**Announcing the Final Examination of Sultan Salamah for the degree of Doctor of Philosophy**

**Time & Location:** June 30, 2017 at 12:00 PM in Engineering II 310

**Title:** BIOLOGICAL NUTRIENT REMOVAL (BNR) PROCESS OPTIMIZATION AND RECOVERY OF IMPEDED ENERGY USING BIODIESEL BY-PRODUCT

Enhanced biological phosphorus removal (EBPR), as well as biological nitrogen removal efficiency, is dependent on the availability of a carbon source. Volatile fatty acid (VFAs) (mainly acetic and propionic acids) are the major driving force for EBPR. Unfortunately, many domestic wastewaters have an insufficient amount of VFAs. Production of acetic and propionic acids for full-scale treatment plants is expensive. VFAs can be produced using the fermentation of primary solids. Due to the cost of VFAs production, scientists thought of adding an external carbon source to the biological nutrient removal (BNR) system that can be fermented to VFAs. Glycerol (biodiesel by-product) can be fermented to acetic and propionic acid or can be used directly as an external carbon substrate for EBPR and denitrification. Since the need for biodiesel energy is increasing, glycerol cost is diminishing. Using glycerol in wastewater treatment can also offset the biodiesel plant disposal cost and reduce the BNR chemical cost. Therefore, the main objectives of this study were to optimize the prefermentation process using glycerol. Optimization of the EBPR performance of the A2O-BNR system was evaluated using the glycerol adding location as the variable (co-fermentation with primary solids versus a direct addition to the anaerobic zone). Also, optimization of the nitrogen removal (especially denitrification) efficiency of the 5-stage bardenphoTM BNR system using the glycerol adding location (co-fermentation with primary solids versus a direct addition to the second anoxic zone) was evaluated. It was found in this study that glycerol was a suitable external carbon substrate for EBPR as well as biological nitrogen removal. The prefermentation experiment showed that glycerol co-fermentation with primary solids produced significantly higher VFAs than primary solids fermentation alone, even more than the possible value from the added glycerol, implying that the glycerol addition stimulated additional fermentation of primary solids. Lowering the prefermenter mixing energy (50 to 7 rpm) resulted in a significant increase in VFAs production (80%). Also, purging hydrogen gas to the headspace of the prefermenter did not lead to more VFAs, but significantly increased the propionic acid to acetic acid ratio by 41%. In the A2O-BNR pilot plant experiment, it was found that glycerol is a suitable renewable external substrate to drive enhanced EBPR as well as denitrification. The results from both locations of glycerol addition (direct vs. fermented) were beneficial to the BNR system. Both systems had similar effluent quality and achieved total nitrogen (TN) and total phosphorus (TP) removals up to 86% and 92% respectively. The 5-stage bardenphoTM BNR experiment investigated the location of glycerol addition (direct vs. fermented) on the performance of denitrification in the second anoxic zone and overall. The results from both systems were beneficial to the BNR system and had virtually similar effluent quality. Both systems achieve complete denitrification and excellent removal of TN and TP up to 95% and 89% respectively. Also, the pilot that received fermented glycerol had significantly higher VFAs loading and lower observed yield. The side-stream prefermenter effluent flowing to the second anoxic reactor did not cause high effluent ammonia concentration.

**Major:** Environmental Engineering

**Educational Career:**
- Bachelor's of Civil Engineering, BS, 2009, Umm Al-Qura University
- Master's of Environmental Engineering, MS, 2014, University of Central Florida

**Committee in Charge:**
- Andrew Randall, Chair, Civil, Environmental, and Construction Engineering
- Jose Jimenez, Brown and Caldwell
- Anwar Sadmani, Civil, Environmental, & Construction Engineering
- Woo Hyoung Lee, Civil, Environmental, & Construction Engineering
- Steven Duranceau, Civil, Environmental, & Construction Engineering
Approved for distribution by Andrew Randall, Committee Chair, on June 13, 2017.

The public is welcome to attend.