Executive Summary

WERF

Looking at the impacts of cold and wet weather events on nutrient removal performance

Evaluating the Impacts of Cold and Wet Weather Events on Biological Nutrient Removal in Water Resource Recovery Facilities (NUTR1R06s)

The Central Issue

Maintaining effective biological nutrient removal (BNR) capability during adverse weather events (AWEs) can be challenging for water resource recovery facilities (WRRFs), especially when they are still required to meet nutrient limits and return to effective and consistent operating performance after the event. Mitigation of the impact of these weather events on BNR requires focused strategies that are known to be effective. Guidelines describing strategies that can effectively minimize the impact of these events on WRRFs are needed.

Context and Background

Cold, wet, and cold-wet weather events (referred to in this report as AWEs) are a challenge for many WRRFs. This is because AWEs are typically characterized by high flows, low temperatures, and wastewater with insufficient chemical oxygen demand (COD) to nutrient ratios for optimal BNR. For this research, cold weather events were defined as scenarios where the water temperature at the facility was less than 15°C (59°F) on more than one consecutive day. Wet weather events were identified when the flow exceeded 1.5 times the average daily flow. Production of high-quality effluent during and after these AWEs is critical for WRRFs which are subject to enhanced nutrient removal requirements, many of which are set to meet total maximum daily load (TMDL) requirements.

The project team worked with 12 WRRFs that experience AWEs to identify critical challenges they face when attempting to maintain optimal BNR performance. From the 12 facilities, the team chose three to perform sampling to quantify the effects of AWEs on nutrient removal. Data collected from the sampling and from surveying the 12 facilities were then used to process simulations of the impacts of operational strategies geared towards mitigating the effects of AWEs. With this information, the project team compiled and evaluated strategies, including those currently implemented by BNR facilities, to produce a conceptual framework for responding to AWEs.

This study identifies potential causes of nutrient removal instability and successful mitigation strategies that plant operators can use to mitigate the impacts of cold and wet weather events.

Findings and Conclusions

The researchers found that resistance to and recovery from AWEs is closely linked to WRRF ability to protect and maintain sufficient mixed liquor concentrations and solids retention times for biomass growth. Strategies that employ biomass storage and recirculation are effective for helping WRRFs maintain BNR capacity during and after AWEs. The findings include:

- The primary cause of nutrient removal instability during and after AWEs is linked to solids inventory management. If solids are not protected through minimal wasting or offline storage, nitrogen (N) and phosphorus (P) removal were found to be negatively impacted.
- Dilution of influent biochemical oxygen demand (BOD), in particular readily biodegradable chemical oxygen demand (rbBOD), during high flows may negatively impact biological phosphorus removal and denitrification.
- Reduction of forward flow hydraulic retention time (HRT) and operation at lower temperatures impairs the overall biological capacity of the basins due to insufficient contact time to accommodate the reduced biomass kinetics.
- High DO concentrations from the influent will reduce the capacity of anoxic and anaerobic zones, thereby reducing N and P removal efficiency.
- During AWEs, an examination of COD concentrations is needed to determine whether a decrease in wastewater strength will significantly impact the biological capacity for denitrification and/or P removal.
- Dilution of influent TN and TP concentrations may be the primary cause of lower effluent concentrations observed during AWEs.
- Developing standard operating procedures/response plans that take into account site-specific infrastructure, operating targets, and effluent limit requirements is essential to help operators respond to long- and short-term AWEs.

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Management and Policy Implications

Future design of new WRRFs and facility upgrades should include the ability to implement recommended operational strategies in the report. Existing facilities that do not have such flexibility should be regulated using useful and appropriate tools such as seasonal nutrient limits that consider the impacts of AWEs. This transitional approach would allow the utility to prepare for a capital improvement project to provide additional operational flexibility, as well as increased treatment capacity as required.

In this report, the researchers list operating parameters to assist facilities with the diagnosis and recovery from AWE impacts. The report provides a concise description of the primary challenges faced by full-scale BNR facilities during AWEs. It also discusses strategies that have been successfully and unsuccessfully used by utilities for minimizing the impact of AWEs on BNR.

Strategies for Mitigation of AWE Impacts to BNR

Stratgegy	Process Implications/Benefits
Increase MLSS	Maintaining a higher MLSS concentration during cold weather conditions effectively increases the SRT, allowing retention of slow growing organisms.
Flow Equalization	Equalization can act to reduce hydraulic loading to the biological process (and clarifiers), minimizing the chances of solids washout.
Step-Feed/Contact Stabilization	Step-Feed / Contact Stabilization can protect sensitive biomass populations by preventing biomass washout in the system. In some cases, complete bypass of some unit processes may be necessary. Optimization of current step-feed systems by operating at different flow splits during dry versus wet weather may also yield a significant BNR performance benefit.
Bypass/Blending	For BNR plants with combined collection systems, bypassing biological treatment and blending using high-rate clarification (such as ballasted flocculation technologies) could help maintain biomass while meeting permit limits during AWEs. This approach may not be permitted in some regions, particularly for plants with separate sanitary sewer systems.
Biomass Off-Line Storage/ RAS Equalization	Allows protection of a portion of the biomass by removing it from the treatment system during wet weather events. This strategy prevents washout and preserves important system biomass.
Increase VFA Addition from Fermenter	Understanding and matching VFA needs is critical to ensuring optimal biological P removal during AWEs when insufficient carbon may be present in the influent.
Change Internal Recycle Rates and Locations	Addition of an internal recycle stream from aerobic to pre-anoxic zone can allow maximization of use of carbon from the influent. There may also be scenarios (e.g., recovery from nitrification failure) when the internal recycle needs to be reduced/eliminated to maximize use of the aerobic volume.
Supplement Biomass from Solids Storage or External Source of Nitrifiers	In this strategy, solids stored in the normal biosolids processing facilities can be used to bioaugment and supplement biomass in existing process units after a storm event has passed. The system may also benefit from low levels of fermentation that occurs during sludge storage.
Intermittent Aeration/Mixing	Prevents washout of biomass during high flow events for plants with limited storage/volume capacity. The plant cycles aeration and mixing for brief periods of time to maximize sludge storage within the reactor basins and also to ensure that aerobic biomass activity is maintained. The schedule of aeration cycles must allow plants to meet weekly and monthly TN and TP limits. Metal salt addition may be needed to ensure that TP limits are met during operation of this strategy.
Aeration Basin "Swing" Zone	An area of the aeration tanks in which the air can be turned off could prevent the biomass from being suspended, thereby reducing the risk of biomass washout. Similarly, areas that are normally unaerated could have the air turned on to ensure sufficient aerobic HRT. Metal salt addition may be needed to ensure that TP limits are met during operation of this strategy.
Sidestream Treatment/ Equalization	Treatment of sidestreams from solids digestion, thickening, and dewatering processes helps to minimize nutrient loads to biological treatment during AWEs, thereby reducing the risk of insufficient treatment. Sidestream storage to equalize nutrient load during AWEs should be done at a minimum.
Chemical addition to assist with settling and achieve P removal	Uses metal coagulants and/or polymer to improve settling of solids in clarifiers to prevent biomass washout. Chemical addition is commenced prior to wet weather events in anticipation of the discharge of effluent solids from the secondary clarifier. The rate at which chemical is added should be determined through site specific jar testing.

Related WERF Research

Project Title	Research Focus
Nutrient Management: Volume 2 – Removal Technology Performance & Reliability (NUTR1R06k)	Highlights a comprehensive two-year study of 22 real-world, full-scale nutrient removal plants designed and operated over three years to meet very low effluent total nitrogen (TN) and total phosphorus (TP) concentrations (as low as 3 mg/L TN and 0.1 mg/L TP). Provides a database for key decision makers looking for 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.
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.

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TECHNOLOGY SCANS PRESENTATION – JUNE 17

The next series of Technology Scans vendor presentations will take place on June 17th at noon EDT. All subscribers are encouraged to register.

NEW LIFT STEERING COMMITTEE MEMBERS APPOINTED

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Proposals in all relevant wastewater, stormwater, and water quality areas are welcome. Submissions are due no later than 5:00 pm EDT on Thursday, July 16, 2015.

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