IFAS Pilot Study for Cold Weather Nitrogen Reduction

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ABSTRACT

Facing a new effluent total nitrogen discharge limit, the Town of Stafford Springs Connecticut chose to upgrade their Water Pollution Control Facility using a fixed media Integrated Fixed-Film/ Activated Sludge (IFAS) system. The IFAS media would allow a retrofit of the existing aeration basins for biological nutrient removal without having to add basin volume. The raw influent wastewater was a mixture of municipal and industrial wastes that included at high concentration of fibrous suspended solids from a local textile manufacturer. Because of the unusual nature of the wastewater, a pilot study was commissioned to confirm the design basis for the IFAS system. After good initial results, the pilot study was cut short due to operational difficulties associated with the fibrous influent. Other fixed media IFAS systems were studied to help confirm the design rate, and the Town decided to proceed with construction of the IFAS system in April of 2009.

KEYWORDS: BioWeb, IFAS, integrated fixed-film activated sludge, nitrification

INTRODUCTION

The Town of Stafford Springs Connecticut Water Pollution Control Facility (WPCF) has elected to install a fixed media Integrated Fixed Film/Activated Sludge (IFAS) system to enhance nitrification as part of an upgrade for biological nutrient removal (BNR). The plant currently treats 1.4 mgd with a two-train conventional activated sludge process. The biological treatment system has not changed since it was constructed in 1972. The current plant process has limited denitrification capacity and therefore struggles to meet the new nitrogen standards established by the Connecticut Department of Environmental Production (DEP). The WPCF received a new effluent discharge limit that requires total nitrogen removal or payment of annual fees to purchase nitrogen credits. A review of the existing WPCF process and operating data indicated that the existing plant has a unique wastewater with high TSS and has been unable to nitrify year round.

After an extensive investigation, the Town of Stafford and their consulting engineer CDM decided that the town would pursue increased treatment effectiveness, rather than purchase nitrogen credits under Connecticut's nutrient trading program. The plant is land locked with no room to build new tanks for enhanced BNR treatment. IFAS technology was determined to be the most suitable and cost-effective solution for nitrogen removal as a result of a desirable

combination of no additional space required, relatively low capital costs, and significantly lower power costs. The high concentration of influent solids is essentially inert and very fibrous in nature and comes from a local manufacturer. The potential for ragging and plugging determined the choice of fixed media over moving media. Representatives from the Town of Stafford and CDM screened potential manufactures and selected Entex BioWeb^{TM} fixed media.

METHODOLOGY

The upgrade for nitrogen removal was designed with three major considerations: the unique raw wastewater characteristics, the conversion of 25% of the basin volume to anoxic basins and the ability to nitrify in cold weather. The raw influent wastewater at the WPCF is a mixed industrial and domestic waste with highly fibrous TSS loading of 564 mg/L, low BOD concentrations at 161 mg/L and high COD/BOD ratio of 3.4. The high concentration of influent solids is largely inert and very fibrous in nature and comes from a local manufacturer. The WPCF shuts down each train once every two years to clean out the accumulation of inert solids in the bottom of the aeration basins. In the past there have been no restrictions on pretreatment from the local manufacturer.

Year round nitrification at waste water temperatures as low as 10 degree Celsius is required. To achieve both nitrification and denitrification the plant will be converted to a Modified Ludzach-Ettinger process in which nitrified mixed liquor is returned from the end of an aeration basin to an anoxic zone in the front of the aeration basin for denitrification. Approximately 25% of the aeration volume will be converted to anoxic basin and an internal mixed liquor recycle will be added.

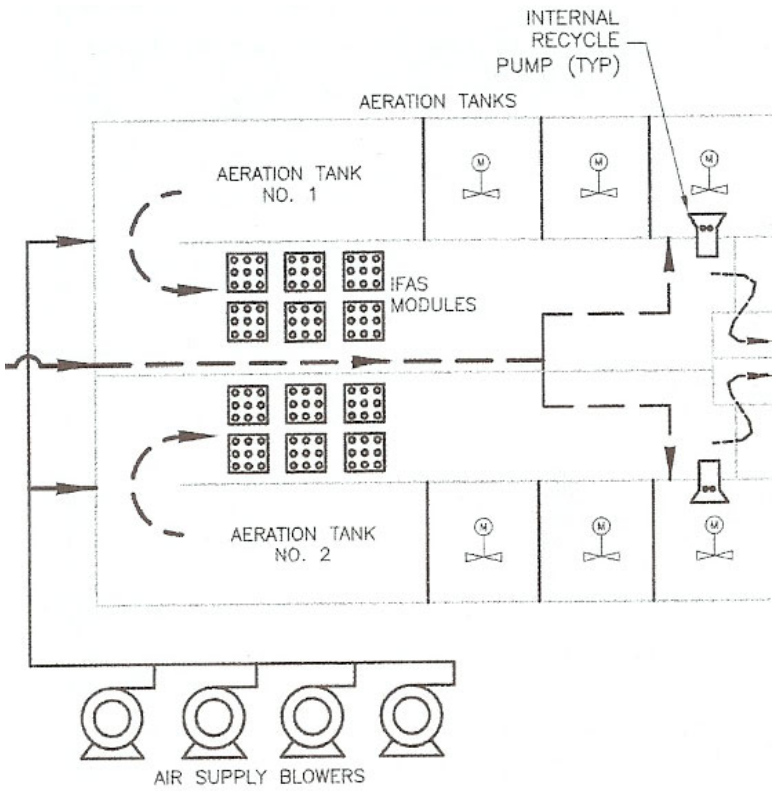

Figure 1 – New Process Flow Diagram – 25% Anoxic Volume

The first two zones are anoxic with a total volume of approximately 74 m^3. The third zone is a swing zone with an approximate volume of 74 m^3. The first aerobic zone has a volume of approximately 283 m^3 and the final aerobic zone is approximately 580 m^3. Because so much of the aerobic volume required for nitrification is being converted to anoxic volume, the IFAS media will be added to the middle of the aerobic zones to increase the effective overall aerobic SRT of the system. The additional fixed biomass provided by the media will ensure that the plant can nitrify even in cold winters.

The media chosen for the Stafford Springs upgrade is the BioWeb fixed media to be operating in an arrangement called Webitat. Webitat modules, as shown in Figure 2, are media cells with dedicated air scouring systems to keep the biofilm thin and provide for redworm control. The thinner biofilm enhances the overall nitrification rate while simultaneously controlling predatory redworms. The Webitat modules will be placed in the aeration zones.

Figure 2 – Webitat Module

Given the influent loading conditions, the system dimensions and the biological treatment requirements the proposed plant was modeled using BioWin 3.1, a simulator used in the analysis and design of waste water treatment plants.

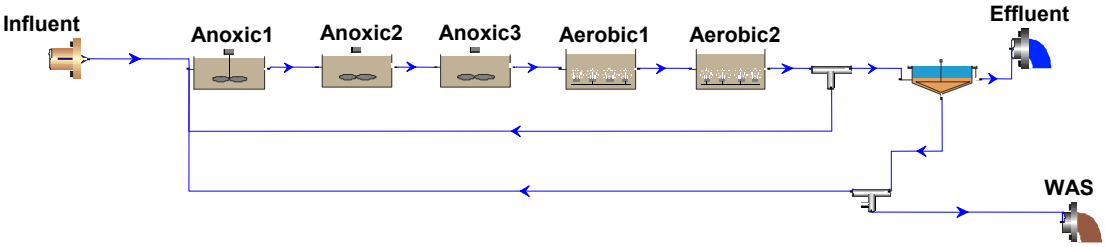

Figure 3 – BioWin Model

The high TSS loading in the influent relative to the low BOD presented major challenges with running the BioWin simulation. Extremely detailed fractionation and characterization of the influent wastewater was not available, so initially the system was modeled ignoring the high inert solids concentrations.

For the IFAS design, a nitrification rate of 12.2 kg of ammonia removed per 1000 m^2 of BioWeb was used. This rate was selected as a design basis after reviewing the performance of a successful full-scale demonstration of a BioWeb fixed media IFAS upgrade at the Windsor Locks WPCF, also in Connecticut (Hubbell, 2004).

Because of the unique characteristics of the Stafford Springs wastewater, and the simplifying assumptions required to make the BioWin simulation work, a decision was made to confirm the design basis for the full scale facility by piloting the fixed media at the WWTP site using actual influent. A pilot plant was constructed and shipped to the WPCF for operation. The pilot plant at a 1:486 scale consists of three anoxic tanks, three aerobic tanks, with fixed media installed proportional to the full scale design and a clarifier as shown below in Figure 4.

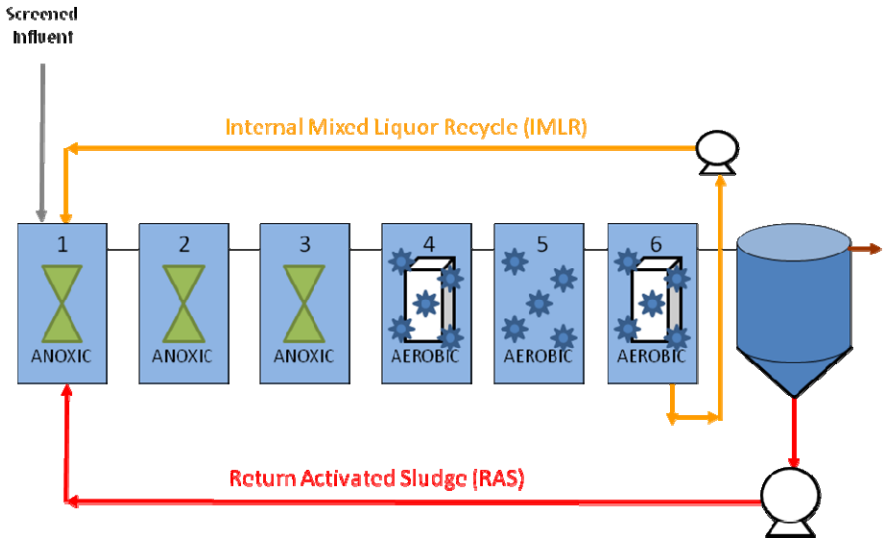

Figure 4 – Pilot Plant Flow Diagram

The influent to the full scale plant was analyzed for BOD, COD, TSS, VSS and TKN before it was diverted to the pilot plant via a rotating drum screen to remove fibers and other inorganic solids. Dissolved Oxygen (DO) and temperature were continuously measured in each of the three aerobic tanks by online probes. A pH probe was mounted at the discharge of the first aerobic tank and a second was mounted at the discharge of the third aerobic tank to the clarifier in addition to an ammonia probe. Grab samples taken from the second aerobic tank were analyzed for BOD, COD, TSS, VSS, NH_3N, PO_4P and TKN. A composite sampler collected effluent of the clarifier to be analyzed for BOD, COD, TSS, VSS, NH_3N, PO_4P and TKN.

Figure 5 – Pilot Plant

The pilot plant began operation in July 2008 and continued to operate through the end of November 2008. Due to the high amount of inert solids, particularly fibers, in the influent from a local manufacture, the pilot plant was a challenge to maintain and operate. After steady state was achieved and nitrification was successfully demonstrated a decision was made to terminate the pilot testing since the effort to maintain the pilot was more that the value of obtaining more data beyond the successful demonstration of full nitrification.

RESULTS

Steady state results (see Figure 6) show effluent ammonia concentrations of 1.1 mg/L at an average wastewater temperature of 22.5 degrees Celsius. This was well below the target effluent ammonia of 2 mg/l. The average IFAS nitrification rate was calculated to be 26.2 kilograms of ammonia removed per 1000 m^2 of BioWeb.

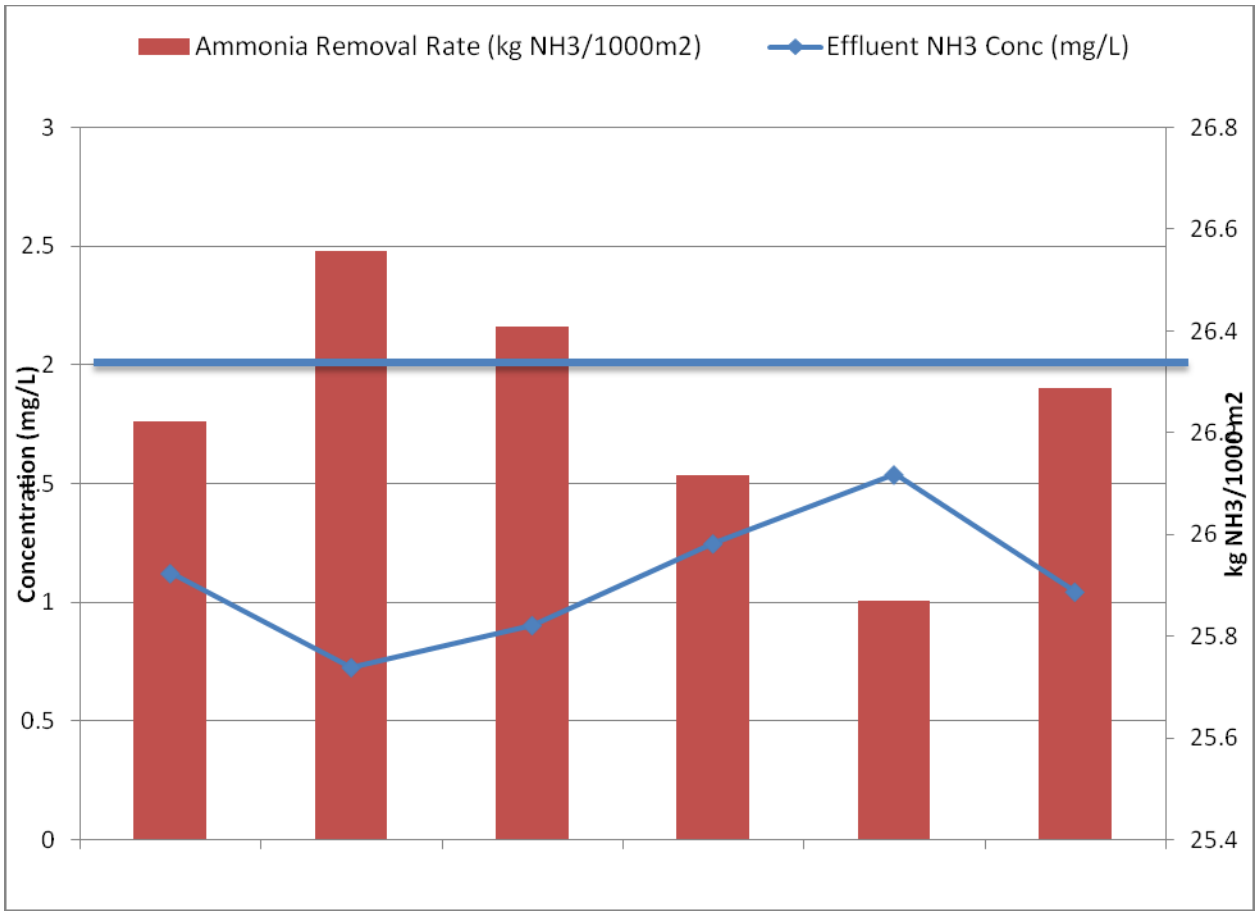

Figure 6 – Nitrification Results

Using the temperature adjustment equation (Sen, 2000) to account for temperature,

$$B_{A,T} = B_{A,10} \bullet \theta^{(T-10)} \quad (1)$$

Where

$\theta = 1.06$

The average nitrification rate was calculated to be 12.7 kilograms of ammonia removed per 1000 m^2 of BioWeb at 10 degrees Celsius.

DISCUSSION

The values observed in the pilot study were cross verified with other fixed media IFAS systems. Entex Technologies Inc has been involved in a joint pilot study with Duke University at the South Durham Water Reclamation Facility (SDWRF) in Durham North Carolina. In the spring of 2006, BioWeb coupons (one square foot) were suspended in the full scale reactors at the locations shown in Figure 7 and they were left in place for approximately 2.5 months before testing. A BioWeb coupon with well-developed biomass is shown in Figure 8.

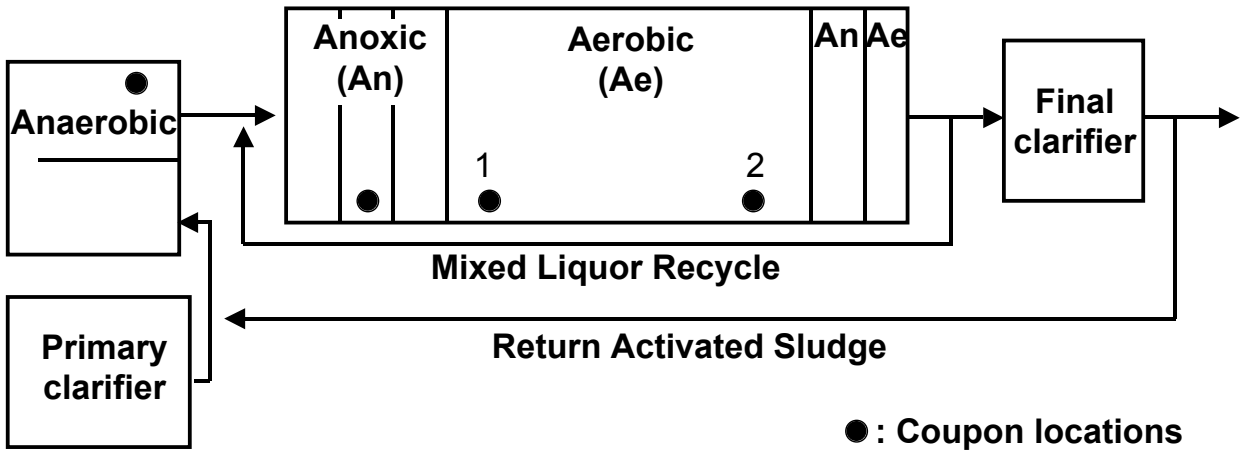

Figure 7 – BioWeb Coupon Locations (Kim, 2007)

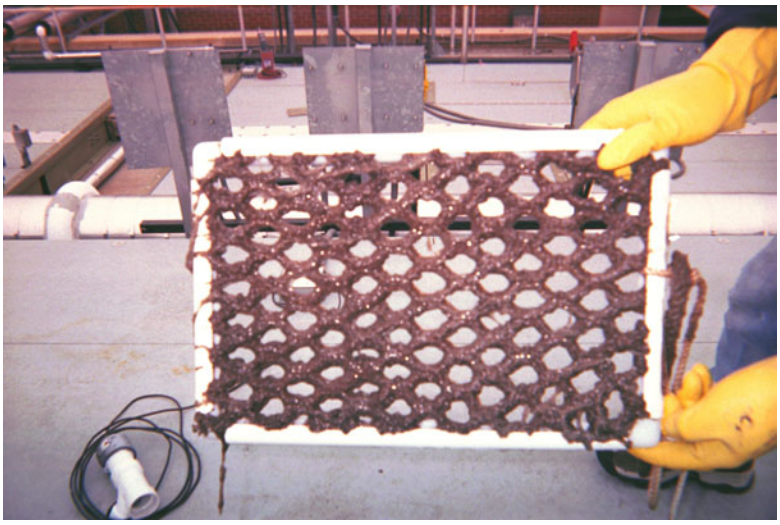

Figure 8 – BioWeb Coupon (Kim, 2007)

The reported spring time nitrification rates on the coupons in the aerobic reactor were 17.6 to 21.0 kilograms of ammonia per 1000 m^2 of BioWeb (Kim, 2007). The Stafford Springs rates at 22.5 degrees Celsius were somewhat higher than these warmer weather rates.

After the pilot confirmation of the design basis the full scale upgrade was bid on March 5th, 2009 and Entex was the named supplier to provide 20 fixed media modules with integral diffusers. The WPCF Upgrade was considered a shovel ready project and was awarded approximately $12.5 million dollars in stimulus money. “This is very good news for the town of Stafford. This is a project that is ready to go and this is the shot in the arm that is needed to get it started,” said Senator Guglielmo**.** Construction is expected to begin in the spring of 2009.

The operational difficulties of the pilot plant alerted the WPCF of the severity of the influent TSS and fiber loading. The Town has never imposed pretreatment regulations on the local industry; however ragging and plugging of equipment became an issue. The solids are essentially

inert and very fibrous and long term exposure may affect the IFAS process. The local industry employs many people in the Town of Stafford and imposing new and costly pretreatment requirements might jeopardize the relationship.

The industry is working with a local consulting firm to reduce the fibers coming into the plant and have established they are releasing fibers, diatomaceous earth (DE) and pearlite into the wastewater facility. They are planning on installing mechanical screening and are looking to recycle the DE for future use and cost savings.

CONCLUSION

In this pilot study the system was tested over a 4 month period to confirm the design basis of the Stafford WPCF full scale facility with BioWeb fixed media. It was observed that the design ratio of 12.2 kg of ammonia removed per 1000 m^2 of BioWeb was sufficient to reduce the effluent ammonia concentration to < 2 mg/L. The addition of BioWeb allowed for conversion of a portion of the aeration basin to anoxic basin at a facility with no room for expansion. The determination of the pilot study is that fixed media IFAS systems are able to achieve the required cold weather nitrification without adding new tanks and is a cost-effective way to increase nitrification in older plants. This is important as the regulatory requirements for older plants are being changed.

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