By Rich Schici

Collection System Bioreactors

Influence of biofilm modification on nutrient removal within sewers

Nitrogen and phosphorous are nutrients that are essential to the growth of plants. Nitrogen and phosphorus are also the primary causes of eutrophication (nutrient enrichment from excessive plant growth and decay) in water that receives wastewater from treatment plants. Eutrophication may cause an algal bloom, a rapid growth in the population of algae.

ARTICLE SUMMARY

Challenge: Nitrogen and phosphorus removal is now even more challenging as limits have been set lower recently.

Solution: Municipalities and treatment plants have begun looking beyond traditional technologies to methods such as biofilm modification.

Conclusion: In-Pipe incorporated its biofilm modification technology into several installations, which then saw decreases of nutrient levels by as much as 87%.

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The algae become unsustainable and eventually die. The bacterial decomposition of the algae depletes the water environment of dissolved oxygen such that most or all of the aquatic animals die. Consequences of the discharge of treated wastewater effluent containing significant concentrations of nitrogen and phosphorus include fish kills, murky water and depletion of desirable plants and aquatic life.

Approximately 25% of all water body impairments are due to nutrient-related causes, including oxygen depletion, algal growth, ammonia and biological integrity. In efforts to reduce the number of nutrient impairments, wastewater discharge permits have lowered effluent limits for nitrogen and phosphorus. In order to achieve these lower limits, municipalities have begun looking beyond traditional treatment technologies.

Biological nutrient removal (BNR) removes total nitrogen and total phosphorus from wastewater through the use of microorganisms under different environmental conditions in the treatment process. It is one of the most significant challenges facing wastewater treatment plant (WWTP) operators today due to the high cost of advanced wastewater treatment. Modification of the biofilm within the sewer aims to reduce the load entering the plant by improving the conversion process in the sewer.

With the help of technology, several municipalities use their collection systems to improve nutrient removal using a patented microbiological method that enhances the BNR processes by creating biological modifications of the sewer biofilm. The technology includes regular additions of a highly concentrated formulation of facultative soil bacteria at multiple strategic locations throughout the entire collection system in accordance with an engineered treatment plan.

Treating Wastewater at the Source

The microbiological community within the sewer and plant includes aerobic, anaerobic and facultative bacteria. Miles of existing sewer piping contain various layers and amounts of biological slime, or biofilm— a community of microorganisms similar to a trickling filter, a rotating biological contactor or rocks in natural streams. The sewer biofilm is the same attached-growth biological process used to remove organic matter in many treatment plants. The microbiology of the biofilm present in the sewer can be utilized as an effective treatment step if engineered and controlled for that purpose.

The added facultative bacteria grow throughout the interior surface of the sewer pipes and dominate the sewer biofilm through the microbiological principal of competitive exclusion. By out-competing the nonbeneficial bacteria for nutrients, the high concentrations of beneficial microbes grow and populate the sewer pipes and lift station wet wells to optimize the entire infrastructure. Modifying the biofilm populations and reactions catalyzed by an increase in biological activity increases the level of nitrification by the engineered biofilm. With the collection system acting as a pretreatment reactor or fermenter, the dominant facultative bacteria take advantage of the residence time of the wastewater within the sewer to degrade the waste.

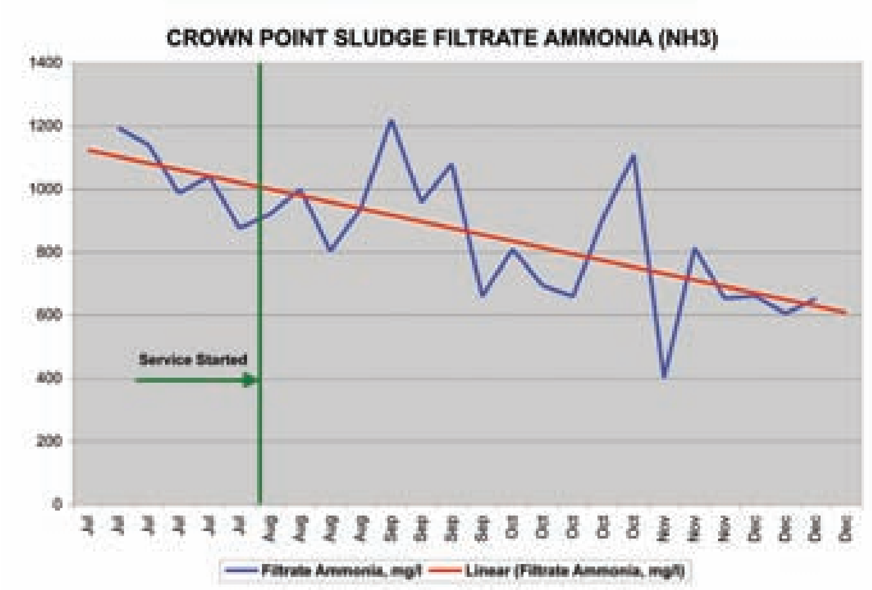
Over time, the added facultative bacteria convert the biofilm on the interior surface area of the infrastructure into a controlled, beneficial microbiological population. They also metabolize fats, oils and grease in the collection system and at the treatment plant. This collection system bioreactor provides beneficial treatment within the sewer by accelerating metabolic conversions that reduce and modify organic, solids and nitrogen loads entering the WWTP.

Biological Process Description

Organisms in the biological formulation are heterotrophic facultative anaerobes that can grow quickly in either anoxic conditions by using nitrate as a final electron acceptor or aerobically, using oxygen as the final electron acceptor and fermentation at any stage in between. The added bacteria have a competitive advantage over the indigenous intestinal bacteria, but only if they are added at a higher level than occurs in normally untreated conditions.

Heterotrophic bacteria were shown to have symbiotic and sometimes communal interactions with nitrifying bacteria. The heterotrophs provide the autotrophic nitrifiers with a carbon source as a byproduct of their nitrification and denitrification activities. The heterotrophs also were shown to reduce the amount of excretion products that can inhibit the growth of *Nitrosomonas* bacteria while they make use of the organic excretion products for their own energy in carbon-depleted environments. In addition, the increase in the influent heterotrophic plate counts beneficially impacts the rates of metabolism within the wastewater treatment for synthesizing organic matter.

The addition of the select facultative microbiology



allows a gradual repopulation of the sewer biofilm by bacteria that are more efficient at biological nutrient removal than the bacteria that are present in natural, untreated conditions. As the added bacteria grow, multiply and reach the wastewater treatment facility, they assist in further degradation of the remaining chemical oxygen demand (COD) in all phases of treatment. The newly diversified bacterial population is better able to assist the bacteria primarily responsible for nitrification and denitrification than the indigenous population present in untreated wastewater treatment facilities by increasing the oxidation of soluble organic matter and reducing influent nitrates.

Performance History & Discussion

In a study of In-Pipe Technology conducted by Dr. Andrew Randall of the University of Central Florida, increased influent rbCOD and heterotrophic plate counts coincided with the start of microbial additions. Readily biodegradable COD increases can improve biological nitrogen removal as a result of significantly lower influent carbonaceous BOD (CBOD) than influent BOD. The study identified that this is largely due to an increase in nitrification within the sewer as the influent changes during biofilm modification have the potential to favorably impact BNR in the collection system and preliminary wastewater treatment.

Case Studies

New York. In-Pipe Technology Co., LLC was selected for Plant 18 (0.15 million gal per day [mgd]) in Suffolk County, N.Y., with goals to illustrate improved effluent quality and increased plant efficiency for nutrient removal. The WWTP's RBC units were heavily overloaded and routinely sanitized. After an engineering review of the collection system, In-Pipe installed six dosing points throughout the system to dispense microorganisms into the sewer.

The results after 18 months (from February 2007 to July 2008) demonstrated that effluent ammonia decreased 54% from 6.0 to 2.7 mg/L, effluent TKN decreased 47% from 11.1 to 5.9 mg/L and influent nitrates decreased 73% from 1.1 to 0.3 mg/L.

Texas. At the Northampton Municipal Utility District in Spring, Texas (0.4 mgd), In-Pipe service began in April 2007, with goals to increase efficiency at the plant without capital expansion of the facility. In-Pipe installed 13 dosing points throughout the collection system. The results after 12 months demonstrated that influent total suspended solids load decreased 26% from 750 to 560 lb/day, effluent CBOD decreased 47% from 6 to 3.1 mg/L and effluent ammonia decreased 87% from 3.9 to 0.5 mg/L.

Florida. Orange Park, Fla., selected In-Pipe service in April 2008 with goals to improve the Ash Street WWTP (1 mgd) performance, reduce influent organic load and reduce influent nitrogen during construction to modify the existing WWTP. In-Pipe installed 20 dosing points throughout the collection system. The results after seven months demonstrated influent CBOD decreased 46% from 206 to 112 mg/L; influent TKN decreased 21% from 40 to 31.8 mg/L; influent total nitrogen decreased 16% from 38 to 32 mg/L; and effluent total nitrogen decreased 40% from 22.4 to 13.4 mg/L.

The foregoing demonstrate, on a variety of locations and processes, the ability of engineered biofilm modifications to deliver valuable performance enhancement and BNR within existing systems without the need of modifications to the treatment process. This solution can be deployed quickly with results beginning in only a few weeks. WWD

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