DESCRIPTION OF THE RESEARCH PROJECT FOR THE 2018 SUMMER RET SITE

Project 1: Membrane Bioreactor system for Wastewater Recycling and Recovery of Phosphorus from Wastewater

Area Coordinator:
Dr. Soryong (Ryan) Chae
Assistant Professor, Environmental Engineering
Department of Chemical and Environmental Engineering
College of Engineering and Applied Science
University of Cincinnati
PO Box 210012
Cincinnati, OH 45221-0012
Office: 736 Engineering Research Center
Phone: (513) 556-4353
Fax: (513) 556-4162
E-Mail: chaesg@ucmail.uc.edu
WEB: http://ceas.uc.edu/chemical-environmental-engineering/envengp/faculty.html

Sub- Area Coordinator:
Dr. Margaret J. Kupferle
Associate Professor & Chair, Environmental Engineering
Department of Chemical and Environmental Engineering
College of Engineering and Applied Science
University of Cincinnati
PO Box 210012
Cincinnati, OH 45221-0012
Office: 770 Engineering Research Center
Phone: (513) 556-3329
E-Mail: Margaret.Kupferle@uc.edu

Graduate Research Assistant:
Ms. Mohini Vinayak Nemade
MEng Student in Environmental Engineering
Phone: (513) 410-7905
E-Mail: nemademv@mail.uc.edu

Project Summary

This research topic is inspired by the **National Academy of Engineers (NAE) Grand Challenge**, "Provide access to clean water" and "Manage the nitrogen cycle" linked to the ***big idea*** that public wastewater systems play a critical role in protecting public health, and, in particular small public utilities face challenges in removing nutrients such as nitrogen and phosphorus from municipal and industrial wastewater.

Eutrophication is a key driver causing a number of pressing aquatic environmental problems including harmful algal blooms. The major factors affecting eutrophication are mineral nutrients such as nitrogen and phosphorus in municipal and industrial wastewater. In nutrient-sensitive estuaries, municipal and industrial wastewater treatment plants (WWTPs) are required to implement more advanced treatment methods in order to meet increasingly stringent effluent guidelines for nutrients. Biological nutrient removal (BNR) processes that incorporate coupled nitrification and denitrification have the potential to remove nutrients, but it is challenging to reach that goal by BNR processes alone. The central ***challenge*** or goal of this RET project is to develop an advanced wastewater treatment technology to upgrade **municipal**

WWTPs based on BNR processes that are NOT specifically designed to recovery phosphorus.

The combination of BNR and membrane technology, which can provide complete retention of biomass allowing higher solid retention time (SRT) with effective bacterial cultures, is becoming an attractive technology. Membrane bioreactor (MBR) technology is based on a biological process designed to remove organic matter and potentially nutrients, combined with membrane separation to enhance the performance of the biological processes by providing complete biomass retention without a secondary clarifier. Compared to the conventional BNR systems, MBR can be operated at longer SRT with higher aeration basin suspended solids concentration, which significantly reduce sludge production from the treatment process.

While MBR technology has those merits for wastewater treatment, a central challenge prevents its wide application for resource recovery (particularly **phosphorus**) from wastewater. The ultimate removal of phosphorus from biological wastewater treatment processes mainly depends on the withdrawal of excess sludge. However, the long SRT in MBR (typically 3-5 times longer than the conventional BNR processes) results in a decrease in sludge production, reducing the removal efficiency of phosphorus from the treatment system.

This research answers the ***guiding question****: How can we improve recovery of phosphorus through WWTPs using chemical adsorbents?*

The **ultimate outcome** of this project will be a community-scale method to treat, and ultimately allow recycling of wastewater through efficient removal of pollutants and recovery of phosphorus from municipal wastewater. The main objective of the project is to optimize phosphate recovery efficiency of magnesium carbonate ($MgCO_3$) pellets in a MBR system. We will study the effects of pollutants in municipal wastewater on adsorption efficiency of phosphate onto $MgCO_3$ pellets. The proposed timeline and milestones of the proposed project are presented in the following table.

Research task	Wk 2	Wk 3-4	Wk 5-6	Wk 7
1. Training for characterization of wastewater samples and operation of a bench-scale MBR system				
2. Optimization of the MBR system for wastewater recycling and recovery of phosphorus from municipal wastewater				
3. Team review of the final report				

Training

Training on documentation and interpretation of the results will be provided during Weeks 2-3 to familiarize participants with the experimental setup to be used, required physical and chemical analyses to be performed, calibration and operation of analytical instrumentation, and use of Excel in plotting / interpreting results. In particular the participants will be trained in:

- The operation of a bench-scale MBR system.
- Characterization of wastewater using UV/Vis spectroscopy (DR6000, HACH).

A field trip is also planned to the Mill Creek WWTP (1600 Gest St, Cincinnati, OH 45204) to showcase to the RET participants the application of the research they were doing to a real world setting

Industrial Advisor

In addition to coordinating the field trip, an industrial advisor, **Dr. Achal Garg** (Supervisor of Chemist-Research & Development) at the Metropolitan Sewer District of Cincinnati, will serve as the Industrial Advisor for this project. He will participate in an *Industrial Advisors Panel Session* during the 2018 Summer RET Site to plan and schedule activities for teachers' students during the school year.

Ideals for Classroom Implementation

Through this project, a participant will be able to introduce a scientific concept of biological principles for wastewater recycling to students. Also, a participant will gain knowledge and computational skill for mathematical interpretation of kinetic studies related to adsorption of phosphorus on $MgCO_3$.

School teachers from different grade bands will be able to teach the following things in the classroom.

- **Intermediate and/or Middle School (5^{th} - 8^{th} grades):** Science: What goes down the drain and toilet at home and where does it go? What nutrients do plants need? Can sewage be used as fertilizer?
- **Junior high school and high school (9^{th} – 12^{th} grades):** Science: Both solids and dissolved pollutants end up in the sewer: do the same processes treat both types? What physical (gravity, density, adsorption, fitration), chemical (flocculation, disinfection) and biological (aerobic, anoxic or anaerobic) processes should be used to separate and treat the pollution? Is order of the processes important? Math: Rate data analysis and visualization, linearization and/or non-linear curve fitting.
- **College (13^{th} – 14^{th} grade):** Advanced knowledge of 1) biological nutrient removal processes for wastewater treatment and 2) physical adsorption for phosphorus recovery from wastewater.