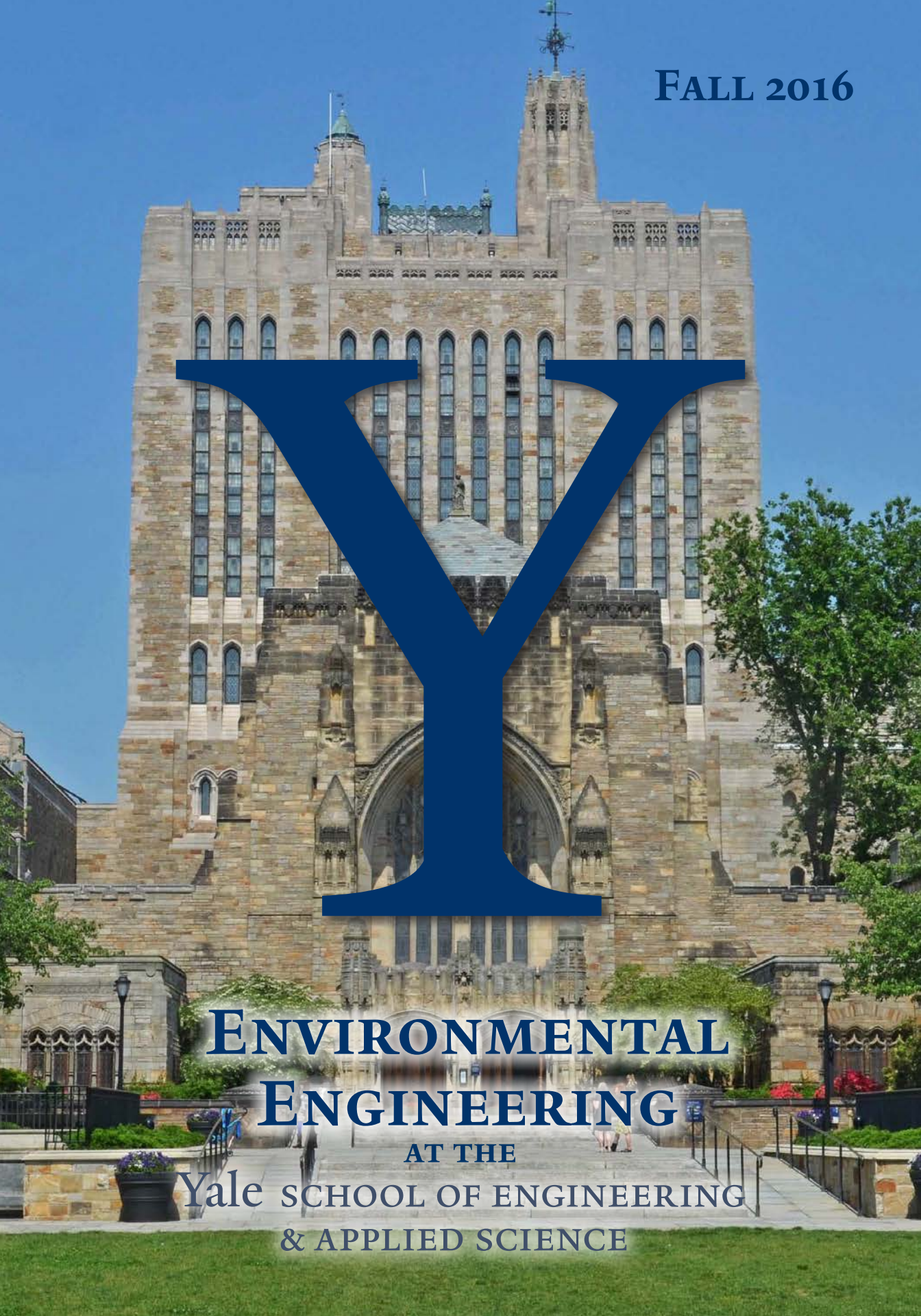


Fall 2016

Environmental Engineering

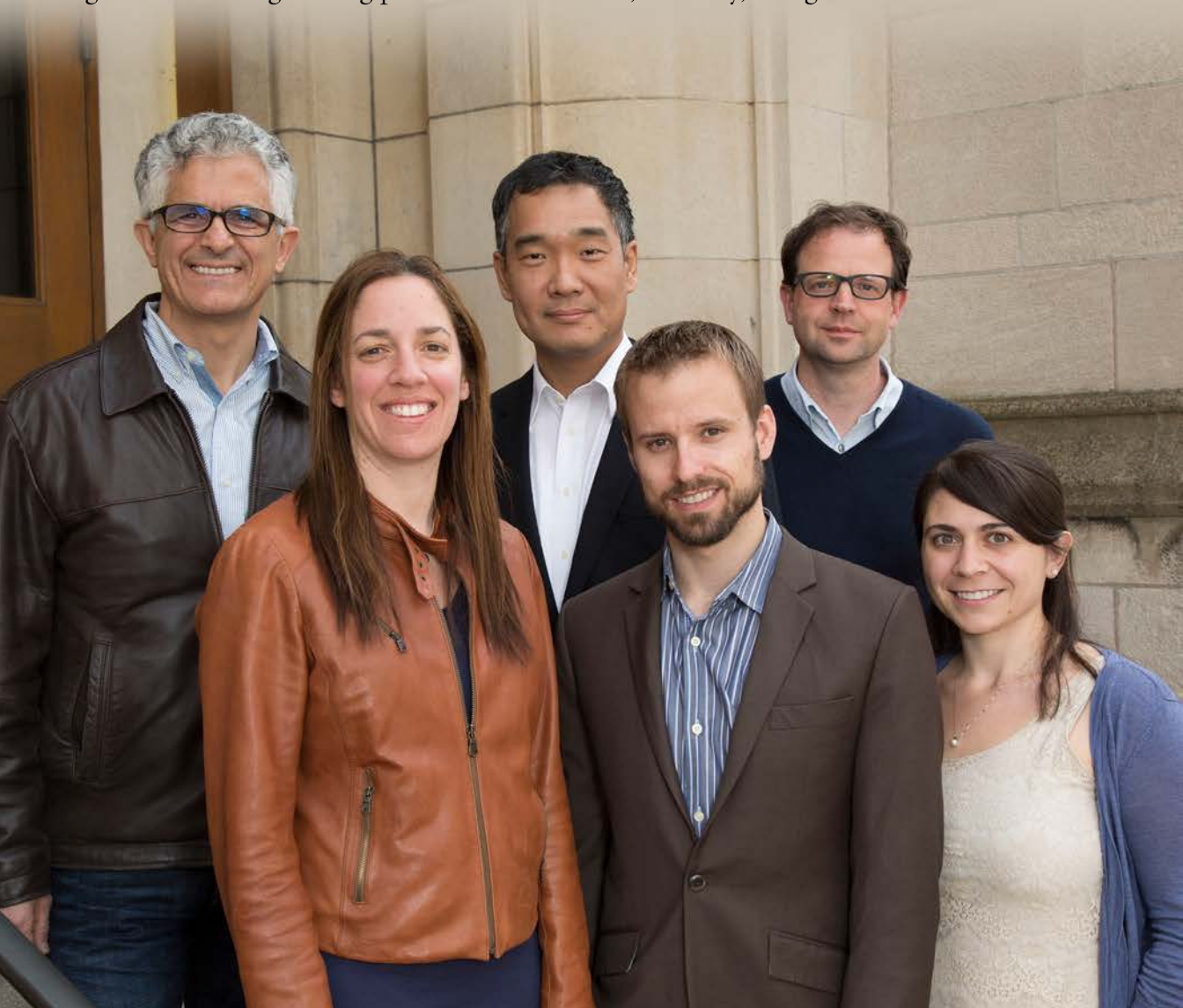
at the

Yale School of Engineering & Applied Science

Environmental Engineering at Yale began in 1998 as an interdisciplinary program within the Department of Chemical Engineering, built upon institutional strengths in environmental, biological, and engineering sciences and guided by the University's global perspective. In 2010, the Department of Chemical Engineering was renamed as the Department of Chemical & Environmental Engineering to more accurately reflect the scope of the research and the degree offerings.

The department now has six core and four adjunct faculty conducting fundamental research in water, air, and energy with both sustainability and molecular focus to address emerging environmental engineering and science problems. The program emphasizes collaborative, interdisciplinary research, leveraging strengths in other schools and departments at Yale, presenting a great example of environmental science and engineering at the nexus.

The department offers Ph.D. and B.S. degrees in Environmental Engineering. The Environmental Engineering Program at Yale continues to attract outstanding undergraduate and graduate students as well as postdoctoral fellows, with many of the graduates having leading positions in academia, industry, and government.



Environmental Engineering at Yale

Leading Mid-Size Program: #1 in National Research Council's S-Ranking; #9 in U.S. News & World Report's Graduate Program Ranking

- ***Frontiers in Research:*** Transformative research at the nexus of environment, energy, and sustainability.

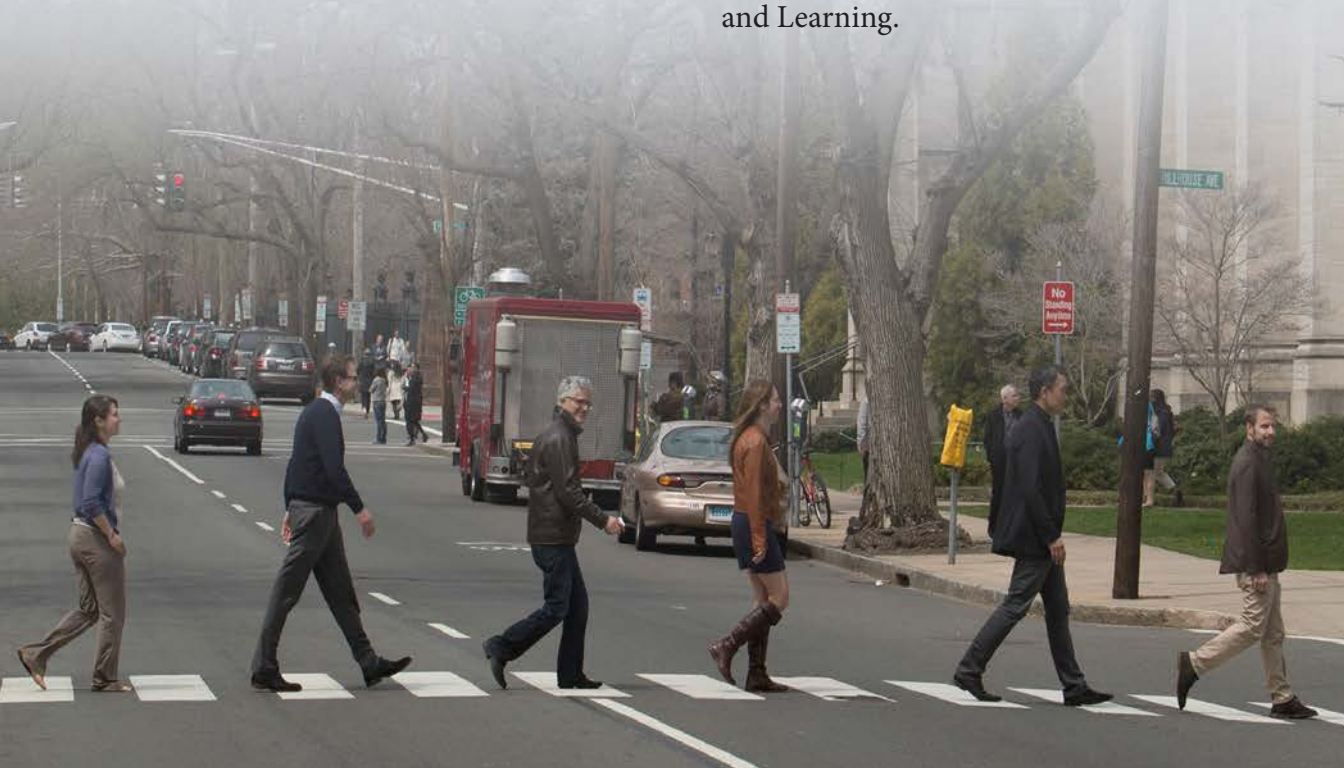
- ***High Impact Publications:*** Publications in high-impact journals (e.g., *Nature, Science, PNAS*); Average of 12 published peer-reviewed journal articles per faculty in 2015; Average h-index of 39 for the six core faculty.

- ***Award Winning Faculty:*** Elected National Academy of Engineering Members (Elimelech, Graedel); Walter Huber Civil Engineering Research Prize (Elimelech, Kim, Zimmerman); Paul Busch Award (Kim); Clarke Prize (Elimelech); NSF CAREER Award (Peccia, Plata); Eni Prize (Elimelech); Heinz Award in the Environment (Anastas).

- ***Research Centers:*** Center for Green Chemistry and Engineering; National Science Foundation Engineering Research Center for Nanotechnology-Enabled Water Treatment (NEWT); EPA Center for Solutions for Energy, Air, Climate, and Health; Molecular Design Research Network and Life Cycle of Nanomaterials.

- ***Outstanding Graduate Students:*** Numerous National Science Foundation and Environmental Protection Agency graduate research fellowship recipients; outstanding job placement after graduation (academia, government, industry).

- ***Strong Collaborations:*** Strong collaborations across Yale, including School of Forestry & Environmental Studies, School of Public Health, School of Management, Yale Office of Sustainability, Yale Center for Teaching and Learning.



Menachem Elimelech
Roberto Goizueta Professor

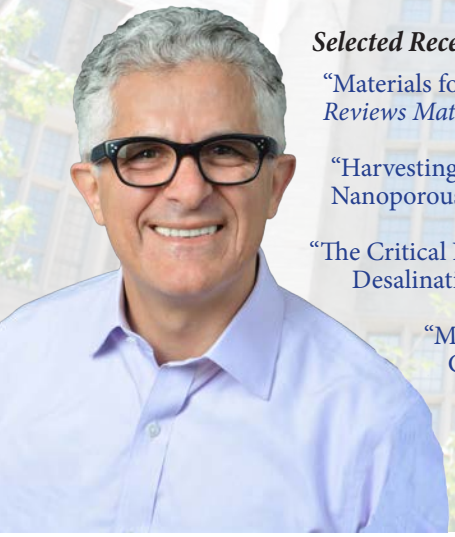
seas.yale.edu/elimelech

Sustainable technologies at the water-energy nexus

Education
Ph.D., Johns Hopkins University, 1989

Research Interests
Materials and technologies for membrane-based processes for desalination, wastewater reuse, and energy production; environmental applications of nanomaterials; water and sanitation in developing countries.

Major Awards
2015 Eni Prize for "Protection of the Environment"
2015 Thomson Reuters Highly Cited Researcher in the Categories of: Chemistry and Environment/Ecology
2015 Chinese Academy of Sciences Distinguished Scholar (formerly known as "Einstein Professorship")
2012 Yale University Postdoctoral Mentoring Prize
2011 The Simon W. Freese Environmental Engineering Award, ASCE
2008 The Lawrence K. Cecil Award in Environmental Chemical Engineering, AIChE
2006 Elected to the National Academy of Engineering
2005 The Athalie Richardson Irvine Clarke Prize



Selected Recent Publications

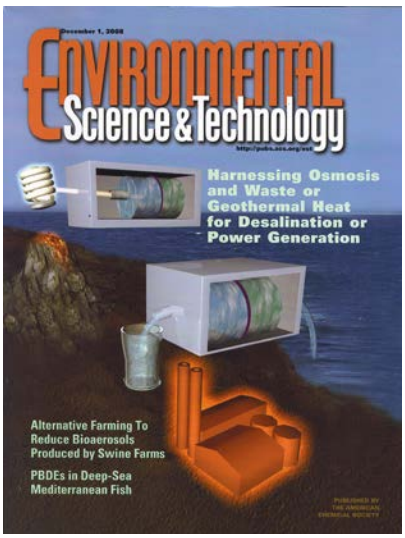
"Materials for Next-Generation Desalination and Water Purification Membranes." *Nature Reviews Materials*, 2016.

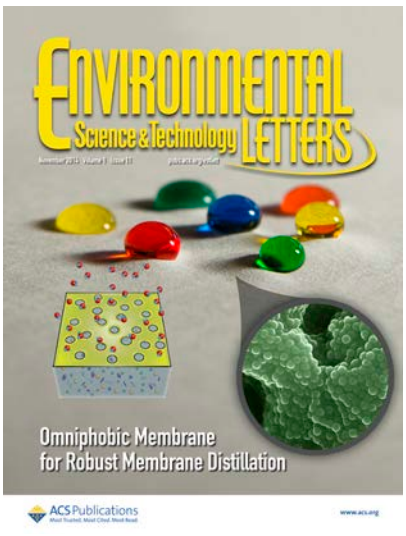
"Harvesting Low-Grade Heat Energy using Thermo-Osmotic Vapor Transport through Nanoporous Membranes." *Nature Energy*, 2016.

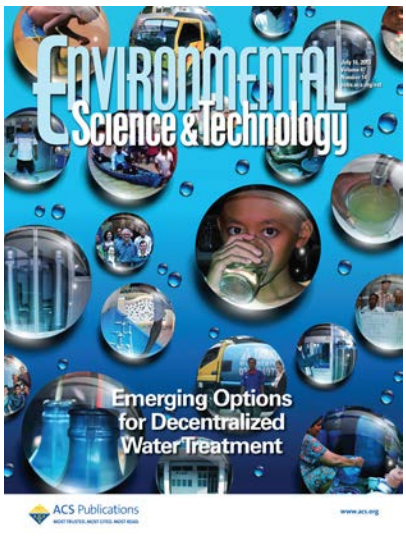
"The Critical Need for Increased Selectivity, Not Increased Water Permeability, for Desalination Membranes." *Environmental Science & Technology Letters*, 2016.

"Membrane-Based Processes for Wastewater Nutrient Recovery: Technology, Challenges, and Future Direction." *Water Research*, 2016.

"Antimicrobial Properties of Graphene Oxide Nanosheets: Why Size Matters." *ACS Nano*, 2015.







The Elimelech group has been carrying out cutting-edge research on membrane-based processes, focusing on technologies at the water-energy nexus. Some of the group work highlighted in ES&T are osmosis-driven membrane processes for sustainable production of water *(left)*, advanced materials for robust desalination membranes *(middle)*, and decentralized membrane systems for developing countries *(right)*.

Drew Gentner
Assistant Professor

seas.yale.edu/gentner

Novel approaches to critical air quality issues at the nexus of air, energy, health, and climate

Education

Ph.D., University of California, Berkeley, 2012

Research Interests

Emissions and physical/chemical processes of primary and secondary air pollution; impacts of traditional and alternative energy production/use on air quality, climate change, and public health; air quality and energy in developing countries and megacities; organic aerosols and ozone in the atmosphere; novel analytical instrumentation to measure understudied components of the atmosphere.

Major Awards

2015 National Academies Education Fellow in the Sciences
2011 Outstanding Graduate Student Instructor Award
2011 Civil & Environmental Engineering (Berkeley) Departmental Service Award
2011 Fellow - Summer Institute for Preparing Future Faculty
2008 Sustainable Energy Fellow

Selected Recent Publications

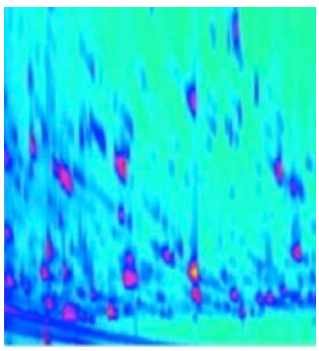
"Oil Sands Operations as a Large Source of Secondary Organic Aerosols." *Nature*, 2016.

"Emissions of Organic Carbon and Methane from Petroleum and Dairy Operations in California's San Joaquin Valley." *Atmospheric Chemistry and Physics*, 2014.

"Chemical Composition of Gas-Phase Organic Carbon Emissions from Motor Vehicles and Implications for Ozone Production." *Environmental Science and Technology*, 2013.

"Nighttime Growth of Particulate Organic Nitrates: A Significant Source of Atmospheric Secondary Organic Aerosols." *Science*, 2012.

"Elucidating Secondary Organic Aerosol from Diesel and Gasoline Vehicles Through Detailed Characterization of Organic Carbon Emissions." *Proceedings of the National Academy,* 2012.



Clockwise left to right: Drew sets up instrumentation to measure size- & chemically-resolved organic aerosol emitted from motor vehicles in a roadway tunnel as traffic rushes by just below his feet; the Gentner group develops new analytical instrumentation that can decipher the complex organic mixture of gases and particles in the atmosphere shown in the 2-D chromatogram; research in the group also seeks to characterize detrimental air quality and its determining factors in megacities and the developing world.

Jaehong Kim
Professor & Department Chair

seas.yale.edu/kim

Pioneering new material-based environmental technologies

Education

Ph.D., University of Illinois at Urbana-Champaign, 2002

Research Interests

Application of engineered nanomaterials for water treatment; development of upconversion technology for environmental application; developing self-healing membranes; photochemical production of alternative energy.

Major Awards

2016 Elected Member, Connecticut Academy of Science and Engineering
2013 Walter L. Huber Civil Engineering Research Prize, American Society of Civil Engineers
2012 *Environmental Science & Technology* Top Environmental Technology Paper Award
2009 Paul L. Busch Award, Water Environment Research Foundation

Selected Recent Publications

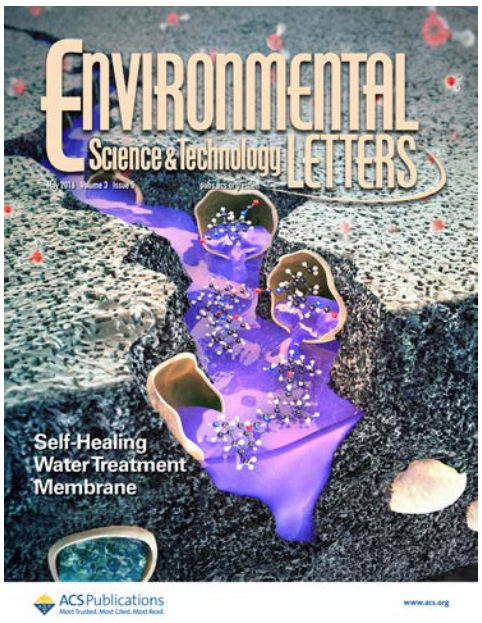
"Toward Microcapsule-Embedded Self-Healing Membranes." *Environmental Science & Technology Letters*, 2016.

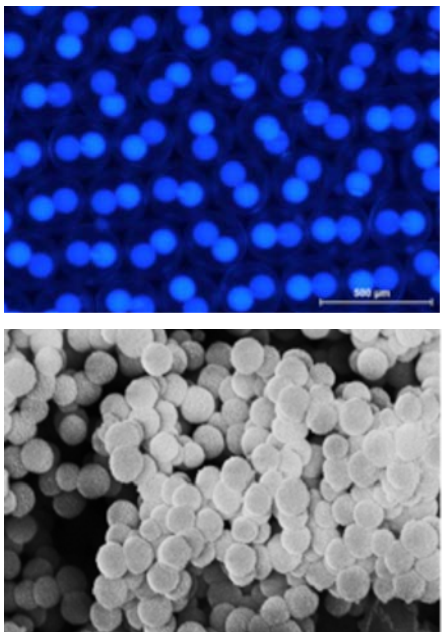
"Beyond the Pipeline: Assessing the Efficiency Limits of Advanced Technologies for Solar Water Disinfection." *Environmental Science & Technology Letters*, 2016.

"Harnessing Low Energy Photons (635 nm) for the Production of H_2O_2 using Upconversion Nanohybrid Photocatalysts." *Energy and Environmental Science*, 2016.

"Facet-Dependent Photoelectrochemical Performance of TiO_2 Nanostructures: An Experimental and Computational Study." *Journal of the American Chemical Society*, 137, 1520–1529, 2015.

"Triplet-Triplet Annihilation Upconversion in CdS-Decorated SiO_2 Nanocapsules for Sub-Bandgap Photocatalysis." *ACS Applied Materials & Interfaces*, 2015.





Left: Recent cover from the May 2016 issue of *Environmental Science & Technology Letters*. ***Right:*** Upconversion micro-(upper) and nano-(lower) capsules that achieve efficient harvesting of low energy photons for environmental photocatalysis.

Jordan Peccia
Professor

seas.yale.edu/peccia

Integrating engineering, molecular biology, and health

Education
Ph.D., University of Colorado-Boulder, 2000

Research Interests
Principle areas of inquiry include studying the sources, transport, and health impacts of microbes in buildings; quantifying human inhalation exposure to bacterial and viral pathogens emitted during the land application of sewage sludge; and improving biofuel feedstock production rates in photosynthetic microorganisms.

Major Awards
2016 Ackerman Award for Teaching and Research
2011 Graduate Mentor Award, Yale University
2004 NSF CAREER Award
2001 AEESP/CH2M Hill Outstanding Doctoral Dissertation Award

Selected Recent Publications

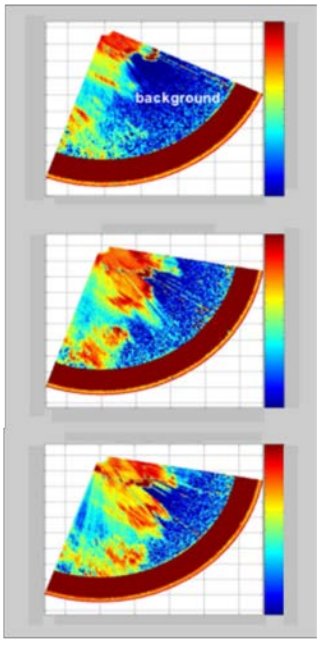
"Buildings, Beneficial Microbes, and Health." *Trends in Microbiology*, 2016.

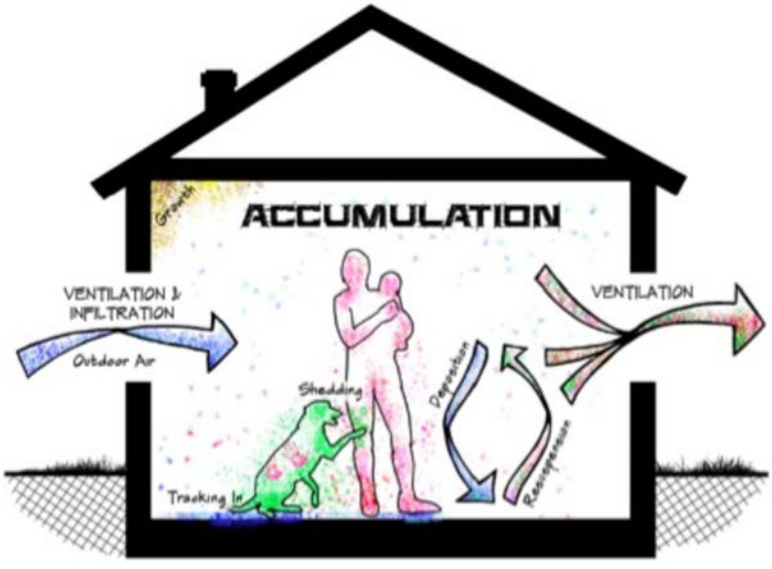
"Indoor Microbial Communities: Influence on Asthma Severity in Atopic and Non-Atopic Children." *Journal of Allergy and Clinical Immunology,* 2016.

"We Should Expect More from Our Sewage Sludge." *Environmental Science and Technology*, 2015.

"Indoor Emission as a Primary Source of Airborne Allergenic Fungal Particles in Classrooms." *Environmental Science and Technology*, 2015.

"Fungal Diversity in House Dust is Associated with Childhood Asthma Development and Measured Home Moisture." *Indoor Air*, 2014.





Left: LIDAR scans reveal that aerosols are emitted from sewage sludge-applied fields during a high wind event. ***Above:*** Integrating the indoor and human microbiome with aerosol physics.

Desiree Plata
Assistant Professor

seas.yale.edu/plata

Sustainable innovation in nanomanufacturing

Education

Ph.D., Massachusetts Institute of Technology/
Woods Hole Oceanographic Institution, 2009

Research Interests

Co-optimization of advanced materials and industrial processes for performance, cost, and environmental metrics during the design phase of innovation; detection methods of carbonaceous nanomaterials (natural, engineered, and incidental); molecular control over graphitic nanostructures to improve atom economy, reduce energy requirements, and enable nanomanufacturing; identification and fate of organic hydrocarbons in oil and gas industry; aerogel materials for oil reclamation; photochemical transformations of hydrocarbons in natural systems.

Major Awards

2016 NSF CAREER Award
2015 Oderbrecht Award for Sustainable Development
2013 Fellow, US-Korea Kavli Frontiers of Science, National Academy of Sciences
2012 Fellow, Frontiers of Engineering, National Academy of Engineers
2011 Fellow, Kavli Frontiers of Science, National Academy of Sciences

Selected Recent Publications

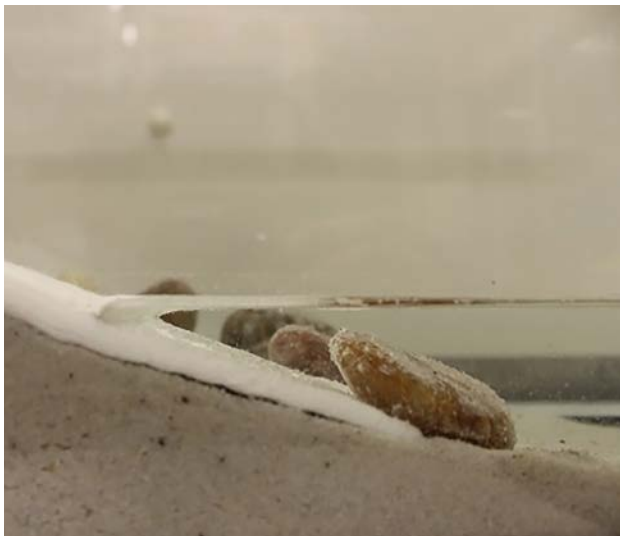
"Oil Sands Operations as a Large Source of Secondary Organic Aerosols." *Nature*, 2016.

"Flexible, Mechanically Durable Aerogel Composites for Oil Capture and Recovery." *ACS Applied Materials & Interfaces*, 2016.

"Elevated Levels of Diesel Range Organic Compounds in Groundwater near Marcellus Gas Operations are Derived from Surface Activities." *Proceedings of the National Academy of Sciences*, 2015.

"Natural Gas Residual Fluids: Sources, Endpoints, and Organic Chemical Composition after Centralized Waste Treatment in Pennsylvania." *Environmental Science & Technology*, 2015.

"Designing Nanomaterials to Maximize Performance and Minimize Implications Guided by the Principles of Green Chemistry." *Chemical Society Reviews*, 2015.



Above: A simulated beach covered with an advanced aerogel composite blanket. The composite can sorb up to 15 times its weight in oil and is mechanically robust, so you can mechanically extract the oil, as well as deploy it via automated techniques (thereby reducing human exposure). It is one of the only available technologies that completely prevents coastal impacts following a large oil spill, and coastal impacts often due the longest lasting ecological harm.

Julie Zimmerman
Professor

seas.yale.edu/zimmerman

Designing a sustainable tomorrow through Green Chemistry and Engineering

Education
Ph.D., The University of Michigan, 2003

Research Interests
Effectively pursuing fundamental research within a broader sustainability context as reflected in three principle areas: ennobling the integrated biorefinery; developing novel, green, selective sorbents for inorganic contaminants; informing the design of safer chemicals and nanomaterials.

Major Awards
2015 Fellow, Royal Society of Chemistry, United Kingdom
2015 Elected Member, Connecticut Academy of Science and Engineering
2013 Finalist, Connecticut Women of Innovation, Research Category
2013 Karman Fellow, RWTH-Aachen University, Aachen, Germany
2012 Walter L. Huber Civil Engineering Research Prize, American Society of Civil Engineering

Selected Recent Publications

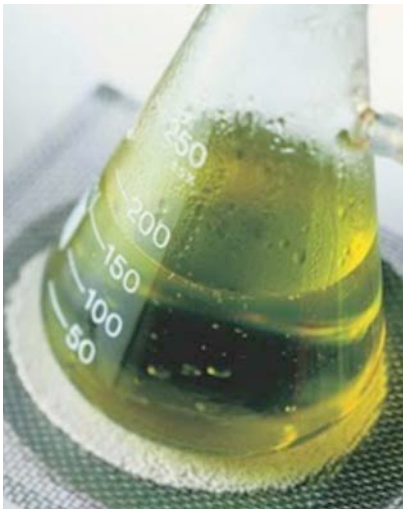
"Hybrid Analysis of Blue Water Consumption and Water Scarcity Implications at the Global, National, and Basin Levels in an Increasingly Globalized World." *Environmental Science & Technology*, 2016.

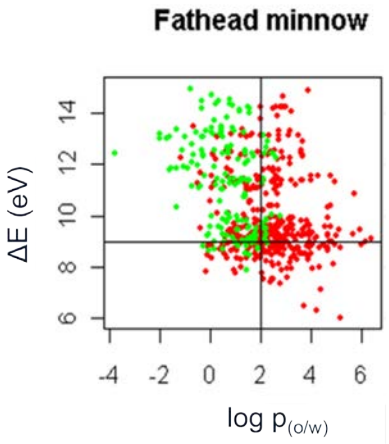
"Shape-Dependent Surface Reactivity and Antimicrobial Activity of Nano-Cupric Oxide." *Environmental Science & Technology*, 2016.

"Towards a Selective Adsorbent for Arsenate and Selenite in the Presence of Phosphate: Assessment of Adsorption Efficiency, Mechanism, and Binary Separation Factors of the Chitosan-Copper Complex." *Water Research*, 2016.

"Role of CO_2 in Mass Transfer, Reaction Kinetics, and Inter-Phase Partitioning for the Transesterification of Triolein in an Expanded Methanol System with Heterogeneous Acid Catalyst." *ACS Sustainable Chemistry and Engineering*, 2015.

"Identifying and Designing Chemicals with Minimal Acute Aquatic Toxicity." *Proceedings of the National Academies*, 2015.





Left: Novel, reusable, green sorbents composed on nano metal oxides and biopolymers for the selective and efficient removal of inorganic contaminants from aqueous systems. ***Middle:*** Algal biomass grown for extraction, fractionation, and transesterification in a one-pot high pressure carbon dioxide system that yields fuels and value-added chemicals. ***Right:*** Zimmerman's work has made significant contributions to advance rational design of safer chemcials and nano-materials from first principles by relating physiochemical properties and toxicity endpoints of concern ranging from cytotoxicity to acute and chronic aquatic toxicity.

Affiliated Faculty

Paul T. Anastas

Ph.D., Brandeis University, 1989

Professor in the Practice of Green Chemistry, Chemical & Environmental Engineering
Teresa & H. John Heinz III Professor in the Practice, School of Forestry & Environmental Studies

Research Interests:
Molecular design to minimize human and ecological toxicity; development of catalysts for energy storage applications; design of new catalyst systems for the transformation of biomass.

Selected Awards:
Wöhler Prize, Gesellschaft Deutscher Chemiker, 2012; Rachel Carson Award, Natural Products Association, 2011; John Jeyes Lectureship, UK Royal Society of Chemistry, 2007; The Heinz Award, Environment, 2006.

Michelle Bell

Ph.D., Johns Hopkins University, 2002

Professor of Chemical & Environmental Engineering
Professor of Environmental Health at the Yale School of Forestry & Environmental Studies

Research Interests:
Understanding the effects of atmospheric systems, including air pollution and weather, on human health using epidemiology, biostatistics, and environmental engineering.

Selected Awards:
Prince Albert II de Monaco/Institut Pasteur Award; Rosenblith New Investigator Award; NIH Outstanding New Environmental Scientist (ONES) Award.

Thomas Graedel

Ph.D., University of Michigan, 1969

Clifton R. Musser Professor of Industrial Ecology; Professor of Chemical & Environmental Engineering; Professor of Geology and Geophysics; Director of the Center for Industrial Ecology

Research Interests:
Industrial ecology; materials use, loss, and recycling; criticality of metals; atmospheric composition and global change; sustainability science and engineering.

Selected Awards:
U.S. National Academy of Engineering, 2002; Society Prize, International Society for Industrial Ecology, 2007; Fellow, American Association for the Advancement of Science, 1998; Fellow, American Geophysical Union, 1995.

Edgar Hertwich

Ph.D., University of California at Berkeley, 1999

Professor of Industrial Sustainability at the Yale School of Forestry & Environmental Studies
Professor of Chemical & Environmental Engineering

Research Interests:
Industrial ecology, energy systems, climate change mitigation – assessment of technological, structural and behavioral options, co-benefits and trade-offs, drivers of global environmental change.

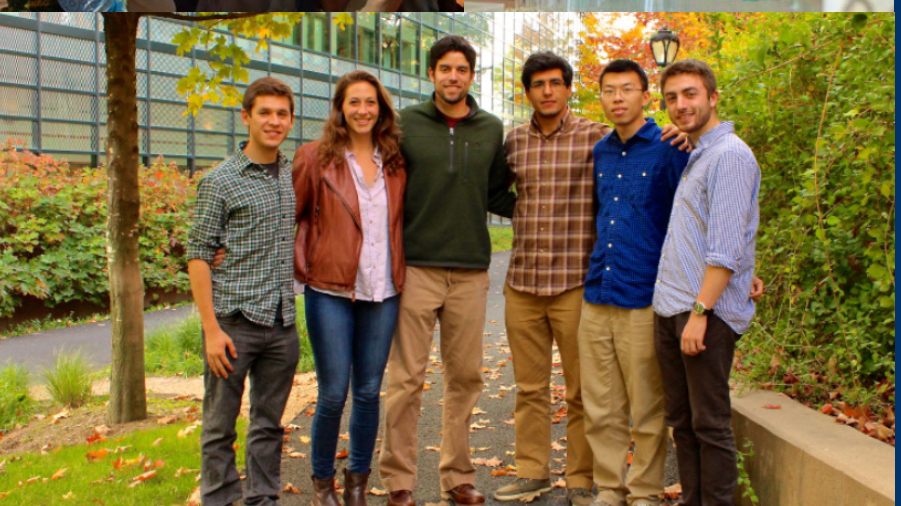
Selected Awards:
Laudise Prize in Industrial Ecology, 2003; Best Environmental Policy Paper Award 2009, American Chemical Society; Member, Norwegian Academy of Technological Sciences, 2015; President-Elect, International Society for Industrial Ecology, 2015-16.

Joseph Pignatello

Ph.D., University of California at Berkeley, 1977

Adjunct Professor of Chemical and Environmental Engineering; Chief of the Department of Environmental Sciences, Connecticut Agricultural Experiment Station, New Haven

Research Interests:
Organic pollutants in soils and sediments in underground and aquatic environments; transport; adsorption mechanisms and kinetics; bioavailability; methods for remediation of contaminated soils and water including bioremediation, physical methods of removal, and advanced oxidation processes.



Some of our recent graduates and postdocs are today at:

FACULTY IN ACADEMIA:

Arizona State University
Carnegie Mellon University
Clemson University
Columbia University
Cornell University
Dartmouth College
ETH Zurich
Harvard University
Johns Hopkins University
Lafayette College
McGill University
Nanyang Technological University
National University of Singapore
Northeastern University
Ohio State University
Polytechnic University of Turin
Peking University
Rose-Hulman Institute
Purdue University
Rice University
Seoul National University
State University of New York, Buffalo
Tennessee Technological University
University of California, Los Angeles
University of California, Riverside
University of Colorado at Boulder
University of Delaware
University of Illinois at U-C
University of Maryland
University of Massachusetts, Amherst
University of Michigan
University of Minnesota
University of Notre Dame
University of Pittsburgh
University of Washington
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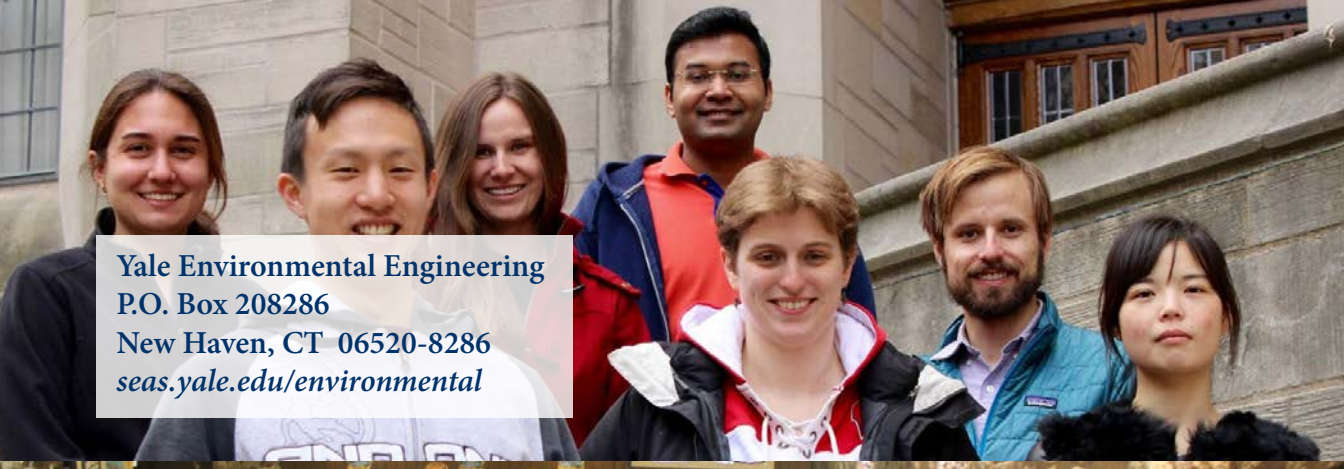
PUBLIC & PRIVATE SECTORS:

Adaptive Biotechnologies Corp.
Boston Consulting Group
U.S. Environmental Protection Agency
U.S. Department of State
Oasys Water
Proctor & Gamble
Pegasus Capital Advisors
P2 Science, Inc.
Brown & Caldwell
Veolia Water Solutions & Technology
Singapore National Environment Agency
World Health Organization



Yale Environmental Engineering
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