Fact Sheet

Frequently Asked Questions: Biological treatment systems for nitrate removal in drinking water applications

**DISCLAIMER: This document is intended to provide answers to questions regarding biological treatment systems to reduce nitrate levels in groundwater wells serving public water systems. Nothing in this document supersedes any statutory or regulatory requirements or permit provisions for public water systems.*

June 23, 2020

What is a biological treatment system?

Biological treatment systems are designed to remove nitrate in groundwater. Nitrate in groundwater is biologically converted to nitrogen gas in the reactor, and the biologically treated water is then filtered and disinfected prior to consumption. A typical biological treatment system contains a bioreactor, a filtration system and disinfection system.

Why are water systems interested in biological treatment systems for nitrate reduction?

The major advantage of operating a biological treatment system is that under anaerobic conditions, the treatment system can remove nitrate with very little energy. In addition, there is no disposal of a brine solution, which is used during the regeneration process of the resin used in ion exchange treatment systems and the waste product of a reverse osmosis and electrodialysis treatment system. The only waste product is from the backwashing of the filtration system, which can be disposed in a sanitary sewer.

Are biological treatment systems listed as a best available technology to remove nitrate in groundwater?

No, biological treatment is not listed as a best available technology in Title 22 for nitrate compliance. However, the State Water Board has conditionally accepted six (6) biological treatment technologies for nitrate removal following extensive acceptance testing.

Each biological treatment system must complete an extensive pilot test to be accepted for use in California. Due to the complexity of biological treatment systems, pilot testing always involves a team of licensed engineers. Sufficient data must be collected throughout the pilot testing to provide valuable information to refine the treatment design and to prove the treatment effectiveness. Treated water generated from the pilot testing cannot be used for drinking water supply.

Following acceptance of the biological treatment system, each treatment system is then engineered to the specific raw water quality and chemistry at the proposed treatment location. A second location-specific demonstration study will need to be completed to show the treatment system is effective and reliable under local conditions.

The process for extensive pilot testing is costly and technically challenging for many public water systems (PWS), and for this reason, biological treatment systems are not extensively used for nitrate reduction at this time. There is limited operating experience of biological treatment systems for nitrate reduction in California.

What are the best available technologies (BATs) for nitrate removal in California?

Ion exchange, reverse osmosis, and electrodialysis are listed as the BATs for nitrate removal in Section 64447.2 of the Title 22, California Code of Regulations.

If a biological treatment system is not one of the best available technologies (BATs) for nitrate removal, how can it be operated by a PWS interested in using it for treatment?

For water treatment technologies not designated as BATs, pilot studies must be conducted to demonstrate the efficacy of the treatment process. A PWS should inform local Division of Drinking Water (DDW) district offices in writing of their desire to use the alternative technology. The Water Treatment Committee (WTC) of DDW will provide assistance on the treatment system specific pilot study and review the study results. The WTC treatment specialist will prepare a recommendation on the technology acceptance or rejection depending on the outcome of the pilot testing.

Approval for the design and use of the specific treatment system at a water system location will be handled on a case-by-case basis by DDW district offices, with assistance from the WTC, and the final approval will be granted through the domestic water supply permitting process. An additional, less extensive, location-specific demonstration test will also be required and evaluated.

What are the things to consider if a PWS is interested in using a biological treatment system for nitrate reduction?

It is imperative to ensure the nitrate reduction biological treatment systems are reliable because nitrate and nitrite (an intermediary of the biological process) are acute contaminants with immediate acute health effects. If a biological treatment system cannot remove nitrate below the regulatory required limits, the community will be exposed to chemical(s) with acute health effects. The technical demands of biological treatment and the challenges encountered in implementing them indicate that certain capabilities are needed for their reliable operation.

1. Treatment system start-up testing is required and is expected to be lengthy.

   A biological treatment system is not a plug-and-play technology that can be operated with minimal operator oversight and maintenance. The reactor contains media that naturally occurring bacteria must grow on for the system to work. To ensure healthy bacteria is developed on the media, an electron donor and nutrient must be added to the raw water prior to treatment, and dissolved oxygen in raw water must be removed. The time to ensure healthy bacteria develops varies; generally speaking, at least four to six weeks have been observed in existing systems without any issues. Also, biological treatment systems operate more effectively if they run 24 hours a day. Start and stop operation may upset the many operational controls and chemical feed systems and can affect the performance of the bacteria. Because many PWS, especially small water systems~~,~~ utilize groundwater sources on an as needed basis, additional treated water storage tanks would be necessary to equalize the flow to the treatment system.

   Because of the unique character, treatment plant operators must be engaged with the vendor who provides the treatment system during piloting and start-up, so that they can get familiar with the system and understand the procedures necessary to fine tune and optimize the treatment processes. Training to operate a biological treatment facility takes weeks of daily training and trouble shooting.

2. Automatic control of the treatment system is critical.

   To ensure bacteria on the media stays healthy, the electron donor and nutrient must be carefully controlled. The chemical feed must be operated, monitored continuously, and adjusted automatically when any of the operational parameters change (e.g., nitrate level increases in raw water). Otherwise, nitrate will not be properly removed. During previous pilot testing which included various challenge testing, chemical feed failures were tested and have resulted in nitrate breakthrough at the bioreactor exceeding 10 mg/L within an hour of the feed failure. Example, the latest biological treatment system installed in California (bioreactor flowrate of 250 gpm) required over 20 in-line monitoring devices to operate effectively, each with alarm settings and shut down settings along with control adjustments. Each monitor was routinely doubled-checked with hand testing equipment and calibrated.

When chemicals overfeed due to lack of operational control, water quality issues in the distribution system may be created by excess levels of Total Organic Carbon (TOC) (e.g., levels of disinfection byproducts increase, bacteriological issues). Chemical dosages must stay optimal to prevent water quality excursions.

3. A team with multiple operators is likely needed to operate the treatment system.

   The classification of drinking water treatment plants ranges from T1 to T5, with T5 being the most complex. All biological treatment plants are rated at T3 or higher. Currently, PWS that have permitted biological treatment systems are large water systems. These systems have an operations team led by a T3 to T5 chief operator and still have struggled with biological treatment systems operating effectively, efficiently, and continuously. Based on experience working with these water systems, operators have to closely monitor the treatment system, calibrate equipment, verify in-line monitoring, record system errors, clear the alarms, and work with engineers and the vendor as a team to resolve the issues and continue to make it more reliable.

4. A typical biological treatment system consists of a reactor, a filtration system, and disinfection system, and operators need to understand how to operate and manage all three.

   To ensure water treated by biological treatment systems is safe to drink, downstream filtration is required to remove any biomass utilizing a coagulant and sometimes a polymer. Disinfection is also required to inactivate any remaining microorganisms. As a result, operators must ensure the biologically activated reactor, filtration, and disinfection processes meet the treatment criteria specified in the domestic water supply permit issued by the local DDW district office. The filtration and disinfection criteria are nearly as stringent as surface water treatment requirements based on turbidity and chlorine contact time. Disinfection must be able to achieve the equivalent of 4-log virus inactivation in the finished water from the biological treatment system prior to entering the distribution system.

5. A back up water supply is required.

   A PWS proposing biological treatment must have access to alternative sources and/or storage available to continue meeting customer water demands during treatment upsets. When biological treatment systems experience treatment upsets, it can take several hours or longer for the condition to resolve.

Are biological treatment systems suitable for all PWS?

Because of the expense and complex requirements necessary to make biological treatment systems function properly, biological treatment systems will not be suitable for most PWS. Currently, biological treatment systems for drinking water application have only been granted

to large PWS that successfully completed the demonstration process, have access to multiple drinking water sources and the technical, managerial, and financial capacities to meet the technical demands described briefly above that are necessary to successfully implement a biological treatment system. The first small water system (serving less than 1000 service connections) with a full-time operating staff will be demonstrating a locational specific treatment plant in 2020.

Water systems permitted for nitrate reduction using biological treatment include:

- City of Delano (Kern County): Serving approximately 52,000 persons (12/10/2019)
- Crescenta Valley Water District (Los Angeles County): Serving approximately 33,000 persons. (6/19/2019)
- Sunny Slope Water Company (Los Angeles County): Serving approximately 30,000 persons. (6/21/2019)
- West Valley Water District (San Bernardino County): Serving approximately 84,000 persons. (two systems: 5/17/2016 and 5/6/2019)

Who should PWS contact if they have questions regarding the use or pilot testing of a biological treatment system?

Please contact the local DDW district office, or local primacy agency if your system is regulated by the local primacy agency. The DDW district office will contact the water treatment committee (WTC) for assistance when necessary. The contact information of the local DDW district offices can be located here: https://www.waterboards.ca.gov/drinking_water/programs/documents/ddwem/ddw_districtofficesmap_wa_version.pdf

(*These FAQs were last updated on June 23, 2020)*