MBBR IMPLEMENTATION INSIGHTS

Solutions and Best Practices for Moving Bed Biofilm Reactor Installation and Start-Up

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Introduction

A top concern among wastewater treatment facility owners is increasing energy efficiency while improving effluent water quality. Municipal facilities must comply with increasingly stringent requirements for biochemical oxygen demand (BOD), ammonia and nitrogen levels, as well as provide for growing populations. On the commercial side, water-intensive businesses have to plan for sustainable growth under the same regulations. And, as always, public and private enterprises alike are aiming to cost-effectively curb their environmental footprint.

The moving bed biofilm reactor (MBBR) is an adaptable and flexible solution that helps owners achieve all of these goals. The MBBR process relies on floating biofilm carriers in a mixed motion aerated treatment basin. The biofilm carriers provide a protected surface to support prolific growth of heterotrophic (uses organic carbon for growth) and autotrophic (uses inorganic compounds for growth) bacteria within its cells. Compared to traditional treatment processes, the method requires less maintenance and a fraction of the space. Without the need for an activated sludge return stream, operation is also simplified while efficiency is improved.

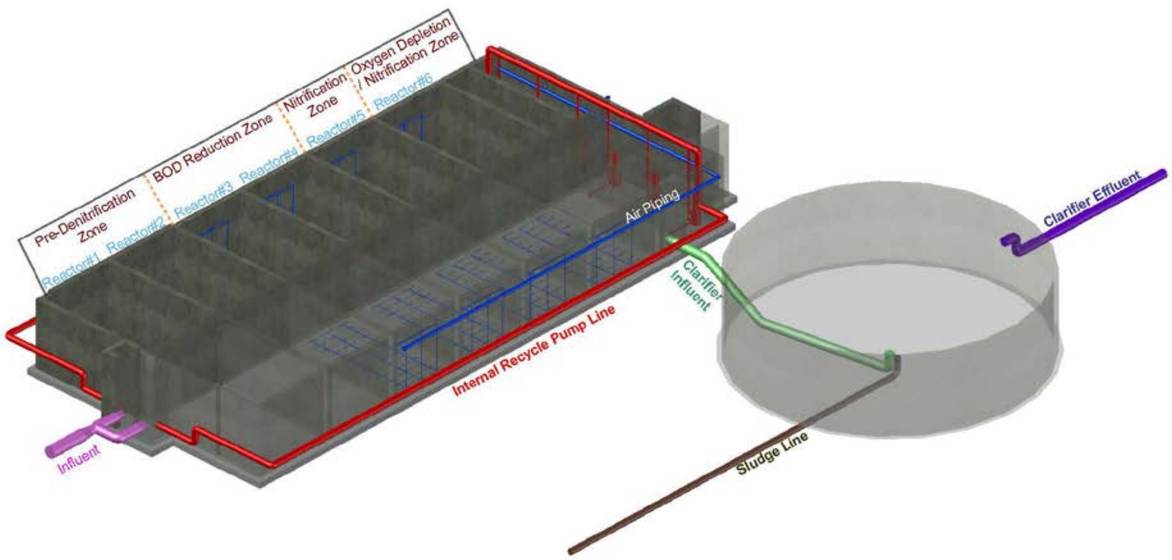
Garney Construction recently commissioned a new MBBR system at the Water Resources Recovery Facility in Midwest City, Oklahoma. The first of its kind to be approved by the Oklahoma Department of Environmental Quality (DEQ) for municipal wastewater treatment, the new technology promises to accomplish the City's three main objectives: comply with current and future discharge requirements, improve the city's energy efficiency, and lower operation and maintenance costs.

We gained valuable insights and discovered several best practices during this system's installation and start-up. From influent treatment to equipment maintenance to providing optimal conditions for bacterial growth, the strategies developed during this project will help owners and engineers reduce costs, avoid logistical problems, and hasten start-up times during future MBBR implementations.

MBBR treatment trains at Midwest City Pollution Control Facility

The Midwest City MBBR Treatment Train

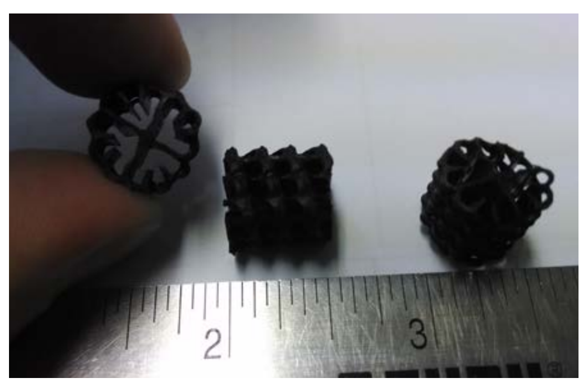
The Water Resources Recovery Facility in Midwest City features two six-reactor treatment trains, each of which contains two anoxic reactors, three oxic reactors, and one oxygen depletion / nitrification reactor. Three high-speed turbo blowers are the workhorses of this process. This blower system aerates, mixes, and maintains a specific dissolved oxygen content in each aerobic reactor. As influent flows through the reactors in the train, it undergoes denitrification (converts nitrates to nitrogen gas), BOD reduction, and nitrification (converts ammonia to nitrates) by the aerobic and anoxic bacteria growing on the floating media. MBBR effluent flows into either of two secondary clarifiers where solids are settled before ultraviolet (UV) disinfection and outflow to Crutcho Creek.



Choosing the Right Recycle Rate

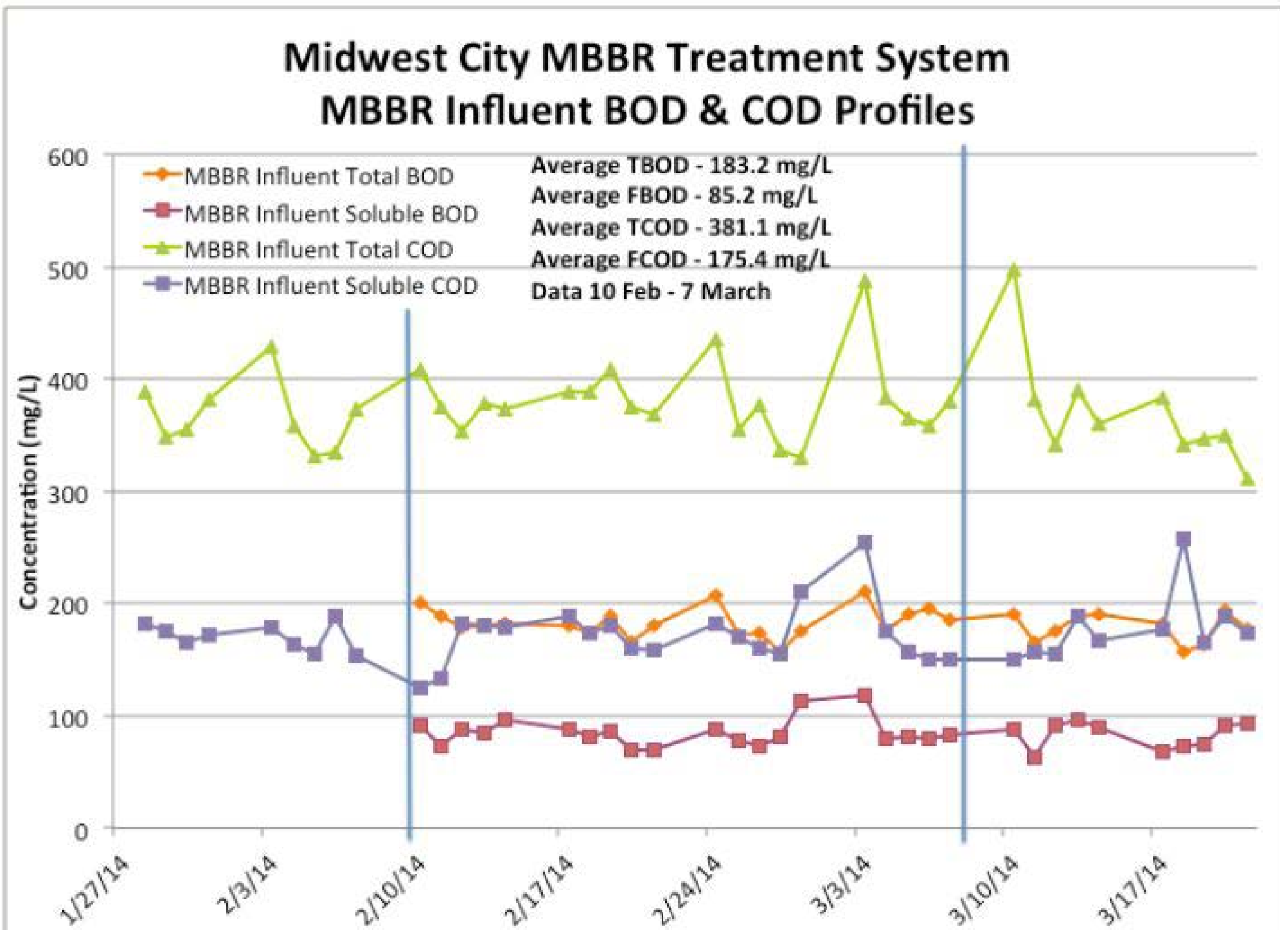
One of the most pressing issues encountered during cold water performance testing of the MBBR was an out-of-specification BOD reading in the effluent. Ammonia, inorganic nitrogen, and carbonaceous biochemical oxygen demand (CBOD) were well within range, yet the total BOD exceeded the plant's permitted levels.

To get to the root of the problem, we examined the effects of different recycle flow rates on our readings. We had been attempting to decrease the total inorganic nitrogen (TIN) content of the effluent by increasing the rate at which influent was recycled back from the nitrification tanks at the end of the train to the denitrification tanks at the beginning. While each increase did produce a lower TIN reading, it also proportionally increased the BOD. The faster we recycled water from the last tank to the first, the less effective the system seemed to become at removing oxygen-consuming microbes from the influent.



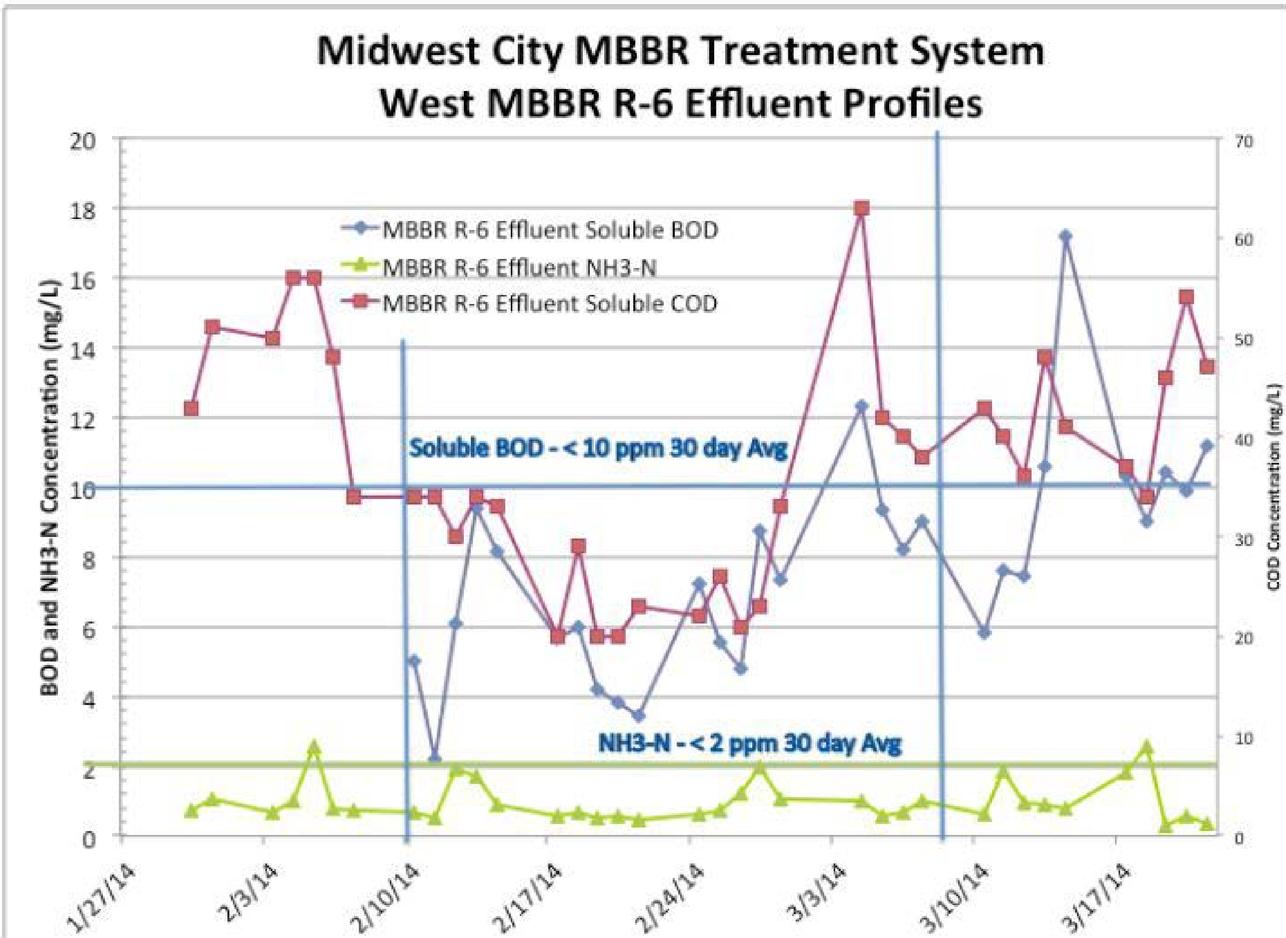
61,000 cubic feet of media were placed into the MBBR basin

The problem didn't lie with the performance of the BOD reduction reactors in the process, however. It turns out that the fastest recycle rates were actually causing some of the newly cultured nitrifying bacteria to slough off from their biofilm carriers in reactors five and six. It was assumed that the surface of the recently manufactured polyethylene biofilm carriers was not yet conditioned sufficiently to hold all of the bacteria in these higher recycle flows. Some of these bacteria passed through the clarifier to the effluent. It was suspected that the continued conversion of ammonia reintroduced into the process stream by fermenting sludge captured in the chlorine contact basin to nitrites and nitrates consumed additional oxygen in the final BOD test. Combined with the oxygen consumed by remaining carbonaceous organisms, this led to a consistently high BOD5 result.



Influent concentration profile for the specified parameters

A reduction in the recycle rate brought the effluent BOD back to well below the specified limit. Oxygen demand in the final effluent testing fell proportionally, at least until the recycle rate reached a threshold at which living nitrifying bacteria were no longer detaching from the growth media. Other factors such as water temperature and maturation time may also affect bacteria's adherence to the biofilm, but the same principle should apply to future MBBR implementations. The ideal cycle rate is one which allows for the most nitrogen removal without increasing the BOD from nitrifying bacteria.



Effluent concentration profile for soluble BOD, soluble COD, and ammonia

Managing Influent Ammonia Concentration

Another concern that initially skewed effluent readings was an overload of ammonia- and BOD-rich influent to the MBBR. While MBBR doesn't require activated sludge to be returned to the front of the treatment train, the secondary clarifier settles out flocked bacteria that have naturally detached from their biocarriers during the MBBR's self-regulated treatment process. This mass of bacteria is collected by the clarifier mechanism and thickened by the addition of polymer and processing through drum thickeners. The thickened sludge is then transferred to the digesters for anaerobic digestion. After several weeks, the digested sludge is pressed and composted on site. The filtrate and pressate is ammonia rich and was initially freely released to the head of the plant anytime there were thickening or pressing operations occurring.

Sludge presses that produce pressate high in BOD and ammonia

Under normal influent conditions, the MBBR is more than capable of handling a large but uniform influx of additional ammonia from biosolids processing operations. At the beginning of our start-up process, however, accelerated sludge removal operations to accommodate construction and rehabilitation activities at the digesters resulted in higher than expected levels of BOD and ammonia in the influent. In addition, biomass accumulated rapidly in the secondary clarifier due to the MBBR start-up operation and high recycle rates. These factors resulted in a large amount of filtrate and pressate that was higher in ammonia than the nitrifying bacteria in the treatment train could handle at once.

The solution? To avoid overload while still processing influxes of BOD and ammonia rich filtrate and pressate, we moderated the flow from the pressate holding tank to the head of the tank. A computer-controlled pinch valve was installed on the holding tank return, which now provides a slow, steady ammonia load that the nitrifying bacteria can handle. The slower flow has also allowed those bacteria to adapt to higher loading, making the treatment train even more efficient.

Drum thickeners that produce filtrate high in BOD and ammonia

Digesters where thickened sludge is transferred for anaerobic digestion

Screening the Influent

Aside from concerns within the MBBR train, the influent itself needed to be better prepared for treatment. Because of the small size of the biofilm carriers and the MBBR's maintenance free reactors, the tanks are designed without drains and don't allow for quick removal of accumulated debris. Eventually, masses of small, settled particles or trash would have reduced the capacity and efficiency of the system.

Black & Veatch, the project's design engineer, re-evaulated this concern early on in the construction phase and determined that a 6mm perforated plant fine screen (two-dimensional screening) would be better suited for removing particulate debris. The fine screen was installed in lieu of a mechanical bar rack screen in the headworks prior to the MBBR commissioning.

Still, another method was necessary to remove particles small enough to pass through the fine screen but large enough to cause buildup in the MBBR. For additional debris removal, a vortex-based grit removal system had been designed downstream from the headworks, which flows into any of three primary clarifiers. That clarifier then provides the last line of debris removal before the influent enters the MBBR for reduction of BOD, nitrogen and ammonia.

Given the need for drain-free tanks within the treatment train, a similar multi-tiered debris removal system would be necessary for most future MBBR installations. Removing particles does more than prevent buildup-related problems in the future, however. It actually makes the MBBR train itself more efficient. Reducing debris also reduces BOD, allowing owners to achieve their required effluent qualities with higher daily volumes of influent.

Equipment Operating Environment

Through the start-up and commissioning of support equipment for the MBBR, Garney gained valuable insight into numerous concerns that should be examined while selecting and reviewing equipment for future installations. Initial issues with the turbo blowers delayed the performance testing associated with the commissioning of the MBBR system and continued for the first several months of blower service. Adjustments to the blower design to meet efficiency standards caused a pathway that allowed core cooling air to bypass the filters. This combined with a dusty environment inherent to central Oklahoma during dry periods, was attributed to the blowers seizing on three different occasions. Retrofits to the blower enclosure and modifications to the control system settings were made to remedy the issue.

The 16 electric mixers used to maintain mixing energy in the anoxic and post denitrification reactors also developed issues after commissioning. The mixer motors power 36" diameter stainless steel propellers that keep the media evenly distributed throughout the reactor. Welds were found to be separated and cracked on several individual propeller lobes during the first year of service. It was assumed that the buffeting effects that breaking apart concentrated clumps of media were having on the mixer blades caused the weakened welds. In order to remedy this situation, the vendor furnished replacement impellers with gussets to allow for stiffening of the blades. Overall thicker blades were considered but the gussets were deemed the best solution as they would not require larger mixer motors to be installed.

The dissolved oxygen (D.O.) probes selected for the basins were resistant to normal abrasion that would be associated with the flow of waste water. However, the abrasion from biofilm carriers in the MBBR process proved too much for the standard membranes in the D.O. probes. Replacement frequency was required three times what would be considered normal. Garney worked with the supplier of the probes in order to retrofit the probes with a protective cap that would allow the free passage of liquid while protecting the membrane of the D.O. probe. The City now follows membrane replacement frequency on par with the manufacturer's operation and maintenance statements.

Timing for Robust Bacterial Growth

Finally, timing is key when planning an MBBR implementation in variable and cold weather climates. Bacteria growing on the biocarriers need time to multiply and adapt to influent BOD, nitrogen and ammonia loads, and colder temperatures can significantly delay their maturation. Most performance tests are also run during the coldest months.

In Oklahoma, the MBBR began treating wastewater at partial capacity in November in order to meet cold water performance tests in January. However, colder than expected weather in November and December slowed bacterial growth and delayed the new system's start-up time by several months. When feasible, beginning bacterial growth in the spring and summer allows for faster maturation, lower implementation costs, and a shorter timeline between construction and full operational capacity.

Cold temperatures can significantly delay maturation of the bacteria

Garney: A Valuable Team Member in MBBR Implementation

Overall, moving bed biofilm reactor technology can be a more efficient, cost-effective, and environmentally friendly way to treat wastewater – and we know how to put it to work. Garney has a proven track record with MBBR, including the Midwest City project and a project completed for the City of Cheyenne, Wyoming. By including Garney Construction on your team, clients can expect:

- Cost saving input and review of construction materials
- Detailed start-up sequencing and real-world timeframes for MBBR implementation
- Avoidance of the pitfalls inherent with a multiple supplier system
- A best practices evaluation of third party testing procedures during the performance evaluation
- A partner in obtaining the workability and performance desired from the new system

Most importantly, owners who upgrade to MBBR with Garney can count on cost-effective compliance with current and future discharge requirements. Regulations are only becoming more stringent as populations grow, and owners need an experienced contractor who can deliver results. With the insights we've gained, we can work with owners and engineers from start to finish to plan, construct and troubleshoot treatment systems that will deliver results for decades to come.

To learn more about the Midwest City project, or for additional information on the MBBR process, contact **Bart Slaymaker at (816) 520-6545 or bslaymaker@garney.com**.

Garney Construction is a 100% employee owned company specializing in the construction of water and wastewater treatment facilities, pipelines, pump stations, water storage tanks, and related heavy civil work. For more information, visit www.garney.com.