



DIVINING ROD

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NM Tech Researchers Study Methods to Thwart “Biofouling”

by George Zamora, NM Tech

New Mexico Tech researchers are studying the cannibalistic nature of certain bacteria in hopes of finding new ways to prevent other bacteria species from forming “biofilms” that commonly foul up and clog filtering processes in water purification and desalination systems and facilities.

Frank Huang, associate professor in the New Mexico Tech Department of Civil and Environmental Engineering, and Snezna Rogelj, a biology professor at the research university in Socorro, are specifically focusing on applying bacterial cannibalism to mitigate the biofouling that occurs in membrane filters used to remove salt from the briny water that is routinely produced in crude oil and natural gas production.

Recent records supplied by the oil and gas industry in New Mexico show that more than 100 million barrels of produced water are generated each year in the state, with most of it being reinjected back into the same geological formations in which the fuel reserves are found.

“Lea County, New Mexico, for example, disposes of roughly 70,000 acre-feet of oilfield-produced water (brine)/year—enough to sustain a city of 300,000 for a year, if it could be purified,” the Tech researchers note in

point out. “Even partial desalination of water for use in industry, agriculture, and recreation would dramatically decrease pressures on freshwater aquifers and provide more water for beneficial uses.”

Recurring problems with biofouling, however, invariably arise when large-scale implementation of membrane filters are used for desalinating produced waters.

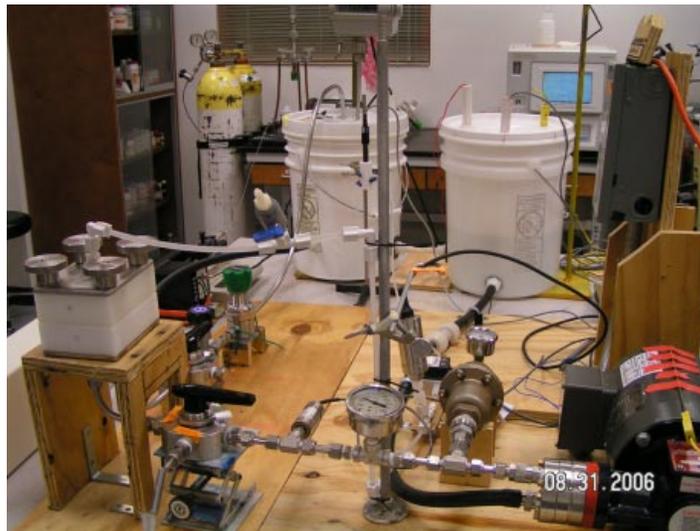
“Naturally occurring bacteria tend to form complex bacterial communities, or biofilms, on the surfaces and interiors of the filters, where they build ‘houses,’ and, in short order, soon clog up the works,” Rogelj says.

Various biofilm matrices are relatively common and widespread throughout nature, Rogelj says, and range from the slippery residue that forms a ring around bathtubs to the bacteria species

responsible for tooth cavities and kidney infections.

The New Mexico Tech researchers are using a two-fold bacterial approach to alleviate the biofouling problem—

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Bench-scale Reverse Osmosis (RO) System used by the researchers.

a recently submitted technical report on their study.

“Water produced from oil and gas operations is therefore increasingly seen as a potential asset, as opposed to an environmental liability,” the researchers

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developing ways of breaking down the biofilms that are already formed and preventing the bacterial matrix from forming.

“We looked at injecting these bacterial cannibals into the biofilms to burst open the bad bacteria, but these parasites are very specific to their hosts, and you have to match them up exactly,” Huang says. “This is difficult to do, so it’s not a practical solution.”

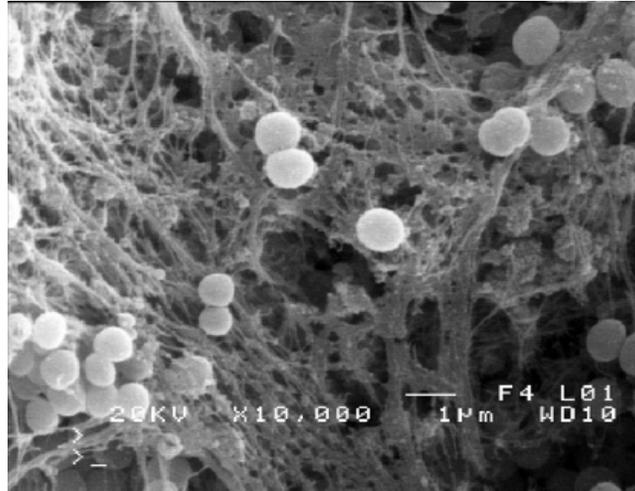
“Now, we’re exploring the possibilities of using agents to prevent the bacteria from sticking to each other before they form the biofilms on the filters,” Rogelj adds. “Prevention is a better approach. . . . You know what they say, ‘A gram of prevention is worth a kilogram of cure.’”

Huang and Rogelj’s research study has been conducted at the laboratory scale for the past two years, but the researchers recently have garnered

additional support and funding from Sandia National Laboratories and the State of New Mexico to expand the research to a “trailer-scale” operation that can be easily transported and used for field site testing and experiments.

“Whatever we come up with, it has to work all the time to be entirely reliable,” Rogelj points out, “not just on some days.”

Huang and Rogelj are joined in their research study by New Mexico Tech assistant professor of biology Scott T. Shors and are also assisted by several Tech undergraduate and graduate students. The research is financed in large part by funding made available through the New Mexico Water Resources Research Institute.



A scanning electron micrograph of S. epidermidis biofilm. The filmy extracellular material, characteristic for biofilms and secreted by the cells, protects the bacteria and makes the biofilm tough and difficult to remove.

(Rogelj continued from page 3)

Current Projects

Co-PI: Mitigation of Membrane Biofouling by Harnessing Bacterial Cannibalism, WRRRI

PI: Investigation of Degradative Enzymes Found in Bacitracin, NIH

Co-PI: Mitigation of Biofouling in Membrane Processes, Sandia Labs

Co-PI: Enzymatic Treatment of Membrane Biofouling, NMSU

Co-PI: Immuno-PCR Detection of Biological Food Contamination, WERC

Recent Publications

Shen, H., S. Rogelj, and T.L. Kieft. 2006. Sensitive, Real-time PCR Detects Low-levels of Contamination by *Legionella pneumophila* in Commercial Reagents. *Molecular and Cellular Probes*. 20:147-153.

Allen, R.C., S. Rogelj, S.E. Cordova, and T.L. Kieft. 2006. An

Immuno-PCR Method for Detecting *Bacillus thuringiensis* Cry1Ac Toxin. *Journal of Immunological Methods*. 308:109-115.

Zhang, P., S. Rogelj, K. Nguyen, and D. Wheeler. 2006. Design of a Highly Sensitive and Specific Nucleotide Sensor Based on Photon Upconverting Particles. *Journal of the American Chemical Society*. 128:38:12410 -12411.

(Huang continued from page 3)

Co-PI: Mitigation of Biofouling in Membrane Processes, Sandia Labs

Co-PI: Santa Fe County Lagoon Wastewater Improvements Project, Global Filtration, Inc.

Recent Publications

Huang, F.Y.C. and P. Natrajan. 2006. Feasibility of natural zeolites to remove sodium from CBM produced water. *Journal of Environmental Engineering*. 132:12.

Huang, F.Y.C., R. Gundewar, D. Steed, and B. Loughridge. 2005. Feasibility of Using Produced Water for Crosslinked Gel-Based Hydraulic Fracturing. *Society of Petroleum Engineers*. SPE-94320-PP.

Huang, F.Y.C. 2005. *Toward Green Engineering: Multi-Functional Magnetic Nanoparticles for the Enhancement of Protein Bioprocessing*. Final report submitted to DOE-WERC.

Huang, F.Y.C. 2004. *Waste-to-Resource Approach for Produced*

Water. Final report submitted to U.S. EPA.

Brady, P.V., C.F.J. Colon, G. Carr, and F.Y.C. Huang. 2002. Soil Radionuclide Plumes, In *Geochemistry of Soil Radionuclides*. Soil Science Society of America.

Huang, F.Y.C. 2002. *The Impact of Cooling Water Pumping at the Sabinal Site on the Groundwater Levels in Surrounding Wells*. Final report submitted to Cobisa Corp., Houston, TX.



Meet the Researchers

Snezna Rogelj

Professor of Biology, NM Tech
E-mail: snezna@nmt.edu

Research Focus

Cell-cell adhesive interactions, particularly as they pertain to immunosuppression by pesticides, pollutants and drugs; development of molecular methods for pathogen detection; nanobio-sensors; nano-particle toxicity; biofilm mitigation; anti-bacterial properties of functionalized chitosan; and drug discovery.

Education

1985 PhD biochemistry, Boston University School of Medicine
1982 Summer Physiology Course at Woods Hole Marine Biological Laboratory
1976 BS physics with emphasis on astronomy, Ohio State University

Frank Huang, P.E.

Associate Professor
Department of Environmental Engineering, NM Tech
E-mail: huang@nmt.edu

Research Focus

Water treatment; wastewater reuse; soil and groundwater remediation

Education

2001 MS chemical engineering, Massachusetts Institute of Technology
1993 PhD environmental engineering, Vanderbilt University
1989 MS environmental engineering, Vanderbilt University
1984 BS civil and environmental engineering, National Chung-Hsing University, Taiwan

Experience

Snezna Rogelj joined the New Mexico Tech faculty in 1998. From 1993 to 1998, Dr. Rogelj was a research scientist at UNM's Medical School, Department of Pathology, where she studied the molecular mechanisms of leukocyte target recognition in the human immune and inflammatory responses. From 1989 to 1992 she worked as a scientist for ASTRA, Biomedical Research Center, Bangalore, India where she carried out



Experience

Frank Huang joined the faculty at New Mexico Tech in 1994. While at NM Tech, he has managed and conducted research and projects sponsored by the State of New Mexico, DOE-WERC, Sandia National Labs, Los Alamos National Lab, USEPA, WRRI, Gaz de France, Bernalillo County, NM, National Park Service, and other private companies. Prior to coming to New Mexico, Dr. Huang worked for one year at the Gulf Coast Hazardous Substance Research Center. He is a registered Professional Engineer in New Mexico and a member of the New Mexico Wastewater Technical Advisory

research in parasitology. During her Lecturer year at Harvard, she studied tumor angiogenesis. Her postdoctoral work was at MIT's Whitehead Institute where she participated in molecular cloning of the first known tumor suppressor "anti-oncogene." In November 1999, Dr. Rogelj received the U.S. Department of Energy's Defense Program's Early Career Scientist and Engineer Award.

Courses Taught

Cell Biology; Advanced Cell Biology; Molecular Biology and Molecular Biology Laboratory; General Biology; Biology of Cancer; A variety of seminar courses for seniors and graduate students (Nanotechnology, Parasitology, Genetic & Molecular Basis of Human Mental Illness, etc.)

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Committee appointed by the NM Secretary of Environment.

Courses Taught

Introduction to Environmental Science & Engineering; Water Treatment Processes Design; Wastewater Treatment Processes Design; Unit Operations for Environmental Engineering; Solid & Hazardous Waste Engineering; Physicochemical and Biological Processes

Current Projects

Co-PI: Mitigation of Membrane Biofouling by Harnessing Bacterial Cannibalism, WRRI
Co-PI: Preventive Measures for Membrane Biofouling, State of New Mexico

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2007 New Mexico Water Research Symposium



Macey Center
New Mexico Tech
August 14, 2007



Call for Abstracts

Abstracts for consideration for presentations and/or posters at the 2007 New Mexico Water Research Symposium will be accepted through July 6, 2007. Abstracts related to any and all water research and management topics will be considered, but abstracts that exhibit multidisciplinary work are strongly encouraged. Abstracts must be submitted online via the New Mexico WRII homepage: <http://wrii.nmsu.edu>. Presenters whose papers are accepted for oral presentations will be limited to a 20-minute talk. The registration fee for everyone, including speakers, poster presenters, and other attendees is \$20. The fee will be waived for students presenting an accepted paper or poster. Final symposium agendas will be emailed to all poster presenters and speakers in early August and will be posted on the WRII website.

Technical sessions will be organized around the following topics:

- Water and wastewater treatment and reuse
- Erosion and sediment control
- Reservoir evaporation
- Economics and policy analysis
- Watershed assessment, planning, and management
- Wetlands and riparian issues
- Agricultural, industrial, and municipal water use
- Drinking water
- Atmospheric, surface, and groundwater modeling
- Impacts of climate variability on water resources
- Ground and surface water
- Fish and wildlife; endangered species
- Water supply
- Water management
- Impaired water
- Desalination
- Pollution prevention
- Water security
- Ecosystem services
- Public health
- Water quality
- Hydrogeoecology

Timetable

- Abstract Deadline: July 6, 2007
- Notification of Acceptance: July 20, 2007
- Registration deadline for speakers and poster presenters: August 3, 2007
- Online Registration Deadline: August 12, 2007
- Symposium Reception: August 13, 2007; 5:30-6:30 pm
- Symposium: August 14, 2007

Sponsored by New Mexico WRII in cooperation with

- Sandia National Laboratories
- Los Alamos National Laboratory
- University of New Mexico
- New Mexico Tech
- New Mexico State University
- New Mexico Interstate Stream Commission
- New Mexico Office of the State Engineer
- U.S. Geological Survey
- American Water Resources Association - New Mexico Section



UNM Doctoral Student Monitors Middle Rio Grande Water Quality

by Sara Ash, WRII

With the support of a WRII student water research grant, Lydia Zeglin, a doctoral student in biology at the University of New Mexico, and her advisor, Cliff Dahm, initiated research along the Middle Rio Grande from the Otowi gauge above Cochiti Dam to Elephant Butte Reservoir to monitor water quality and identify sources of nutrients in the river.

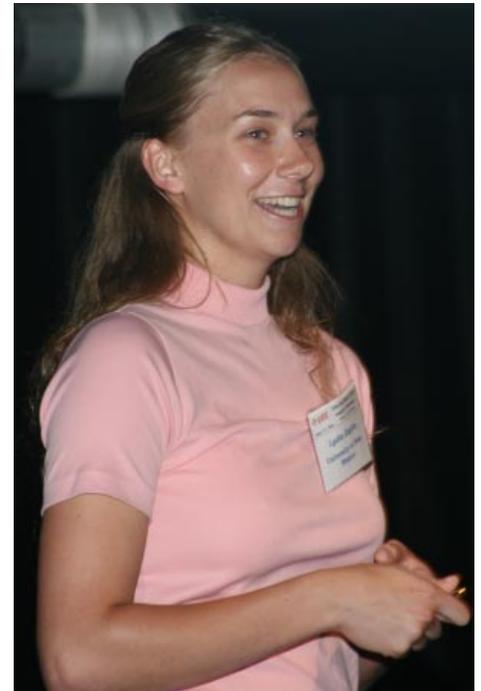
Along the 300 km study area, Zeglin collected surface water samples from each significant tributary of the Rio Grande and from the main channel below each tributary. The samples were analyzed for temperature, pH, salinity, dissolved oxygen, cations, anions, dissolved organic carbon (DOC), the inorganic nitrogen species ammonium ($\text{NH}_4\text{-N}$) and nitrate ($\text{NO}_3\text{-N}$), total

dissolved phosphorous as phosphate ($\text{PO}_4\text{-P}$), dissolved inorganic carbon, chlorophyll-a, and carbon quality. Zeglin focused her research on salinity and the nutrients DOC, $\text{NO}_3\text{-N}$, and $\text{PO}_4\text{-P}$.

Zeglin observed moderate variability in the distribution of salinity throughout the study area. The salinity increases downstream, especially during the summer, and high salinity inputs correspond with wastewater effluent discharges and certain tributaries. While evapoconcentration accounts for much of the surface water salinity variability in the Middle Rio Grande, tributaries between Albuquerque and Socorro where saline, deep groundwater upwelling occurs may also significantly affect river salinity.

“urbanization provides the most significant inputs of nutrients that affect Middle Rio Grande water quality, specifically in the form of treated effluent.”

The distribution of DOC along the study area did not vary due to urbanization or channel modification, but the nitrate and phosphate concentrations varied greatly. The maximum DOC concentrations were 3 mg/L in the summer and 4 mg/L in the winter, which is relatively low compared to modified rivers



Lydia Zeglin presented her research results at the 2006 New Mexico Water Research Symposium at New Mexico Tech. She received an award for her presentation.



Confluence of the Albuquerque wastewater treatment plant and the Rio Grande.

in other regions, according to Zeglin. The $\text{NO}_3\text{-N}$ and $\text{PO}_4\text{-P}$ concentrations increased below the Bernalillo, Rio Rancho, and Albuquerque wastewater treatment outflows. During the summer, the $\text{NO}_3\text{-N}$ and $\text{PO}_4\text{-P}$ carried by the river decrease below the discharges, while during the winter the nutrients are carried downstream.

According to Zeglin, the results of the project suggest that “urbanization provides the most significant inputs of nutrients that affect Middle Rio Grande water quality, specifically in the form of treated effluent.” The results of this study reveal the sources and sinks of nutrients in the Middle Rio Grande and how these

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change from season to season. “This information can be used to understand when and where the greatest threats to water quality occur in this river and thereby how to avoid or remediate related problems,” Zeglin says.

After graduating from UNM, Zeglin hopes to continue conducting research focused on the dynamics of bacterial communities that affect nitrogen retention and export in desert freshwaters.

Zeglin sampling in the Rio Grande, Bosque del Apache National Wildlife Refuge.



Grant Recipient Studies Human Impacts on Nitrate Dynamics

by Sara Ash, WRII

Anthropogenic nitrogen has dramatic and sometimes devastating effects on many ecosystems. In some areas of the country, such as the Mississippi watershed, efforts are being made to reduce nitrogen pollution, but to do this effectively nitrogen uptake must be better understood.

Chelsea Crenshaw, a graduate biology student at the University of New Mexico, received one of WRII’s student water research grants to study the nitrate dynamics in hyporheic zones, or the regions where surface water and groundwater interact. Hyporheic zones are an important element in the uptake and release of nitrogen. “Stream



The Rio Salado is an example of a pristine stream in New Mexico.

installed a total of nine wells into the streams at 30 cm deep. The wells had a high variability in the percentage of surface water, representing the connectivity between surface and groundwater. After the 24-hour $^{15}\text{NO}_3^-$ injection, samples were taken and analyzed for the major cations and anions.

Crenshaw found that surface water nitrate and ammonium concentrations were very low in all of the streams, with nitrate concentrations ranging from 0.45 to 220 ug/L and ammonium concentrations below 5 ug/L. The concentrations of nitrate and ammonium were also low in the wells. Crenshaw detected $^{15}\text{NO}_3^-$ in all of the wells sampled, as well as $^{15}\text{NH}_4$ in the agricultural wells.

The results of Crenshaw’s analysis show that nitrate may be converted to $^{15}\text{NH}_4$ and remain in the system instead of being released into the atmosphere as a harmless byproduct, such as N_2 . If $^{15}\text{NH}_4$ is not released from the system, it can travel to the ocean, where it is potentially harmful to aquatic ecosystems. “The connection between surface water and groundwater is very important in the removal of harmful

“The connection between surface water and groundwater is very important in the removal of harmful nitrogen products in the desert Southwest,”

hyporheic zones can contribute up to 90% of nitrogen uptake in pristine streams,” Crenshaw says.

With the help of her advisor Cliff Dahm, Crenshaw conducted 24-hour $^{15}\text{NO}_3^-$ stable isotope tracer releases in streams to measure nitrate cycling dynamics. Nine streams with various intensities and types of human impacts were selected throughout central New Mexico and Arizona. Agua Fria River, Rio Salado, and Sycamore Creek were used as reference streams, while the Rio Rancho Drain, Bernalillo Drain, Rio Puerco, and San Pedro River represented agriculturally impacted streams in New Mexico. Crenshaw

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nitrogen products in the desert Southwest,” Crenshaw says. “When the connection is lost there may be storage of nitrogen, and it may not be released.”

After earning her doctorate from UNM, Crenshaw will begin post-doctoral research at Utah State University in May.

Upcoming Deadlines

May 10-11, 2007 Law of the Colorado River. CLE International, Las Vegas, NV; www.cle.com

May 14, 2007 New Mexico Water Markets. H₂O Economics and John Shomaker & Associates, Inc., Hotel Albuquerque at Old Town, Albuquerque, NM; www.shomaker.com

August 14, 2007 2007 New Mexico Water Research Symposium. New Mexico Tech, Socorro, NM; <http://wrii.nmsu.edu>

August 29-Sept. 1, 2007 Sustainable Water, Unlimited Growth, and the Quality of Life: Can We Have It All? Southwest Hydrology magazine and the Arizona Hydrological Society, Tucson, AZ; www.swhydro.arizona.edu/symposium

October 13-18, 2007 New Mexico Environmental Health Conference, Hotel Albuquerque at Old Town. Albuquerque, NM; www.nmehc.net

November 7-9, 2007 NWRA Annual Conference. Hyatt Regency, Albuquerque, NM; www.nwra.org/meetings.cfm

November 12-15, 2007 43rd AWRA Annual Water Resources Conference, Albuquerque, NM; www.awra.org (Abstracts deadline: May 14, 2007)

November 29-30, 2007 52nd Annual New Mexico Water Conference: Beyond the Year of Water: Living Within Our Water Limitations. La Fonda, Santa Fe, NM; <http://wrii.nmsu.edu>



Corrales Drain is an example of an urban system in New Mexico.



Chelsea Crenshaw (second from left) was presented with an award for her oral presentation, “Nitrogen Dynamics in Hyporheic Sediments using ¹⁵NO₃-N Tracers” at the 2006 Water Research Symposium at New Mexico Tech. Sarah Shannon (left) won an award for her poster presentation, and Lydia Zeglin also received an award for her oral presentation. All three students are from the University of New Mexico. AWRA-New Mexico Section sponsored the student presentation and poster competition at the symposium. Peter Castiglia (right), AWRA-NM representative presented the awards. Other students receiving awards were Frederick Partey of New Mexico Tech and Elizabeth Rodriguez of El Paso Community College.



photo by Nichole Valdez, 2005 WRRI photo contest honorable mention

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