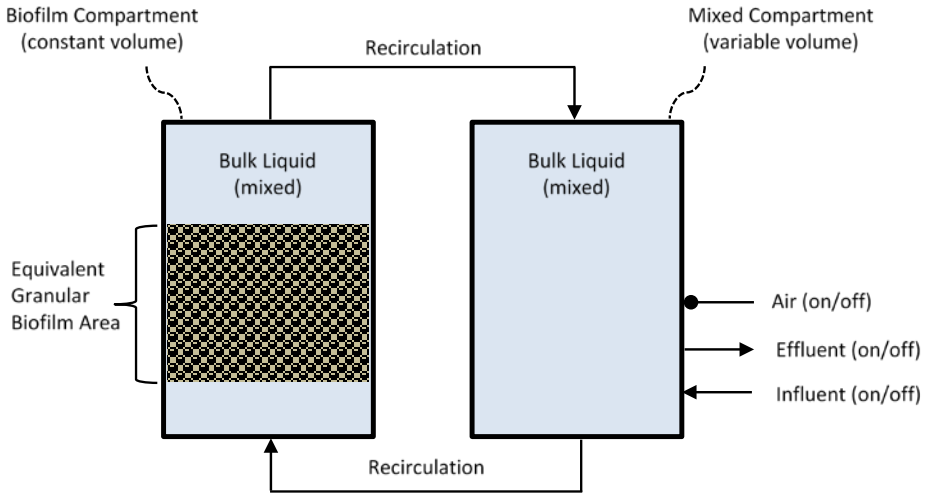
Executive **Summary**

Aerobic granular sludge technology worth considering for certain water resource recovery facilities

Aerobic Granular Sludge for Biological Nutrient Removal: White Paper (NUTR5R14h)



Schematic of commonly used process configuration in modeling of aerobic granular sludge SBRs.
Lines with arrows represent advective links. Lines with circles represent diffusive links.

The Central Issue

The outlook is promising for the use of aerobic granular sludge in water resource recovery facilities (WRRFs) with nutrient removal requirements that want to maximize the treatment capacity of existing infrastructure or maintain a small footprint and/or implement resource recovery. With greater awareness of aerobic granulation mechanisms and broadened understanding of their performance capabilities, research needs, and potential applications, increased use of aerobic granular sludge-based wastewater treatment and resource recovery are anticipated.

Context and Background

Interest in granular activated sludge for biological nutrient removal has been growing since the first full-scale aerobic granular activated sludge system was commissioned in the Netherlands in 2011. Granular sludge exhibits faster settling rates when compared to flocculent activated sludge. This leads to operating at higher mixed liquor suspended solids (MLSS) concentrations and more compact biological process designs. However, the development and application of this technology is less mature compared to other aerobic biological processes. There are unique features regarding the granular selection, physical characteristics, and microbial composition. The project team performed a comprehensive review of fundamental aspects of selector mechanisms for granular versus flocculent sludge growth, types of aerobic granular sludge and their microbial composition, and experiences with aerobic granular sludge biological nutrient removal (BNR) processes performing simultaneous nitrification, denitrification, and enhanced biological phosphorus removal (EBPR).

Findings and Conclusions

The researchers determined that aerobic granular sludge technology might be worth considering for WRRFs that must comply with stringent nutrient removal requirements, are trying to maximize the treatment capacity of an existing infrastructure or maintain a small footprint, or are seeking opportunities in resource recovery.

Management and Policy Implications

While the potential to use aerobic granular sludge is promising, additional research is required. This research project revealed unaddressed aspects of wastewater treatment and the intensification of the existing infrastructure using aerobic granular activated sludge.

Related WE&RF Research

Project Title	Research Focus
Nutrient Management Volume II: Removal Technology Performance and Reliability (NUTR1R06k)	Comprehensive study of nutrient removal plants designed and operated for three or more years to meet very low effluent total nitrogen (TN) and total phosphorus (TP) concentrations examines what can be learned from existing technologies in order to provide a database to inform decision makers about proper choices for both technologies and rationale bases for statistical permit writing. Helps establish a practical and quantifiable protocol for the analysis of nutrient removal and nitrification plants striving to achieve low effluent concentrations. It found that statistical variability is a characteristic of all exemplary plants and that variability should be recognized in technology evaluation in an engineering environment, as well as determining appropriate effluent limits in the regulatory permit-setting environment.
Technologies for Sidestream Nitrogen Removal (NUTR1R06w)	Reviews technologies which treat nutrient-rich industrial wastewaters and recycle streams (sidestream) generated by the dewatering of digested municipal sludges, animal manures, and source separated wastes, focusing on treatment technologies for the removal and recovery of nitrogen. Includes a brief description of the general principles of biological and physical/chemical processes.
Balancing Flocs and Granules for Activated Sludge Process Intensification in Plug Flow Configurations (U1R14)	Develops mainstream BNR processes that balance flocculent and granular growth to intensify existing activated sludge systems.

Principal Investigators:
Bryce A. Figdore, P.E., Ph.D.
University of Washington

Project Team:
H. David Stensel, Ph.D., P.E., BCEE
Mari K.H. Winkler, Ph.D.
University of Washington

JB Neethling, Ph.D., P.E., BCEE
HDR, Inc.

Water Environment & Reuse Foundation
1199 N. Fairfax Street ▪ Alexandria, VA 22314
www.werf.org

For more information contact:
Christine Radke, PMP at cradke@werf.org

Project #NUTR5R14h **November 2017**