Executive **Summary**

WATER ENVIRONMENT & REUSE FOUNDATION

Improving water quality modeling simulations to provide more accurate portrayals of current and future conditions

Nutrient Speciation and Refractory Compounds in Water Quality Models (NUTR1R06aa)

The Central Issue

Water quality models do not generally include an appropriate method to address refractory compounds and monitoring data is not available to fully characterize nutrient speciation and refractory compounds. As a result, inaccurate conclusions may be reached about the response of a waterbody to nutrient loadings following advanced levels of nutrient removal treatment which alters effluent speciation and bioavailability. By understanding and improving water quality models for nutrient speciation and refractory compounds, regulators can better set nitrogen (N) and phosphorus (P) effluent limits and TMDLs that are more representative of conditions following the implementation of nutrient removal.

Context and Background

This study sought to review how nitrogen and phosphorus, specifically the refractory compounds, are defined in the input, interactions, and output of water quality models and to provide recommendations for model updates. The project team used WE&RF research on N and P speciation and reduced bioavailability in comparison to the use of data as input to water quality models for receiving waters. The team also examined a range of other water quality models including available user manuals and model software, discussions with a panel of water quality model experts and code developers, and current examples of model applications.

Findings and Conclusions

The researchers found that more sophisticated deterministic models must be selected to provide the opportunity to consider nutrient speciation and bioavailability. The selection of simplistic mass balance or empirical models will limit the ability to consider nutrient speciation and bioavailability. They also determined that models of nutrient species and refractory compounds are most important when in-stream nutrient target concentrations approach U.S. EPA eco-region nutrient criteria concentrations, or receiving water requirements result in low-effluent nutrient limits approaching limits of treatment technology. The research report provides a summary of receiving water model capabilities which can simulate nutrient species and refractory compounds with case studies.

Management and Policy Implications

This research bridges gaps in the terminology used in wastewater practice and water quality modeling to describe nutrient species and refractory compounds. It provides recommendations for enhancements in water quality modeling practices to improve characterization of wastewater discharges to reflect nutrient species and refractory compounds.

Wastewater Terminology for Nitrogen Species

	Total N (TN)						
	Total Soluble N (TSN)			Total Particulate N (TpN)			
	Ammonia (NH_3) + Ammonium (NH_4)	Nitrate (NO_3)	Nitrite (NO_2)	Soluble Organic N (SON)		Particulate Organic N (pON)	
MODELING TERMINOLOGY	***Ammonia + Ammonium***	***Nitrate***	***Nitrite***	***Dissolved Organic Nitrogen Labile***	***Dissolved Organic Nitrogen Refractory***	***Particulate Organic Nitrogen Labile***	***Particulate Organic Nitrogen Refractory***
	Total Ammonical N (TAN)	Total Oxidized N (NOx)					
	Total Inorganic N (TIN)			Total Organic N (TON)			

Related WE&RF Research

Project Title	Research Focus
Uptake by Algae of Dissolved Organic Nitrogen from BNR Treatment Plant Effluents (NUTR1R06e)	Demonstrates that recalcitrant or very slowly reactive forms of DON can be separated from the bioavailable effluent DON with an XAD-8 resin cartridge based on the different hyrdophocity of these two fractions of DON.
Nutrient Management Volume II: Removal Technology Performance and Reliability (NUTR1R06k)	Studies nutrient removal plants designed and operated for three or more years to meet very low effluent total nitrogen and total phosphorus concentrations. The results will help establish a practical and quantifiable protocol for the analysis of nutrient removal and nitrification plants striving to achieve low effluent concentrations.
The Bioavailable Phosphorus (BAP) Fraction in Effluent from Advanced Secondary and Tertiary Treatment (NUTR1R06m)	Investigates the current analytical methods, speciation of P in different wastewater treatment processes, and the influence and effect of various molecular forms of P on algae growth.
Bioavailability and Characteristics of Dissolved Organic Nutrients in Wastewater Effluents (NUTR1R06o)	Investigates the bioavailability and characteristics of various phosphorus fractions, particularly dissolved organic phosphorus (DOP) fraction, from effluents in advanced tertiary treatment processes targeting for extremely low effluent total phosphorus concentrations.
Mineralization Kinetics of Soluble Phosphorus and Soluble Organic Nitrogen in Advanced Nutrient Removal Effluents (NUTR1R06p)	Examines the dissolved phosphorus uptake kinetics characterization for five treatment facilities in the Spokane, Washington region.
Water Quality Models: A Survey and Assessment (99WSM5)	Evaluates the availability, assessment, and use of hydrodynamic, land-based runoff, and fate and transport models.
Spokane Regional Wastewater Phosphorus Bio-Availability Study (NUTR4C09)	Uses algal bioassays to determine bioavailable phosphorus (BAP) to determine whether the effluents of facilities designed for advanced phosphorus removal tend to make the residual phosphorus more or less bioavailable compared to conventional treatment processes.
Modeling Guidance for Developing Site-Specific Nutrient Goals (LINK1T11)	Presents guidance and tools for the use of models to set waterbody-specific nutrient goals, including numeric nutrient criteria and allowable nutrient loadings.
Modeling Guidance for Developing Site-Specific Nutrient Goals: Demonstration – Boulder Creek, CO (LINK2T14)	Demonstrates that screening-level models can be used effectively to support adaptive management.

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