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Monday, Sept. 11
10:30 AM – 12:00 Noon
SESSION 7: Wastewater Treatment and Other Technologies

Enhanced N bio-kinetics Driven by Peroxide Addition to Secondary Effluents Bio-Filtration: Linking Function-Structure by N-mass Balance and Metagenomics - Liron Fridman, Tel Aviv University, Tel Aviv, Israel (co-authors: D. Avisara, H. Cikurelc, M. Jekeld, K. Chandrane, H. Mamane)

Rapid deep-bed filtration of secondary effluent is a tertiary treatment that can effectively remove particles and somewhat organic matter; however ammonia and nitrite are not easily removed. This study examined the performance of a biofiltration pilot system as part of a multi-barrier treatment process using, short (5 min) hydraulic retention time (HRT), hydrogen peroxide (HP) enhanced biofiltration, at 5-6 m/hr filtration velocity for particle, ammonia, nitrite and organic matter removal. HP was used as a bio-specific oxygen source to support oxygen demand for full nitrification. The use of HP is advantageous upon aeration due to solubility limitations of the latter. As a result of enhanced biofiltration by 27 mg/l HP (as immediate source of dissolved oxygen), 3-5 mg/l N-NH4+ and 0.4-0.65 mg/l N-NO2 were removed in the short HRT as compared to filtration without HP addition which only removed up to 0.6 mg/l N-NH4+ and almost no N-NO2. In parallel, 15-20% removal of organic matter (measured as DOC and UVA) and >90% particle removal was obtained as a result of the combined coagulation-flocculation and biofiltration. DNA metagenome analysis of the media, demonstrated that the community structure and potential function reflects significant (29%) N pathways related activity when the low community diversity indicates conditions of selective pressure in favor of Nitrospira species. It is suggested that HP addition increased biofilm growth and thickness and as a result more anoxic micro-niche formed which enhanced anoxic activity supported by higher availability of NOx due to intense nitrification. A model was suggested for biokinetics of the biofiltration system with the addition of HP.

Onsite Remediation of Dairy Farm Sewage by Aerated Bioreactor and Halophyte-Zeolite Treatment Wetlands - Ezra Orlofsky, MIGAL Galilee Research Inst., Qiryat Shemona, Israel (co-authors: S. Chernoivanov, A. Cohen, M. I. Litaor)

New regulation in Israel requires that 'hard' sewage producers treat wastewater onsite before release to the municipal sewage line. The main parameters under regulation are organic matter, solids, nitrogen and phosphorous. Certain heavy water footprint industries such as olive mills, wineries and dairy farms stand out because their onsite treatment options are limited. Previous technological developments at MIGAL include nano-composite modified clays for benign and rapid solids removal, and aerated solid state bioreactors for organic matter decomposition. The combination of these innovations resulted in a compact onsite treatment system for wastewater of wineries, to the point that onsite reuse for irrigation can be considered, thus allowing further progress towards sustainability. A crucial, as yet unaddressed aspect is the sodium content, conventionally removed by energy-intensive reverse osmosis or distillation. Sodium concentration above 150 mg/L renders treated wastewater unfit for irrigation,

while in dairy farms the sodium content can range between 290-1000 mg/L. We present a combination halophyte and ion exchange wetland for removal of sodium from the treated wastewater. The sodium accumulating plants, collected from waterlogged saltmarsh in Israel, are currently under propagation at a specialized nursery constructed for this purpose at the Neot Mordechai Experimental Research Station. In parallel, natural zeolites are undergoing a battery of sodium exchange tests in a bench-top setup, using treated wastewater spiked with sodium. Preliminary results indicate that the plants can contain up to 5% sodium in their leaves and that the zeolite can remove 40% of sodium in a single pass, independent of flow rate. The salt-remediation wetlands are currently under establishment and will begin operation at a pilot scale in the Spring 2017, at a dairy farm located in Kfar Blum. If successful, the model will be scaled up to include the treatment of the entire dairy farm waste stream. Options for onsite reuse for agriculture will be considered as well.

Complete Nutrient Removal, Phosphorus Recovery, and Energy Production via Microbial N2O Generation from Wastewater - George Wells, Northwestern University, Evanston, IL, USA (co-author: H. Gao)

Coupled Aerobic-anoxic Nitrous Decomposition Operation (CANDO) is a promising emerging microbial bioprocess for wastewater treatment that enables direct energy recovery from nitrogen (N) in three steps: (1) nitritation of ammonium to nitrite (NO_2^-); (2) denitrification of NO_2^- to nitrous oxide (N_2O); and (3) N_2O capture and conversion to N_2 with energy generation. Compared with conventional biological nitrogen removal processes, CANDO mitigates release of N_2O (a potent greenhouse gas) to the atmosphere and provides a route for direct recovery of energy from waste nitrogen sources. Our previous work demonstrated 75-80% conversion by a mixed culture denitrifying community of NO_2^- to N_2O, and introduction of N_2O into a biogas-fed engine has been reported to increase power output by 5.7-7.3%. However, CANDO does not currently target phosphorus (P) removal and recovery from wastewater. To address this gap, we've demonstrated that enrichment cultures of little-understood denitrifying polyphosphate accumulating organisms (DPAOs) are capable of catalyzing simultaneous biological N and P removal coupled to N_2O generation in a 2nd generation CANDO process, CANDO+P. Over 2 years of operation of a prototype lab-scale CANDO+P sequencing batch reactor treating synthetic municipal wastewater, we observed stable and near complete N removal accompanied by sustained high rate, high yield N_2O production. In parallel, we observed near complete P removal and sequestration in DPAO biomass. Established methods are applicable for recovery of this bioconcentrated P as a fertilizer. 16S rRNA gene amplicon sequencing and FISH-based monitoring of the underlying microbial community indicated a substantial increase in abundance of the PAO 'Candidatus Accumulibacter phosphatis', from 5% of the total bacterial community in the inoculum (from a full-scale enhance biological phosphorus removal wastewater treatment bioreactor) to >50% after four months. PAO enrichment was accompanied by a shift in the dominant Accumulibacter population to Clade IA, based on cloning and sequencing coupled to qPCR monitoring of polyphosphate kinase 1 gene variants. Subsequent genome-resolved shotgun metagenomic analyses have allowed assembly of near complete genomes for Accumulibacter clades IA and IB, as well as 59 draft genomes (>80% complete) representing the flanking (non-PAO) CANDO+P microbial community. Surprisingly, both Accumulibacter genomes harbor complete denitrification pathways, suggesting that the unusually high levels of N_2O accumulation observed in this system derive either from competition for intracellular electron equivalents between nitrogen oxide reductases in the electron transport chain or from regulation of gene expression of nitrous oxide reductase (nosZ). Ongoing work seeks to test these potential mechanisms for N_2O generation. The flanking CANDO+P microbial community, in contrast, is characterized by a high diversity of taxa with truncated denitrification pathways, the majority of which lack nosZ. This indicates strong genomic potential in the flanking community for N_2O production. Our

work to-date demonstrates the feasibility of combining high rate, high yield N2O production for bioenergy production with combined N and P removal from wastewater, and provides new insights into genomic and environmental factors underlying N2O emissions from complex microbial consortia in wastewater treatment bioreactors.

Locating Hidden Water Leaks and Condition Assessment of Pipes Using Fixed Remote Monitoring System Based on Acoustic and Pressure Sensors - Oded Fruchtman, Aquarius-Spectrum, Netanya, IL, Israel

Water leaks and water scarcity are major challenges faced by water utilities around the world. The costs of maintaining pipes that are worn out is high and sometimes require emergency work with higher costs. Water pipes are eroded unevenly due to environmental conditions, soil, loads and raw material. The ability to identify defective parts in the pipeline in order to replace them and prevent costly maintenance (bursts repairs), water losses and disturbances in the water supply is of great value both to the water corporation and to its customers - the water consumers. Aquarius Spectrum's fixed leak detection system (AQS-SYS) automatically monitors the water pipeline on a daily basis, enabling identification and detection of hidden leaks and their exact location. The system, which is based on cloud technology and integrates fixed acoustic sensors, pressure sensors and dedicated software, is an efficient tool for monitoring and controlling the water network, providing a detailed and useful picture of the condition of the pipes every day. The use of the system can assist in prioritizing pipe repairs & replacement. The company's technology, which is adapted for all types of pipes, is successfully implemented in five major cities in Israel through their water utilities: Hagihon (the largest water utility in Israel which is responsible for supplying water to the city of Jerusalem and the cities around it), Mey-Netanya, Mey-Modi'in, Ein Kramim (Karmiel) and El-Ein. In addition, during 2016, the Company carried out successful installations in the US and Europe. To date, through the Aquarius system, over 2,000,000 cubic meters of water have been saved. For over three years, since the system has been implemented at Hagihon Water and Sewage Corporation of Jerusalem, there is a substantial improvement in its NRW (Non-Revenue-Water). NRW was reduced in specific neighborhoods (DMA's) by 20%, mainly due to locating and fixing hidden leaks and repairing malfunctioning equipment located by Aquarius. In addition, there is a clear trend of a yearly decline in the number of visible (reported) bursts. During the two years prior to the implementation of the Aquarius system in Hagihon, there was an increasing trend in the number of bursts per year, which was clearly reversed to a declining trend apparent. More than 2,000 sensors have been installed in Jerusalem, monitoring over 1,000 kilometers of water pipes every day. AQS system has found more than 226 hidden leaks in the Jerusalem area, 171 of which were in the public distribution network and 55 in private properties. Fixing those leaks resulted in potential savings of over a million cubic meters of water. In addition, the system has discovered more than 250 non-leak faults, including partially closed valves, faulty water meters, malfunctioning non-return valves and other items of equipment under the responsibility of the water Utility. In addition to the fixed monitoring system, Aquarius developed a mobile solution for water leak detection - iQuariusTM - The first of its kind in the world, enables listening to the pipeline and perform manual leakage surveys, including correlation, simply by connecting to smartphone using a dedicated application.