Modern living necessitates double-filtering residential sewage

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In the 1950s, Ontario riverfronts were often smelly addresses for residential living, as sewers directed raw sewage into rivers and lakes. As kids we swam in and rafted on the Speed and Bighead, for instance, alongside still recognizable pieces of sewage. (Natural immunity to H1N1 may have been an unanticipated benefit!)

The Ontario Ministry of the Environment (MOE) cleaned up the rivers almost overnight in the 1960s by installing sewer systems and treatment plants. These are professionally operated and consistently remove organics, solids, ammonium, total nitrogen, phosphorus, and pathogenic microbes, before dispersal of treated effluent into now healthy rivers.

Natural soils 'managing' sewage

But what about septic systems used for residential sewage? In the 1950s, they consisted of a septic tank and a tile bed in natural soils; these were larger for clay soil and smaller for loamy soil, with no maintenance contracts. There was modest use of water, chemical cleaners and disinfectants, etc., and septic systems were deemed acceptable if the sewage did not rise out of the ground to create a health risk.

Today, the same sized septic tank and a tile bed, with no maintenance contracts required, are still the norm, but water usage has increased as has the use of chemical cleaners and disinfectants. Deterioration in septic tank health is very noticeable with excessive use of household chemicals. Without healthy microbes, sewage treatment will not occur.

There is no sign of improvement for septic systems, and, perhaps, not even any recognition of poor habits. Natural soils and groundwater are still relied upon to degrade sewage and disperse and dilute the products of decay; surface break-out is the only trigger to take care of unsafe operation. Disposal, not treatment, is still the objective of soil-based septic systems.

In 2001, a study was made of treatment performance in a code-required 900-mm-deep soil vadose (unsaturated) zone. After five months of biological maturing, effluent concentration over the next five months averaged ~30 mg/L BOD and ~20 mg/L TSS, with 96-99% removal of fecal coliform. This effluent quality, entering groundwater at a depth of 900 mm, is poorer than that following the double filtration technologies described below.

NSF Standard 40 testing for secondary quality effluent (<25 mg/L BOD, <30 mg/L TSS) ends six months after startup. The 900-mm-thick profiles tested in 2001 would not pass an NSF-40 test for secondary treatment units even with the underdrain, controlled laboratory conditions, and after the five-month startup period. When a treatment unit cannot pass a test protocol, then it should not be called a treatment unit.

The Ontario MOE requires campgrounds, golf courses, truck stops, churches, etc., to treat their sewage before it enters the natural soil. Organics and solids are to be removed before subsurface disposal, and treatment objectives for phosphorus, nitrate-nitrogen, and pathogens are becoming more prevalent before subsurface disposal. The same can be carried out for residences.

Figure 4. Multiple-barrier Waterloo "flat bed" and shallow area bed system protecting sensitive lakefront property — as simple and aesthetic as a filter bed, but with an underdrain to promote free-draining aerobic conditions and a maintenance contract for sustainability.

regulatory body has said:

"The potential for contamination is increased when highly treated effluent is used and there is no clogging layer formed on the soil surface. The clogging layer, which is formed when septic tank effluent passes through the soil, significantly reduces the coliform bacteria count before it reaches the groundwater. Pre-treated effluent is less likely to form a clogging layer, in which case the effluent will reach the groundwater more quickly with less treatment in the soil."

"The detrimental effect of non-uniform distribution is further amplified when ..... highly treated effluent is applied."

Some scientists echo this. In a 2001 article in *Water Research*, S. Van Cuyk and others stated; "If clogging zone development is retarded or absent altogether, for example due to the application of highly pretreated effluent (e.g., sand filter effluent), purification of pathogens and other constituents of concern may be less than predicted and desired."

The logic of this argument would lead us to believe that rainwater infiltrating the soil is very risky because it is too clean to develop a septic biomat. Of course, this stance is as insupportable as saying, "Brantford should not treat its sewage — only the Grand River can do it safely."

Biological film does, of course, develop in a sand filter, as in all biological filters, and microbes have already done the job of the soil-based biomat, but independent of the natural environment.

Oxygen supply is needed

Ignored is the fact that high-quality effluent carries its own oxygen supply (4-8 mg/L D.O.) into the soil and, with <5% of the organic content of septic effluent, it is far less reliant on the vagaries of natural soils for treatment, especially on soil air influx to promote the aerobic treatment objective.

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Oxygen delivery down through soil pores to treat sewage, and its effect on biomat and sewage ponding, were discussed by J. Erickson and E.J. Tyler in the 2000 NOWRA *Conference Proceedings:* "Clogging mats [biomat] develop when organic matter loading is higher than the oxygen supply for aerobic bacteria. If the oxygen supply meets the demand of the soil organisms, then the organic clogging mat will not form. In the absence of a mat, the soil could accept wastewater at rates of two to three orders of magnitude higher than the current design loading rates."

Biomat and ponding are an effect of organic overloading of the soil interface at times when insufficient oxygen enters the soil-water interface to promote aerobic decomposition. Septic biomat appears not to be a desirable or necessary development. It may instead indicate overloading from insufficient trench length and poor soil air infiltration.

On filtration treatment units, such as sand, peat or absorbent foam, excessive sewage ponding on the filtration surface is viewed as hydraulic failure and requires recovery; the same standard applies to soil filters. Because it is an introduced accumulation of excess sewage by-products in the soil profile, septic biomat may in fact be termed a "soil contaminant".

Erickson & Tyler also stated, "...... the soil component of the wastewater infiltration system should be large, shallow, narrow, and have separated infiltration areas to maximize oxygen supply." In order to promote aerobic treatment in soils (which clogs the soil far less), it is better to have longer and narrower trenches, wider spacing between trenches, and higher-quality effluent with low organic loading.

In Ontario residences, sewage may be placed directly in trenches, 900 mm wide and 900 mm deep, and in tight soils, counter to oxygen delivery requisites. Even if treatment does occur, it is not verifiable, and soil-based systems can be termed only 'disposal', 'absorption' or 'dispersal', not 'treatment'.

Sand filtration: integrated disposal system

The MOE carried out world-class research in the 1970s on tank sludge accumulation rates, sand filtration (Figure 2), contaminant attenuation in groundwater plumes, etc. It formed the basis of Ontario's prescriptive subsurface regulations in 1982 and of OBC Part 8 in use today.

It has been demonstrated that sewage can be treated outside the natural environment to very high "sand-filter quality" (<10 mg/L BOD and <10 mg/L TSS) in the Canadian climate, with only clear effluent entering the earth for "polishing." Fecal coliform attenuation is excellent with a smaller sand grain size, but the coarse fractions can emit >200,000 cfu/100mL.

Biological filtration is the mainstay of small sewage treatment systems in Canada, because of low-energy input, ease of use, and ability to treat cold sewage. Biological film-forming microbes populate the surfaces of the filtration medium and consume contaminants that pass by. Septic and aerobic biofilm stays within the filtration unit and outside the natural environment.

The MOE sand filter (OBC Filter Bed) began the trend of recognizing poor habits of soil disposal, and of minimizing soil and groundwater contamination.

Under present practices, the filter bed is installed without the underdrain (as it was originally tested), and, therefore, its performance cannot be predicted or verified. It is a single, integrated system, with sand and soil disposal combined. Clay soil below the sand filter is wetted and "smothered" by the sewage and sand cover, and its permeable topsoil structure is destroyed. A sand "mantle" is placed to the side for lateral dispersal into the shallow topsoil, but integrated into the filtration unit with no chance of verification.

It would be an improvement to underdrain the filter bed to verify treatment as tested, use the finer sand sizes and lower 50 L/m^2/d loading rate to improve pathogen removal, collect the effluent to verify treatment, polish the effluent in a separate finer sand bed to provide further removal of viruses and residual *E. coli*, and have maintenance contracts. These additions would bring filter beds up to the standard of the multiple-barrier, detached treatment-disposal systems discussed below.

Absorbent filtration: detached treatment disposal system

The industry has developed technologies that separate the aerobic filtration treatment and infiltration polishing foil and go4/T ed to pro