbon is fundamentally important to the functioning of our planet. My research has focused on the biogeochemical transformations of carbon with an emphasis on process-oriented studies of the evolution and fate of organic matter in surficial environments. Methanogenesis, methane oxidation, and the influence of macrofauna on organic carbon turnover are some of the processes that have been investigated in field areas ranging from the North Carolina slope to the Amazon shelf.

Delineating the transformations of carbon from source (mountains) to sink (marine sediments) in small watershed systems ranging from Northern California to Papua New Guinea and New Zealand is a recent focus of research. Understanding what controls the persistence and/or breakdown of organic species in the environment is the major impetus for this work.

My group has specialized in the development of novel stable isotope and radiocarbon tools to study carbon-cycling processes.

Teaching

- CIV_ENV 395, 20 Organic Geochemistry (offered jointly with EARTH 314)
- CIV_ENV 447 Biogeochemistry (offered jointly with EARTH 317)

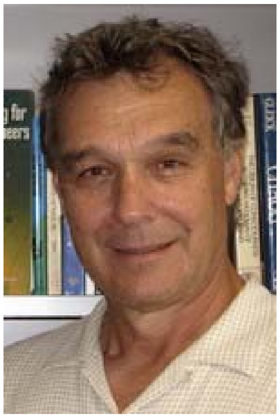
Professional Awards and Activities

- National Ocean Sciences Accelerator Mass Spectrometry Advisory Board (10/05-06, chair 2007)
- NASA "Landscapes to Coast" panelist (2006)

- RioMar Planning Workshops (2001, raconteur for 2004)
- Biocomplexity Workshop on Animal-Sediment Interactions (2002, invited speaker)
- Carbon Erosion Workshop (2002), Palmerston North, New Zealand (invited international reviewer and speaker)
- NSF MARGINS Source to Sink planning workshops (1999 - invited speaker; 2000, 2003, 2006)

Selected Publications

- Early diagenetic cycling, incineration, and burial of sedimentary organic C in the central Gulf of Papua (Papua New Guinea). JGR-Earth Surf. (2007) *in press* (R.C. Aller, N. E. Blair, and G.J.Brunskill).
- Geomorphologic controls on the age of particulate organic carbon from small mountainous and upland rivers. *Global Biogeochem. Cycles (2006), 20, GB3022, doi:10.1029/2005GB002677* (Leithold, E. L., N. E. Blair, and D. W. Perkey)
- Carbon remineralization in the Amazon-Guianas tropical mobile mudbelt: a sedimentary incinerator. *Continent. Shelf Res.(2006) doi 10.1016/j.csr.2006.07.016* (R.C. Aller and N.E. Blair).
- Sedimentation and carbon burial on the northern California continental shelf: the signatures of land-use change. *Continent. Shelf Res. (2005) 25:* 349-371 (E. Leithold, D.W. Perkey, N.E. Blair. T. Creamer).
- Intramolecular carbon isotopic composition of monosodium glutamate: Biochemical pathways and product source identification. *J. Agricultural and Food Chemistry (2005) 53:* 197-201 (W.B. Savidge and N.E. Blair).
- Patterns of intramolecular carbon isotopic heterogeneity within amino acids of autotrophs and heterotrophs. *Oecologia (2004) 121:* 178-189 (W.B. Savidge and N.E. Blair).
- Early diagenetic remineralization of sedimentary organic C in the Gulf of Papua deltaic complex (Papua New Guinea): net loss of terrestrial C and diagenetic fractionation of C isotopes. *Geochim. Cosmochim. Acta (2004) 68:*1815-1825 (R.C. Aller and N.E. Blair).
- From bedrock to burial: the evolution of particulate organic carbon across coupled watershed-continental margin systems. *Mar. Chem. (2004) 92:* 141-156 (N.E. Blair, E.L. Leithold and R.C. Aller).
- Seasonal and within-plant gradients in the intramolecular carbon isotopic composition of amino acids of *Spartina alterniflora. J. Exp. Mar. Biol. Ecol. (2004) 308:* 151-167 (W.B. Savidge and N.E. Blair).



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Education

- B.S., Civil Engineering, University of Missouri – Columbia
- M.S., Environmental Engineering, University of Missouri – Columbia
- Ph.D., Environmental Engineering, Johns Hopkins University
- Post-doc, École Nationale Supérieure des Industries Chimiques (Nancy, France)

Research

My research in drinking water treatment has focused in two primary areas, mechanics of coagulation/flocculation, and membranes. In the coagulation area we have developed new approaches to (1) directly measure floc size distributions, (2) characterize relative velocity fields and secondary flows in impeller-driven mixers, and (3) predict floc growth using new kinetic models that incorporate floc breakup, flow inhomogeneity and flow periodicity, and which are sensitive to process scale. In the membrane area we have developed new methods of characterizing (and minimizing) membrane fouling by natural organic matter. Recent work includes (1) molecular dynamics simulation of the interaction of humic materials with membrane surfaces, (2) development of a low-cost laser-scanning cytometer to monitor low concentrations of particulate foulants in fresh and saline waters, (3) development of a nanostructured polysulfone adsorbent for organic fouling control, and (4) development of an aquaporin-impregnated polymer membrane.

Teaching

- CIV_ENV 444 Physical/Chemical Processes in Environmental Control
- CIV_ENV 306 Uncertainty Analysis in Civil Engineering
- CIV_ENV 340 Fluid Mechanics II

Professional Awards and Activities

- Organized Committee of 20 University of Illinois researchers and local nursing home administrators to discuss remediation of nursing home odors (2006 -2007).

- Developed student and faculty exchange between University of Illinois Engineering College and the French CNRS (2000)
- Editor of "Membrane Processes for Potable Water Treatment: Research Needs," AWWA Membrane Technology Research Committee, published in Journal American Water Works Association, 90, 4 (1998).
- Chair, Membrane Technology Research Committee, American Waterworks Association (1995-1998)
- Associate, Center for Advanced Study, University of Illinois, 1999-2000.
- Presidential Young Investigator, National Science Foundation, 1991-1996
- Xerox Award for Faculty Research, University of Illinois, 1990.

Selected Publications

- Clark, M.M. *Transport Modeling for Environmental Engineers and Scientists* (Second Edition), Wiley-Interscience, New York, in preparation, 2008.
- Ahn, W.-Y., Kalinichev, A.G, and M. M. Clark, "Effects of Background Cations on the Fouling of Polyethersulfone Membranes by Natural Organic Matter: Experimental and Modeling Study," *J. Membrane Science*, 309, 128-140 (2008).
- Kumar, M., Grzelakowski, M., Zilles, J., Clark, M., and W. Meier, "Highly Permeable Polymeric Membranes based on the Incorporation of the Functional Water Channel Protein Aquaporin Z," *Proc. National Academy of Sciences*, 104, 52: 20723-20728 (2007).
- Ladner, D., Lee, B., and Clark, M.M., "Laser Scanning Cytometry for Fluorescent Microsphere Enumeration," *J. American Water Works Association*, 99, 3: 110 (2007).
- Koh, L.C, Ahn, W-J., and M.M. Clark, "Selective Adsorption of Natural OrganicFoulants by Polysulfone Colloids: Effect on Ultrafiltration Fouling," *J.Membrane Science*, 281, 1-2: 472-479 (2006).
- Howe, K., and M.M. Clark, "Effect of Coagulation Pretreatment on Membrane Filtration Performance," *J. American Water Works Association*, 98, 4: 133-146 (2006).
- Clark, M.M. Ahn, W.Y., Li, X., Sternisha, N. and Riley, R.L., "Formation of Polysulfone Colloids for Adsorption of Natural Organic Foulants," *Langmuir*, 21, 7207-7213 (2005).
- Menniti, A, Rajagopalan, K., Kramer, T., and M.M. Clark, "An Evalaution of the Colloidal Stability of Metal Working Fluid," *J. Colloid and Interface Science*, 284, 477-488 (2005).
- Koh, M., Clark, M.M., Howe, K.J., "Filtration of Lake Natural Organic Matter: Adsorption Capacity of a Polypropylene Microfilter," *J.Membrane Science*, 256, 169-175 (2005).
- Howe, K.J. and M.M. Clark. "Fouling of Microfiltration and Ultrafiltration Membranes by Natural Waters," *Environmental Science and Technology*, 36, 3571-3576 (2002).
- Kramer, T.A., and M.M. Clark, "Modeling Orthokinetic Coagulation in Spatially Varying Laminar Flow," *J. Colloid and Interface Science*, 227, 251-261 (2000).

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Education

- B.S., University of Savoie, Environmental Engineering
- M.S., University Pierre et Marie Curie (Paris VI), Water Sciences
- Dr., University Pierre et Marie Curie, Water Sciences
- D.Sc., University Denis Diderot (Paris 7), Docteur És Sciences Physiques -Géochimie

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Research

Professor Gaillard's current research focuses on the study of the chemical forms (speciation) and the biogeochemical cycles of elements in aquatic systems. The chemical speciation of elements determine their toxicity and availability to microorganisms. Conversely, microbes mediate changes in oxidation state and coordination, controlling therefore the speciation of elements in natural systems. The primary objective of his research group is to determine the analytical speciation of metals to better understand their fate in the environment and define appropriate remediation actions. To that end, he and his group are using a multi-method approach combining electrochemical, microscopic, and molecular tools.

Teaching

- ENVR_SCI 201 Earth: A Habitable Planet
- CIV_ENV 365 Environmental Laboratory
- CIV_ENV 367 Aquatic Chemistry
- CIV_ENV 468 Chemical Speciation in Aquatic Systems

Professional Activities and Honors

- Associate Editor: Journal of Hydrology
- Chief Scientist of the oceanographic cruise: ANTARES 1, France-JGOFS (1993)
- Guest Editor: Deep Sea Research II: ANTARES 1: France JGOFS in the Indian Sector of the Southern Ocean: Benthic and Water Column Processes (1997).
- Northwestern University, Fulbright Fellowship Committee member (2006-present)
- IUPAC Fellow. (2006)

Selected Publications

(Please note: bold names are those of my graduate students or postdoctoral fellows, underlined names are of graduate students or Postdoctoral fellows under the supervision of collaborators)

Gaillard, J.-F., Chen, C., Stone, S., Lau, B., Keane, D.T., and Packman, A.I. (2007), Imaging of colloidal deposits in granular porous media by x-ray difference micro-tomography. *Geophys. Res. Lett*. (in press).

Alsina M., **Saratovsky I**., Gaillard J.-F., and Pasten P.A. (2007) Arsenic Speciation in Solid Phases of Geothermal Fields. In *Adsorption of Metals to Geomedia II. ACS Symposium Series* (in press).

Smit, J.P., Kim H.-S., **Saratovsky, I.,** Stark, K.B., Fitzgerald, G., Zajac, G.W., Gaillard, J-F., Poeppelmeier, K.R., Stair, P.C. (2007) A Spectroscopic and Computational Investigation of the Vanadomolybdate Local Structure in the Lyonsite Phase Mg2.5VMoO8. *Inorganic Chemistry*, **46**, 6556-6564. DOI: 10.1021/ic7006815.

Sahai, N., Lee Y.J., Xu H., Ciardelli M., Gaillard J.-F. (2007) Role of Fe(II) and Phosphate in Arsenic Uptake by Coprecipitation. *Geochimica et Cosmochimica Acta*. **71**, 3193-3210.

Gaillard J.-F. (2007) Probing Environmental Particles and Colloids with X-Rays. In *Environmental Particles and Colloids: Behaviour, Structure, and Characterisation*, Eds. K.J. Wilkinson and J.R. Lead. *IUPAC Series on Analytical and Physical Chemistry of Environmental Systems*. Wiley, Chichester, 613-666.

Packman A.I., Marion A., Zaramella M., Chen C., Gaillard J-.F., Keane D.T. (2006) Development of layered sediment structure and its effects on pore water transport and hyporheic exchange. *Water, Air, and Soil Pollution: Focus*, 6, 433-442.

Saratovksy, I., Wightman P.G., Pasten P.A., Gaillard J.-F., Poeppelmeier K.R. (2006) Manganese Oxides: Parallels between Abiotic and Biotic Structures. *Journal of the American Chemical Society*, **128**, 11188-11198.

Peltier, E.F., Dahl. A.L., Gaillard, J-F. (2005) Metal Speciation in Anoxic Sediments: When Sulfides can be Construed as Oxides. *Environmental Science & Technology*, **39**, 311-316.

Santschi, P.H., Burd, A.B., Gaillard, J.-F., and Lazarides A.L. (2005) Transport of Materials and Chemicals by Nano-scale Colloids and Micro to Macro-scale Flocs in Marine, Freshwater, and Engineered Systems. In *Flocculation in Natural and Engineered Environmental Systems*, Eds I. Droppo, G. Leppard, S. Liss, and J. Milligant, CRC Press, 191-209.

Kim, H.-S., **Pasten**, P.A., Gaillard, J.-F., Stair, P.C. (2003) Nanocrystalline Todorokite-like Manganese Oxide Produced by Bacterial Catalysis. *Journal of the American Chemical Society*, **125**, 14284-14285.

Webb, S. M., Gaillard, J.-F., Ma L.Q., Tu, C. (2003) XAS Speciation of Arsenic in an Hyperaccumulating Fern. *Environmental Science & Technology*, **37**, 754-760.

Peltier E.F., **Webb**, S. M., Gaillard, J.-F. (2003) Zinc and lead sequestration in an impacted wetland system. *Advances in Environmental Research*, **8**, 103-112.

Taillefert, M., MacGregor B.J., Gaillard J.-F., **Lienemann** C.-P., Perret D., Stahl D.A. (2002) Evidence for a Dynamic Cycle Between Mn and Co in the Water Column of a Stratified Lake. Environmental Science & Technology, **36**, 468-476.

Luisa Marcelino

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Education

- BS./MS., University of Lisbon, Portugal, (Plant Biotechnology and Molecular Biology)
- Ph.D., University of Lisbon, Portugal, degree in absentia through Massachusetts Institute of Technology, Cambridge, MA (Molecular Biology/Genetics)

Research

Our group works on developing and applying optical and genetic methods to study fundamental aspects of reef-forming corals and their associated algae. We are currently investigating why some reef-forming coral species are resistant to bleaching and/or recover quickly from bleaching while others suffer high mortality after a bleaching episode.

Toward this goal, we are developing a two-level approach. First, we are studying specific optical properties of the stony corals to understand the role that the coral's tissue and skeleton play during bleaching. We are collaborating with biomedical engineers at Northwestern to characterize the light transport properties of coral skeleton and tissue for coral species showing resistance and susceptibility to bleaching. Second, we are collaborating with Field Museum scientists to characterize the coral-algae association at the cellular and genetic level to establish indicators of susceptibility to bleaching.

Teaching

- CIV_ENV 361-1 Environmental Microbiology
- CIV_ENV 361-2 Public and Environmental Health

Selected Publications

- Marcelino L.A., Backman V., Donaldson A., Steadman C., Thompson J, Pacocha S., Lien C., Veneziano D., Lim E., and Polz M.F., Accurate identification of low abundant targets in pools of similar sequences by revealing hidden correlations in oligonucleotide microarray data, Proc Natl Acad Sci U S A. 2006; 103(37):13629-34.
- Sudo H., Li-Sucholeiki X.-C., Marcelino L.A., Thilly W.G., et al., Mutation of nuclear genes in the bronchial epithelium of smokers and non-smokers, Mutation Res, 2006; 596(1-2):113-1127.
- Thompson J.R., Randa M.A., L.A Marcelino, Tomita-Mitchell A., Lim E., Polz M.F., Diversity and dynamics of a North Atlantic coastal Vibrio community, Applied and Environmental Microbiology 2004; 70(7):4103-10.
- Acinas S.G., Marcelino L.A., Klepac-Ceraj V., Polz M.F., Divergence and redundancy of 16s rRNA sequences in genomes with multiple rrn operons J. Bacteriology, 2004; 186 (9): 2629-2635.
- Thompson JR, Marcelino L.A., Polz MF. Heteroduplexes in mixed-template amplifications: formation, consequence and elimination by 'reconditioning PCR". Nucleic Acids Res. 2002; 30(9):2083-8.
- Tomita-Mitchell A., Kat A.G., Marcelino L.A., Li-Sucholeiki X.-C., Griffith J., and Thilly W.G., Mismatch repair deficient human cells: spontaneous and MMNG-induced mutational spectra in the HPRT gene, Mutation Res, 2000; 450:125-38.
- Monteiro C, Marcelino LA, Armour JA et al.,. Molecular methods for the detection of mutations. Teratog Carcinog Mutagen, 2000; 20(6): 357-86.
- Marcelino L.A., and Thilly W.G., Mitochondrial mutagenesis in Human cells and tissues, Mutat Res, 1999; 434,177- 203.
- Li-Sucholeiki X.-C., Khrapko K., Andre P.C., Marcelino L.A., Karger B.L., and Thilly W.G., Applications of constant denaturant capillary electrophoresis/high fidelity polymerase chain reaction to human genetic analysis, Electrophoresis, 1999; 20, 1224-1232.
- Marcelino L.A., Andre P., Krapko K., Coller H.A, Griffith J. and Thilly W.G., Chemically induced mutations in mitochondrial DNA of human cells: mutational spectrum of N-methyl-N'-nitro-N-nitrosoguanidine, Cancer Res, 1998; 58, 2857-2862.

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Education

- B.S., Washington University, Mechanical Engineering
- M.S., California Institute of Technology, Environmental Engineering Science
- Ph.D., California Institute of Technology, Environmental Engineering Science

Research

My research focuses on environmental and microbial transport processes, with particular emphasis on understanding the basic processes that control interfacial transport in aquatic systems and the coupling of physical transport processes with biological and biogeochemical processes. I seek to define critical structure-transport-transformation relationships in dynamic natural environments such as rivers and surface-attached microbial communities (biofilms). My work is highly collaborative and encompasses basic fluid mechanics, particle transport and morphodynamics, microbiology, and aquatic and surface chemistry. Important applications include contaminant transport and water quality, microbial habitat conditions and benthic microbial ecology, nutrient and carbon cycling, ecosystem degradation and restoration, control of biofilm-based infections, and the transmission of waterborne disease.

Teaching

- CIV_ENV 260 Fundamentals of Environmental Engineering
- CIV_ENV 440 Environmental Transport Processes

Professional Activities and Awards

- Northwestern Murphy Institute Faculty Fellow (2007-2008)
- NIH Career Award (2006)
- McCormick Excellence Award, Northwestern University (2006)
- Searle Junior Teaching Fellow (2001-2002)
- NSF CAREER Award (1999)
- Associate Editor, *Water Resources Research* (1999 – present)
- Editorial Board, International Journal of Sediment Research (2003 – present)
- Board of Directors, International Association for Sediment Water Science (2005-present)
- UNESCO International Hydrological Programme, Groundwater-Surface Water

Interactions and Nutrient Behavior in River Corridors, Invited Panelist (2005)
- NSF/DOE Workshop, Water: Challenges at the Intersection of Human and Natural Systems, Invited Panelist (2004)

Selected Publications

1. Wörman, A., Packman, A.I., Marklund, L., Harvey, J.W., and Stone, S.H., 2007, Fractal topography and subsurface water flows from fluvial bedforms to the continental shield, *Geophysical Research Letters*, 34(7), L07402, doi:10.1029/2007GL029426 [Editor's highlighted article].
2. Ryan, R.J., Packman, A.I., and Kilham, S.S., 2007, Relating phosphorus uptake to changes in transient storage and streambed sediment characteristics in headwater tributaries of Valley Creek, an urbanizing watershed, *Journal of Hydrology*, 336(3-4), 444-457.
3. Arnon, S., Gray, K.A., and Packman, A.I., 2007, Biophysicochemical process coupling controls nitrogen utilization by benthic biofilms, *Limnology and Oceanography*, 52(4), 2007, 1665-1671.
4. Gaillard, J.-F., Chen, C., Stonedahl, S.H., Lau, B.L.T., Keane, D.T, and Packman, A.I., 2007, Imaging of colloidal deposits in granular porous media by x-ray difference micro-tomography, *Geophysical Research Letters*, 34(18), L18404, doi:10.1029/2007GL030514 [Cover article and Editor's highlighted article].
5. Boano, F., Packman, A. I., Cortis, A., Revelli, R., and Ridolfi, L., 2007, A continuous time random walk approach to the stream transport of solutes, *Water Resources Research*, 43, W10425, doi:10.1029/2007WR006062.
6. Ren, J., and Packman, A.I., 2007, Changes in fine sediment size distributions due to interactions with streambed sediments, *Sedimentary Geology*, 202, 529-537, doi:10.1016/j.sedgeo.2007.03.021.
7. Arnon, S., Peterson, C.G., Gray, K.A., and Packman, A.I., 2007, Influence of flow conditions and system geometry on nitrate utilization by benthic biofilms: Implications for nutrient mitigation, *Environmental Science & Technology*, 41(23), 8142-8148, doi: 10.1021/es0710048.
8. Battin, T.J., Kaplan, L.A., Findlay, S., Hopkinson, C.S., Marti, E., Packman, A.I., Newbold, J.D., and Sabater, F., Biophysical controls on organic carbon fluxes in fluvial networks, *Nature Geoscience*, in press.
9. Cardenas, M.B., Harvey, J.W., Packman, A.I., and Scott, D.T., Ground-based thermography of fluvial systems at low and high discharge reveals potential complex thermal heterogeneity driven by flow variation and bioroughness, *Hydrological Processes*, in press.

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Education

- Postdoctoral Scholar, MIT/HHMI & Caltech/HHMI: Molecular Geobiology
- Ph.D., Johns Hopkins University: Aquatic Chemistry
- M.S., Nankai University
- B.S., Nankai University

Research

Our research is at the interface of the medical/environmental microbiology and geochemistry. We apply an interdisciplinary approach to studying the link between reactions of bioactive small molecules (e.g., antibiotics) with environmental constituents and their mode of action on microbial biofilm architecture and physiology. Current research directions include:

- Investigating the roles of redox-active "antibiotics" (phenazine- and quinone-based molecules) in iron acquisition and microbial physiology. We use two opportunistic pathogens, *Pseudomonas aeruginosa* and *Burkholderia cepacia*, as our model organisms.
- Optimizing small molecule-facilitated electron transfer in biofilm processes, with emphasis on improving bioenergy generation and bioremediation efficiency.
- Determining the fate and transformation of (bio)molecules and environmental pollutants at mineral-water interfaces.
- Developing imaging techniques for studying (bio)molecules and organic pollutants *in vivo* and *in situ*.

These studies will not only help us predict the chemical and biological impact of bioactive molecules in natural aqueous environments but also highlight strategies for manipulating clinical and environmental biofilms.

Selected Publications

- **Wang, Y.**; Newman, D. K. (2008) Redox Reactions of Phenazine Antibiotics with Ferric (Hydr)oxides and Molecular Oxygen. *Environ. Sci. Technol.*, 42: 2380-2386.
- **Wang, Y.**; Stone, A. T. (2008) Phosphonate- and Carboxylate-Based Chelating Agents that Solubilize (Hydr)Oxide-Bound Mn^{III}. *Environ. Sci. Technol.*, 42: 4397-4403.
- **Wang, Y.**; Stone, A. T. (2006) Reaction of $Mn^{III,IV}$ (Hydr)Oxides with Oxalic Acid, Glyoxylic Acid, Phosphonoformic Acid, and Structurally-Related Organic Compounds. *Geochim. Cosmochim. Ac.*, 70: 4477-4490.
- **Wang, Y.**; Stone, A. T. (2006) The Citric Acid-$Mn^{III,IV}$O2(Birnessite) Reaction. Electron Transfer, Complex Formation, and Autocatalytic Feedback. *Geochim. Cosmochim. Ac.*, 70: 4463-4476.

... Affiliated Faculty

- **Nicholas P. Cianciotto**
  NU-Department of Microbiology-Immunology
  Microbial pathogenesis
- **Richard J. Finno**
  NU-Department of Civil and Environmental Engineering
  Environmental geotechnology
- **Franz M. Geiger**
  NU-Department of Chemistry
  Geochemistry, aquatic chemistry, and atmospheric chemistry
- **Michael E. Graham**
  NU-Department of Materials Science and Engineering
  Photoactive materials
- **Keith I. Harley**
  Chicago Environmental Law Clinic
  Environmental law and ethics
- **John Hudson**
  NU-Department of Anthropology
  Cultural/physical/settlement geography
- **Andrew D. Jacobson**
  NU-Department of Earth & Planetary Sciences
  Cycling of elements between Earth's lithosphere, hydrosphere, atmosphere, and biosphere
- **Richard M. Lueptow**
  NU-Department of Mechanical Engineering
  Fluid mechanics, membrane processes
- **Margaret M. MacDonell**
  Argonne National Laboratory
  Environmental impact assessment
- **Lance Peterson, M.D.**
  NU-Feinberg School of Medicine, Department of Pathology
  Biodefense, antimicrobial resistance
- **Kenneth Poeppelmeier**
  NU-Department of Chemistry
  Inorganic environmental materials and inorganic synthetic chemistry
- **Bradley B. Sageman**
  NU-Department of Earth & Planetary Sciences
  Paleontology, sedimentology
- **Peter C. Stair**
  NU-Department of Chemistry
  and Catalysis Center
  Catalysis, spectroscopy
- **Richard B. Thomson**
  NU-Feinberg School of Medicine, Department of Pathology
  Microbiology, virology
- **Joseph B. Walsh**
  NU-Program in Biological Sciences
  Restoration ecology, biogeography
- **Eric Weitz**
  NU-Department of Chemistry
  Emissions treatment, photocatalysis, spectroscopy

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