Westchester County's Success Story Using Biofiltration

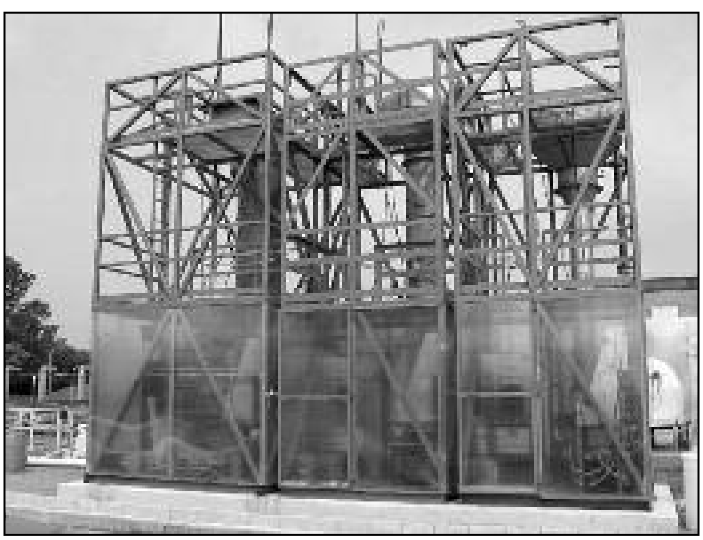
by Frederick M. Kincheloe, Ralph Butler, Thomas Lauro and R. Srinivasaraghavan

Westchester County, New York owns and operates four wastewater treatment plants that discharge to the Long Island Sound – Blind Brook, Mamaroneck, New Rochelle, and Port Chester. Water quality issues in the Sound have led to the assignment of nitrogen waste load allocations (WLAs) by the Environmental Protection Agency (EPA) to communities surrounding the Sound. As the permitting authority in New York State, the New York State Department of Environmental Conservation (NYSDEC) modified existing discharge permits to include these WLAs (as well as other parameters). Based on the WLAs and the permitted flow, all four plants are required to meet an average total nitrogen concentration of less than 4 mg/L (milligrams per liter).

As an integral part of developing a nitrogen management strategy, several pilot studies were performed. One of these pilot studies includes the investigation of the biofiltration process for total nitrogen (TN) removal. The principal objective of the study was to verify the capability of this process to meet the future TN, total suspended solids (TSS), and carbonaceous biochemical oxygen demand (CBOD) limits. A principal concern was meeting the nitrogen discharge goals under low temperatures seen in Westchester County's wastewater. Other objectives included evaluating varied process operating conditions to determine target hydraulic and pollutant loading rates.

Methodology

The pilot study was carried out at the New Rochelle wastewater treatment plant, which includes pumping, screening, primary treatment, pure oxygen activated sludge process tanks, secondary settling, and disinfection. Primary and secondary sludge are combined with sludge from another facility (Mamaroneck) and thickened in gravity thickeners. Thickened sludge is dewatered in belt presses and trucked off site. Thickener overflow is directed to the secondary influent channel. The biofilter pilot facility utilized primary effluent (upstream of secondary influent channel) and secondary effluent (upstream of disinfection) as feed sources.



Courtesy of Savin Engineers P.C.

Figure 1. The three-stage biofilter pilot facility

Biofiltration is a multi-step biochemical process that uses media and fixed film bacteria to remove organics and nitrogen. There are several different vendors and media types that are available. In this pilot test the BIOFOR™ submerged biological filter was evaluated under a range of wastewater conditions and under three different process configurations.

Flow was directed through 2 mm (millimeter) screens and then upward through a bed of clay media which is used for both filtration and as a surface for fixed film bacteria to grow. As flow moves through the media, solids are filtered and pollutants are biologically removed. The pilot test included a combination of three biofiltration units that were used to assess TSS, BOD, and nitrogen removal. The pilot facilities are shown in ***Figure 1*** and a schematic is shown in ***Figure 2***.

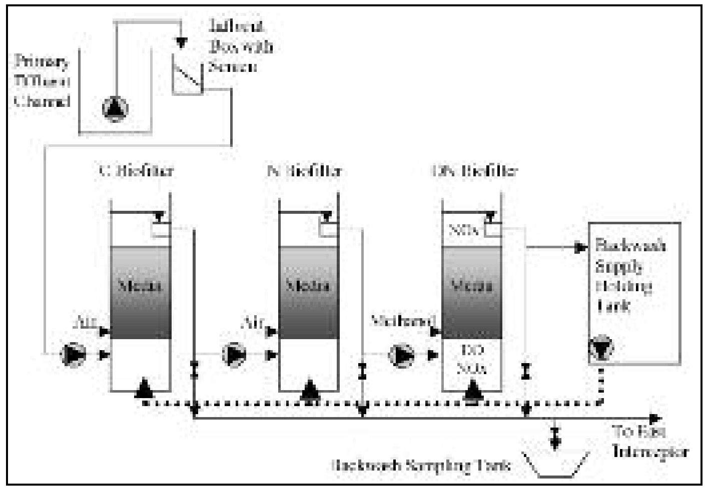


Figure 2. Three-stage biofilter process schematic

The three pilot units were modified during the study to evaluate alternative process configurations. Initially, wastewater was taken from the primary effluent channel to evaluate a three-stage process configuration (carbonaceous removal, nitrification, and denitrification) for the removal of TSS, CBOD and TN ***(Figure 3)***.

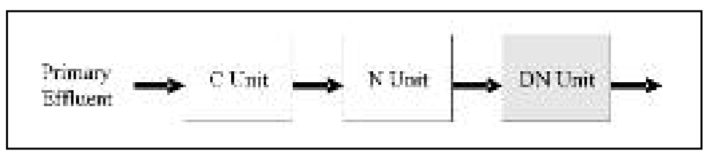


Figure 3. Three-stage process configuration

For the second process configuration, wastewater was also taken from the final effluent chamber to evaluate a two-stage add-on process (nitrification and denitrification) for the removal of TN ***(Figure 4)***.

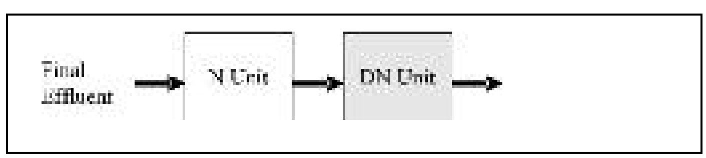


Figure 4. Add-on process configuration

The third process configuration evaluated a potential cost savings approach to nitrogen reduction by recycling flow between the first and second stages to evaluate the three-stage pre-denitrification (PDN) process ***(Figure 5)***. The recycling of flow allows the process to utilize the inherent wastewater characteristics and reduce the supple-

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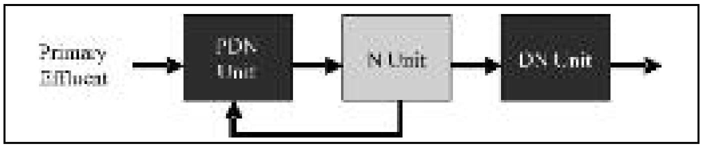

Figure 5. Three-stage pre-denitrification (PDN) process configuration

mental chemical requirements.

The pilot facilities started up in July 2004 and testing occurred from September 2004 through June 2005. Characteristics of the pilot facilities are shown in ***Table 1***. A wide range of operating and wastewater conditions was evaluated.

Key to the pilot testing was the ability of the pilot to be tested at the low design temperature that typically limits nitrification processes. As shown in ***Figure 1,*** the pilot facility and the system filter feed tanks were located outdoors throughout the study period. This provided some additional maintenance issues during cold weather, but because the pilot was not heated, the wastewater was chilled below design temperature. Even though the detention time through the biofilter system is very low (approximately 1.5 hours through the filters), the waste stream passed through the metal filter column and was cooled as it went through the process. Temperatures were actually lower than what the plant has historically seen.

Results

The pilot testing showed that regardless of the configuration, biofiltration is a technology that is capable of meeting future secondary treatment and nitrogen reduction requirements at the New Rochelle WWTP. The three different process configurations show that the average effluent nitrogen discharge was less than 3 mg/L (2.6 mg/L over the study period). Effluent TSS and CBOD were 7.9 mg/L and 7.2 mg/L, respectively. Performance of the system was maintained even as daily temperatures reached 8 degrees Celsius. Performance is shown in ***Figures 6 through 8***.

The three-stage (C-N-DN) and pre-denitrification (PDN-N-DN) process configurations were operated under varied hydraulic loading conditions to stress test each system. The add-on (N-DN) process configuration was operated under the optimal hydraulic loading conditions identified during the C-N-DN testing and was only operated for a brief period of time. The intent of the N-DN configuration was to confirm that the performance of the N and DN units would be the same regardless of the secondary treatment process. The N-DN testing showed better performance because it was not stress tested and was operated for a brief period of time. It is anticipated that over a longer period of time and under greater loading conditions, the N-DN configuration will have similar performance to the other process configurations.

Alkalinity and methanol usage during the testing period was monitored and showed uptake rates consistent with the EPA Nitrogen manual. The methanol control system provided by the vendor worked well with limited maintenance. The control system consisted of upstream nitrate and dissolved oxygen probes and a separate downstream nitrate probe. An algorithm was developed to control the dose with the upstream probes and trim the dosage based on the effluent. The system maintained good nitrogen removal with minimal methanol bleed through.

Discussion

The N and DN units in all three configurations showed the same pollutant load and hydraulic load limitations. The choice to use a three-stage system versus using an add-on system will be based on a cost comparison of the C (carbonaceous removal) unit to the upgrade costs of the existing secondary treatment system.

The practicality of using the PDN-N-DN configuration over the C-N-DN configuration is questionable for this application. The PDN-N-DN configuration was able to significantly reduce the nitrate load that went to the DN unit resulting in a savings of methanol. However, the PDN configuration requires recycling of flow that forces the sizing of the PDN and N unit to be based on each unit's hydraulic limitation. In comparison to the C-N-DN configuration, the hydraulic limitation of the PDN or 7.6 gpm/sf (gallons per minute per square foot) is higher than the hydraulic limitation of the C unit (2.9 gpm/sf). However, depending on the amount of recycle flow, the total size of the PDN unit may be slightly larger, smaller, or comparable.

Under both configurations, the N unit had the same hydraulic limitation. Based on the higher hydraulic loading caused by the recycle flow, the overall size of the N unit will be significantly larger under the PDN-N-DN configuration. The DN unit under both configurations is limited by hydraulics and is not impacted. In the case of New Rochelle, the wastewater characteristics are relatively dilute. The sizing of the filters will be based on hydraulics and, therefore, additional recycling will result in a much larger system. In comparison with the necessary infrastructure costs, the chemical savings will not offset the cost for construction. For plants with a more concentrated

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Table 1. Pilot facility characteristics

Pilot Unit	Pilot Diameter (ft)	Media Depth (ft)	Media Size (mm)	Hydraulic Loading Rate (gpm/sf)	
				Min	Max
3 Stage Process Configuration					
Carbonaceous	3	12.1	2.7	2.3	4.5
Nitrification	2	12.1	2.7	1.9	3.8
Denitrification	1	9.5	3.5	5.1	11.5
Add-on Process Configuration					
Nitrification	2	12.1	2.7	2.9	2.9
Denitrification	1	9.5	3.5	6.4	6.4
3 Stage Pre-denitrification Process Configuration					
Pre-denitrification	2	9.5	3.5	6.4	8
Nitrification	3	12.1	2.7	2.6	3.1
Denitrification	1	9.5	3.5	6.4	6.4

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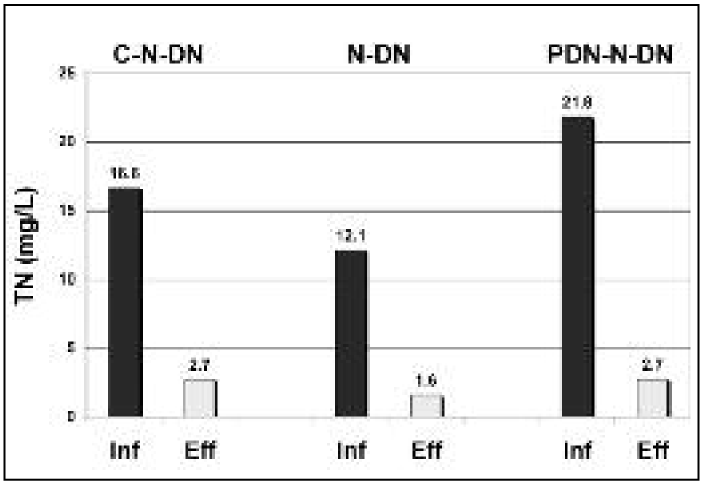

Figure 6. TN discharge performance

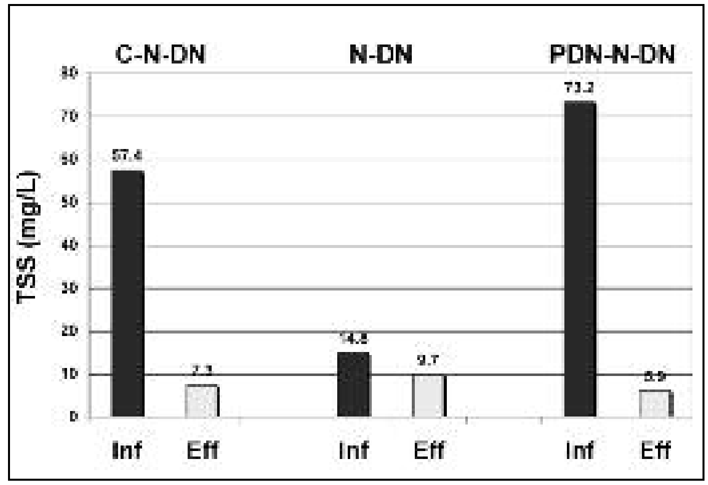

Figure 7. TSS discharge performance

wastewater source where the limiting sizing factor is pollutant load, additional flow can be recycled without impacting the necessary size of the biofilters.

Conclusions

The results of this pilot study confirm that a total nitrogen of less than 3 mg/L can be achieved under the cold wastewater temperatures anticipated in Westchester County. Three different process configurations are viable to meet these stringent limits. Hydraulic and pollutant load limitations for each process configuration have been identified. Alkalinity usage through nitrification is similar to standard values. On occasions where there was bleed-through of ammonia from the N unit, a portion of that ammonia was removed in the DN unit and the overall total nitrogen remained low. The methanol control system provided with the BIOFOR™ system achieved an effluent NOx concentration of less than 1 mg/L with minor methanol bleed-through. The PDN unit was able to successfully remove CBOD without the addition of air. The information gained by the pilot results helped to size full-scale facilities and develop the most cost effective nitrogen removal approach for Westchester County.

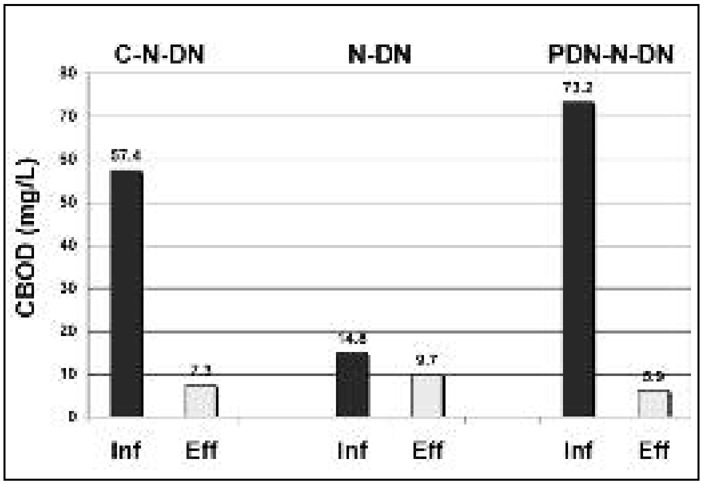

Figure 8. $CBOD_5$ discharge performance

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