Process Control Monitoring for Nitrogen Removal

The goal of this process control monitoring is to obtain data that will help in evaluating and understanding the nitrogen removal process at your facility and are necessary for making informed operational changes related to total nitrogen removal.

Raw domestic wastewater typically contains 40-70 mg/L of total nitrogen that enters the wastewater treatment facility in the form of Total Kjeldahl Nitrogen (TKN). Nitrification is an aerobic treatment that converts of ammonia to nitrate and is the first step in the removal of total nitrogen. Nitrification is often the most difficult step in removing total nitrogen. The following parameters should be monitored to assist in process control.

Temperature

Nitrification rates drop significantly at low temperatures. Typically, the temperature must be greater than 7 degrees Celsius to maintain nitrification. Once nitrification is lost due to low temperatures, it is very difficult to re-establish a population of nitrifying bacteria without warming the water. Therefore, care should be taken to protect the system from low temperatures.

pH/Alkalinity

It is recommended that the pH of the wastewater be between 6.8 and 8.0 to maintain consistent nitrification. It is also important to have a consistent pH to allow the bacteria to acclimate. Alkalinity will act as a buffer in controlling the change in pH. In order to verify that enough alkalinity is available to stabilize the pH, it is recommended that the effluent alkalinity be at least 50 mg/L with a level of 100 mg/L preferred. The process of nitrification will consume 7.14 mg of alkalinity per 1 mg of ammonia converted to nitrate. Therefore having high influent ammonia can significantly reduce alkalinity reducing the nitrification rate. Systems with low alkalinity that experience large swings in pH or pH levels outside of the recommended operating range should:

- Add alkalinity in the form of chemical addition.
- Consider internal recycle of nitrified wastewater back to an anoxic zone ahead of the aeration zones to assist in dentification. Half of the alkalinity used to nitrify can be recovered through the denitrification process.
- Check influent for toxic condition contributing to high/low pH.

Dissolved Oxygen (DO)

DO levels less than 2 mg/L can limit nitrification. It is important to maintain 2 mg/L throughout the aeration zone. DO should be checked at multiple points in the system to ensure there are not locations with low DO. If DO is lower than 2 mg/L:

- Increase time blowers are operating.
- Increase the number of blowers that are operating if possible.
- Check diffusers and pipes for breaks or leaks.
  - Checking air pressure and flow rates regularly can help with detection of leaks.
- Increase recirculation rates.
- Check influent loading and any return flows that might be high in loading.

- It is also important that DO is not too high as the denitrification process will need an anoxic condition with no free oxygen. Any oxygen passed on to the denitrification process will consume additional BOD and require additional tank volume before the anoxic condition is met.

Ammonia

Nitrification converts ammonia to nitrate. Measuring ammonia after the nitrification process (aeration zone) verifies that the facility is nitrifying. The ammonia after nitrification should be as low as possible, typically systems designed for complete nitrification will achieve 1 mg/l or less of ammonia. Any rise in ammonia from normal operating conditions should be monitored closely as it may indicate the system is losing nitrification. If ammonia levels begin to rise:

- Follow above guidance for temperature, pH/alkalinity and DO.
- Verify actual pumping rates and recirculation rates.
- Check for short circuiting/even distribution of wastewater across the tank/media.
- Increase recirculation rate.
- Increase solids retention time.
- Check for toxicity.
- Evaluate treatment capacity with respect to influent BOD and TKN loading.

Nitrate

Denitrification is the final step to remove total nitrogen and is the reduction of nitrate into nitrogen gas. The concentration of nitrate at this point in the process indicates the amount of carbon source (BOD) needed to denitrify. Approximately 4 mg/l of BOD is required for every 1 mg/l of nitrate removed. Depending on the process configuration, this carbon demand will need to be met through either chemical addition or by recycling nitrified effluent to the head of the plant to pick up BOD or a combination of both. The concentration of nitrate also indicates the potential alkalinity that may be recovered for use in the nitrification process.

Things to consider in the denitrification process if nitrate remains high in the effluent and ammonia is low:

- Presence of DO in the anoxic zone will prevent denitrification. DO could be coming from many sources.
  - Too much DO in the flow from the nitrifying unit, return flows or the use of air lift pumps.
  - Too much turbulence from mixing resulting in air entrainment.
  - Back mixing from the aeration zones may introduce DO and prevent an anoxic condition.
- Insufficient mixing leading to short circuiting and reduced efficiency.
- Insufficient carbon source.
- Overloading of the system beyond design conditions.
- Mixing should not damage media or prevent biofilms from establishing on the media.

In additional to the above internal monitoring parameters, influent wastewater characteristics are important in evaluating operational changes. The presence of toxicity or high influent total nitrogen may require some facilities to add additional treatment capacity or find the source of toxicity.

Process control monitoring that leads to optimizations that would altering treatment processes outside of current Operation and Maintenance manual or require construction will require prior MPCA approval. The approval will follow the Pilot testing guidelines.