Technical Overview

NESC

BIOLOGICAL FILTRATION

National Environmental Services Center

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TECHNICAL OVERVIEW
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Item Number: SFBLTO02

Cover photo: Installation of peat filter module for a residence. Photo courtesy of Bord na Mona.

INTRODUCTION

A biofilter, short for biological filter, is a secondary treatment process for onsite wastewater. Here, secondary refers to the second step in the treatment process. Primary treatment refers to settling out of solids, a physical reaction. Secondary treatment comes after this and usually involves biological treatment.

Filtration is one of the more common biological treatment processes. Filters are commonly constructed using sand, gravel, peat, or a synthetic material. These synthetic materials, such as foam, fabric, or plastic and natural materials, like peat, are grouped together under the generic title "biofilter."

Biological treatment is a natural process, where bacteria living in the wastewater or in the environment consume organic contaminants in the waste stream. The basic idea of a filter is to provide a place for the bacteria to attach to while they "eat" the contamination in the effluent that passes by. Bacteria, as they live and eat, grow and reproduce, forming a slimy black layer called a biomat on the filter.

This biomat, while necessary for treatment, can pose problems. If it grows too thick, it will clog the pore spaces in the filter, and the effluent will pond on top. This introduces the critical variable for filters: surface area to volume ratio. This ratio shows how much area is available for the bacteria to live on as opposed to the amount of volume the filter media takes up.

DESIGN

Biofilters, using foam, plastic, textile, or peat, provide a high ratio of surface area to volume. Foam has an intricate structure with lots of pore spaces. Plastic can be formed into spheres with lots of interior bracing to provide more space for bacteria to attach. Peat is a naturally occurring form of carbon with a high void ratio. Thus, biofilters can support a large amount of bacterial growth while still allowing water to filter past. The offset to this is a higher cost for the filter media than sand or gravel. The other main difference is maintenance. With a biofilter, a backwash device should be included that will force clean water upwards through the filter, scouring off the biomat to clean out the filter pores. Backwashes can be used on sand or gravel filters, but it is simpler to remove the top few inches of sand, with the biomat, and add clean sand to maintain the filter.

Possible configuration of a foam biofilter at the WV Onsite Demonstration Center

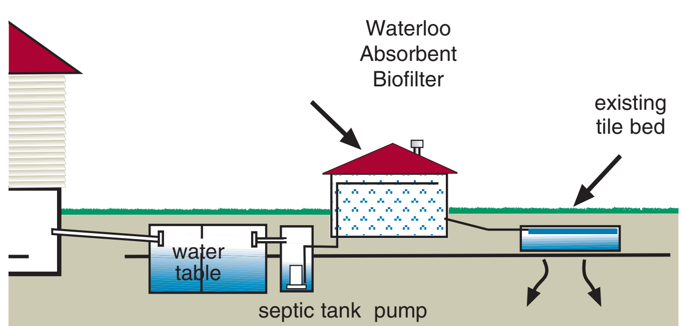

Figure 1: Typical Foam Biofilter Configuration

Biofilters have the advantage of higher loading rates because of their increased pore spaces. Foam biofilters are usually dosed at 12.5 gallons per day per square foot (gpd/sf), as opposed to 2 gpd/sf for single-pass sand filters. This means that a foam biofilter sized for a typical residence (three or four bedrooms, producing approximately 350 gallons per day of wastewater) would be about 6 feet long by 6 feet wide and 4 to 5 feet deep. This can be economically housed in a small shed, which improves cold-weather performance. Additionally, foam filters can be fitted with ventilation fans to improve aeration of the system.

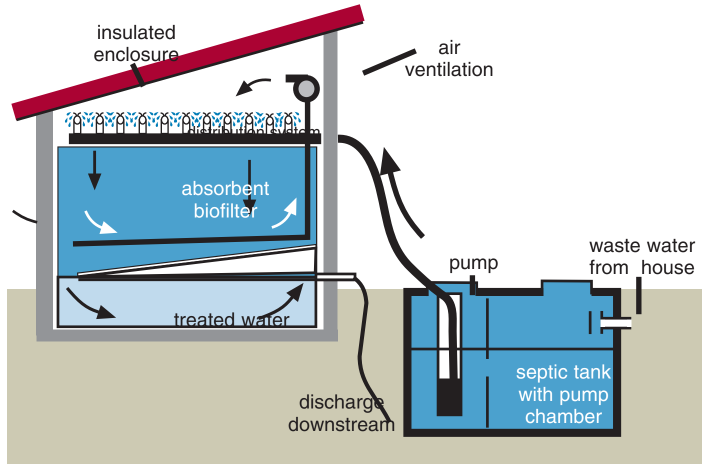

Figure 2: Diagram of Foam Biofilter Installation

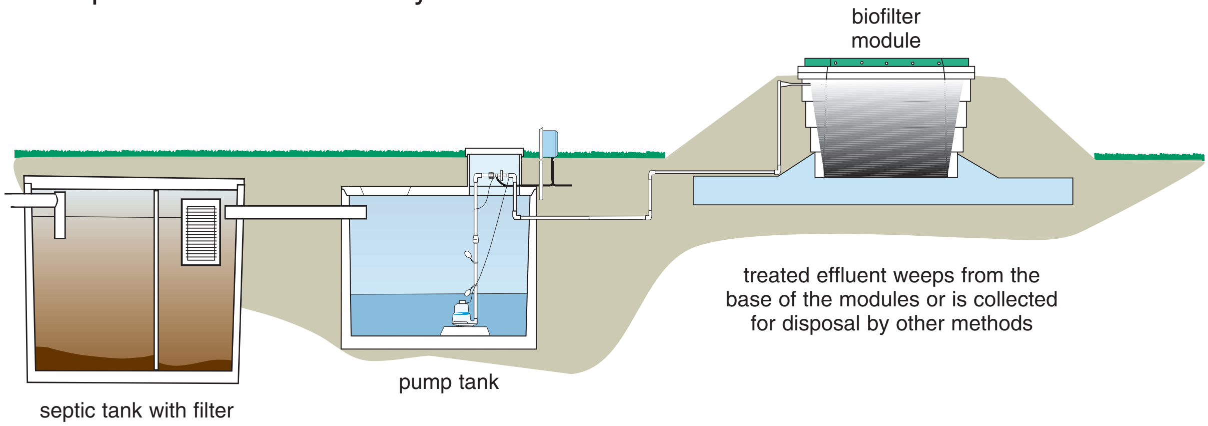

Figure 3: Typical Peat Filter Configuration

Peat biofilters are usually sold in modules, each approximately 7 feet long by 4.5 feet wide and 2.5 feet deep. This provides a surface area of 31.5 square feet, and can treat one bedroom, or roughly 150 gallons per day. This yields a loading rate of 5 gallons per square foot per day for a typical peat biofilter.

Textile filters also have a small land footprint and a high loading rate. These use textile sheets as a filter media and have a loading rate similar to foam cubes. A demonstration project in Rhode Island has shown that textile filters provide excellent reduction in BOD, solids, and nitrogen, especially with recirculation (Loomis, 2003).

Recirculation is an important consideration when discussing filtration. In a simple filter, the effluent passes the filter once and flows off to further treatment or discharge. This is called “single-pass.” However, the effluent can be collected from beneath the filter and returned to the dosing tank. Here, it mixes with raw wastewater and is sent to the filter again.

Recirculating filters usually dose effluent 6 to 12 times before discharge. While recirculation requires a more complex system of pumps, controls, and valves than a single-pass filter, the treatment efficiency is greatly increased. Multiple passes give the biomat more opportunity to clean the effluent and provide aeration to the wastewater as well. Further, the cycle of aeration in the filter and anaerobic conditions in the dosing tank facilitate denitrification and nutrient removal. This can provide an effluent clean enough for surface discharge in states where that is permitted. However, it must be emphasized that the filter is one part of the treatment process and that some thought must be given to the ultimate discharge of the effluent.

SITING ADVANTAGES AND DISADVANTAGES

As to when you should consider a biofilter as opposed to a conventional drainfield, that will depend largely on your site conditions. Put simply, a drainfield is just a single-pass filter using natural soil instead of another type of media. But many housing sites are unsuitable for drainfields. Either the lot is too small, or there is not enough depth of soil, or the soil is the wrong type. In these cases, a filter can be used to treat the wastewater to a high quality. The filter effluent can then be more easily discharged into the soil, or with disinfection, surface discharged to a nearby stream.

Typically, two methods of subsurface discharge are used. The more common method is small trenches, similar to a conventional drainfield. However, for single-pass filters, it is also possible to place the filter on a gravel pad and allow the effluent to soak into the soil directly beneath the filter. Subsurface dispersal systems are usually reduced in size compared to normal drainfields, since the effluent quality after a biofilter is much better than from a septic tank. However, the amount of drainfield reduction varies from state to state. Check with local authorities to determine the required size.

Drainfields are considered conventional treatment because they are low cost, reliable, and user friendly. Thus, they are the first consideration for onsite systems. However, if your site conditions preclude the use of a drainfield, check with your local health department about the possibilities of improving your wastewater treatment with a biofilter.

OPERATION AND MAINTENANCE

As previously mentioned, cleaning the filter is an important part of the required maintenance. For single-pass filters, this predominately means replacing the filter media periodically. It is sometimes necessary to add peat to peat filters to account for settling. For recirculating filters, a backwash system can be installed to regularly force clean water backwards though the filter and scour solids back to the pump tank.

There are also electrical and mechanical parts to consider, especially the pumps and alarm systems. These systems need to be checked regularly, usually every six months to one year, by a qualified technician. Pumps have a life span of roughly 15 years, so some thought should be given to eventual replacement costs.

COSTS

Biofilters are slightly more expensive than other treatment processes. An actual foam biofilter should cost around $5,000, not including the septic tank, any drainfield needed for ultimate disposal, disinfection, or labor for installation. A complete system should cost in the neighborhood of $8,000 to $10,000.

Bags of peat moss ready for installation in a filter

Peat filter module at the WV Onsite Demonstraton Center

Peat biofilters are sold in modules, each costing approximately $2,000. One module should be installed per bedroom, so a three-bedroom house would need 3 modules, or about $6,000 worth of filters. The entire system, installed would cost approximately $9,000. A four-bedroom house would need another filter module, for a total installed cost of approximately $11,000.

A fabric biofilter would be priced approximately $4,500 for materials plus the cost of installation by a local contractor. This includes the filter and filter tank, pump, controls, and recirculation piping, but does not include the septic tank or ultimate soil dispersion system.

Added to this are the annual operation and maintenance costs. These should cost approximately $250 per year for service on the electrical and mechanical components, pumping out the septic tank regularly, and cleaning the filter.

CASE STUDIES

A house with low permeable soils in eastern Canada was selected as a demonstration site for a biofilter installation. The system included a 1,000-gallon septic tank, with effluent filter, a 250-gallon pump tank, with timer controls and float switches, the biofilter measuring 6 feet by 6 feet, a denitrification filter using wooden pellets as media, and a single drainfield trench for ultimate effluent disposal.

Originally, the system was dosed four times each day. Now, the timer turns on the pump for 30 seconds every 15 minutes, as it was found that smaller, more frequent doses led to more efficient treatment. Float switches operate the pump should the effluent level rise too high, or set off an alarm if the pump fails to work.

The denitrification filter is a 3 foot by 3 foot box with 12 inches of wooden pellets as a filter material. Effluent from the biofilter is dosed over the pellets, which serve as a carbon source for denitrification. Keeping this filter ponded, and thus anaerobic, is a key to providing effective denitrification.

This system removes 97 percent of the biological oxygen demand (BOD), 79 percent of the solids, and 71 percent of total nitrogen. This highly treated effluent is then clean enough to disperse in the tight soils, where the drainfield removes the remaining BOD, solids, and nitrogen before the effluent reaches the groundwater.

Virginia has experimented with peat biofilters to provide pretreatment of effluent for tough soils. Their system layout resembles the biofilter, with septic tank, pump tank, filter module, and drainfield, lacking only the denitrification filter. The peat is provided in prefabricated modules, each capable of treating 150 gallons per day, or essentially, one module per bedroom.

The peat system removes 98 percent of the BOD, 99 percent of solids, and 41 percent of total nitrogen. The nitrogen exists almost completely in the form of nitrates, which are not significantly removed. However, the addition of a denitrification filter, as with the Canadian example, would account for this, if needed. Again, the drainfield accounts for the removal of the rest of the contaminants.

A demonstration project in La Pine, Oregon, installed three recirculating fabric filters for individual homes. In this package from Orenco Systems, the filter is installed on top of the septic tank, with a pump installed in the tank for recirculation. A control system increases the recirculation ratio based on incoming flow rates. Ultimate disposal is in a drip irrigation field. The system meets high effluent quality limits, providing an average effluent of 7 mg/l BOD, 6 mg/l TSS, and 16 mg/l total nitrogen. Results have shown that modifying the recirculation ratio can affect the nitrogen removal, and total nitrogen removal should reach 70 percent.

All of these systems provide effective pretreatment of residential wastewater, allowing it to be dispersed onsite even with tight or low-permeable soils. Evaluation programs in Canada and several U.S. states have repeatedly shown the effectiveness of treatment with biofilters.

If you would like more information on biofilters, the National Environmental Services Center maintains a Bibliographic database with articles about biofiltration and a Manufacturers database with company listings of firms that market biofilters. Both databases are searchable online at the website http://www.nesc.wvu.edu/nsfc/. Or you can call the toll-free hotline at (800) 624-8301, option 2, and request a database search from the technical assistance unit.