Grease and Oil in Restaurant Wastewater

(From Issue 7)

Wastewater from restaurants and other commercial food service facilities differs significantly from residential wastewater. In addition to higher surge volumes during busy periods, and generally higher temperatures, restaurant wastewater is typically higher in strength than residential wastewater. This is due to higher levels of oil, grease and foods which cause a higher biochemical oxygen demand (BOD). Oil and grease frequently cause problems for both on site sewage disposal systems and public sewer systems. The problem occurs when oil and grease liquefy at the high water temperatures used to wash dishes and later solidify in sewer lines or sensitive soil interfaces in the leaching facilities of onsite systems. The problem is exacerbated when highly efficient detergents are used to emulsify the oil and grease, keeping them in suspension until they enter the leach field. Although conventional grease traps are supposed to prevent grease from entering the septic tank or sewer line, high grease loads, emulsified grease, and surge wastewater loads often cause grease to bypass the grease trap and enter the leach field.

When grease reaches the soil absorption system it can physically clog the soil pores preventing both water infiltration and the free transfer of oxygen necessary to digest waste. The high BOD present in grease also promotes excessive bacterial growth which causes the formation of a thick anaerobic biomat that has less ability to actually treat the waste. The result is premature failure of the soil absorption system. Data suggests that if soil absorption systems at restaurants are to function in the long term, design modifications must be made which take into account the much higher wastewater strength, flow variations, and oil and grease constituents found in restaurant wastewater.

UNDERSTANDING OIL IN WATER

Oil in water can be present in four basic forms: free oil, mechanically emulsified oil, chemically emulsified oil, and dissolved oil. The majority of oil and grease found in restaurant waste is free oil which will rise to the surface of the water in which it is contained. All conventional grease traps and grease recovery devices discussed here are basically designed to recover free oil by allowing it to coalesce. The liquid oil can then be collected by skimming the water surface (grease recovery devices) or the oil can be allowed to congeal on the water surface for later collection (conventional grease traps). A second form of oil in water is mechanically emulsified oil. This is caused by agitating a free oil and water mixture to the point where it breaks the oil up into very small droplets (10-20 microns). High water temperatures and use of liquid vegetable oils promote mechanically emulsified oil. Mechanical oil emulsions will separate by themselves given enough time, but without sufficient time for separation to occur (i.e. if the grease trap is too small or there is excessive surge water loading) these oils can be carried over into the leach field. Oil and grease may also become chemically emulsified, primarily through the use of detergents and other alkalis. Chemically emulsified oil particles are very small (<1 micron) and do not rise to the surface of the water regardless of how much time is allowed. Chemically emulsified oils can be removed by specially designed pre-treatment units, however these are generally sized for higher volume industrial uses, and we are unaware any small-scale units which are available. Chemically emulsified oil may be a significant portion of the total grease in food service wastewater and is quite likely to be carried through the septic system to the leaching facility. The best strategy for dealing with chemically emulsified oil in restaurant wastewater seems to be preventing it from becoming emulsified in the first place. This can be done by using detergents which promote
rapid oil/water separation. Lastly, oil may be present as dissolved oil in which case it is no longer present as discrete particles. Oil generally becomes dissolved in water through the use of degreasing compounds which are soluble in both oil and water (hence their ability to be degreasers). Since many degreasers are chlorinated solvents or other prohibitively strong chemicals we recommend that these compounds not be used, hence eliminating the problem of dissolved oil.

WASTEWATER CHARACTERISTICS

Several studies characterizing restaurant wastewater were conducted at the Universities of Washington and Wisconsin in the 1980's. Results from both studies are shown in Table 1, along with results for typical domestic wastewater. The Washington study analyzed raw (no pretreatment for grease removal) restaurant wastewater for oil and grease, BOD, and total suspended solids (TSS). The Wisconsin study characterized pretreated septic tank effluent (STE) from 12 full service restaurants. All systems included 1 or more septic tanks for pretreatment and 8 of the 12 restaurants also had indoor grease interceptors. All but one of the restaurants served full dinners and many served lunch. However, 5 of the 12 restaurants received substantial amounts of non-restaurant wastewater (2 were located at large restaurant/motel complexes and 3 were at golf clubs). The data shown in Table 1 for the 6 selected restaurants refer to the six restaurants which served full dinners but did not receive wastewater from other sources such as showers or locker rooms. As shown, pretreatment by simple septic tank/grease traps results in a significant reduction in oil and grease, BOD, and TSS compared to raw restaurant wastewater, although these constituents are by no means reduced to levels of residential wastewater by these measures.

Table 1

<table>
<thead>
<tr>
<th>Type of Wastewater</th>
<th>BOD mg/l</th>
<th>Oil and Grease mg/l</th>
<th>TSS mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw restaurant wastewater (Washington Study)</td>
<td>1000-2000</td>
<td>100-300</td>
<td>300-625</td>
</tr>
<tr>
<td>Pretreated restaurant wastewater (Wisconsin Study- 12 restaurants)</td>
<td>101-880</td>
<td>24-144</td>
<td>avg = 365</td>
</tr>
<tr>
<td>Pretreated restaurant wastewater (Wisconsin Study-6 selected full-service restaurants)</td>
<td>245-880</td>
<td>40-144</td>
<td>avg = 506</td>
</tr>
<tr>
<td>Domestic Wastewater</td>
<td>100-400</td>
<td>16-65</td>
<td>100-350</td>
</tr>
</tbody>
</table>

The Wisconsin study concluded that preventing oil and grease from getting into the septic system was the best way to prevent problems. Other solutions recommended to protect soil absorption systems included: plumb kitchen waste separately since it contains the majority of grease, BOD and TSS; install grease traps or grease recovery devices; provide biological pretreatment of wastewater before its discharge to the soil absorption system; properly size soil absorption systems based on wastewater strength; and educate restaurant personnel in kitchen practices which minimize discharge of grease to the plumbing. Each of these strategies is discussed below.

OPTIONS FOR REMOVING OIL AND GREASE FROM WASTEWATER

Grease Interceptors (Under the Sink Grease Traps)

Grease interceptors are typically small, ranging from five to fifteen gallons of liquid capacity (Figure 1). Because of their small capacity, traps connected to a multiple compartment sink or dishwasher can easily be filled within a week's time. Once filled, hot water running through the interceptor will dissolve the grease and a steady state (grease coming in, equals grease going out)
will be reached. A further problem is that cleaning these interceptors is a smelly messy job with the result that they are rarely cleaned. It is generally recognized that grease interceptors alone are not particularly effective in preventing grease from entering the septic system leachfield.

**Conventional In-Ground Grease Traps**

Title 5 requires that grease traps be installed to handle kitchen flows at restaurants, nursing homes, schools, hospitals and other facilities from which quantities of grease can be expected to be discharged. Grease traps must have a minimum depth of four feet, a minimum capacity of 1000 gallons and sufficient capacity to provide a 24-hour detention period for wastewater flows. Warm greasy liquid wastes from the kitchen enter the tank and mix with the cooler liquid in the tank causing the grease to separate and congeal. As long as the mixing is not turbulent, the warmer liquid rises and the cooler liquid, from which the grease has been separated, settles and is carried out to the leach field. Sizing the tank to provide at least a 24 hour retention time is supposed to ensure sufficient cooling time for the grease to separate from the water. In some cases, however, this designed tank volume may not be large enough, especially if the kitchen produces very greasy wastes or there are periods of surge loading (several hours at dinner, high weekends loads, etc.). An important note is that when cleaning the grease trap only the grease layer should be removed. It is optimal not reduce the liquid volume available for cooling the greasy wastes entering the tank. A schematic of grease trap placement is presented in Figure 2.

Even under the best of conditions, in-ground grease traps remove only a percentage of the total grease and BOD. Comparison of raw vs. in-ground grease trap treated wastewater in the Washington and Wisconsin studies discussed above suggests that grease traps are capable of removing up to 50-60% of oil and grease and 50-80% of BOD and TSS (Table 1).

<table>
<thead>
<tr>
<th>Restaurant Type (with 1,000 gal grease trap)</th>
<th>Grease influent (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fried Chicken</td>
<td>120-6500</td>
</tr>
<tr>
<td>Chinese</td>
<td>76-1300</td>
</tr>
<tr>
<td>Mexican</td>
<td>96-1040</td>
</tr>
<tr>
<td>Country Club</td>
<td>130-706</td>
</tr>
</tbody>
</table>

The **Zabel® Filter** is a product designed to improve the efficiency of grease traps. The filter is installed in the grease trap in place of the standard outlet baffle. It is intended to prevent most grease and food products.
from leaving the grease trap. Information provided by Zabel on the grease removal efficiency of its filter installed in a 1000 gallon in-ground grease trap is presented in Table 2. The filter cartridge must be serviced regularly; if not serviced it will continue to stop the outflow of grease but will eventually shut down the flow of effluent from the tank. Restaurant personnel can clean the filter themselves into a waste grease container or can save the mature cartridges for a septic service company to clean. The cost of a Zabel filter including cartridge is $185.00 plus installation; replacement cartridges cost $86.00 each.

**GREASE RECOVERY DEVICES**

Grease recovery devices (GRDs) are designed to intercept, trap and remove floating (free) grease and oil in kitchen waste before it leaves the building. They are typically installed in the kitchen to receive wastewater from dishwashers and/or three-compartment sinks. The basic design consists of a baffled box which receives warm kitchen wastewater. Grease and oil separate and rise to the water surface where it is mechanically skimmed or allowed to drain off the top of the water and flow to a recovery chamber.

In the design used by the **Atlas® Systems**

Grease Recovery Device (Figure 3) the water enters the box and is forced downward by an inlet baffle. The grease separates as it passes through the perforated baffle. The separated grease rises to the surface and is contained by the outlet baffle. A heating unit in the box maintains water temperature at 120°C so that all grease will remain in liquid form which ensures maximal grease/oil separation. As grease builds up in the retention area it signals a sensor which opens the grease draw-off valve. Grease then flows to the grease collector box for reclamation. The purchase cost of the device is approximately $3500.00. Many of these are presently in use in Dennis and Barnstable and testimony on their performance generally is quite positive.

The **Big Dipper** (Figure 4) grease recovery device operates on a similar design which allows grease to rise to the water surface. In the "dipper" design, a surface is exposed to the grease/water mixture and subsequently wiped to an oil conveyance/collector pipe. The pipe lets the grease flow to a storage unit beside the skimmer. The cost of this unit is $2500-$3500 depending on size. It is important to note that all of these grease recovery devices are designed for and are only capable of removing free grease and oil that is floating on top of water. They are not effective in removing emulsified grease (i.e. grease held in suspension by detergents).

**BIOLOGICAL PRE-TREATMENT**

Another option for preventing oil and grease from entering the soil absorption system is the use of biological pretreatment to breakdown and digest the grease. Biological pre-treatment units are basically small secondary sewage treatment systems designed to aerobically digest BOD and grease in wastewater. **The Nibbler** (Figure 5) is a pretreatment system specifically designed to treat high strength commercial wastewater. The Nibbler is purported to reduce wastewater strength (BOD) by approximately 90%, making the wastewater roughly equivalent to domestic septic tank effluent and therefore suitable for disposal in a soil absorption system. It is specifically marketed to restaurants, schools, supermarkets, and other food processing establishments. The Nibbler is an aerobic digester which uses up-flow aeration. The Nibbler unit is comprised of buoyant media held in place just below the liquid surface by pods of molded plastic which resemble milk crates. The buoyant media provides a large surface area to support growth of the microbial population which digests the grease. An airblower forces air through airtubes located in the center of each pod. This creates an aerated liquor which turbulently circulates through the buoyant media. The continual aeration and turbulence introduce oxygen which supports microbial growth and digestion of the waste. Turbulence also promotes
biological sloughing from the media. The air blower is the only mechanical portion of the system and is housed in a separate vault. **A typical Nibbler installation consists of an inground grease trap followed by a surge tank followed by the Nibbler unit then a clarifier tank before the leach field.** The Nibbler unit itself is installed in a 1750-2000 gallon single compartment concrete tank with the top exposed at ground level. The surge tank supplies flow to the Nibbler unit at a constant rate and compensates for the surge water loads common at restaurants. The Nibbler is sized based on average daily flow and biological loading and each unit ideally should receive no more than 6.5 lb. BOD per day and 1100 gpd wastewater. Multiple units can be installed if flow and wastewater strength warrant. A mandatory contract for quarterly maintenance and monitoring is required by the Stuth Company which sells the unit. A single Nibbler unit including the buoyant media pods and airblower costs about $7000.00 installed.

In some cases, recirculating sand filters can be another option for pretreatment of wastewater before discharge. The sand filter acts as a biological treatment unit to digest grease and food waste and thereby lower BOD. A properly sized, efficiently operating sand filter should be capable of reducing BOD to levels equivalent to untreated domestic wastewater. However, there are several design constraints which must be taken into consideration. BOD in wastewater entering the sand filter should not exceed 720 mg/L (most restaurant kitchen waste should be able to meet this limit if it passes through a grease trap first). Assuming a BOD of 720 mg/L, the sand filter can accept a hydraulic load of about 1.6 gpd/sf (loading rate(gpd/sf) = 1150/BOD per DEP RSF design guidance). To accommodate such a low loading rate, the sand filter must have a very large surface area. For example, the wastewater from only the kitchen flow of a 100 seat restaurant (100 seats X 15 gal/seat=1500 gal) would require about 940 sf of sand filter surface (surface area(sf) of filter bed=design flow/loading rate; SA=1500/1.6=937 sf). It is apparent that RSFs are feasible only for restaurants with low volume flows or where lots of space is available for construction of the sand filter.

Other small package systems which utilize extended aeration may also provide a degree wastewater treatment although they are not specifically designed for this purpose. As long as these units are not overloaded with grease to the point of clogging they are able to significantly reduce BOD and TSS and over time will usually develop a bacterial population that is capable of digesting a significant portion of oil and grease. For example, the Biocler® unit has been installed at a number of supermarkets where it is effectively reducing total grease in finished effluent. Typical influent to the Biocler unit (which has already passed through a septic tank) contains 40 mg/L grease and finished effluent contains 7 mg/L. It is not known how effectively the Biocler unit would function with the higher levels of oil and grease in restaurant waste.

**BACTERIA AND ENZYMES**

Most Boards of Health have heard manufacturers and sales representatives make wonderful claims for these products. However, there have been few well designed studies and there is no conclusive evidence about the effectiveness of specific bacterial or enzyme products for treating grease in either grease traps or in the
OTHER STRATEGIES FOR REDUCING GREASE OVERLOADING AND SEPTIC SYSTEM FAILURE

Restaurant Kitchen Practices

Possibly the most cost effective way of protecting the septic system from the effects of grease is to change kitchen practices. Dishwashing personnel should be trained to thoroughly scrape plates and cookware to remove all food waste, especially cooking oils and creamy sauces and gravies which are high in grease, before rinsing dishes. Higher water temperatures and higher water flow rates promote mechanical emulsification of oil. Low temperature (sanitizing rinse) dishwashers may assist in keeping oil from being emulsified and may promote more rapid separation of free oil and grease in the grease trap. Use of shortening in place of liquid vegetable oil also promotes more complete separation of grease, since shortenings solidify at room temperature and liquid oils do not. Another strategy to improve grease separation in the grease trap is the use of specially formulated dishwashing and general cleaning detergents which promote rapid oil/water separation. These special detergents are formulated to create an unstable oil-water emulsion which rapidly breaks down releasing the grease so it can rise to the water surface. One manufacturer is Allied Enterprises Inc. of Norfolk, Virginia. Restaurant supply wholesalers may know of other sources to purchase these products.

Correct sizing and loading rate for soil absorption system

The Wisconsin study cited above was prompted by the hydraulic failure of a number of restaurants’ soil absorption systems (SAS). Several of these systems failed hydraulically within months of being put into operation despite the fact that no errors in system design or construction could be found. The Wisconsin study found that most of the restaurants' SAS's had been designed using guidelines for domestic systems with only minor modifications for organic loading, problem wastewater constituents and water flow variations. The Wisconsin study examined SAS's at 12 restaurants for efficiency of operation and for evidence of failure such as ponding within the SAS. The study found that these systems were dosed at hydraulic loading rates of 0.08-0.9 gpd/sf. Of the 12 systems, 5 were performing badly and 3 of the 5 had surface effluent breakout. The study results suggested that hydraulic loadings higher than 0.4 gpd/sf may be too high for long-term successful operation of the SAS where higher organic loads are expected.

The Wisconsin study also concluded that, more important than the hydraulic loading of the SAS, is the mass loading of selected wastewater constituents. High mass loading of organic matter and suspended solids may result in clogging of the SAS. The mass organic load applied to the SAS's of all 12 restaurants studied varied from 8.8 to 99.8 lb/BOD/acre/day. Four of the 5 systems whose SAS's were performing poorly were found to have organic loading rates greater than 40 lb/BOD/acre/day. This organic loading rate is more than twice as high as that typically applied to SAS's for domestic septic tank effluent.

The study also found that SAS design may be important. All 5 of the poorly performing SAS's in the study were bed designs. One trench system seen performed well even at very high hydraulic and organic mass loading rates. The study suggests that trench designs perform better than bed designs, possibly because trench designs offer greater infiltrative surface area and greater aeration.

The study concluded that for SAS bed designs installed in sandy soils (perc rate <10 min/inch) maximum application rates in the range of 0.70 gpd/sf hydraulic load, 40 lbs.BOD/acre/day, and 15 lb TSS/acre/day were appropriate. Higher mass loadings may possibly be successfully applied to SAS's using shallow narrow trench designs.

Septic System Maintenance

Because restaurant wastewater contains significantly higher levels of organic matter, solids and grease than residential wastewater it is possible that sludge accumulation in restaurant septic tanks may occur more rapidly than in household units. This may require the septic tank to be pumped more frequently than the every 2-3 years recommended for residential tanks. It may be prudent to pump the sludge and scum from restaurant septic tanks quarterly during their initial period of operation; after the rate of solids accumulation is known the pumping schedule can be adjusted as needed.
SOURCES OF INFORMATION ON PRODUCTS

The following flyer was created for boards of health to distribute to restaurant owners, and is reproduced here. If you would like a camera-copy for duplicating on your own letterhead, contact Barnstable County Department of Health and the Environment.

RESTAURANT OWNERS
12 SIMPLE WAYS TO PROTECT YOUR SEPTIC SYSTEM

Restaurant kitchen wastewater usually contains high levels of food waste and grease. If grease or food solids reach your leaching field they can permanently damage the field so that it no longer functions to dispose of wastewater. This leads to costly leaching field repairs. You can help protect your leach field by following these simple procedures.

**Changing kitchen practices** is a low cost but very effective way of protecting your septic system from the effects of grease:

1. **Train dishwashing personnel to thoroughly scrape plates and cookware** to remove all food waste, especially cooking oils and creamy sauces and gravies which are high in grease, before rinsing dishes. Thorough scraping of dishes will prevent the majority of grease in your waste stream from entering your septic system.

2. **Consider installing a grease recovery device (grease skimmer).** These devices, installed in the kitchen, are designed to trap and remove floating grease from wastewater before it leaves the building. Wastewater enters the trap where grease rises and is continually skimmed off the water surface. The grease then flows to a collection chamber for recovery. Grease recovery devices can remove a large percentage of grease in wastewater.

3. **Practice water conservation.** Restaurant kitchens produce surge water flows during mealtime dishwashing periods. Surge water loads push wastewater through the grease trap too rapidly for grease to separate. Water conservation helps prevent surge loading.

4. **Low temperature (sanitizing rinse) dishwashers** may assist oil and grease to separate out in the grease trap. High water temperatures cause grease to become emulsified. Emulsified grease does not separate out in a grease trap and may be carried over into your leaching field. Check with your dishwasher manufacturer to see if your machine can be used as a low temperature sanitizing rinse dishwasher.
5. **Look for special dishwashing and general cleaning detergents that promote rapid oil/water separation.** These detergents are formulated to release oil quickly so that it can rise to the water surface instead of remaining emulsified.

6. **Use proper concentrations of solvents, cleaners and disinfectants.** Solvents and cleaners can cause grease to become emulsified and be carried past the grease trap to the leach field. Excess use of disinfectants reduces bacterial action in the septic system which in turn reduces treatment of wastewater.

7. **Use shortening in place of liquid vegetable oil.** shortenings solidify at room temperature while liquid oils do not. Shortenings will separate out more rapidly and thoroughly in a grease trap while liquid vegetable oils are more likely to be carried over into the leach field.

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**Make sure your septic system and grease trap are serviced regularly:**

8. **Pump grease trap quarterly (unless local regulations require more frequent pumping).** Leaving grease in the grease trap too long causes it to harden which makes it very difficult to pump out.

9. **Leave most of the liquid in the grease trap when it is pumped.** Only the layer of grease which accumulates on the water surface should be removed when the trap is pumped. Leave the underlying liquid to act as a reservoir of water so that new grease entering the trap can cool rapidly and solidify.

10. **Pump septic tank frequently to prevent buildup and carryover of solids.** Because restaurant wastewater contains high levels of solid food waste sludge may accumulate rapidly. If too much sludge accumulates solids can be carried over into the leach field and damage it.

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**If you are upgrading your septic system:**

11. **Consider installing a larger in-ground grease trap, or a series of grease traps.** A standard grease trap has a 1000 gallon capacity. This volume is intended to provide wastewater with a long enough residence time so that it can cool and grease can separate and solidify. If the grease trap receives high surge volumes of water and/or high temperature water there may not be enough time for wastewater to cool and grease to separate. A larger grease trap, or a number of smaller grease traps in series, will compensate for this problem by providing a longer residence time. The longer the residence time of the wastewater, the better the grease removal.

12. **If you are replacing your leaching system, consider installing leaching trenches instead of a leaching bed design.** Leaching trenches provide more oxygen to the wastewater entering the leaching field. This promotes bacterial growth which breaks down the wastewater and helps to prevent clogging of the leaching field.