EXECUTIVE SUMMARY

WERF

WATER ENVIRONMENT RESEARCH FOUNDATION

NUTRIENTS

Nutrient Management Volume II: Removal Technology Performance and Reliability

To help wastewater utilities and regulators better understand the capability of nutrient removal facilities, WERF partnered with WEF on a two-year comprehensive study of 22 treatment plants nationwide. The plants were designed and operated to meet very low effluent total nitrogen (TN) and total phosphorus (TP) concentrations, some as low as 3.0 mg/L TN and 0.1 mg/L TP. Managers of the 22 plants, 10 achieving low effluent TP, nine achieving low effluent TN, and three achieving low effluent ammonia (NH_3-N), provided three years of operational data that were analyzed using a consistent statistical approach.

This research establishes a practical and quantifiable protocol for the analysis of nutrient removal and nitrification for plants striving to achieve low effluent concentrations.

Technical information was compiled for each plant. It included a summary of influent loading, process design and operating conditions, unusual events, upsets and anecdotes related to process operation, and the statistical summary of final effluent data that considered both process reliability and the permit limits applied.

Performance Varies for All Plants – 100% Reliability is Unrealistic

A major finding of the study was that statistical variability is a characteristic of all these exemplary plants. This variability should be recognized in both evaluation of technologies (e.g., stratifying them in terms of their capabilities) in an engineering environment and in determining the appropriate effluent limits in the regulatory permit setting environment.

Although water quality protection must be the focus of point source nutrient permitting efforts, almost all discharge permits applied to treatment plants in the United States require near 100% reliability. The consequence of not achieving this level of reliability is a permit exceedance, which can lead to fines for violating the permit limit. This study found that deterministic permit limits may not be appropriate for plants achieving very low nutrient limits, particularly when the limit is based on technology (concentration) rather than water quality-based (load). In addition, long averaging periods (i.e., annual average) are warranted given the inherent increase in variability of processes that must remove N and P species to concentrations approaching zero.

Local site conditions impact the performance achieved on average and in terms of statistical variability. These factors include:

- Process design
- Climate impacts
- Wet weather flow influences
- Attributes of the service area
- Variation in influent flows and loadings
- Presence/absence of industrial contributions
- Is solids processing on the same site
- Sustained/interrupted chemical supply
- Construction impacts
- Mechanical failures
- Degree of difficulty in operating the process
- Ability to automate the controls of a process
- How close actual operation is to design flows and loadings
- Other factors

BENEFITS

- Focuses on maximizing what can be learned from existing technologies in order to provide a database that will inform decision makers about proper choices for both technologies as well as a rational basis for statistical permit writing.
- Demonstrates that statistical variability is a characteristic of all exemplary plants.
- Demonstrates that variability should be recognized in both technology evaluations in an engineering environment, and in determining appropriate effluent limits in the regulatory permit setting environment.

RELATED PRODUCTS

Nutrient Management Volume I: Regulatory Approaches to Protect Water Quality – Review of Existing Practices (NUTR1R06i)

Striking the Balance between Nutrient Removal in Wastewater Treatment and Sustainability (NUTR1R06n)

Nutrient Management Volume III: Guidance on Permitting Strategies for Achievable and Sustainable N & P (NUTR1R06o)

AVAILABLE FORMAT

Soft cover and online PDF

Note: Additional data files for each of the 22 participating facilities are available online for WERF subscribers (WEF/WERF Study Quantifying Nutrient Removal Technology Performance)

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The inherent variability makes it inadvisable to directly translate either the average performance or the statistical variability directly from a known plant situation to another location where there is no supporting database (for example, for a plant converting from secondary treatment to nitrification or nitrogen removal).

Practical and Quantifiable Protocol Developed

A statistically valid technique was developed to analyze treatment plant data and help determine the reliability of nutrient removal process performance. Using percentiles calculated from final effluent data, the performance of the process and its associated reliability and variability can be better described and quantified. These are proposed as "Technology Performance Statistics" (TPS) and defined as three separate values representing the *ideal*, *median,* and *reliably achievable* performance. TPS values provide plant owners, designers, and regulators a tool to determine the ability of a technology or process to meet permit limits under consideration.

- The lowest 14-day per year performance (3.84th percentile or rank) represents the ideal TPS value (TPS-14d). It provides an unbiased value of the "ideal" (albeit impractical or unrealistic) performance of the technology – when it is minimally influenced by all the factors that cause statistical variability in real plants.

- The median value (TPS-50%) provides a statistical assessment of expected performance on an annual basis and provides a means for quantifying process variability when compared to other TPS values.

- The reliable performance is typically based on the 95th percentile, a typical measure of maximum month performance, but this selection depends on the risk tolerance of the utility, as this value would also represent three exceedances of a monthly permit limit in a typical five-year permit cycle.

It should be noted that operating conditions and specific conditions under which the data were collected impacts TPS values. Permit or target treatment goals, external factors such as wet weather or industrial discharges, and internal factors such as construction also impact the variability of results. All data should be included in the analysis. If special circumstances exist to exclude some data, these exclusions should be clearly stated.

Additional Findings

- Separate stage N plants outperform combined N plants due to the higher degree of denitrification control possible.

- Four- or five-stage Bardenpho plants come close to meeting TN of 3 mg/l, 95% of the time; and 10 Florida plants show a capability of 3.5 mg/L. The exemplary performance of the cold climate Kalkaska (MI) plant shows that it may reach close to 3.0 mg/L TN.

- New plants without a good database need to use caution in relying on the data – process design models do not capture reliability issues for effluent limits that are close to zero.

- Governing boards, councils, and regulators need to reassess "no violation" or "no risk" policies, as operating close to "zero" can never be risk free.

- The common goal for regulators, operators, and plant designers should be to define plant investments that are supported by sound statistical bases for regulation that are environmentally protective and technologically achievable.

- Many claims are made about the capabilities of specific technologies in reaching low nutrient concentrations. Unless supported by statistical analysis of data from longer term operating periods, these claims should be viewed with a high degree of skepticism. This investigation establishes a new protocol that should be used for data presentation in the future, so data between studies can be comprehensively compared.

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