

BIOLOGICAL & ECOLOGICAL ENGINEERING

Winter 2017



Diane Steek, City of Eugene Wetlands Ecologist, discusses with the Senior Design class the coordination of engineers and ecologists in the restoration of the Coyote Prairie during a tour of the wetlands in Eugene, Oregon. Photo credit: John Selker.

Senior Design Tackles Clean Water

Every year the Senior Class of Ecological Engineering designs a project that simulates the experience of being a hired as a contractor by a specific client or group of clients. This capstone project, titled Senior Design, combines the skills the students have learned during their time at Oregon State University into one project that they work on for two terms (Fall and Winter).

This year's class has record numbers with 27 students, leading the instructors, Drs. Ganti Murthy and John Selker, to re-structure things a little bit this year by giving students two projects to choose from.

One project has the students designing a woodchip bioreactor to treat affluent runoff from a pasture irrigated with effluents from dairy barns at OSU. The objective is to minimize the concentration of nitrates at the outlet of the bioreactors. "The systems should be suitable for the Willamette valley," says Dr. Murthy, "and a location where line-power electricity is available but may not have internet or cellular connectivity." The other project they can choose tackles issues of water for developing countries with highly variable inputs of water quality. The goal of this project is to make a water filter that

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DONOR & ALUMNI EVENTS

Engineering Expo

When: Friday, May 18, 2017; 11-4 pm

Where: Kelley Engineering, OSU

What: See what EcoE students are doing and ask them questions about their design projects.

Spring Banquet

When: Thursday, May 24, 2018.

Appetizers at 5:30 pm, Dinner at 6 pm, followed by an awards ceremony

Where: Memorial Union Horizon Room

What: Our end of the year award banquet for a chance to recognize the exceptional students in BEE.

Dinner is included

Graduation BBQ

When: Friday, June 15, 2017; 12:30-2 pm

Where: Outside Gilmore Hall

What: A potluck BBQ for graduating seniors and their families to tour Gilmore and meet the department. All students, alumni and donors are welcome.

Rethinking Wastewater

Multimodal Algal Bioprocess for Municipal Wastewater Treatment and Bioproducts Recovery

Photos and story by Dr. Ganti Murthy and Dr. Durga Mahapatra

Centralized waste water treatment systems around the world consume lots of electricity (and result in GreenHouse Gas or GHG emissions), require intense maintenance and hence are expensive. These systems are seldom adopted in developing countries and even if adopted suffer from failures due to various reasons, such as lack of maintenance and funds to operate.

Dr. Ganti Murthy, Professor in Biological & Ecological Engineering at OSU, invited Dr. Durga Mahapatra from Bangalore, India, onto his team as a PostDoctoral scholar to design an algal based waste water treatment system that eliminates and/or drastically minimizes electricity uses and operation costs, as well as producing a fertilizer coproduct with superior characteristics.



Dr. Ganti Murthy, Professor, seeds the bioreactor at the Corvallis Municipal Waste Water treatment facility with *Chlorella*.



Dr. Durga Mahapatra, PostDoc in BEE, tests the dissolved oxygen and other water quality parameters as part of regular monitoring and analysis of his research project.

The objective of the project is to develop a multimode algal treatment/cultivation system for efficient nutrient removal and recovery as algal biofertilizer.

A schematic representation of the pilot scale Multimode Algal Treatment unit built at the Corvallis Municipal Wastewater Treatment Plant is illustrated on page five and referenced throughout this article.

The present study is based on cascading biological processes working as a function of redox, where

a) The organic matter in the wastewater is initially degraded by heterotrophic microflora into easily assimilative volatile fatty acids (VFA) through acidogenesis in the Heterotrophic growth phase (Mode I of illustration)

that leads to phenomenal COD and solids reduction

b) VFA produced is uptaken by algal biomass in the **Mixotrophic growth phase** (Mode II of illustration), this leads to rapid volatile COD reduction with uptake of nutrients (N and P) and finally

c) The mineralized forms of nutrients as ammonium, nitrates and phosphates with inorganic C (carbonate/bicarbonate/carbonic acid) are assimilated by autotrophic algae in the **Phototrophic growth phase** (Mode III of illustration). This stage essentially kills the pathogens at high pH as a result of rapid photosynthetic dissolved CO₂ assimilation and thus ensures higher quality treated water.

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removes bacteria, fluoride and arsenic.

Both design projects require the teams to balance cost, environmental sustainability, robustness, and feasibility, as well as having little to no impact on a family's daily routine. They will build their solution and test them under real-world conditions. Students will also be marketing their designs via fundraising in order to get enough funds for future, on-site implementation.

The primary objective of the design sequence is to provide students with hands-on experience in solving the kind of complex open-ended design problems they are likely to encounter in ecological engineering practice, including physical, legal, economic, social and environmental constraints. The class also provides the students with experience in real-world applications of mathematics, science, engineering economics, ethics and other disciplines related to engineering analysis and design, and a clearer perspective on the value of research in addressing contemporary problems in engineering design.

The term began with an introduction to the projects and a field trip to Orenco Wastewater Treatment Facility and the Coyote Prairie Wetlands in Eugene. During their trip they learned about different engineering processes and had the opportunity to work with the professionals. The students feel the fieldtrip helps them get to know their cohorts a little more leading to stronger collaboration amongst team members as they pull from each other's individual strengths for their designs.

The Senior Design students finalized their designs at the end of Fall term and will begin building their systems starting Winter term in January and present them, along with their final reports, at the Annual Engineering Expo at OSU's Kelley Engineering building on May 18. Like many professional engineers, the engineering students are raising funds in hopes of building a final, full-scale system that has the possibility of being implemented throughout Oregon and Cameroon.

If you would like to make a tax-deductible donation to this year's designs, visit the OSU Foundation's Fundraising page: create.osufoundation.org.

BEE 101: First Year Students

This year the Ecological Engineering undergraduate program admitted 8 freshman and 7 transfer students. Every student in the program is required to take BEE 101 with Dr. Roger Ely, which is an introduction to engineering course with an Ecological Engineering focus. The students study engineering analysis and problem solving, professional ethics, the design process and teamwork. They test their knowledge of these topics at the end of the term with a final group irrigation project.

Irrigation projects around the world often require that water be raised to a higher elevation and in developing regions water lifting devices are often hand powered. Their final project was to research, design, plan, construct, demonstrate and report on a hand-powered water lifting device with limited available resources, a typical issue many developing countries face.

The learning objectives of the project were to improve engineering teamwork and problem solving skills; to engage in practical creativity; and to practice writing a report, preparing plans, and documenting construction and testing. The teams compete at the end of the term to see



which team can raise the most water the highest with the least amount of materials.

Dr. Ely also had a smaller challenge for the class earlier in the term, the Marshmallow Spaghetti Tower challenge (made popular by Tom Wujec's TED Talk: Build a tower, build a team). Students were given 20 sticks of uncooked spaghetti, 1 yard of tape, 1 yard of string and 1 marshmallow. Using just these supplies, the teams attempted to build the tallest tower. The catch - the marshmallow has to be at the very top of the tower and the whole tower must stand with no help for five seconds. Roger said the challenge really helps the students work together and come up with more efficient designs.

Ecological Engineering Student Society

By Lucas Evans, EESS President

The Ecological Engineering Student Society (EESS) of OSU was founded in 2009 by a group of motivated students in EcoE. Members view the club as a place to acquire hands-on experience with system design and construction, data collection, professional communication and research. The club allows students to be involved with a wide range of ecological engineering applications that aren't necessarily available in the classroom.



EESS at the Fall Term Plant Sale (Picture: Lucas Evans)

Current Projects:

This year the club undertook the EPA Campus Rainworks Challenge: a national competition to design innovative green stormwater infrastructure to improve campus. A team of nine Ecological Engineering students and faculty advisor Dr. Meghna Babbar-Sebens from the School of Civil & Construction Engineering proposed a design along campus way. The proposal consisted of a continuous bioswale on the south side of Campus Way that drained into a constructed wetland on the east side of 14th street.

The team collaborated with OSU Capital Planning and Development to develop a feasible design and put together

a great report and design board. Wish them luck for when they hear back from the EPA in spring!

EESS also has continued work on their aquaponics system in the Weniger Greenhouse, with a proposal in the works to build another system collaborating with Agricultural Sciences students. To make the system more eco-friendly, EESS built a ram pump to pump the water in the system without electricity, which will be installed shortly.

Last spring the EESS joined the "Adopt a Park" program through Corvallis' Parks and Recreation Department when they adopted Chintimini Park. The club has had the chance to volunteer at



EESS Volunteering with the Sustainability Coalition at the Dunawi Creek Regeneration Project (Pictured Left to right: Lucas Evans, Lars Larson, Miranda Nelson, Jordan Laundry, Jorie Cheng-Liever)

the park three times since then, helping to plant native flowers and bulbs, repaint benches, and help with general park clean up.

Looking Forward:

As the club moves forward they are constantly looking for new projects to take on. Next term the club intends to revisit a bioswale restoration project that they considered taking on last year. The club has been

Mission Statement:

"An interdisciplinary assembly of students focused on facilitating student engagement in campus and community opportunities, promoting professional growth and development, and to stimulate student reasoning towards the design of diverse, adaptable, and resilient engineering solutions."

Faculty Advisor: Chad Higgins

President: Lucas Evans

Vice President: Lars Larson

Greenhouse Manager: Thomas DeBell

Project Manager: Jordan Laundry

Event Coordinator: Nick Dunstan

Treasurer: Jessica Chadwick

Secretary: Grace Spann

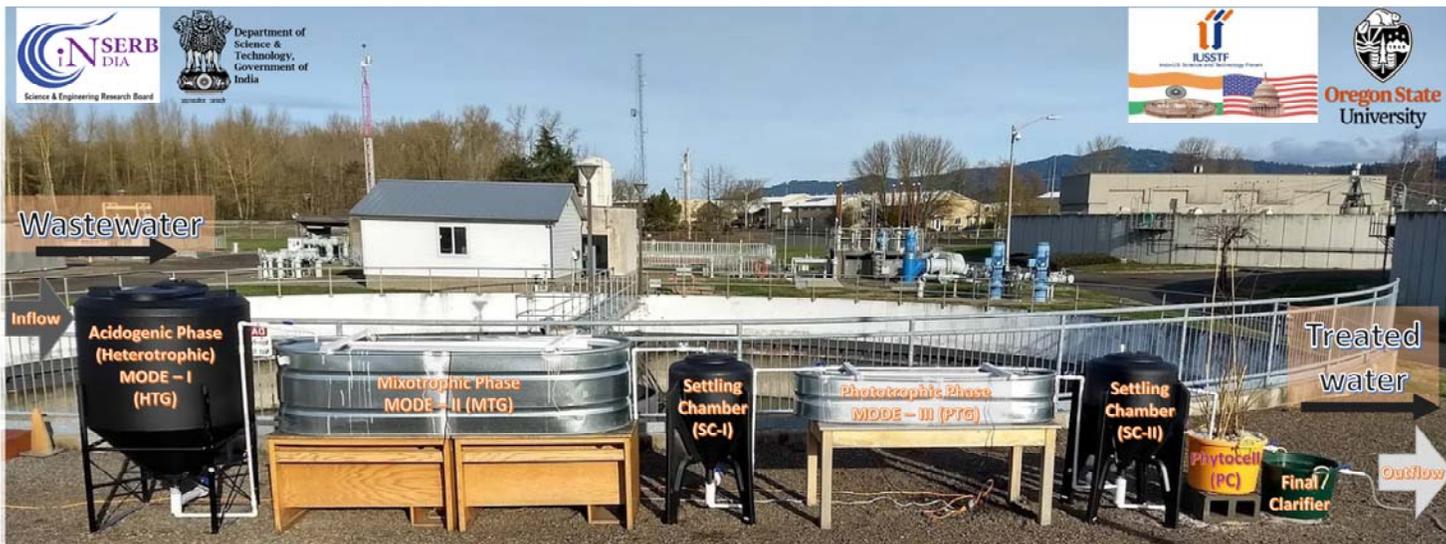
propagating native plants in their greenhouse and intends to replant a bioswale near the intramural fields on campus. During this project the club will work with Dave Eckert, the leader of the Corvallis Sustainability Coalition Water Action Team, and OSU's Capital Planning and Development department. This work will be done with the hope that students from the club will get experience redesigning the bioswale and

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www.campaignforosu.org/bee

www.campaignforosu/bee scholarship



Pilot scale multimode algal treatment unit at the Corvallis Municipal Wastewater Treatment Plant

Besides this the settling chambers (SC-I and II) are devised for capturing algal solids formed in MTG and PTG that can be further harvested, sun dried and subsequently used as algal biofertilizer for increasing crop productivity. Addition of willow/poplar phyto cell with a porous growth media at the end of the treatment chain ensures complete nutrient assimilation by phyto uptake and residual algal solids capture in porous root media (perlite). Such augmentation aids in ensuring complete nutrient removal with reduced turbidity in the treated water. The various stages of reactor development, growth of algal inoculum, seeding algal biomass into the bioreactor and regular water quality monitoring and analysis.

Dr. Mahapatra envisions a future where this would be adopted by many rural communities around the world as the system has low operation cost and produces a valuable coproduct to offset operations costs.

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monitoring its effectiveness at pollutant removal. In a similar fashion to the professional world, all projects taken on by the EESS offer future opportunities to alter or improve upon past work. Projects can be proposed by any club member and must pass through the EESS Fee Board committee. This committee acts as an oversight to the feasibility, relevance to ecological engineering, sustainability and educational value of all projects.

How you can help

The EESS is constantly looking to grow and improve. Please contact the club President (evansluc@oregonstate.edu), the Event Coordinator (dunstann@oregonstate.edu) or the Project Coordinator (laundryj@Oregon state.edu), if you wish to propose a project, present research or professional work, or believe that your job location would make for an informative and practical field trip. Finally, thank you for all your work and involvement within the realm of ecological engineering and beyond to make this world a better place.



EESS at the Annual Sustainability Fair during Welcome Week showcasing the new Ram Pump (Pictured from left to right: Nick Dunstan, Lars Larson and Jessica Chadwick.

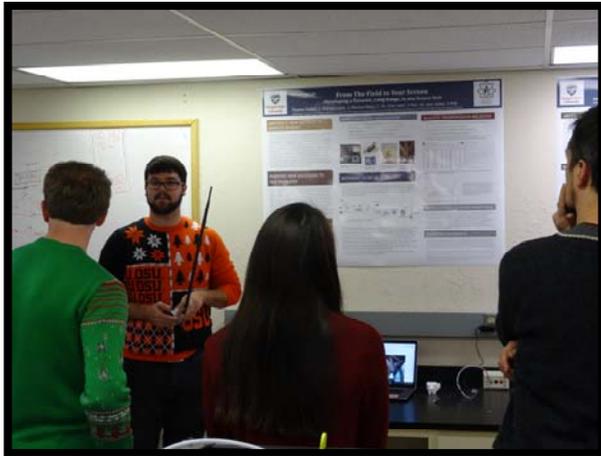
Find EESS online: sites.google.com/a/onid.oregonstate.edu/eess/about
and on Facebook:
[www.facebook.com/groups/EcologicalEngineeringStudent Society/](https://www.facebook.com/groups/EcologicalEngineeringStudentSociety/)

BEE Research

Water Resource Engineering PhD student advised by Dr. John Selker, Liz Jachens, traveled to Cotonou, Benin for the TAHMO Globe Teacher Training Workshop, where Geography teachers from across the area came to learn about using real-time weather data in their class and curriculum. Find out more TAHMO.ORG



Dr. Chad Higgins' lab group ran an experiment during the solar eclipse on August 11 to see how the land - soil, plants and microbes - responds to the darkness. Find out more about the Nexus of Energy, Water and Agriculture Laboratory at agsci-labs.oregonstate.edu/newaglab/



Tom DeBell, EcoE Undergraduate, practices his American Geophysical Union Conference poster presentation. Tom has been working in the BEE OPENs Lab under the guidance of Dr. Chet Udell designing a new sensor hub. Find out more at open-sensing.org.



OSU Distinguished Professor

Congratulations to Dr. John Selker, Professor, who was named one of two of OSU's 2017 Distinguished Professors. Dr. Selker has been with Biological & Ecological Engineering since 1991 after graduating from Cornell University with a PhD in Agricultural Engineering.

The award recognizes outstanding OSU faculty who have had an impact nationally and/or internationally via their scholarship/creative activity, research, education and service. John is known for his innovative work in environmental instrumentation, soil physics and hydrology, as well as creating new applications in fiber optics. He has brought his work to countries in need around the world via his TAHMO.org and CTEMPS.org programs.

On top of the amazing research John is doing, he also advises several students from the Water Resources Graduate program, mentors all levels of student in BEE and around campus, and his excitement for research and innovation is infectious. We are honored to have him as part of the program.





Welcome to BEE

BEE welcomed Drs. Gerrad and Rachel Jones to the department this year. Gerrad is an assistant professor specializing in water chemistry and Rachel is our new undergraduate advisor. The pair, along with their three daughters, come to us after living in Switzerland for 3 years where Gerrad was working at the Swiss Federal Institute of Aquatic Science and Technology as a Postdoctoral Researcher. They both received PhDs from the University of Nevada, Reno in 2014.

Rachel has been shadowing faculty advisors this fall and will begin advising undergraduate students in the winter. She will also be teaching courses in the Integrative Biology department in the winter and spring. Gerrad hired a graduate student this fall and has been working on proposal and grant writing. He will be teaching BEE 399: Design of Microbial Processes for Ecological Engineering Applications (co-taught with Dr. Frank Chaplen) in the spring.

Gerrad's research focuses on using machine learning tools to explore how water quality impairment and other environmental phenomena are driven by complex interactions between biological, chemical, and physical processes. Future projects include: 1) identifying the relevant compounds driving observations of endocrine disruption in surface bodies of water, 2) predicting how changes in environmental variables will affect future trace element concentrations in soils, and 3) better understanding how terrestrial landscapes affect stream temperatures in agricultural and urban areas.

Thank you

By Dr. John Bolte, Department Head

As Fall term comes to an end we wanted to take the time to thank you for your continued support and contributions to the Department of Biological & Ecological Engineering. Your contributions and support help our students develop the skills and tools necessary to be successful in their careers and in life.

The undergraduate program in Ecological Engineering continues to show growth. We are into our tenth year and we have over 100 undergraduate students enrolled in the program, with 55% being female (well above the national average for an engineering program). Our graduate program also continues to do great things, with our faculty currently serving as major advisors to 29 graduate students.



We are very excited about the changes that are taking place within the department and I welcome the opportunity to visit with you about the goals we hold for the future. Please stop by and say hello if you are ever on campus or visit our website.

Over the past year our students and faculty have worked in Ecuador, Ghana, Kenya, Chile, Sweden, and all over the United States, continuing BEE's commitment to meaningful Biological and Ecological Engineering research.

From everyone in Biological & Ecological Engineering, we wish you and your families Happy Holidays and a Wonderful New Year!

Sincerely,

Miner Scholarship Recipient



The Ron Miner Memorial Scholarship honors the memory of J. Ronald Miner, an Agricultural Engineering professor at OSU from 1972-2003. Dr. Miner was an internationally recognized expert on livestock waste management, water quality and odor control. At the same time, he served as an endlessly supportive coach and mentor to his graduate students and is remembered for his charm, enthusiasm for life and love for teaching.

Catherine Finkenbinder is a Water Resources Science Ph.D. student and the recipient of the Ron Miner Memorial Fellowship. Catherine is working

under advisor Dr. Stephen Good.

Catherine graduated with her M.S. in Natural Resources Science from the University of Nebraska-Lincoln in 2017. Her thesis applied multivariate analyses to soil spatial datasets for improved agricultural irrigation management. Last summer, Catherine researched vadose zone hydrology field and laboratory methods at the Czech Technological University in Prague, Czech Republic as part of an International Research Experiences Program.

Catherine, along with advisor Dr. Stephen Good, Biological & Ecological Engineering, is currently using soil modeling software to investigate ecohydrologic separations between soil and stream water. She is using stable water isotope datasets as tracers within these models to investigate the water extracted by plant roots for transpiration and the water discharged by the stream. Catherine is hoping to gain an advanced understanding of ecohydrologic processes and environmental modeling for applications in her professional career.

Thank you to Betty Miner and the family of Dr. Ron Miner for their continued support of the Biological & Ecological Engineering program via their generous donations which give us the opportunity to fund a phenomenal students like Catherine.

Biological & Ecological Engineering
116 Gilmore Hall
Oregon State University
Corvallis, OR 97331

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