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Environmental Assistance Division
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Troubleshooting Bacteria Levels at Wastewater Treatment Plants

Information and tools to help wastewater system operators and utility managers minimize bacteria in effluent.

Abbreviations

BOD	biochemical oxygen demand
BST	bacteria source tracking
DO	dissolved oxygen
EPA	U.S. Environmental Protection Agency
FROG	fats, roots, oil, and grease
I/I	inflow and infiltration
mg/L	milligrams/liter
MLSS	mixed-liquor suspended solids
RAS	return activated sludge
TMDL	total maximum daily load
TSS	total suspended solids
UV	ultraviolet
WWTP	wastewater treatment plant

Know your influent

How strong is the wastewater coming into your plant? How high is the organic loading to the wastewater plant? Are there dense, multifamily properties connected to the system? Do the homes have water-saving devices? Who are the industrial users? Car washes, restaurants, industrial facilities, and water-saving devices can create a high organic loading in the influent.

Older wastewater treatment plants were designed with an organic loading of 200 mg/L biochemical oxygen demand. Because of water-saving devices, many newer WWTPs are being designed with a higher organic loading (350–450 mg/L BOD). If you have an older plant, you may need to diligently monitor influent more closely to reduce incoming organic material.

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Monitor the influent for BOD, total suspended solids, metals, oil and grease, and other parameters. Monitor the users; even small operations can upset the plant. In addition, supernatant from sludge processing, decant from digesters, and scum return can contribute to high organic and hydraulic loading on the WWTP.

Create clear ordinances with inspection fees, and include penalties for violating those ordinances. It is important to develop and enforce a program addressing fats, roots, oil, and grease (FROG).

Understand the effects of inflow and infiltration

Inflow and infiltration may be affecting the system by increasing the volume of influent and decreasing the organic load (food supply for the plant's microorganisms). Are there broken collection-system lines, separated joints, missing manhole covers, broken manhole structures, poor seals, or unauthorized lines tied into the collection system? Does the flow spike at the WWTP when it rains? If you have high I/I, it is increasingly difficult to meet permit limits because the influent volume and food supply for the microorganisms can be unpredictable.

Can you control influent from your lift stations?

Lift pumps are usually designed to pump peak flow (normally four times the daily average flow). Make sure the floats are adjusted properly, so that lift- station effluent doesn't overwhelm the plant. These are some options to help equalize hydraulic loading on the WWTP from lift stations:

- Reduce the impeller size in each pump.
- Install one or more variable-frequency drives.
- Install a lift pump with a smaller capacity.
- Adjust pump settings.
- Put timers on pumps (with backup float control) or making sure not all of your lift-station pumps come on at the same time.

Maintain optimal solids

Maintain optimal solids in the aeration basin to prevent microorganisms from dying or becoming unhealthy.

- Mixed-liquor suspended solids contain bacteria and other microorganisms. Although MLSS concentration in many types of WWTP designs should be between 2,000 and 4,000 mg/L, you should operate your system based on its particular design.
- High MLSS in the aeration basin can result in low levels of dissolved oxygen and in the discharge of solids to the chlorine chamber, causing the exceedance

of bacteria permit limits and possibly other parameters, such as total suspended solids.

- DO should be approximately 2 mg/L in the aeration basin to maintain healthy microorganisms.

Keep your weirs clean

Make sure that the weirs are kept clean (free of algae and solids). Here are some options for decreasing algae, sludge, grease, and sewage debris:

- Install brushes or washers on clarifier weirs.
- Block and divert discharge when cleaning weirs to a screening device (sending the screened wastewater to the head of the plant).
- Set the scum-return device properly to remove all floating debris.
- Install fine screens at the head of the plant to remove sewage debris.
- Maintain healthy, appropriate types and appropriate ratios of microorganisms in the plant to prevent bulking, denitrification, and washout of solids.
- Spray the surface of the clarifier with non-potable water to help settle light solids.
- Clean walls often to prevent solids from building up.

Optimize chlorination

Chlorine feed should be automatically regulated based on flow. If there are I/I issues, then the flow-based system should be designed to feed adequately at very high and very low flows.

Automatic switchover for chlorine-gas systems should be available. Tablet systems are difficult to control and require tablets that are labeled for wastewater use; swimming-pool tablets are not allowed.

Chlorine chemistry is complicated and requires that you add enough chlorine to overcome the competing nitrogen reactions. You should understand chlorine chemistry, because monochloramines are stronger disinfectants than dichloramines and trichloramines. Therefore, you may need to monitor the ammonia-nitrogen levels coming into the chlorine contact chamber and adjust the chlorine dosage appropriately.

Maintain the chlorine contact chamber

Suspended solids in the contact chamber will interfere with disinfection, and settled solids will reduce the capacity of the chamber. Ensure 20 minutes of detention time at the 2-hour design peak flow (or higher if you have I/I issues). You should also ensure proper mixing and proper baffling to avoid short-circuiting.

Detention time and chlorine use in pond systems

Additional chlorination may not be required if the detention time in the pond or lagoon is 21 days or more. Common issues with pond systems include:

- Excessive sludge will reduce capacity in the pond and reduce detention time.
- Wind can cause short-circuiting.
- The level or placement of the discharge pipe can drain surface scum.
- TSS, algae, and wildlife can contribute to bacteria loads.

Properly located and designed inlet and outlet structures (with baffles or screens to reduce solids discharge) and sludge removal to maintain capacity can help with bacteria compliance. However, further disinfection or sterilization systems may be needed.

Ultraviolet-light systems

As with all disinfection systems, ultraviolet-light systems require proper design and maintenance to work efficiently. Ensure that the system is designed with adequate capacity and proper mixing. Each approach and departure channel in the system must be at least 4 feet long and unobstructed to prevent turbulence.

The type of bulb makes a difference in how effective the UV treatment is at killing bacteria. Medium- and high-pressure bulbs produce an abundance of wavelengths (including 254 nanometers) and are not significantly affected by temperature, as opposed to low-pressure bulbs. Disinfection relies on light intensity, which decreases with the age of the bulb. Bulbs must be changed when the intensity becomes too low to kill the bacteria.

Consider the following issues when using a UV-light system:

- The wastewater must be clear to transmit UV light at germicidal wavelengths for disinfection; therefore, also monitor its transmissivity.
- The water level must be above the level on the bulb where it emits light.
- Clean the bulb sleeves by hand periodically, no matter what type of system you have. Take care not to etch bulb sleeves when cleaning. Abrasive cleaners cannot be used.
- Keep TSS, algae, and debris to a minimum. They will shield the microorganisms from the UV light, preventing sterilization.

Sequencing batch reactors or batch discharge

For sequencing batch reactors or any batch discharge, disinfection must be optimized to meet permit limits. This includes ensuring 20 minutes of detention for chlorination systems or ensuring that the UV-system bulbs are at full operating intensity before discharge. This requires immersion of UV bulbs in water at the appropriate level while they warm up.

Sample properly and calculate averages correctly

Use proper laboratory techniques to collect samples for bacteria analysis:

- Wear gloves to prevent contamination of the sample.
- Collect your sample directly into clean, sterilized containers for bacteria analysis.
- Do not collect samples in another container and transfer them to the bacteria containers.
- Use the equipment that is designed for direct sampling of wastewater streams.
- A sodium thiosulfate tablet is included in the bacteria sampling jar. If the wastewater flow is turbulent, and the tablet needs to be removed, transfer the tablet into the bottle's lid. Then collect your sample and return the tablet to the bottle. Do not touch the tablet.
- The daily average for bacteria concentration is a geometric mean. Calculating the geometric mean requires that you multiply the numbers for the month and take the nth root of the result. What does that mean? If you have 4 bacteria results, multiply the results and take the fourth root. Where your results are 20, 35, 40, 60, the geometric mean is

$$\sqrt[4]{(20\times35\times40\times60)}=\sqrt[4]{1{,}680{,}000}=36$$

To calculate anything other than the square root, you may need to buy a scientific calculator with the $x\sqrt{y}$ function or use the geometric mean calculator here: <www.tceq.texas.gov/goto/geomean>.

Source tracking

Bacteria source tracking may use one of several methods to distinguish between potential sources of fecal contamination found in environmental water samples (for example, from human, livestock, or wildlife origins).

As shown in EPA's Wastewater Technology Fact Sheet: Bacterial Source Tracking these methods have been used to develop and implement TMDLs. This fact sheet is available online at <www.epa.gov/npdes/pubs/bacsortk.pdf>.

For additional information and publications on BST, go to Texas Bacterial Source Tracking Program at <www.texasbst.tamu.edu>.

Stormwater runoff

Concentrations of bacteria can be high during and immediately after storms in most rivers and streams as a result of stormwater runoff. Stormwater runoff entering through poorly maintained or missing manhole covers can increase concentrations of bacteria entering the wastewater treatment facility. This can also cause short-circuiting, which in effect reduces detention time in treatment ponds or lagoons.

Seasonal conditions

Differences in temperatures between lagoon wastewater and warmer wastewater entering the treatment system result in thermal stratification. These layers of water don't mix well and cause untreated wastewater to flow across the surface of the pond or lagoon to the effluent—short-circuiting the treatment system.

Wildlife

Migratory birds and other warm-blooded wildlife and domestic animals (horses, cattle, sheep, etc.) may also significantly increase bacteria concentrations in the facility's effluent.

Making changes to your system

Remember that your facility's permit is written specifically for the processes at your plant. You may determine that you need to make changes to your plant. Before you consider making changes, consult a permit writer on the Municipal Permits Team at the TCEQ to determine how you will need to amend your permit.

If the changes are not urgent, you may consider waiting to make them until your permit is scheduled for renewal. Depending on the type of changes you want to make, you may be able to renew your permit with a minor amendment. If the changes are extensive, a major permit amendment may be required. Major amendments require mailed public notices to affected landowners in addition to the published notices. Your permit writer will be able to advise you on application timelines.

Links about treatment options

Information provided at these websites includes costs, advantages, and disadvantages.

Ozone Disinfection

<www.epa.gov/npdes/pubs/ozon.pdf>

Ultraviolet Disinfection

<www.epa.gov/npdes/pubs/uv.pdf>

Chlorine Disinfection

<www.epa.gov/npdes/pubs/chlo.pdf>

Dechlorination

Ways to remove residual chlorine from disinfected wastewater before discharging it into the environment (EPA, Wastewater Technology Fact Sheet: Dechlorination, 832-F-00-022, 2000).

<www.epa.gov/npdes/pubs/dechlorination.pdf>