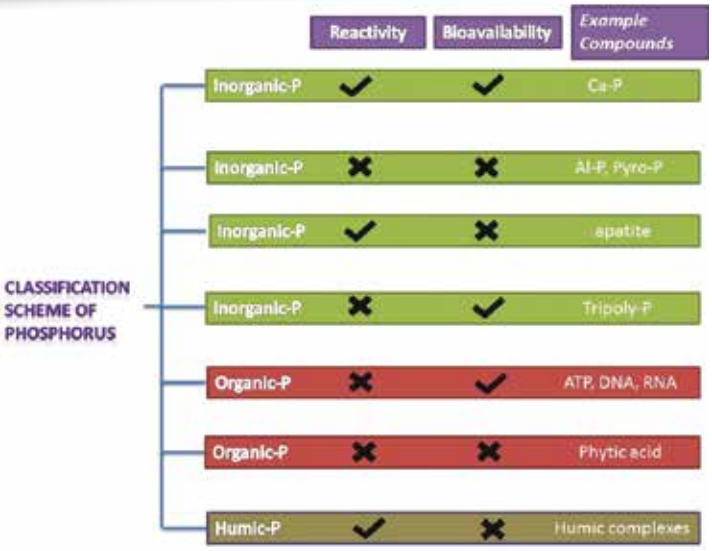
Executive Summary

WERF

Alternatives to bioassays for effluent phosphorus measurement

The Bioavailable Phosphorus (BAP) Fraction in Effluent from Advanced Secondary and Tertiary Treatment (NUTR1R06m)



Classification Scheme of Phosphorus.

The Central Issue

Excessive amounts of phosphorus (P) in receiving waters can cause environmental problems such as harmful algal blooms, hypoxia, and fish kills resulting from biomass decay. This is because P is one of the two key macro-nutrients (the other is N, nitrogen) that algae need to grow, primarily in inland waters (freshwater lakes, streams, rivers, etc.). Water resource recovery facilities (WRRFs) located inland are increasingly being required to reduce the amount of P (and N) in their treated effluent – often below current detection/measurement levels – using significant amounts of energy and chemicals with very little understanding of whether the various fractions of P are readily bioavailable for algae growth.

Context and Background

This study examined effluent of 17 full-scale WRRFs representing a wide range of P removal technologies. The researchers studied current analytical methods and P speciation and bioavailable phosphorus (BAP) in 17 wastewater treatment plant effluents around the country to compare the different types of advanced secondary and tertiary P removal processes, the impact of chemical addition in the effluent from these advanced nutrient removal processes, and the influence of dissolved phosphorus molecular forms on recalcitrance and bioavailability.

Findings and Conclusions

The effluent total reactive phosphorus (TRP) concentration was found to have a strong relation to the total effluent BAP concentration. The bioavailability and P species composition was found to vary with the selected nutrient removal process. In most cases, a large portion (>50%) of the effluent P was recalcitrant to algal growth. Higher chemical doses, which also achieved lower effluent P concentrations, decreased the fraction of the phosphorus that was bioavailable (% of BAP). Algal phosphorus uptake experiments suggested that P species with high bioavailability, including some organic P species, are unlikely to persist in natural surface waters because their uptake kinetics are very rapid. These results further suggest recalcitrant P compounds, such as humic-metal-P complexes, phytic acid and/or apatite may be the dominant components of the recalcitrant dissolved P pool in effluents identified in this and other studies.

Management and Policy Implications

TRP measurement can be a useful surrogate for the more complex, time consuming, and expensive bioassay – it is also much easier, cheaper, and quicker to measure. This can help water quality modelers and permit writers consider the importance of BAP when assessing the likely ecological impacts of municipal nutrient removal facility effluent discharges. Because many watershed protection plans (e.g., TMDLs) use total P for setting limits without considering the possibility that P fractions may differ in bioavailability, regulations on total phosphorus should take into consideration the results from this study.

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Related WERF Research

Project Title	Research Focus
Uptake by Algae of Dissolved Organic Nitrogen from BNR Treatment Plant Effluents (NUTR1R06e)	Investigates whether a professionally accepted method to measure forms of dissolved organic nitrogen (DON) that are not readily taken up by algae can be used by wastewater treatment plant operators and regulators to more effectively understand and control eutrophication. Provides a relatively simple and robust method to determine the bioavailability of DON in the effluent from BNR wastewater treatment facilities.
Variability of Low Phosphorus Analytical Measurement (NUTR1R06f)	Provides information regarding the ability of wastewater treatment facilities and commercial laboratories to measure low levels of phosphorus (20 µg/L) accurately and reliably. Suggests that measurements to comply with very low limits will inherently vary, making it challenging to determine both the environmental impact of the discharge stream and the performance of the facility.
Nutrient Management: Volume 2 – Removal Technology Performance and Reliability (NUTR1R06k)	Comprehensive two-year study of 22 real-world full-scale nutrient removal plants designed and operated over three years to meet very low effluent TN and TP concentrations (as low as 3 mg/L TN and 0.1 mg/L TP). Provides database for key decision makers about proper choices for both technologies and rationale bases for statistical permit writing.
Phosphorus Fractionation and Removal in Wastewater Treatment – Implications for Minimizing Effluent Phosphorus (NUTR1R06l)	Investigates wastewater treatment configurations to determine the various P fractions, and their fate and susceptibility to a range of different P removal processes in order to gain better insight into the removal efficiency and mechanism of different P fractions through various treatment technologies.
Striking the Balance Between Nutrient Removal in Wastewater Treatment and Sustainability (NUTR1R06n)	Provides a bench-top analysis on finding the balance between nutrient removal and sustainability in order to determine if a point of diminishing returns is reached where the sustainability impacts of achieving increased levels of nutrient removal outweigh the benefits of better water quality.
Bioavailability and Characteristics of Dissolved Organic Nutrients in Wastewater Effluents (NUTR1R06o)	Investigates the bioavailability and characteristics of various phosphorus fractions from effluents in advanced tertiary treatment processes that are targeted for extremely low effluent TP concentrations.
Surface Complexation Modelling and Aluminum Mediated Phosphorus – White Paper (NUTR1R06r)	Tests a conceptual surface complexation modeling framework which had originally been developed for ferric mediated removal finding that the same model framework described for ferric experiments also works for aluminum experiments, albeit at a different rate of removal.
Solids Role in Tertiary Chemical Phosphorus Removal by Alum (NUTR1R06t)	Examines the capacity and kinetics of phosphorus (P) removal by chemical solids from wastewater and several factors that affect the reactions. Results from the study can help develop process flowsheets to take advantage of the sorptive capacity of these used solids in a cost-effective manner, which in turn could lead to ultra-low effluent phosphorus concentrations at significantly reduced alum doses.
Development of Sustainable Approaches for Achieving Low Phosphorus Effluents (NUTR1R06v)	Evaluates operational practices and performance results for water resource recovery facilities designed to meet very low effluent total phosphorus (TP) concentrations, focusing on maximizing what can be learned from existing facilities to help utilities operate more sustainably while achieving necessary levels of performance.
Phosphorus Analysis in Wastewater: Best Practices White Paper (NUTR1R06cc)	Examines best practices for low level phosphorus analysis in wastewater and discusses whether the lessons learned from freshwater analysis apply to wastewater, or if wastewater has unique characteristics that confound low level phosphorus measurements.

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