



AEX-756

# Calculating Loadings Rates for Design of Small Flow Onsite Wastewater Treatment Systems

## Hydraulic vs. Organic Loading

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Wastewater loading rate is a critical design factor for wastewater treatment systems. Soil leaching systems, mound systems, and sand and artificial media bioreactors are all referred to as fine media fixed film systems. If loading is too high, these types of wastewater treatment systems tend to clog.

Most wastewater treatment systems are designed to treat domestic sewage, and hydraulic loading rates are recommended to ensure long-term performance with no clogging. Hydraulic loading rates are simple to calculate and monitor. Through years of research and experience, recommended loading rates have been established for different types of soils, sand, and other media.

Domestic wastewater is assumed to have BOD<sub>5</sub> concentrations in the range of 150 to 300 mg/l. Some wastewaters, however, can be of higher “strength.” Food processors, restaurants, or other small businesses can produce wastewater that has higher BOD<sub>5</sub>. Ongoing research at the Ohio State University and other institutions is studying the treatment of food processing wastewaters ranging from 800 mg/l to 10,000 mg/l BOD<sub>5</sub> in fine media fixed film systems.

To prevent clogging from high-strength wastewater, research shows it is important to adjust the hydraulic loading rate and loading pattern. It is not always necessary to pretreat high-strength wastewater, since the organic loading rate can be considered in design.

This fact sheet will present how to calculate hydraulic and organic loading rates.

### Hydraulic loading rate

The hydraulic loading rate is presented as volume per day applied over a surface area, such as gallons per day per square foot. It is based simply on the amount of water applied with time.

$$\text{Hydraulic Loading Rate (gal/ft}^2\text{/day)} = \frac{\text{Design Flow (gal/day)}}{\text{Area (ft}^2\text{)}} \quad (1)$$

Typical hydraulic loading rates for fine media fixed film systems are 0.25 to 1 gal/ft<sup>2</sup>/day. For systems that recirculate wastewater through the fine media several times, hydraulic loading rates of 3 to 10 gal/ft<sup>2</sup>/day are often used.

### Organic loading rate

Organic loading rate is presented as the weight of organic matter per day applied over a surface area, such as pounds of BOD<sub>5</sub> per day per square foot. The BOD<sub>5</sub> is a measure of the oxygen needed to degrade organic matter dissolved in the wastewater over 5 days. It is reported as mg/l of oxygen consumed to degrade the wastewater in 5 days. BOD<sub>5</sub> is one way to measure the amount of easily degradable organic matter in sewage. To calculate organic loading the first step is to convert BOD<sub>5</sub> in mg/l to pounds/gal.

$$\text{Organic matter (BOD}_5\text{ lb/gal)} = \frac{\text{BOD}_5\text{ (mg/l)} * 3.785\text{ l/gal}}{453,600\text{ mg/lb}}$$

Next consider the flow rate and the area for application to calculate the organic loading rate.

**Organic loading rate (lbs BOD<sub>5</sub>/ft<sup>2</sup>/day) =**

$$\frac{\text{Organic matter (lbs BOD}_5\text{/gal)} * \text{Design Flow (gal/day)}}{\text{Area (ft}^2\text{)}}$$

Organic loading rates for fine media fixed film systems, like septic leach fields, mounds, and sand bioreactors range from 0.00025 lbs BOD<sub>5</sub>/ft<sup>2</sup>/day to 0.0012 lbs BOD<sub>5</sub>/ft<sup>2</sup>/day.

## Selecting loading rates

When overloaded, fine media fixed film wastewater treatment systems clog. This feature does have benefits. As the media begins to clog, wastewater is retained for a longer time in the media, producing high quality effluent. Therefore, a little clogging is desirable. If severely overloaded, the media can clog completely, causing wastewater to back up, so that poorly treated wastewater is not discharged into the environment. These systems are considered “fail-safe.” However, clogging is a problem that needs to be considered in design and maintenance of septic leach fields, mounds, and sand bioreactors that receive high-strength wastewater.

The clogging processes in soils, sands, and other fine media in wastewater treatment is complex. Inert and slowly degradable solids, excessively thick and sloughing biofilms, and anaerobic conditions causing the development of mineral deposits and microbial slimes, can all contribute to clogging in fine media fixed film wastewater treatment systems.

Simply adjusting the organic loading of a high-strength wastewater down to that of domestic sewage is not always effective. For many high-strength wastewaters, this step may result is unnecessarily large bioreactors. Research has shown that wastewater application patterns, the ratio of easily degradable organic matter (BOD<sub>5</sub>) to slowly degradable organic matter (COD – BOD<sub>5</sub>) and layering

different types of media, all impact the design organic loading rate.

Pilot scale testing of specific high-strength wastewater is an effective way to establish a reasonable hydraulic loading rate. Research has shown that applying frequent small doses of wastewater throughout the day (up to 3 doses per hour) reduces the incidence of clogging, allowing for the application of higher hydraulic and organic loading rates. Filtering high-strength wastewater first through layers of coarse media (such as pea gravel) has also been shown to be effective at preventing clogging.

Once clogged, fine media fixed film systems recover easily. Simply resting the bioreactor for a few months (from 4 to 12 months) has been demonstrated to restore the clogged media. The ability to close off areas of a wastewater treatment system to rest a portion of it is an important feature in the system design. It is important to have an expansion area identified for systems treating high-strength wastewater. If loading rates prove to be too high, additional surface area can be added to reduce the loading rate.

## Additional information

### ***For more information on organic loading go to:***

<http://setll.osu.edu/research.html> and look under Food Processing Wastewater Treatment

Web site at the Washington State Department of Health:  
<http://www.doh.wa.gov/ehp/ts/WW/TechIssueReports/T-3aOrganicLoading-VSD.pdf>

### ***For more information on fine media fixed film wastewater treatment systems go to:***

Mound Systems for On-site Wastewater Treatment,  
Bulletin 813-04

<http://ohioline.osu.edu/b813>

Sand Bioreactors for Wastewater Treatment,  
Bulletin 876-99

<http://ohioline.osu.edu/b876>

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