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Safe In-Ground Disposal of Treated Sewage

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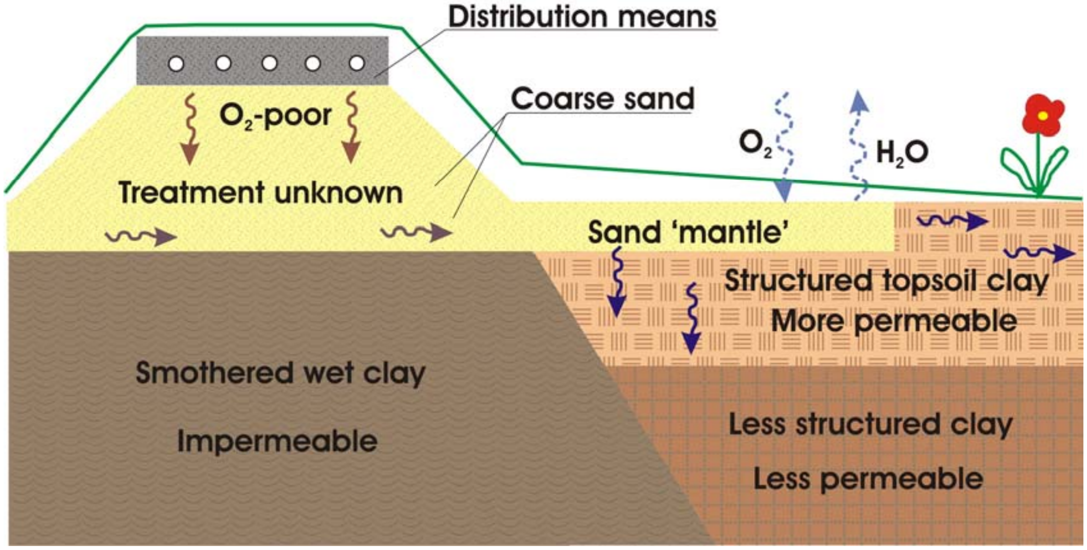
Conventional Septic Filtration and Disposal

The leaching bed treats septic tank effluent in the natural environment by biological filtration, and disposes of filter-treated effluent deeper down by dispersion and infiltration. Potent septic tank effluent promotes slime-forming microbes in an anoxic biomat, which renovates the sewage as it passes downward through the filter. However, the anoxic biomat also clogs the soil pores, decreases permeability dramatically, and increases the risk of unhealthy surface break-out.

In a conventional system, a large area and a thick layer (e.g., 900 to 1500 mm) of free-draining, coarse-grained soil is required for acceptable filtration. If these physical conditions are not present naturally (e.g., clay soil), a raised filter bed may be constructed to create them artificially (Figure 1). The raised bed is composed of a thick (900-1500 mm) raised filter that biologically treats the sewage, and a thin (250-300 mm) 'mantle' of soil or sand lateral to the raised bed in contact with the underlying native soil that disposes of treated effluent.

Figure 1. Raised filter beds combine both treatment and disposal functions in high-risk areas of clay, water table, and fractured bedrock. In this conventional system, a lateral 'mantle' in the topsoil is needed for disposal because the raised bed smothers underlying soil, making it impermeable.



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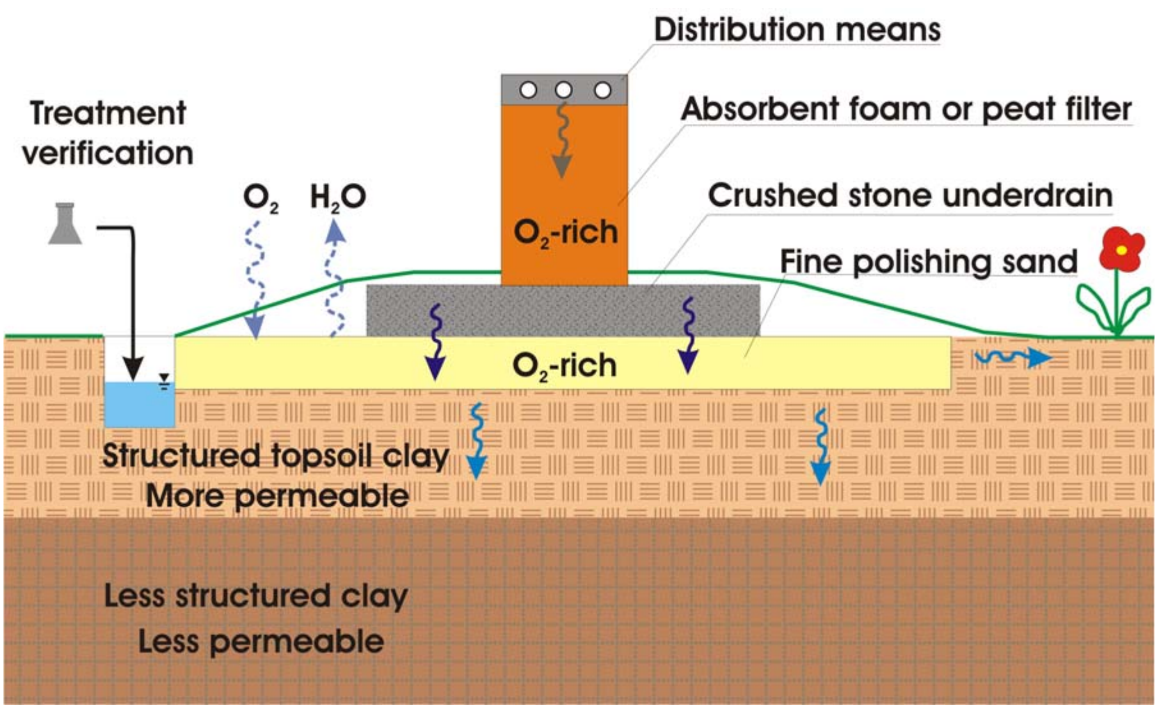
The raised filter bed is a mature, well-understood and accepted mode of septic filtration and disposal. However, because typically there is no under-drain below the raised bed, free-drained filtration is not guaranteed. Furthermore, treatment cannot be verified. Also, because the raised bed is wet with sewage, it ‘smothers’ underlying clay soil, destroys permeable topsoil structure, and severely impedes infiltration directly underneath the raised bed. A shallow ‘mantle’ is therefore sometimes required to be used in conjunction with the raised filter bed in order to provide for additional disposal of treated effluent in adjacent topsoil.

Detached Filtration and Shallow Disposal

To ensure enhanced safety and groundwater replenishment, the industry has in more recent years seen the development of technologies wherein the filtration-treatment and the infiltration-disposal functions have been separated. In such systems, a free-draining biological treatment filter is followed by disposal in a thin sand bed high in the soil horizon, to simulate the role of the ‘mantle’ seen in certain circumstances in the conventional raised filter bed (Figure 2).

Figure 2. In this type of system, proprietary filter technology and specifically engineered, sized and oriented Area Beds work together to perform distinct treatment and disposal functions. The filter-treatment component is under-drained and contains sampling points to ensure filter-treatment. The disposal component of the system is comprised of a thin layer of specifically engineered fine sand for dispersal and near-complete fecal removal.



Absorbent attached-growth biological filters, such as open-cell foam or sphagnum peat, operate similar to natural soils but use a manufactured filter medium with properties optimized for water retention and microbial growth. With under-drains built in, free-draining filtration is ensured.

Anoxic biomat develops within the absorbent filter medium, and clear effluent, with >95% of organics and suspended solids removed, can readily infiltrate the natural environment. With high oxygen, low ammonium content, advanced aerobic life forms, and >99% removal of fecal bacteria, filtered effluent discourages slime-forming bacteria, and encourages earthworms to thrive, maintaining natural soil structure and permeability.

Disposal of Filtered Effluent

There is a residual belief retained by some in the industry that only an anoxic septic biomat in native soil removes pathogens safely, and that clear filter-treated effluent moves through soil too quickly. The unfounded speculation is that an anoxic biomat is required to remove even the 1% or so fecals remaining in the treated wastewater, and that filter-treated effluent is *too clean* to be disposed of safely! First, as stated above, an anoxic biomat does form within the filter medium. Second, an aerobic biomat does also form in the shallow disposal area, although it is not so well-developed as to impede infiltration. Finally, as described below, third party testing shows that the specifically engineered thin disposal area, when used in conjunction with highly treated effluent from two proprietary technologies (Waterloo Biofilter open-cell foam and Ecoflo sphagnum peat filter systems), produces a clean effluent that is in fact stripped of virtually all remaining fecals before reaching the natural environment.

Some may not be familiar with the concept of physically detaching the treatment function from the disposal function. The safety of separate disposal of filter-treated sewage as compared to that of a conventional septic system can be demonstrated by sampling; (a) the biological filter effluent to verify sewage treatment, and (b) pan lysimeters under the disposal bed to verify final kill of fecal coliforms. These tests can be compared to any lysimeter tests on conventional soil or sand filter systems, which represent an acceptable benchmark that is presumed safe.

Designing a Shallow Disposal-Polishing Bed

Shallow topsoil has the highest permeability and has substantial lateral permeability by way of fractures, bedding planes, roots and organism churning. Oxygen supply and evaporation are maximized near the surface, and this allows higher-life forms such as earthworms to flourish and keep the soil light-weight and permeable for long-term, sustainable disposal.

A thin, homogeneous sand layer embedded in shallow topsoil allows treated effluent to filter down and laterally through the sand, being thoroughly cleaned before disappearing into the inhomogeneities of underlying soil or bedrock or into watertable. Fine sand remove fecals better than coarse, as shown in the MOE study by Chowdhry 1974. However, because fine sand plugs with anoxic biomat more readily, a clear, filter-treated effluent should be used instead of untreated septic sewage.

Vertical Fecal Polishing Studies at Buzzards Bay

To test for fecal polishing, effluent with 99.3% fecals removed by proprietary Waterloo Biofilter foam filtration was applied to disposal trenches for 24 months at the EPA-sponsored Buzzards Bay Test Facility in Massachusetts. (www.buzzardsbay.org/etistuff/results/waterlooresults.pdf). A 300-mm layer of coarse sand (100% passing #4 sieve, 0-5% passing #200 sieve) with a 'percolation rate' of <0.8 min/cm, was dosed at a vertical (basal floor) loading rate of 80 L/m^2/day (Figure 3, upper), and the effluent collected in pan lysimeters. Median values of fecals in the lysimeters were 400, 295, and 100 cfu/100mL for the 3 test units in the 1999-2001 period, respectively, for a final total kill of >99.99%.

A second study in 2003-2004 was carried out using 250 mm of finer sand (95.4% passing #4 sieve, 16.9% passing #200 sieve) with an estimated 'percolation rate' of ~5 min/cm (Figure 3, upper). At a vertical loading rate of 106 L/m^2/day and analysed from 10 mL aliquots, median fecals were all <10 cfu/100mL (non-detectable), and at 212 L/m^2/day from 100 mL aliquots, they were <1 cfu/100mL (non-detectable), for an overall final kill of 99.9993%.

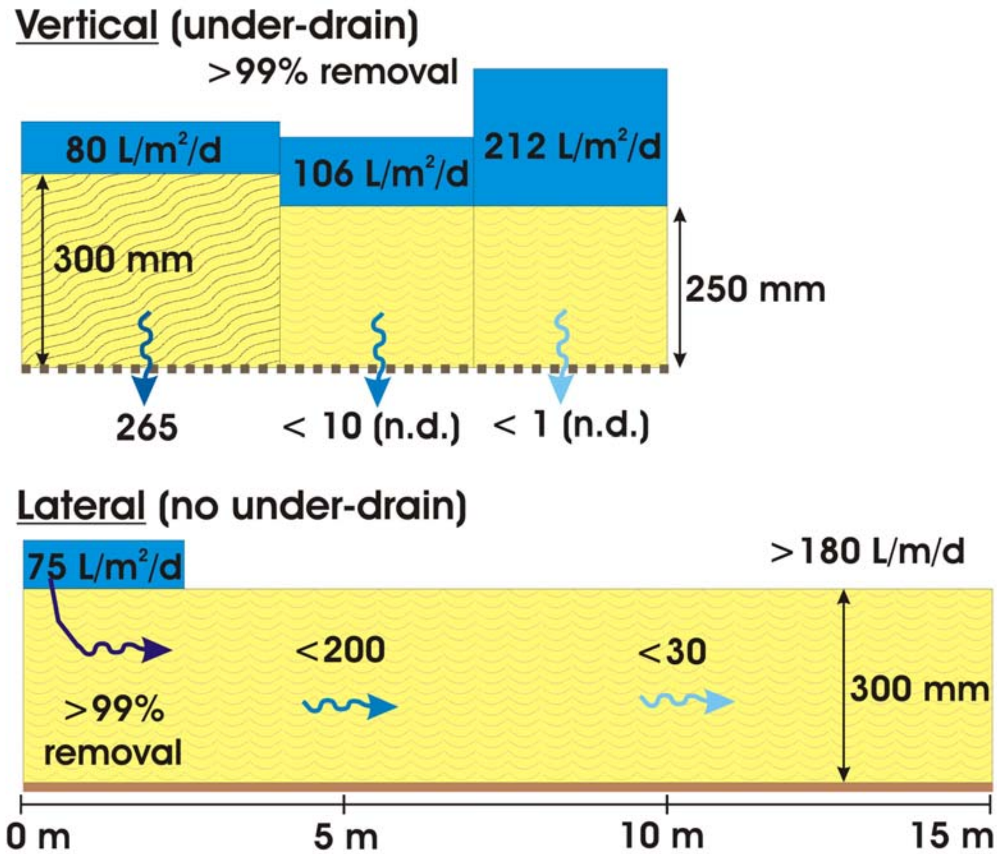
The conclusions reached here are that 300 mm of coarse sand removes fecals to a level that is near 'swimming water' quality (200 cfu/100mL), at a high vertical loading rate of 80 L/m^2/day. With the finer sand, just a 250 mm layer removes virtually all fecals from filter-treated effluent, to non-detectable limits, even at very high vertical hydraulic loading rates of 106 and 212 L/m^2/day.

Lateral Fecal Polishing Studies at Alfred College

Field studies were carried out at Alfred College of University of Guelph in eastern Ontario, with proprietary Ecoflo peat filter effluent directed laterally through a 300-mm thick bed of medium-fine sand on an angled impermeable floor with no vertical infiltration allowed (Figure 3, lower). The measured grain-size distribution of the medium-fine sand was D_{10}=0.2 mm, Cu = 3.3 (~75% passing through #16 sieve and 20% passing #60 sieve), with an estimated 'percolation rate' of 4-7 min/cm.

Fecal samples were taken at distances of 0 m, 5 m, and 10 m away from the filter unit over a 12-month period, including a severe winter. At a lateral loading rate of ≥180 L/m/day on a linear front, median values of fecals were <200 cfu/100mL at 5 m distance along the sand, and <30 cfu/100mL at 10 m distance.

Figure 3. (Upper) Filter-treated effluent moving vertically through 300 mm of coarse sand is polished to 265 cfu/100mL, whereas just 250 mm of finer Area Bed sand removes fecals to non-detectable at higher loading rates. (Lower) In the absence of an under-drain (as in clay soils or bedrock), the lateral movement of filter-treated effluent through 300 mm of Area Bed sand removes fecals to <200 cfu/100mL in 5 m, and to <30 in 10 m.



The conclusions reached here are that the proprietary peat filter removed 99.6% of the fecals from the septic tank, and that only 5 m is required for lateral migration of filter-treated effluent to produce 'swimming water quality' (200 cfu/100mL) and only 10 m is required to remove virtually all of the fecal bacteria, even at very high lateral loading rates of ≥180 L/m/day. In real life, much of the water will penetrate down into the soil, and evaporate, and lower this lateral loading rate, with even lower fecal counts at the 5 m distance.

Application of Findings for Safer Operation

Based on the results of these third-party field experiments of the filter-treatment systems discussed in this paper, following biological filtration, a 250-300 mm layer of medium-fine sand is adequate to kill effectively all remaining fecals when vertical migration occurs, and that the sand layer need only extend 5-10 m in the direction of flow for the same effect under lateral migration conditions.

With respect to infiltration into underlying soil observed in these filter-treatment systems, in extensive Michigan State University field tests, filter-treated effluent infiltrated tight soil 7-12 times more readily than septic tank effluent. University of Wisconsin researchers estimate 2-16 times rate, possibly >100 times in shallow, aerated soils.

In Ontario, the 'Area Bed' used in conjunction with the Ecoflo and Waterloo systems consists of 250-300 mm of medium-fine sand and has been installed and operated successfully over the last 8-10 years at thousands of large and small sites and even in the heavy, lacustrine-clay belt in SW Ontario. Gravel under-drains are sized to 75

L/m^2/day using conservative peak flows, with actual average loads being <40 L/m^2/day, well below the 106 and 212 L/m^2/day rates tested in these studies.

The underlying sand layer is sized to 17 L/m^2/day, not including adjacent topsoil, and its finer grain size retards vertical flow by capillary action much more than coarse sand, even when under-drained by fractured bedrock. Capillarity directs water sideways to encourage fecal removal and evaporation, decreasing the vertical and lateral loading further. With this built-in safety margin, and together with verifiable, free-draining filtration, the shallow Area Bed system provides sustainable sewage treatment and disposal.

Conclusions

Health and safety risks can be minimized when sewage is first treated separately by verifiable filtration, and the collected effluent is placed in a shallow sand bed to disperse the effluent and polish remaining fecals before reaching the natural environment.