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Session Fr1D: 10:00am -11:30am, Friday February 1, 2013 (Room 005)
Biological Water and Wastewater Treatment
Session Organizer: Catherine O'Connor, Metropolitan Water Reclamation District of Greater Chicago
Session Chair: Catherine O'Connor and Heng Zhang, Metropolitan Water Reclamation District of Greater Chicago

10:00am **Microbial Assessment Of Biological Nutrient Removal** *Geeta Rijal, Heng Zhang and Joseph Kozak*
Metropolitan Water Reclamation District of Greater Chicago
Enhance Biological Nutrient Removal (EBNR) has become more prevalent in the wastewater industry as regulations have begun to include stringent nutrient limits. The microbial population dynamics of Ammonia Oxidizing Bacteria (AOB), Nitrite Oxidizing Bacteria (NOB), and Phosphorus Accumulating Organisms (PAO) play an important role in the removal of nutrients in the wastewater. These microorganisms are dependent on the optimization of wastewater treatment plant design and operating conditions. Microbiological assessment of PAO, AOB and NOB population is necessary to facilitate wastewater treatment enhancement and operation. This presentation will provide a review of the microorganisms involved in EBNR processes using fluorescently labelled gene probes, as well as simple microscopic staining methods as a screening tool for the full-scale EBNR testing at the Metropolitan Water Reclamation District of Greater Chicago's Stickney and Calumet Water Reclamation Plants. The preliminary findings suggest the presence of PAOs, AOBs and NOBs in certain quantity in the full-scale testing facilities. Additional investigation will focus on the influence of key environmental and operational parameters on the abundance of these microorganisms and comparison with the enumerated baseline PAO and AOB/NOB ratio. The data acquired will guide the full-scale test and assist the EBNR operations.

10:30am **Enhanced Biological Phosphorus Removal: Implementation with Existing Infrastructure at the Stickney Water Reclamation Plant**
Heng Zhang, Joseph Kozak and Catherine O'Connor, Metropolitan Water Reclamation District of Greater Chicago
In November 2011, the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) informed IEPA of a multi-year plan of implementing enhanced biological phosphorus removal (EBPR) with existing infrastructure at its three large water reclamation plants (WRPs). As the initiation of this plan, a full-scale test was conducted in 2012 at one of the four secondary treatment batteries of the Stickney WRP. This battery was converted to three different zones to biologically reduce phosphorus concentrations in the liquid stream. The main objective of this plan is to reduce final effluent TP concentrations to less than 1 mg/L on a monthly average basis. The Stickney WRP has four nearly identical aeration batteries. Each battery has 8 aeration tanks and each tank has 4 passes. The overall length to width ratio is about 49, which indicates that the flow in a tank has a plug flow pattern and the tank is ideal for conversion to different zones. Each battery also has a return activated sludge (RAS) channel for conveying the activated sludge from final settling tanks to aeration tanks and a mixing channel for distributing the mixture of primary-treated effluents and activated sludge to eight different aeration tanks. For achieving EBPR, an anaerobic zone should be created at the location where activated sludge in the system meets the primary-treated effluent or immediate downstream, and the anaerobic zone should be large enough, generally providing 45 minutes to two hours residence time, so that phosphate accumulating organisms (PAOs) in the activated sludge can be proliferated. Dissolved oxygen (DO) and nitrate, the end product of nitrification for ammonia removal, are inhibitory to PAOs in the anaerobic zone. Therefore, an anoxic zone is created in the RAS and mixing channels to reduce DO and nitrate concentrations before the anaerobic zone, which is located in the first 12.5 percent of an aeration tank. The anoxic and anaerobic zones are created by turning air in these zones to minimal to support the suspension of activated sludge. EBPR was evident in the test battery, because it had relatively lower effluent TP and higher phosphorus content in its waste activated sludge (WAS). Initial results indicated that the average effluent TP concentration was 0.97 mg/L in the test battery, compared to 1.15 mg/L in the control battery. The average percent TP in WAS was slightly higher in the test battery (2.23%) relative to the control battery (2.18%). Whereas the preliminary results show that the difference between the test and control batteries may not be significant enough, further improvement in phosphorus removal efficiency at the test battery is expected through process optimization which is currently ongoing. As a side benefit of EBPR, more denitrification occurred in the test battery because of lower DO concentrations in the RAS, mixing and anaerobic zones. In the three month evaluation in Spring and Summer 2012, the average daily total nitrogen concentration was 9.4 mg/L in the effluent of the test battery, compared to 11.6 mg/L at the control battery, which was achieved with no increase in operation cost and no compromise of effluent quality. In contrast to biological phosphorus removal, chemical phosphorus removal requires a significant increase in operational cost. In the full-scale demonstration study conducted at the Egan WRP by MWRDGC, TP concentrations in the final effluent decreased from an average of 3.7 mg/L to about 0.5 mg/L by chemical precipitation using ferric chloride ($FeCl_3$). To meet the effluent TP target of 0.5 mg/L, approximately 12

pounds of $FeCl_3$ was required to remove one pound of phosphorus and 10 pounds of chemical sludge was generated in the process. The operational cost for the chemical phosphorus removal was about $1,300 per day for chemical and $400 per day for chemical sludge disposal at the Egan WRP with average daily flow of 27 MGD. The data from this full-scale study was used to estimate the consequence of chemical P removal at the other WRPs in the metropolitan Chicago area based on average plant flows and phosphorus concentrations. For a total flow of 1350 MGD from 7 plants and a target effluent TP of 0.5 mg/L, approximately 31.5 million gallons of $FeCl_3$ per year would be consumed and 51,300 dry ton of chemical sludge generated. Transporting the chemical and sludge would result in a significant negative environmental impact to the area.

11:00am **De-ammonification of Wastewater Sidestreams: Process Mechanisms and Pilot Results from the Egan Water Reclamation Plant**

Joseph Kozak, Dongqi Qin and Heng Zhang, Metropolitan Water Reclamation District of Greater Chicago

The conveyance of the centrate from the Metropolitan Water Reclamation District of Greater Chicago (District) John E. Egan (Egan) Water Reclamation Plant (WRP) to the North Side WRP has historically caused odor problems in the sewer lines. This ammonia (NH_3)-rich centrate cannot currently be recycled at the Egan WRP due to limited nitrification capacity in its aeration basins. In order to mitigate the odor problem in the sewer lines and to be able to recycle the centrate continuously within the plant without imposing harm on the existing operations, sidestream ammonia removal treatment technologies were reviewed. The deammonificaition sequencing batch reactor suspended growth process (Demon®) was determined to be one of the most suitable technologies. Demon® is a partial nitritation and ammonia oxidation process. The first step of the process is that only nitrite is produced aerobically by controlling the ammonia oxidizing bacteria (AOB) and nitrite oxidizing bacteria (NOB) in the bioreactor. Then NH_3 is converted to nitrogen gas (N_2) directly by Anaerobic Ammonia Oxidation (ANAMMOX) bacteria that use nitrite (NO_2^-) as an electron acceptor under anaerobic conditions. In this process, the fundamental control parameters are aeration and anoxic times, solids retention times (SRTs), temperature, pH, dissolved oxygen (DO), NH_3 and NO_2^- concentrations, phosphate, sulfide, seed concentration, and inoculation time. More than 80% nitrogen removal has been documented at current Demon® plants treating wastewater from recycle streams. Additionally, compared to conventional nitrification/denitrification technology, Demon® can significantly reduce energy costs by 60 percent. Furthermore, no carbon substrate is required in the process, because NH_3 itself is an electron donor. Given its viability and cost effectiveness, the District is investigating the nitrogen removal of the Egan WRP centrate sidestream by a Demon® pilot reactor. The Egan pilot reactor has been in operation for two months starting September 2012 to assess the ammonia removal efficiency through monitoring of the influent and effluent. Special consideration was given to: length of start up time; process control including fill, react, and decant cycles and extent of aeration and mixing times; ease of operation; and affect of influent characteristics including but not limited to ammonia, temperature, alkalinity, suspended solids, nitrite, and organics. The initial nitrogen (N) loading rate was kept low in order to minimize nitrite and nitrate effluent concentrations as well as to avoid shock feed to the system. Subsequently, the load to the pilot system was gradually increased to 0.6 kg N/m^3-day (85% of 0.7 kg/m^3-day target loading) over the two-month period while achieving an average ammonia nitrogen (NH_3-N) removal efficiency of 88%. The system was considered alkalinity limited due to the fact of ferric chloride ($FeCl_3$) is added upstream to the centrifuges to minimize struvite precipitation in the centrate lines and to improve dewatering characteristics of digested sludge. Thus, sodium bicarbonate ($NaHCO_3$) was added to the pilot unit when lacking in alkalinity and reduction in performance. Results of the pilot study show that once alkalinity was restored to the system, its removal efficiency increased. The future goal of Demon® operation is to continue increasing the centrate loading rate to the system to determine the maximum nitrogen removal capacity; to increase the mixed liquor inventory; to investigate impact of low temperatures on pilot operation performance; and to optimize process control. This data along with a full evaluation of the pilot study results will be presented at time of the conference.