University at Buffalo
Department of Civil, Structural and Environmental Engineering
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Environmental and Water Resources Engineering

S2EBPR Enables Sustainable Nutrient Removal with Carbon Footprint Reduction

Abstract: The increasingly stringent limits imposed on wastewater effluent phosphorus demand for higher-level treatments through more reliable and better optimization of phosphorus removal processes. Although enhanced biological phosphorus removal (EBPR) process is considered a potentially efficient process with economic and environmental advantages compared to traditional chemical phosphorus removal, the benefits are often offset, in practice, by the needs to have standby chemicals for achieving reliable and consistent performance. In this study, a promising new side-stream EBPR process (S2EBPR) that involves a side-stream anaerobic biological sludge hydrolysis and fermentation reactor, as an alternative to address the common challenge in EBPR related to weak wastewater influent and to improve EBPR process stability, was investigated that presents a suite of potential advantages. The overall goals of this study were to elucidate the fundamental mechanisms involved in the S2EBPR process and to develop criteria for effective design and operation of the process. To achieve the objectives, the research team conducted a survey of data from full-scale S2EBPR facilities, simulated side-stream reactor batch testing, performed full-scale pilot testing with side-by-side S2EBPR and conventional EBPR processes, and developed an improved biological process model for S2EBPR.

The research team conducted both full-scale and lab-scale investigations and employed conventional as well as advanced microscopic and bio-molecular tools to elucidate the mechanisms involved in S2EBPR process. Full-scale pilot testing with comparison of S2EBPR and conventional EBPR configurations further demonstrated that with the same influent wastewater characteristics, S2EBPR configuration had more effective and stable phosphorus removal performance than conventional EBPR, especially when the mixers in side-stream reactor were operated intermittently. The research team proposed and developed an improved EBPR model with staged cellular maintenance and decay, and PAO and GAO modules to investigate the dynamics in PAO-GAO competition under extended anaerobic incubation. The proposed model can be employed to form guidance on further investigation of the design and operation conditions and criteria for plant-specific cases.

In summary, the research team investigated and revealed the potential mechanisms of an alternative side-stream EBPR process (S2EBPR) as a promising new side-stream EBPR process/scheme that presents a suite of potential advantages, and enables more robust and stable EBPR performance over a wide range of wastewater characteristics and process configurations. The research team developed a modified mechanistic process model for the side-stream EBPR process to describe and predict its behavior, which cannot be achieved with the present commonly used models. This pioneering research will significantly advance knowledge and understanding that could fundamentally change how WERF Subscribers design and implement effective phosphorus removal technologies. The outcome will help transform our understanding and ability to protect and preserve water resources in a sustainable and cost effective manner and to minimize impact on the environment.

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Dr. Gu is currently professor in School of Civil and Environmental Engineering at Cornell University in Ithaca, NY. Dr. Gu received her B.S. in Environmental Engineering and Science from Tsinghua University in Beijing, China and a Ph.D. in Civil and Environmental Engineering, jointly in Microbiology, from the University of Washington, US. Her expertise and area of research interest include: 1) biotechnology for water and wastewater treatment and biological nutrient removal; 2) risk-based water quality monitoring and toxicity assessment; 3) biosensors and nano-biosensors; 4) global phosphorus cycling and bioavailability of nutrients in natural ecological systems. She has led and participated over 30 research projects funded by various agencies including NSF, DOE, EPA, WERF and NIEHS. She has over 120 journal, conference and other technical publications and given 220 presentations at conference and workshops, including 70 invited talks. She and her students have received a number of national awards including NSF CAREER award, SETAC Endowment Travel Award, National Pathfinder Award for Creativity (HDR Inc.), SETAC Global Best Student Paper Award and, IEEE Yong researchers Forum Award, ACS Outstanding Presentation Merit Award. She received the Søren Buus Outstanding Research Award and excellence in mentor award from Northeastern University and elected to be COE faculty Fellow in 2014. She was invited speaker for Gordon Conference-Drinking Water Disinfection Byproducts 2017, Gordon Conference -Environmental Nanotechnology 2013, and Gordon Conference – Water Science in 2012. She has been elected to serve on the Board of Directors for AEESP since 2017.

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