Environmental Engineering Seminar

The Astani Department of Civil & Environmental Engineering presents

Dr. George Wells
Civil and Environmental Engineering
Northwestern University

Date: April 6, 2018
Time: 3 - 4 pm
Place: RRI 101

The Promise and Peril of DPAOs: Probing Propensity and Mechanisms for Nitrous Oxide Generation by Denitrifying Polyphosphate Accumulating Bacteria

Human alteration of the nitrogen (N) cycle via the Haber process, intensive crop cultivation, and fossil fuel use has approximately doubled the rate of N input to the terrestrial environment. Loss of anthropogenic N to natural systems has led to an array of environmental and public health problems, including emissions of the potent greenhouse gas nitrous oxide (N_2O), eutrophication of nutrient limited water bodies resulting in vast dead zones in the ocean margins, and direct adverse effects to human health (e.g. methemoglobinemia caused by nitrate). Similarly, excess reactive phosphorus (P) pollution is linked to both eutrophication of receiving waters and to harmful algal blooms that can impair water quality and endanger human health. N_2O emissions and energy-intensive operation are hallmarks of conventional wastewater treatment plant bioreactors that rely on diverse microbial functional groups to remove reactive N and P from wastewater prior to release into receiving water bodies. However, the last two decades has seen the emergence of several novel microbial 'players' in the global biogeochemical N and P cycles that may facilitate entirely new approaches to energy efficient nutrient removal bioprocesses with minimal GHG emissions. In this talk, I will detail our efforts to leverage new understanding of one of these microbial functional groups, Denitrifying Polyphosphate Accumulating Organisms (or DPAOs), to develop sustainable routes for N pollution prevention coupled to P removal and recovery. DPAOs appear to be particularly prone to N_2O accumulation under certain environmental conditions, including exposure to nitrite (NO_2^-). Paradoxically, in addition to being a potent greenhouse gas, N_2O is also a powerful oxidant and a potential renewable energy source. I will highlight ongoing research directed at intentional microbial production and capture of N_2O by DPAOs as a source of bioenergy by DPAOs in a novel bioprocess, termed CANDO+P. In addition to converting waste N to an energy source, this process prevents fugitive emissions of N_2O, and feeds into a mature technology for P recovery as a fertilizer. Our efforts to date have demonstrated robust high rate and high yield (~75-80%) conversion of NO_2^- (a key intermediate in all low energy shortcut N removal processes) to N_2O coupled to P removal by DPAOs in a lab-scale sequencing batch reactor fed with synthetic wastewater over 2.5 years of operation. Molecular analyses have demonstrated strong enrichment in this reactor of multiple clades of as-yet-uncultivated '*Candidatus* Accumulibacter phosphatis' putatively capable of denitrifying P uptake. I will detail our recent efforts to elucidate underlying mechanisms for the unusually high levels of N_2O production we observe in this system via genome-resolved metagenomics, long-term kinetic analyses, and ex-situ batch assays to investigate nitrogen transformation potential. By resolving functional potential within a denitrifying N_2O-producing culture, our results provide insight into genomic and environmental factors underlying N_2O emissions by denitrifiers in complex environment systems. From an applied standpoint, CANDO+P is an example of efforts in my group to accelerate an emerging paradigm in which waste streams are viewed not as costly energy sinks but as feedstocks for energy and resource recovery.

About the Speaker

Dr. George Wells received his B.S. in Chemical Engineering and B.A. in Environmental Engineering from Rice University, and his M.S. and Ph.D. from Stanford University. Dr. Wells is currently the Louis Berger Junior Professor of Civil and Environmental Engineering at Northwestern University. The Wells Environmental Biotechnology and Microbial Ecology (WE BioME) Lab works at the interface of environmental biotechnology and microbial ecology, with an emphasis on the study of microbial diversity, dynamics, interactions, and function in engineered and impacted natural aquatic systems. Our primary research interests are microbial nitrogen cycling and short-circuit biological nutrient removal processes, microbial ecology of engineered and natural settings, sustainable biological wastewater treatment, microbial greenhouse gas production, and resource and energy recovery from waste.

USC University of Southern California