Janesville Explores The Limits Of Technology

Wisconsin's new phosphorus rules require planning

By Jay Kemp

Wisconsin recently promulgated new rules for phosphorus (P) discharges from permitted facilities which will require communities to begin planning for compliance. The state has provided some flexibility for combining point and non-point control to produce overall water quality improvement, but it is likely that many facilities will need to modify or add onto existing treatment processes to meet the new limits. Janesville is also subject to the effluent limit derived from the Rock River TMDL.

The Central States Wisconsin Section Government Affairs Committee has been tracking the implementation of the new rules and TMDL implementation and has been seeking a role in a technical advisory role, especially as it concerns proposed water quality trading frameworks and anti-degradation rules. The work of the committee will be aid to communities as part of the planning process.

Biological processes cost-effectively remove P to low levels

The City of Janesville wastewater treatment plant has been operating biological phosphorus removal (bio-P), with chemical (ferric chloride) backup since 2001. The nutrient removal system was modified in 2003 and further expanded and upgraded in a recently completed major project.

Bio-P processes incorporate un-aerated zones into the activated sludge process to develop anaerobic conditions which select for phosphorus-accumulating bacteria. These organisms actually release phosphorus and take up volatile fatty acids (VFAs) under anaerobic conditions. When exposed to an aerobic environment the bacteria then absorb an excess amount of phosphorus.

Before the recent upgrade, the bio-P process performed well but was subject to periods where the bio-P was not effective, due primarily to insufficient VFAs to feed the bacteria that accumulate excess phosphorus. Primary sludge fermenters were added in the recent project to increase the production of VFAs and provide a more consistent food source for the bio-P organisms. The fermenters have been in service almost one year and have provided much more consistent performance from the bio-P process. However, the effluent total phosphorus remains variable at times.

In nitrifying systems, like Janesville, ammonia is oxidized to nitrate. The presence of nitrate inhibits the development of anaerobic conditions, because nitrate is an oxygen source. Nitrate is removed by conversion to nitrogen gas by bacteria that use the same food as the bio-P organisms, so there is a need to manage the carbon resources and nitrate contained in the wastewater. Most of the nitrate entering the anaerobic zones comes from the return activated sludge (RAS) and can be

Click HERE to return to Table of Contents

effectively controlled with a small anoxic zone. Further reduction in nitrate can occur through recycling mixed liquor to a second anoxic zone, following the anaerobic zone. The Janesville process was upgraded to include this additional nitrate removal step which provides energy recovery through the nitrate oxygen credit and reduces the total amount of nitrogen in the plant effluent.

The Janesville system has demonstrated the capability to produce very low effluent phosphorus values. In the fall of 2011 the plant received regular loads of high strength wastewater from an ethanol plant that was undergoing process modifications. The ethanol waste is an ideal food for the bio-P organisms and as shown in Figure 1, during this time the plant produced effluent total P values under 0.1 mg/L., without the use of ferric chloride. Using ferric chloride ($FeCl_3$) to reduce P to low levels requires an excess of the chemical compared to ratios in which P and Fe react, because the concentration of P is very low. Chemical addition is costly compared to biological P removal.

So how low can you go?

This summer Janesville is embarking on a study to improve the performance of the biological system through optimization of the fermenters, determination of the best mean cell retention time (MCRT), varying the number anaerobic zones, control of the mixed liquor recycle rates and continued refinement of dissolved oxygen control. In addition, a pilot cloth filter will be operated to determine the reduction in effluent P through filtration. The filtration study will include ferric chloride addition at various points in main plant flow and additional chemical polishing ahead of the filters.

Effluent polishing is accomplished by chemical addition directly ahead of the cloth filter which will be pilot tested. Chemicals such as iron and aluminum salts may be tested in combination with polymers to determine the best removal of P from the plant effluent. Pilot testing is a key piece of any technology evaluation as illustrated in Figure 2.

Demonstrating consistent effluent total phosphorus (TP) levels below 0.20 mg/L would be an expected result. A demonstration of producing

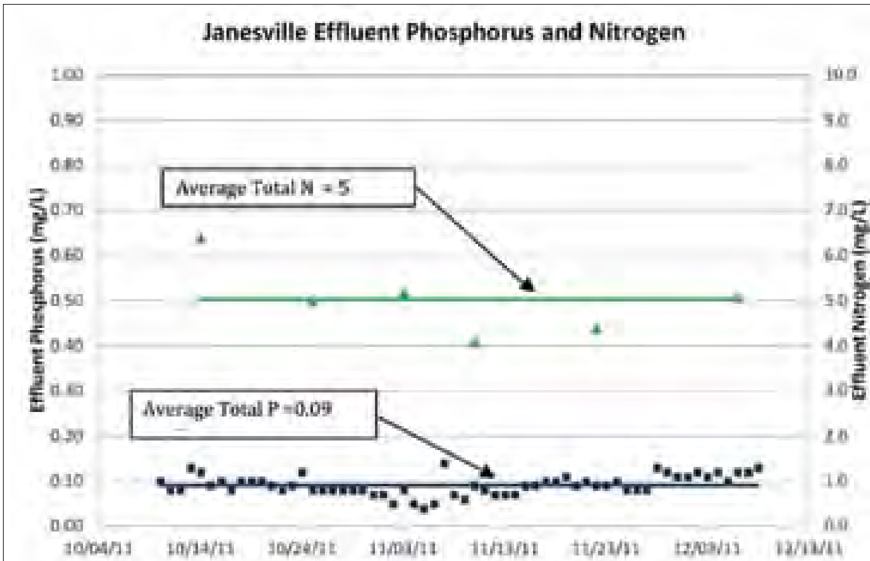


Figure 1: Janesville Nutrient Removal Performance when receiving ethanol plant wastewater

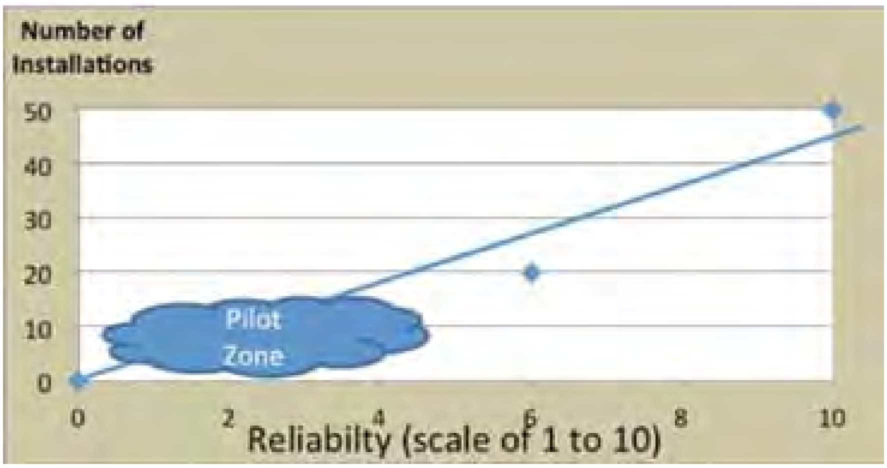
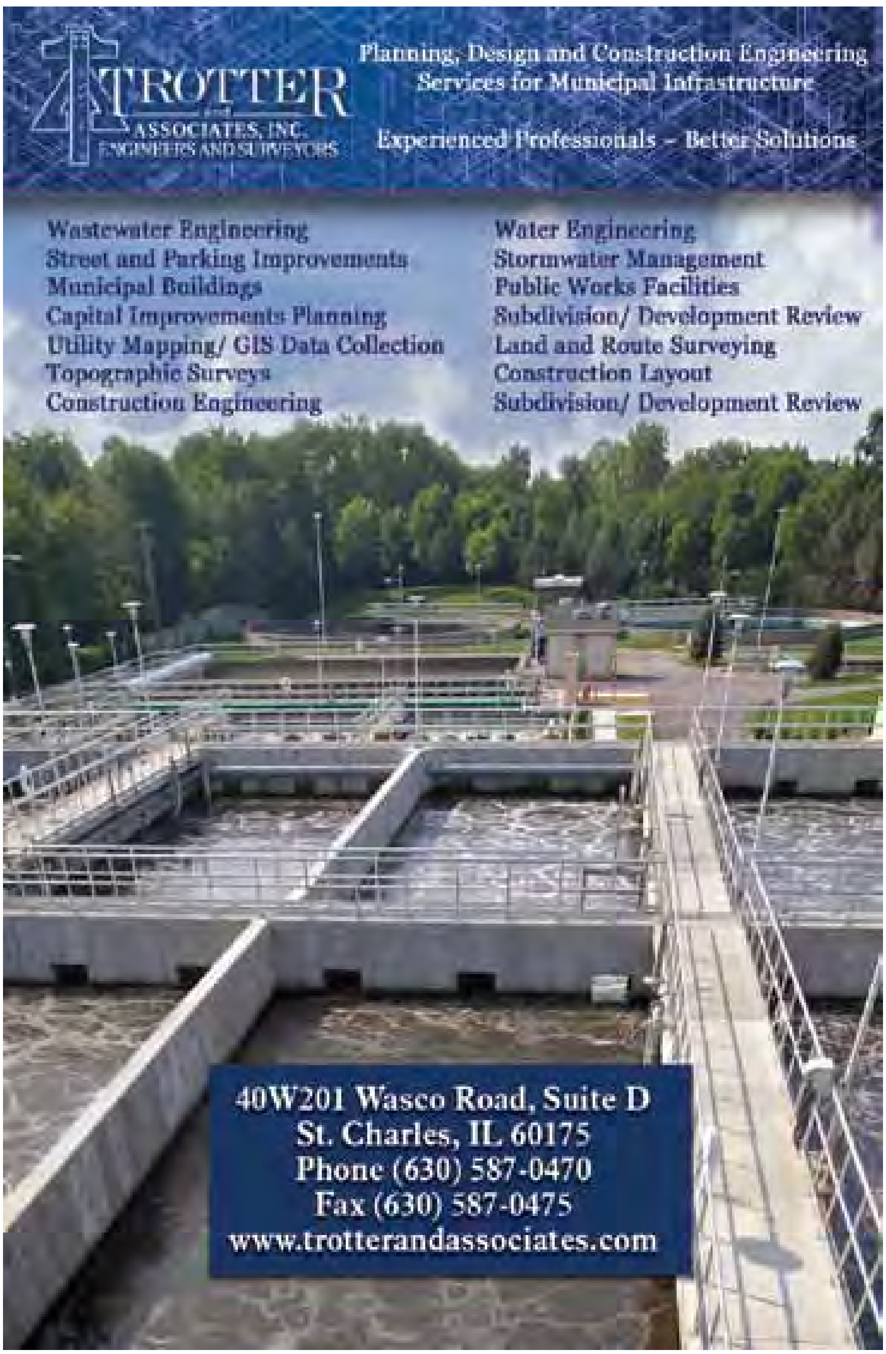


Figure 2: Pilot Testing Needs

lower effluent TP values would be a very important result for Janesville, since permit limits could go as low as 0.10mg/L.

The optimization study will begin with a focus on the fermenters. Operating the fermenter to produce an optimal level of VFAs to feed the bio-P process, will save on additional chemical costs. Primary sludge fermenters should be operated with a dilute sludge feed and overflow rates in the range of 200 to 400 gpd/ft^2. Important process control parameters include: sludge blanket depth, torque on the sludge collector, underflow solids concentration and sludge withdrawal rate.

In bio-P systems phosphorus is removed only in the waste activated sludge (WAS). Therefore, in general, a shorter MCRT which results in a higher wasting rate is desirable for P removal.

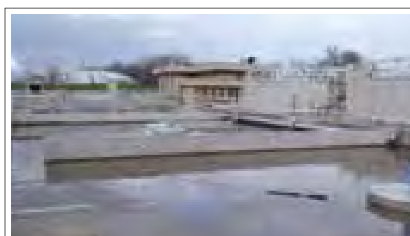


However, the activated sludge process must also produce a sludge that settles well and in Janesville's case also oxidizes ammonia. So the appropriate sludge age will be site specific and may require seasonal adjustments. In addition, good dissolved oxygen control is essential. If DO is too high in the aeration tanks there may be excess oxygen in the RAS returning to the anaerobic zone (or pre-anoxic zone), if DO is too low denitrification and phosphorus release could occur in the final clarifier.

Janesville can add ferric chloride at multiple points in the solids and liquid processes:

- Primary influent
- Mixed liquor (secondary clarifier feed)
- Anaerobic digesters
- Centrifuge feed

The above points can be used to enhance and supplement the biological process and control sidestream impacts. These chemical addition points in conjunction with the filters and chemical polishing will complete the picture for achieving low level phosphorus removal at Janesville. CS



Click HERE to return to Table of Contents