DIRECTOR’S MESSAGE

It has been a truly remarkable year! The re-birth of the Environmental Engineering Science Program resulted due to a grass-roots planning effort by the School of Engineering and Applied Sciences starting in the mid 1990s as a part of the Project 21 Initiative. With the help of the alumni and well wishers of the Program, most of the initial goals have been met; which has resulted in the establishment of three key focal areas (see Figure below) and hiring of faculty to attain critical mass in these areas. State of the art research laboratories have been set up, and the Jens Molecular and Nanoscale Instrumentation Laboratory has been a very useful addition, not only helping in our research efforts but also in bringing our students from diverse research groups together in the sharing and exchange of ideas. We marched into our University’s sesquicentennial year and what a ride it has been! The University wide Environmental Committee with the support of Chancellor Wrighton organized a year long set of Colloquia (see page 9 for details). This will be helpful as we formulate our ideas and begin to develop our next 10 year plan. We have a lot to look forward to as we continue training the next generation of Environmental engineers and scientists, and continue contributing to the well being of our Environment!

Pratim Biswas
Stifel and Quinette Jens Professor
Director, Environmental Engineering Science

YESTERYEAR…A LITTLE HISTORY ON THE SCHOOL OF ENGINEERING

(excerpted from Washington University in St. Louis Magazine, Summer 2003)

From the outset, University founders emphasized “useful knowledge,” so it’s no surprise that the O’Fallon Polytechnic Institute, the forerunner of the University’s School of Engineering & Applied Science (SEAS), was the University’s first principal functioning department. Known first as a night school for working “mechanics,” the School’s graduates had many successes, such as developing a water-purification system that supplied clean water from St. Louis’ water mains for the first time, just before the 1904 World’s Fair.

Today, SEAS, whose nine academic departments include 1,100 undergraduates and 581 graduate students, grants diplomas to a quarter of the University’s graduates.

Among other things, SEAS is developing innovative ways to prevent, diagnose, and treat disease; using nanotechnology to improve manufacturing processes; creating urban systems; developing devices to improve national security and devices to reduce pollution; applying physics to biological systems; decoding signals from the universe; and studying complex systems such as the U.S. economy and a space voyage.

The technological nature of the world and its internationalization present great opportunities to educate engineers who will enhance the quality of life, create wealth and opportunities, and improve the human condition.
Lars T. Angenent  
Ph.D., 1998  
Iowa State University  
Assistant Professor, Department of Chemical Engineering.  
*Molecular Biology for Environmental Engineering, Biodigesters, Anaerobic Waste Treatment, Biological Wastewater Treatment*

Richard L. Axelbaum  
Ph.D., 1988  
University of California  
Associate Professor, Department of Mechanical Engineering.  
*Nanoparticle Synthesis, Combustion*

Pratim Biswas  
Ph.D., 1985  
California Institute of Technology  
Stifel and Quinette Jens Professor. Director, Environmental Engineering Science Program.  
*Aerosol Science and Engineering, Air Quality and Pollution Control*

Da-Ren Chen  
Ph.D., 1997  
University of Minnesota  
Assistant Professor, Mechanical Engineering.  
*Particle Measurement and Instrumentation, Particle Filtration and Separation, Aerosol Dynamics Modeling, Aerosol Science and Technology*

Milorad P. Dudukovic  
Ph.D., 1972  
Illinois Institute of Technology  
Department Chairman, Chemical Engineering. Laura and William Jens Professor of Environmental Engineering

Daniel Giammar  
Ph.D., 2001  
California Institute of Technology  
Assistant Professor, Civil Engineering.  
*Aquatic Chemistry, Water Quality Engineering, Fate and Transport of Inorganic Contaminants*

Rudolf B. Husar  
Ph.D., 1970  
University of Minnesota  
Director, Center for Air Pollution and Trends Analysis, (CAPITA), Professor, Mechanical Engineering.  
*Environmental Informatics, Aerosol Pattern and Trend Analysis*

Maxine Lipeles  
J.D., 1979  
Harvard University  
Professor, College of Law  
*Environmental Law*

Jay R. Turner  
D.Sc., 1993  
Washington University  
Associate Professor, Chemical Engineering.  
*Air Quality Management*

Brian A. Wrenn  
Ph.D., 1994  
U. of Illinois  
Assistant Professor, Civil Engineering.  
*Bioremediation Processes, Soil, Sediment, Groundwater Treatment*

Stephan Falke  
D.Sc., 1999 - Washington University  
Mechanical Engineering Department, Research Assistant Professor, Air quality data analysis, environmental information systems

Charles A. Buescher  
M.S., 1961 - Washington University  
Senior Professor, Water Quality

H. G. Schwartz  
Ph.D., 1966 - California Institute of Technology, Senior Professor
The 2003-2004 school year was busy with many activities for EnvESA, the Environmental Engineering Student Association. The purpose of the association is to provide a forum for interactions with individuals interested in environmental engineering science. The organization is also focused on effecting environmentally responsible change within the department and the engineering school.

The school year began with a panel discussion for prospective graduate students. The panel included several EnvESA members with various backgrounds and the EnvESA advisor Dan Giammar. More than fifteen undergraduate students attended. This year EnvESA joined the Missouri Department of Transportation’s Adopt-A-Highway program. The project is a three year commitment to cleanup a section of I-170 around the Forest Park Parkway Exit. Another community service activity involved the St. Louis Gifted Resources Council. EnvESA faculty advisor Dan Giammar and several EnvESA members coordinated lab experiments on water treatment for middle school students. To close the school year, EnvESA plans to volunteer at the Forest Park Earth Day Celebration.

This year, EnvESA formed a student chapter of the Water Environment Federation and plans to form a chapter with Air & Waste Management Association. EnvESA is hoping to get funding for conferences next year, as well as open doors for scholarship and career opportunities for members.

Social activities this year included several potluck dinners, a trip to the Forest Park Ice Skating Rink, and trips to Blueberry Hill. An end of the year cookout is planned. On the sports scene, our co-ed intramural softball team, coached by James Noel, provided both social and physical activity for EnvESA. A car wash fundraiser is also planned for April.

EnvESA meetings are held twice a month and frequently begin with a guest speaker. Guest speakers this year included representatives from the Electric Power Research Institute, Washington University Career Service Office, Black and Veatch, Missouri Water Environment Association, Water Environment Federation, and Air and Waste Management Association. EnvESA members also have the opportunity to have roundtable discussions with Environmental Engineering Department Seminar Speakers.
Dr. Cecil Lue-Hing, D.Sc. 66, Member, NAE, was selected as the Kappe Lecturer in 2003. He visited the University and presented a thought provoking talk on “Challenging Environmental Regulations: Some DOs & DON’Ts: A Summary of Case Studies” (http://www.env.wustl.edu/Seminars/Abstracts/2003Kappe.pdf) on September 12, 2003. Cecil Lue-Hing joined the consulting firm REACT after graduation, and in 1972 accepted the position of Director of Research and Development for the Municipal Water Reclamation District of Greater Chicago. He has achieved acclaim for his applied research work with this major utility for more than three decades. He is internationally recognized as an expert in residuals management and is also well versed in the operation of wastewater treatment systems. Dr. Cecil Lue-Hing has received numerous professional honors - he is a member of the National Academy of Engineering, a Diplomate of the American Academy of Environmental Engineers, the Charles Alvin Emerson Medal from WEF, the Civil Engineer of the Year Award from ASCE and the Distinguished Alumni Award from Washington University in St. Louis.

Dr. Bruce E. Rittmann, B.S. 74 and M.S. 74, is the John Evans Professor of Environmental Engineering at Northwestern University, IL. He was recently elected to the National Academy of Engineering, and was also selected as the AEESP Distinguished Lecturer. He had visited WUSTL and presented an invited talk on Jan 31, 2003 (http://env.wustl.edu/seminars/abstracts/rittmannsp03.pdf). Bruce received his Ph.D. in Environmental Engineering from Stanford University. He has been the President of AEESP, the Vice-Chair of the Water Science and Technology Board of the National Research Council (NRC), and a member of the E.P.A. Science Advisory Board (SAB).

Dr. D.W. Ryckman and the first Doctoral Candidate, Dr. Sotirios Grigoropoulos, now a distinguished professor at the University of Patras in Greece. (Also pictured are his wife and son).

DISTINGUISHED ALUMNI AWARDS

Two of our prominent Alumni, Jack Stein, EN67, SI69, (left) and Dr. Richard (Dick) Pinckert, D.Sc., EN62, (right) were awarded the School of Engineering Distinguished Alumni Awards. Both Jack and Dick are actively involved with the Environmental Engineering Program and members of the Advisory Board.

OUR NEWEST ALUMNI

2003 Graduates
· Rafael McDonald · Matthew Gim
· Pramod Kulkarni · Sean Raffuse
· Scott Duthie
ENVIRONMENTAL ENGINEERING SCHOLARSHIPS

2003 RECIPIENTS

Rebecca Hoffman Charles Buescher Jr. Scholarship
Rafael McDonald Charles & Marlene Buescher Scholarship
Marina Smallwood Forest & Patricia McGrath Scholarship
Brad Goodwin Sverdrup Scholarship
James Noel Henry G. Schwartz Scholarship and
Paul B. Hodges Memorial Scholarship
Achariya Suriyawong Otis, Dorothy & Bryce Sproul Scholarship
Catherine Reid Ed Edgerly Scholarship
Jason He Henry & Marjorie Reitz Scholarship
Eric Kettleson ENVIRSAN Scholarship and
Cecil Luc Hing Scholarship
Prakash Kumar Charles & Gayle Leben Scholarship

INDUSTRIAL PARTNERS

CURRENT MEMBERS

· Ameren UE
· Johnson Controls
· American Bottoms
· The Boeing Company
· DuPont Corporation
· EPRI Community Center

The objectives of the Industrial Partners Group are to provide access to cutting edge, state of the art research and developments in Environmental Engineering and allow interaction of faculty and students with counterparts in the Industrial sector. Members can participate in fundamental and applied research projects at Washington University; participate in technology transfer of novel developments; have access to state of the art research facilities; be able to pool Industrial Funding with Federal Research Funding; obtain specialized training in focused areas; hire Graduate Student Interns who will participate in Industrial Research and Development as part of the Degree Program, and participate in an Industrial Advisory Board for the Program. Details of the program are available at http://www.env.wustl.edu/indpartmain.htm.

NSF FUNDED REU PROGRAM

The Environmental Engineering Science Program successfully organized the Research Experience for Undergraduates (REU) Program for the third summer, and 16 students from all over the US participated. The students attended Workshops wherein they were introduced to research methodologies and data analysis techniques, in addition to Laboratory safety procedures. They had hands-on experience working in our research Laboratories and were assigned their own independent projects. Several interesting field trips were also organized, providing the students an idea of industrial scale environmental applications. Additional details on the REU Class of 2003 can be viewed at http://www.env.wustl.edu/REU/2003/2003.htm. The batch of students for the Class of 2004 has been selected and will be working with 10 faculty members in the Environmental Engineering Science Program.

Total Research Awards in 2003 = $4.6 million
Total number of graduate students = 35
Full-time faculty in Environmental Engineering = 10
Students pursuing Undergraduate Minor = 7
Major Program Endowments are:
Jens, Browne, & McGrath
REFEREEED JOURNAL PUBLICATIONS


Xue, Junli; Al-Dahhan, Muthanna; Dudukovic, Milorad P.; Mudde, R. F. “Bubble dynamics measurements using four-point optical probe.” Canadian Journal of Chemical Engineering (2003), 81(3-4), 375-381.

Nedeltchev, Stoyan; Kumar, Sailesh B.; Dudukovic, Milorad P. “Flow regime identification in a bubble column based on both Kolmogorov entropy and quality of mixedness derived from CARPT data.” Canadian Journal of Chemical Engineering (2003), 81(3-4), 367-374.


The Environmental Engineering Science Program Advisory Board had its annual meeting at Washington University in St. Louis in September, 2003 and several action items were developed. It was decided that a Vision/Mission/Goals statement be developed for the Advisory Board. The group also decided to have a set of goals and progress discussed at the Board Meetings.

The Faculty are further streamlining Program activities with regards to the curriculum, student recruitment, development of focal areas of emphasis; and discussing operational and sustainability considerations.

Major Research Funding Sources: NSF, EPA, NASA, DOE, NIEHS, NIH, Center for Filtration Research, Ameren UE, and EPRI.
Dr. Perry McCarty, eminent scientist and researcher in Environmental Engineering, Professor at Stanford University, Member NAE, presented the Inaugural Ryckman Lecture on Nov. 21, 2003 at Washington University in St. Louis. He spoke on “Precautionary Approach for Toxic Chemicals in the Environment - Experiences and Concepts in the Making”. Man-made (anthropogenic) chemicals have greatly improved the quality of life over the past half century, however, they also have been the root of numerous human health and environmental problems of local to global scale. The presentation discussed examples of problem chemicals such as synthetic detergents, pesticides, polychlorinated biphenyls (PCBs), chlorinated solvents, chlorofluorocarbons (CFCs), methyl tertiary butyl ether (MTBE), and perchlorates. Compounds, such as DDT, PCBs, CFCs, and MTBE, were designed to help solve environmental problems resulting such as disease, fire hazard, toxicity, and air pollution, yet resulted in their own set of difficulties, which were generally unforeseen at the time of their production and widespread distribution. Dr. McCarty pointed out the complexities in adequately predicting the environmental fate and affects of many new chemicals, often because the affects are subtle, ecosystems are complex, and our understanding of the many chemical, physical, and biological linkages in the ecosystems comprising the Earth is far from adequate. Dr. McCarty eloquently discussed the nature of this dilemma, and what could be done about it - suggesting the need for preventive measures and a precautionary approach to be adopted.

The Environmental Engineering Science Program established the annual “Distinguished Ryckman Lecture in Environmental Engineering” in recognition of all the faculty members - Drs. D. W. Ryckman, E. Edgerley, N. Burbank, H. D. Tomlinson, R. Skrinde and J. Buzzell who helped start the program at Washington University in St. Louis in the mid 1950’s. One hundred fifteen graduate degrees were conferred and the Seminar is also a testimonial to the achievements of the students of the original program. An Endowed Fund has been created to support the expenses associated with the invitation of a Distinguished Scholar to the University every year. Please contact Libby Gutberlet (Tel: (314) 935-8730 or Libby_Gutberlet@aismail.wustl.edu if you are interested in supporting this Endowment.

In honor of the The Rick and Betty Ryckman Lectureship, a memorial plaque has been placed in the Environmental Engineering Science Program’s conference room.
During its 150th year, Washington University has launched an initiative to explore the role that research universities can play in addressing issues related to the environment. This initiative will build on the strengths of the existing Environmental Programs and shape the University's educational programs, research, and operations as they relate to the environment and become one of the defining interdisciplinary programs at the Washington University in St. Louis.

This series was supported by the Washington University in St. Louis Sesquicentennial Commission and by generous funding from the V. Kann Rasmussen Foundation (www.vkrf.org). The following are the list of Seminars and Colloquia that have/will be held on the campus of WUSTL:

Government, Politics, and the Environment: A Sesquicentennial Environmental Initiative Lecture Friday, October 3, 2003 Two former administrators of the U.S. Environmental Protection Agency, Carol M. Browner and William Reilly presented their thoughts on how politics and government influence the nation's environmental landscape.

Science and the Environment: A Sesquicentennial Environmental Initiative Lecture Thursday, October 9, 2003 Two noted environmental scientists, Drs. Jane Lubchenco and Mario Molina, Noble Laureate, presented their thoughts on the scientific challenges and opportunities in environmental research.

Colloquium on Energy Friday, October 31, 2003 This colloquium brought together key people in a discussion of energy-related policies and challenges facing us at home and abroad. The keynote address: “Alternate Energy Sources: The Indian Context” was presented by Prof. S.P. Sukhatme, chair, Atomic Energy Regulatory Board of India; Professor Emeritus and former Director, Indian Institute of Technology, Bombay. The talk was followed by a Panel Discussion with participants including Pratim Biswas, WUSTL, Dennis Houston, Exxon/Mobil Refining and Supply; Martin J. Lyons, Ameren Corporation; Jason Makansi, Pearl Street Inc. Ambar Rao, Washington University in St. Louis was the moderator of the Event.


Part II: Bridging the Gap Between Research and Policy: Childhood Lead Poisoning as a Case Study was a panel discussion that explored the gap between academic research and public policy.

Plant Sciences: The Environment and Sustainability Thursday, February 26, 2004 Four eminent scientists, Aaron Kaplan, The Hebrew University of Jerusalem; Ganesh Kishore, Vice President, DuPont Agriculture & Nutrition; François M.M. Morel, Princeton University; Jerald L. Schnoor, University of Iowa; spoke on topics ranging from phytoremediation, the inorganic carbon cycle, carbon sesquestration, the impact of genetically modified crops on the environment, and sustainability.

Research in Aerosols and Air Quality: Impact on Nanotechnology to Global Climate Tuesday, March 2, 2004 Three world-renowned scientists, Sheldon K. Friedlander, Parsons Professor of Chemical Engineering, University of California at Los Angeles; John H. Seinfeld, Louis E. Nohl Professor and Professor of Chemical Engineering, California Institute of Technology; Jonathan Samet, Professor and Chairman of Epidemiology, Johns Hopkins University, presented talks on aerosols and their impacts. The first talk described the wide-ranging applications of aerosol science engineering. The second talk covered the role of aerosols and their effect on global climatology. The health effects of fine particles were elucidated in the third talk.

Colloquium: The Sustainable University Tuesday, March 30, 2004 William McDonough, Architect

Educational Practices and the Environment Wednesday, April 21, 2004 Participants include Michael M. Crow, President, Arizona State University; David H. Marks, Morton and Claire Gould Family Professor of Engineering Systems and Civil and Environmental Engineering, and Director of the Laboratory for Energy and the Environment, Massachusetts Institute of Technology; Michael B. McElroy, Gilbert Butler Professor of Environmental Studies, Harvard University; Franklin M. Orr, Jr., Keleen and Carlton Beal Professor of Petroleum Engineering, Stanford University. The Panel Discussion will be moderated by Mark S. Wrighton, Chancellor, Washington University in St. Louis.

Colloquium: Our Rivers: A Sustainable Resource? Thursday, April 22, 2004 These presentations provide a background history of the rivers in our region, as well as their various uses in transportation, agriculture, power production, recreation, and public water supply. Participants include Charles Buescher, Professor of Environmental Engineering, Washington University in St. Louis; Robert Criss, Washington University in St. Louis; William Lowry, Washington University in St. Louis.
INACTIVATION OF BIOAEROSOLS

By Eric Kettleson, Lars Angenent, and Pratim Biswas

Aerosol particles of biological origin, such as bacteria, viruses, and spores, are commonly referred to as “bioaerosols.” Inhalation of various bioaerosols can result in a number of serious respiratory ailments. Examples of respiratory disorders associated with the inhalation of infectious or allergenic bioaerosols include: asthma, influenza, legionellosis, and tuberculosis. In addition to naturally occurring bioaerosols, the deliberate release of airborne bacterial and viral pathogens that cause anthrax, plague, and smallpox also poses a legitimate public health concern. Preventative measures, in the form of efficient control technologies, are required to limit exposure to bioaerosols.

This project examines the capture and inactivation of bioaerosols using a soft x-ray enhanced electrostatic precipitator, building on previous research conducted in the Aerosol and Air Quality Research Laboratory (Dr. Pratim Biswas, see page 15 of this issue). This research showed that the combination of a soft x-ray unit and unipolar coronas effectively charged ultrafine particles and improved their capture efficiencies. By extension, an x-ray enhanced corona system will be used to remove bacteria and nano-sized viral particles from air streams.

Our intent is to develop a disinfection system that separates, inactivates, and completely decomposes bioaerosols. It is hypothesized that 100% removal of bacterial and viral bioaerosols can be achieved by using x-ray irradiation and photocatalytic oxidation to enhance the effects of an electrostatic precipitator. Particular attention focuses on understanding the mechanism of inactivation. Potential inactivation mechanisms include: complete mineralization, immobilization on the catalytic surface, cell lysis/particle break-up, and DNA damage.

Overall, this project is capable of providing a number of benefits to society from an air quality standpoint. If shown successful in the lab setting, and then scaled to meet the needs of an industrial, healthcare, or residential environment, an x-ray enhanced corona system could have millions of people breathing cleaner air. This improvement in indoor air quality will manifest itself in fewer respiratory disorders, a lower occurrence of sick-building syndrome related to biological contaminants, and a decrease in nosocomial infection. The anti-bioterrorism implications of this type of research should also be noted. In an era when homeland security is at the forefront of many peoples’ minds, possessing the ability to effectively combat a deliberate release of air-borne pathogens is extremely beneficial.

CENTER FOR ENVIRONMENTALLY BENEFICIAL CATALYSIS (CEBC)

The Sustainable Technology component of the Environmental Engineering Program will benefit from the recently announced (October 2003) Center for Environmentally Beneficial Catalysis (CEBC). This new (one of four started in 2003) NSF Engineering Research Center is headquartered at the University of Kansas at Lawrence and core partners are the Biocatalysis Center at the University of Iowa and the Chemical Reaction Engineering Laboratory (CREL) at Washington University directed by Dr. Dudukovic. The Center will explore novel environmentally benign and sustainable processes for production of chemicals, fuels, pharmaceuticals and various materials. A major thrust is the development of “green chemistry” techniques and the appreciation of green engineering principles that will enable the chemical industry to whittle costs to keep the environment clean. Courses will be available via interactive video systems. CEBC opens the door for research of graduate students in the Environmental Engineering Program interested in sustainable technology.

In the sustainable processing area, students have been involved in building process models for the newly opened Corn to Ethanol Pilot Plant at the Southern Illinois University in Edwardsville (SIUE). Under the leadership of Dr. M.P. Dudukovic, CREL researchers have continued their activities in the quantification of flow and mixing in multiphase reactors.
In the Aquatic Chemistry Laboratory (ACL), Daniel Giammar and his students have been investigating chemical reactions that affect the fate and transport of lead in contaminated soil, sediment, and groundwater environments. Lead contamination has resulted from activities associated with lead mining, smelting, and refining, and Missouri is the largest lead producer in the United States. Work in the ACL is currently focusing on two specific processes: lead adsorption to iron oxyhydroxides and the dissolution-precipitation of lead phosphate solids. The results of this work will benefit site remediation and management efforts and can help improve predictions of lead mobility in the environment.

Metal mobility in soil and groundwater systems is often governed by adsorption to mineral surfaces including those of iron oxide and oxyhydroxide minerals. Quartz sand was coated with the iron oxyhydroxide goethite (α-FeOOH) and used in lead adsorption experiments. Goethite-coated sand represents natural porous media that are both permeable to water and have strong affinities for heavy metal adsorption. Batch adsorption experiments were performed over the pH range 3-8 with uncoated sand, pure goethite, and goethite-coated sand. Adsorption rates were evaluated in column experiments performed with lead-contaminated synthetic rainwater solutions. Lead adsorption to goethite-coated sand was significantly greater than to uncoated sand. The lead adsorption to the coated sand is interpreted as the combination of adsorption to goethite and quartz surfaces. Adsorption increases with pH and isotherms display expected surface saturation behavior. Lead transport through goethite-coated sand columns was retarded by adsorption, and transport could be modeled by considering adsorption rates. Experiments on lead adsorption have been conducted by students Vince DeCapio (REU from West Virginia University), Angelica Gonzalez (REU from University of Texas El Paso), and Carolyn Moore (Washington University, B.S.).

Addition of phosphate amendments to lead contaminated soils has been proposed as a remediation method because of the low solubility of lead phosphate solids, but further research is necessary to evaluate the long-term stability of lead phosphates in contaminated soil systems. Synthetic pyromorphite (Pb₅(PO₄)₃Cl) dissolution and precipitation rates were investigated in flow-through reactors for the pH range 2-7. Dissolution rates determined in flow-through experiments and equilibrium dissolved lead concentrations in batch experiments both increased with decreasing pH (Figure 1). Changes in the structure of the solid phase were investigated by Fourier transform infrared spectroscopy, electron microscopy, and x-ray diffraction. Results suggest that the effectiveness of lead immobilization by phosphate addition will depend on the system pH and the nature of the lead-containing solid. The pyromorphite research has been performed by students Claire Farnsworth (Washington University, B.S.) and Liyun Xie (Washington University, D.Sc.).

Figure 1. Pyromorphite dissolution rate constant (k') versus pH. The arrows for the values at pH 2, 6, and 7 indicate that the values are only upper or lower limits to the actual rate constant.
It is estimated that 80 - 85% of environmental data is geospatial. In other words, most data collected for monitoring and understanding the environment can be uniquely related to a specific location above, on, or in the earth’s surface. That percentage is likely to increase in the future as advances in monitoring instrumentation allows more frequent data collection at more locations.

New information technology and analysis methods are making the processing and interpretation of this increasing amount of data manageable. Among new technologies improving our ability to handle vast quantities of environmental data are geographic information systems (GIS); tools for accessing, processing, visualizing, analyzing, interpreting, and presenting geospatial data.

At its foundation, GIS is used to make maps. Superimposing data that share a similar spatial coverage on a map provides insights into their relationships. Exploring their spatial patterns and temporal trends can shed light into casual factors of observed environmental conditions. A variety of data analysis types are supported by GIS including point data, area data, and continuous surface data.

GIS extends beyond the creation of maps to include a variety of data analysis methods including slope derivation, watershed delineation, least cost path determination, and suitability analysis where, based on multiple criteria, the most "suitable" locations are identified. Advanced statistical analysis can also be conducted to quantify the spatial behavior of a data set, its correlation with other data sets, and to model their spatial-temporal characteristics.

The Center for Air Pollution Impact and Trend Analysis (CAPITA) is actively involved in a more recent research area of GIS known as “Web GIS.” The Web offers tremendous potential for sharing, analyzing, and presenting geospatial information but numerous challenges exist in how to efficiently transfer large quantities of data through the Internet and build Web tools for working with those data.

GIS is being used within Environmental Engineering Science Program projects including research on monitoring network density, analyze the relationship between measured air pollutant concentrations and the locations of pollutant emission sources, and spatially interpolating pollutant monitoring data to create continuous surface estimates of pollutant concentrations. An ongoing project aims that is studying sources of phosphorus in Table Rock Lake in Southwestern Missouri is combining topographic, soil type, land cover, permitted discharge facilities, hydrological feature, and aerial photography data to determine the optimal water quality monitoring sites within the lake.

**Spatial data analysis and GIS Software**

Spatial data analysis and GIS are sought after skills in the job market as the technology is being adopted by a wide range of fields. The Environmental Engineering Science Program offers a course in spatial data analysis and GIS that introduces undergraduate and graduate students to the theory underlying data analysis and teaches them how to use GIS software. The class has attracted not only Engineering School students but also students from Earth & Planetary Sciences, Biology, Political Science, Business and the School of Arts & Sciences undergraduate Environmental Studies Program.

The School of Engineering and Applied Science was awarded a special education grant from ESRI for their ArcGIS software. ArcGIS allows students to create maps, conduct spatial data analysis and advanced analysis such as geostatistics and 3-dimensional visualization.

**Campus-wide GIS Community**

The application of spatial data analysis and GIS is not unique to the environmental science and engineering fields. A group of faculty, staff, and students at Washington University who share an interested in spatial analysis and GIS has formed in an effort to develop collaborative opportunities and to explore possibilities in sharing GIS resources, such as data and software. In fact, there is a concerted effort to make the ArcGIS software available across the university with a campus wide license. Plans are also underway for a GIS focused seminar series later in the fall.

A useful online resource for learning more about GIS and spatial data analysis is [www.gis.com](http://www.gis.com).
NANOPARTICLE RESEARCH AND TECHNOLOGY LABORATORY

By Da-Ren Chen

Under the direction of Dr. Chen, the objectives of the Nanoparticle Research and Technology Laboratory are: (1) investigating nanoparticle behaviors in different environments, especially in chemically reactive systems; (2) developing instrumentation to characterize nanoparticles in high temperature conditions. Seven students are currently working in the lab (three DSc candidates: Weiling Li, Eva Crespo and Chaolong Qi; three Master students: Edgar Chay, Nalin Perara and Georg Pingen; and one undergraduate student: Emily Hoffman).

Several projects related to environmental applications are ongoing in the lab. One is to study the physico-chemical dynamics of nanoparticle formation in the laser ablation process. The project is funded by the Department of Energy and is currently in its second year. Laser ablation has been applied to remove toxic contaminants from surfaces in many industrial cleaning applications. The process involves using a pulsed and focused laser beam or sheet to remove contaminants by either ablating or evaporating them. The pulsed laser beam/sheet delivers a series of high energy bursts to contaminated surfaces in the microsecond duration and evaporates toxic contaminants (as well as the surface material in some instances). During the process, particles in the nanometer size range are often produced by homogeneous or heterogenous nucleation mechanisms. The process is further complicated by shock waves and their motion induced by bursts of laser energy. The objective of this project is to investigate particle formation in such a process and to identify technologies to reduce/avoid their formation if possible. In addition to the fundamental study, a stackable differential mobility analyzer (SDMA) has been developed to characterize nanoparticles in this process. The device is capable of measuring the size distribution of nanoparticles with diameters ranging from 5 nm to 500 in sub-second duration. At the highest flow operation the lower detection limit of SDMA can be further reduced to 1 nm. The stackable feature of the device allows researchers to customize their own sizers based on the application needs and thus achieve the best size resolution.

Another ongoing project is to study the filter loading characteristics for hygroscopic particles. Experiments have revealed that the hygroscopic property of particles has a significant effect on the loading curves of a particulate filter. As an example, a filter can be loaded more than eight times in mass when challenged with hydrophilic particles before the pressure drop across the filter reaches a specified value. The effect on the filter loading was not studied in detail previously and the results were controversial. Through the financial support from Center for Filtration Research at the University of Minnesota a systematic study has been performed in the lab. Particles of different materials, including sodium chloride, Arizona road dust, and alumina, were used as challengers. Particles were loaded on different filters at different relative humidity conditions. A semi-empirical model has thus been developed to characterize the effect.

A collaborative project amongst Drs. Chen, Biswas, Axelbaum, and Indeck, funded by the NSF, “Synthesis and Application of Magnetic Nano- and Nano-composites Particles” was initiated in 2003. The objective of this project is to synthesize magnetic nanoparticles or nano-composites, and to systematically investigate them for bio-medical applications, e.g., drug delivery, and brain aneurysm treatment. In this project, nanoparticles or composites in different composition will be synthesized and classified in well-defined sizes. Sized particles will then be used to test their feasibility for medical applications. As a part of the tasks the project also seeks the feasibility of scale-up for the mass production of desired nanoparticles.
The St. Louis – Midwest Supersite entered its third year of field operations in Summer 2003. The first two years featured sustained measurements to characterize the physical and chemical properties of ambient fine particulate matter. Emphasis was placed on high data capture across all measurements to support atmospheric science, health effects, and source apportionment studies. A subset of these measurements are being sustained in the third year which also includes a series of special studies. In this issue of *EnviroNews*, we report on measurements conducted to gain insights into the contribution of atmospheric processing to ambient fine particle formation.

Organic compounds typically comprise about a third of the ambient fine particulate matter (PM-2.5, particulate matter smaller than 2.5 micrometers diameter) mass concentration. An important issue in developing control strategies is the split between the organic fraction directly emitted by sources and the organic fraction resulting from the atmospheric processing of compounds that were originally emitted as gases. The former case would lead to particulate matter emissions control while the latter case would focus on the control of gaseous hydrocarbon emissions. As part of our measurement platform at the East St. Louis, IL, field site we have been quantifying at high time resolution the mass concentration of low molecular weight organic acids in ambient particulate matter. A Particle-into-Liquid Sampler (PILS) developed by Professor Rodney Weber of the Georgia Institute of Technology has been deployed at our site since June 2001. PILS is coupled with ion chromatographs for automated measurement of a suite of inorganic cations (e.g., ammonium) and anions (e.g., sulfate, nitrate) at 15-minute time resolution. In collaboration with the Weber group, we also measured three organic acids - formate, acetate, and oxalate. To our knowledge, our work is the first sustained (greater than one year) measurement of these compounds at high time resolution.

While there can be direct emissions of formate, acetate and oxalate, their presence in the urban atmosphere is likely dominated by formation via gas phase oxidation of emitted hydrocarbons. Environmental conditions and the chemical composition of pre-existing ambient particles dictate how these organic acids partition between the gas phase and particle phase. Indeed, mass concentrations for these compounds were very low (typically below the method detection limits) during the summer. Although the atmospheric production of these compounds is likely high during the summer, the very warm temperatures favor partitioning towards the gas phase. In contrast, measurements conducted during fall and winter seasons yielded particulate phase organic acids – especially oxalate – often with a distinct diurnal profile. Figure 1 shows a one-week time series from November 2002 (dashed lines are midnight CST) for the PM-2.5 mass concentration of oxalate. For several days during this period, oxalate exhibits a distinct diurnal profile with a daily maximum typically around 1600 CST which lags three- to-five hours after the daily maximum solar radiation. During this period, the daily maximum oxalate is positively correlated with solar radiation and negatively correlated with temperature. For example, similar solar radiation profiles were observed on 11/1 and 11/7; the daily maximum temperature was 45°F on 11/1 and 67°F on 11/7 with much greater PM-2.5 oxalate mass concentration on the colder day. Similar daily maximum temperatures were observed for 11/1 through 11/3 (40-45°F) but with monotonically decreasing daily maximum solar radiation; the daily maximum PM-2.5 oxalate decreased with decreasing solar radiation. These trends are consistent with oxalate arising from the atmospheric processing of gaseous hydrocarbons (greater processing on days with stronger solar radiation) with enhanced partitioning to the particle phase for colder temperatures. This data will be useful towards the development and validation of airshed models for ambient particulate matter.

Ms. Megan Yu and Ms. Andrea Clements were the lead Air Quality Laboratory staff for the first year (Yu) and subsequent years (Clements) of PILS-IC measurements at the St. Louis – Midwest Supersite. PILS-IC measurements are conducted in collaboration with the Weber group at Georgia Tech. Preliminary results were presented at the 2003 Meeting of the American Association for Aerosol Research (Anaheim, CA; October 2003) with more-detailed results presented at the International State of the Science Workshop on Organic Speciation in Atmospheric Aerosols Research (Las Vegas, CA; April 2004).
A patented technology that has been developed in AAQRL (See Environews Vol 2, Page 11 for description) is finding potential application in several areas such as nanoparticle charging applications, indoor air cleaning, aircraft cabin air decontamination, and homeland security applications. Work done by a Summer REU, Chris Hogan, from Cornell University, demonstrated 4 logs removal of viral particles. The charge distribution of airborne MS2 bacteriophage nanoparticles and the efficiency of electrical mobility based capture mechanisms with bipolar charging were studied. MS2 virions form large agglomerated particles in a suspension. The application of both soft X-ray irradiation and alpha rays from a Po-210 bipolar charger was shown to not only reduce the average charge on MS2 virion particles, but also partially fragment the larger MS2 virion agglomerates, thereby increasing the number of ultrafine MS2 virion particles. A cylindrical electrostatic precipitator with a mounted soft X-ray emitter was used to determine the effectiveness of electrical capture methods for virus particles. At low applied voltages, it was found that the capture efficiency of ultrafine virus particles can be increased by applying in-situ soft X-ray irradiation with electrostatic precipitation. It has also been shown that in the presence of both a positive and negative corona, virus particles are readily captured with log removal values exceeding 4. The unit developed and demonstrated in this work is a compact, low pressure drop system that can be readily mounted in ventilation ducts or air supply systems to remove ultrafine particles such as viruses.

Several interesting projects continue at our laboratory - and truly demonstrating that aerosol science and engineering is an enabling discipline.
If you are an Alumnus of the Environmental Engineering Science Program, please make a copy of this page, fill out the appropriate information and fax to (314) 935-5464 or mail to:

Washington University in St. Louis
One Brookings Drive
Campus Box 1180
St. Louis, MO 63130

Name:__________________________________________
Address:______________________________________
City:_________________ State:_______ Zip:_______
Phone:______________________________
Fax:______________________________
E-mail:______________________________________

Year of Graduation:___________ Degree:____________

This form is also available on-line at www.env.wustl.edu.