Factors Influencing the Reliability of Enhanced Biological Phosphorus Removal

Enhanced biological phosphorus removal (EBPR) has been used for decades to remove phosphorus from municipal wastewater. EBPR allows facilities to meet water quality goals while minimizing chemical consumption and sludge production. However, there is still substantial variability in both the practices applied to achieve EBPR and the level of soluble phosphorus removal achieved. The purpose of this research project was to provide information to facilities that would assist in improving the reliability of EBPR processes while achieving very low levels of effluent phosphorus.

This project included detailed analysis of routine water quality and operating data, field testing observations, and special studies conducted over the course of the project to evaluate the variability of EBPR, factors influencing EBPR performance, and the relationship between EBPR and the presence of glycogen accumulating organisms (GAOs). GAOs can compete with phosphorus accumulating organisms (PAOs) for substrate and thus may impact EBPR performance.

This study showed that EBPR is capable of achieving very low effluent phosphate concentrations. When operating well, it is possible to achieve soluble phosphate concentrations under 0.1 mg/L. Many of the facilities surveyed have the ability to augment their phosphorus removal through the use of substrate addition or polishing with iron- or aluminum-containing chemicals in order to reduce excursions.

Screening Survey and Field Testing

Forty-seven full-scale facilities responded to the initial survey, representing EBPR plants in five countries. Five facilities were then selected for more in-depth studies to get a better understanding of EBPR performance. These plants provided three years of plant operating records to the project team and were each visited by team members who conducted two, two-week intensive sampling periods at each plant. Several tests were conducted during the field testing, such as phosphate profile measurements and uptake and release tests. Summary information

Anaerobic digester at the Lower Reedy wastewater treatment plant, Greenville, SC.

BENEFITS

- Documents the performance of full-scale EBPR systems.
- Evaluates reliability of facilities with a history of EBPR based on key influent characteristics and operational parameters.
- Documents the lack of relationship between phosphorus release and performance.
- Documents the difficulty associated with predicting successful EBPR in full-scale plants based on a single parameter.

RELATED PRODUCTS

Use of Novel Techniques to Quantify Phenotypes in Biological Treatment (98CTS2)

Use of Enhanced Biological Phosphorus Removal for Treating Nutrient-Deficient Wastewater (00CTS13)

Characterizing Mechanisms of Simultaneous BNR during Wastewater Treatment (00CTS17UR)

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about each plant is provided in the table on the right.

GAOs, a subset of which is referred to as G bacteria, have been implicated in reducing the efficiency of EBPR processes due to their uptake of available substrate that would otherwise be used by PAOs. This study determined that the presence of GAOs in full-scale facilities does not necessarily preclude the plant from achieving EBPR, provided there is sufficient carbon in the influent. In this research, GAOs and PAOs appeared to coexist in EBPR plants without a major impact on the EBPR performance. However, since GAO organisms remove substrate needed for PAO metabolism, their presence poses a threat to having sufficient substrate available to maintain efficient EBPR.

Summary of WWTPs Participating.

	Durham	VIP	Nansemond	McDowell Creek	Lower Reedy
State	Oregon	Virginia	Virginia	North Carolina	South Carolina
Process	A2O***	VIP*	VIP	Modified UCT**	Modified UCT
Design Capacity, MGD	25	40	30	6	9
Notable Feature	Stable process with low effluent phosphorus	Stable process, with apparent annual upset in August	Struggled to achieve EBPR until 2003	Add sugar waste	Consistently meets permit limit. Long HRT system
Permit Limit (mg/L P)	0.07	2.0	2.0	1.0	2.0

*Virginia Initiative Plant **University of Cape Town ***Anaerobic/anoxic/oxic

When operating well, it is possible to achieve soluble phosphate concentrations under 0.1 mg/L.

Conclusions

This research found that EBPR is capable of achieving very low effluent phosphate concentrations. When operating well, phosphate concentrations <0.1 mg/L can be achieved for extended periods (more than a month), 0.03 mg/L for a week, and even below 0.02 mg/L for several sequential days. Excursions above these levels are common. EBPR performance can be estimated by examining the plant influent BOD and TP loading, the level of oxidants in the anaerobic zone, the degree of recycle phosphorus control, and operating parameters (SRT, temperature, DO, anaerobic and aerobic HRT).

Researchersfound that the following conditions favor EBPR and allowed the achievement of consistently low effluent phosphate concentrations:

- Influent composition of high influent ratio of biological oxygen demand (BOD) to total phosphorous (TP) and low variability in composition.
- Exclusion of oxidants, nitrate and dissolved oxygen, from the anaerobic zone.
- Exclusion or minimization of recycle flows and load fluctuations from solids processing.
- Low solids retention time, moderate temperature, sufficient dissolved oxygen in aeration basin, balanced anaerobic and aerobic hydraulic retention times.
- Addition of a carbon source such as volatile fatty acids is a viable method for reliably achieving very low (<0.02 mg/L) effluent phosphate concentrations.

The results of this research should assist facilities who have or are considering EBPR processes to manage them in a more cost-effective manner. This project demonstrates WERF's continuing commitment to identifying and investigating successful nutrient removal processes.

CONTRACTOR

J.B. Neethling, Ph.D., P.E.
HDR

PROJECT TEAM

Brian Bakke, E.I.T.
Mario Benisch
April Gu, Ph.D.
Heather Stephens, P.E.
HDR

H. David Stensel, Ph.D., P.E., D.E.E
University of Washington

Rebecca Moore, P.E.
Moore Engineering Consultants

PROJECT SUBCOMMITTEE

Tyler Richards
Gwinnett County Department of Public Utilities

James Barnard, Ph.D.
Black and Veatch

David Jenkins, Ph.D.
University of California at Berkeley

David Stevens, Ph.D., P.E.
Utah State University

David Waltrip
Hampton Roads Sanitation District

Steve Williams
RWE Thames Water

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