Improving Safety of Septic Systems through Professional Operations and 'Maintenance in Mind

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by

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INTRODUCTION

Servicing what you own is very important, and it does not matter whether the item is a complex machine or a simple shoe. For instance, everyone agrees that automobiles require regular servicing, and because of their complexity, they require expert service people. Most people get this done to protect their investment and to avoid accidents and breakdowns. A bicycle is less complex but still needs servicing, which can be done by service personnel or even the owner. Still less complex are our shoes that we walk in or the carpets we walk on. Even though they have no moving parts, they still need servicing to keep them in good working order! The point we want to make here is that regular servicing is required of most things we use, and it is not dependent on complexity. The same should apply to septic systems, but it doesn't.

Currently under the OBC, all sewage treatment systems require a maintenance contract between the homeowner and a professional service provider. Conventional septic tanks and tile beds are not. This discrepancy is justified by regulators in that treatment systems are considered more complicated than conventional septic systems, requiring electrical and mechanical components such as pumps or blowers. Many conventional systems of course are just as complex. However, in conventional systems, even where pumps are involved, only the homeowner is responsible for its operation, and no maintenance contract is required. It is not easy to explain why one homeowner requires an ongoing maintenance contract whereas the neighbour does not, even though the complexity is the same. This situation is not justified, and should change.

For health and safety reasons, and to protect the groundwater, all septic systems should be maintained by professional operators. Just because nothing moves in a standard septic tank and tile bed doesn't mean servicing is not required. There is something disconcerting about putting untreated septic tank sewage into the ground with no one looking after it.

The EPA recognizes that properly managed on-site systems protect the environment and public health over the long-term and do so at a lower cost than conventional centralized systems (West, 2001). We need to ensure our politicians that our industry is professional, cost-effective, and safe. Septic systems will work for 20 years or so, but with modern lifestyles and modern chemical use, 'flush-and-forget' is not an option for Ontario. Premature failure due to improper design, installation difficulties, or harsh chemical use can be avoided by regular servicing.

If the OBC requires all septic systems to be maintained properly, a whole new industry in Ontario will develop, with companies looking after thousands of systems. This will raise the level of professionalism in our industry, and improve the public image of septic systems in general. Until an operations and maintenance program is put in place, it will be difficult for our on-site industry to thrive or be acknowledged as a permanent solution for wastewater treatment and disposal.

OPERATIONS AND MAINTENANCE – THE PLAYERS

The goal of operations and maintenance is to make sure that the septic system is working properly, protecting health and the environment. Operations and maintenance (O & M) is not the sole responsibility of the maintenance provider, but is the synergistic cooperation between designer, regulator, manufacturer, contractor, maintenance provider, and owner. Just like a professional sports team, each player has a role to make operations and maintenance work. Without cooperation the team will lose and the goal of operations and maintenance will be difficult if not impossible to attain.

The regulator's responsibility is to ensure that operations and maintenance contracts are in place and are executed on an ongoing basis. Designers must design systems such that they are easily accessible and as simple as possible so that components can be serviced with ease. Contractors must install the system correctly and should also be aware of any deficiencies in the design that may hinder performance or maintenance of the system. Manufacturers of concrete tanks, proprietary systems, pumps and other septic system related products should provide training courses, manuals, and products that can be operated and maintained with minimal fuss. Maintenance providers are responsible for providing services in a professional and timely manner. Perhaps the most important player of them all is the owner. The owner must 'buy into' the operations and maintenance program for it to work. They must be educated on how their septic system works, all the dos and don'ts and what they can and cannot put into their septic system. Chemical wastewater is different from sewage wastewater.

When this cooperation among the players is accomplished, and each person performs his/her job with 'operations and maintenance in mind', then a new professional operations and maintenance industry can be opened up and Ontario will again lead the way in innovation.

OPERATIONS AND MAINTENANCE – THE PROGRAM

Many failing septic systems are the result of improper or no maintenance because the OBC leaves the homeowner responsible for their septic system. "Left in the hands of the householder, many on-site treatment systems will continue to fail due to neglect, revulsion, ignorance or lack of skill" (West, 2001). In a 1997 report to Congress, the US EPA found that on average 25% of on-site systems are failing but they also stated that "… decentralized (on-site) systems, where properly managed, could protect water quality over the long term and do so at lower cost than conventional systems in many communities" (EPA, 1997). Therefore, in order for on-site to become a truly sustainable wastewater treatment solution is to have a management plan in place.

The US EPA has done some extensive work to identify the steps in the implementation of management plan for operations and maintenance of on-site systems. In the 'Guidelines for

Management of On-site/ Decentralized Wastewater Systems' (EPA, 2000), the EPA lists five levels of management:

1. Systems inventory and awareness of maintenance requirements
2. Maintenance contracts
3. Operating permits
4. Utility operations and maintenance
5. Utility ownership and management

The first level of management entails becoming aware of the different types of on-site systems in the marketplace and their maintenance requirements. Once this is established, designers, installers and manufacturers will be able to see and possibly change any problems that might arise in the design and construction of on-site systems. This would improve the serviceability of on-site systems, making O & M easier to do.

Once the first level of management is in place, it will open the door up for professional O & M providers and/or septic installers an incentive to provide maintenance contracts, the second level of management. Mandatory contracts will also take the O & M responsibility away from the homeowner, which would help minimize the number of failures because they would be maintained by qualified people. In order to enforce mandatory maintenance contracts, regulators must have a centralized management service in place. This would most likely be a database that would keep track of details such as site locations; owner information; install dates; maintenance provider; pump-out records; last date system was serviced; next service due date, etc.

Once a centralized management program is in place, level 3 can take place where operating permits can be issued to property owners who must ensure that they meet specific quality limits in environmentally sensitive areas (West, 2001). This level would add extra emphasis on the need for maintenance contracts and would ensure their renewal by owners of the on-site system.

In turn this will drive the need for utility companies that can take responsibility for the adequate operation of all on-site systems and that reports to regulators on a regular basis whatever information is needed to make sure that these systems are not causing harm to the environment or to the public health (Jantrania, 1998). At the fourth and fifth level O & M will provided by a utility, much like water, gas and electric utilities. The difference between the fourth and the fifth is that the ownership of the system would be the property owner in the former and would be the utility company itself in the latter. Once all on-site systems fall under this management program, the demand for O & M will increase, which in turn should decrease the servicing cost for each individual on-site system. Each property owner would pay a monthly fee to the O & M provider that covers all maintenance costs, repair costs pump-outs and perhaps even replacement costs of the equipment. This way the homeowner does not have to worry about large unexpected bills for the repair of a failed on-site system (West, 2001).

Ontario is somewhere in between management levels 1 and 2 in terms of systems under the OBC. Currently, only sewage treatment systems require maintenance contracts and conventional sewage disposal systems do not. In order to have all on-site systems require a maintenance contract, there must exist a need. For there to be a need, it is required to address the maintenance issues, which under the OBC is incomplete. The following provides some details on maintenance issues that need to be formally addressed to make sure systems are properly designed and installed.

DESIGN AND INSTALLATION WITH MAINTENANCE IN MIND

Operations and maintenance of septic systems starts with their design and installation. Designers and installers must have maintenance in mind at all times. This entails such things as proper risers and manholes on septic tanks for pump outs and effluent filter access, quick disconnects and lines on pumps so that they can be pulled out, etc. Far too many septic systems are designed and installed without any thought as to how they will be maintained.

Designing and Installing for Accessibility

In order to properly maintain a septic system, it must be accessible. Buried components should have risers to the surface for access to accommodate maintenance and servicing such as pump outs, effluent filter cleaning and pump replacements.

Most septic tanks have two access hatches, one at the inlet and one at the outlet to allow for pump outs. It has been recommended that septic tanks be pumped out every 2-3 years, depending on the accumulation of scum and sludge (Septic-Info.com, 2004). In order to make pump outs easier, the access hatches on septic tanks should have risers that come to or close to the surface (**Figure 1**). If septic tanks do not have risers, maintenance personnel, would have to put much more effort in locating the opening and would have to dig in order to get to the tanks, making pump outs much more cumbersome. However, care must be given when using concrete risers which dissipate heat away from the septic tank, preventing adequate microbial activity and poor septic treatment in winter.

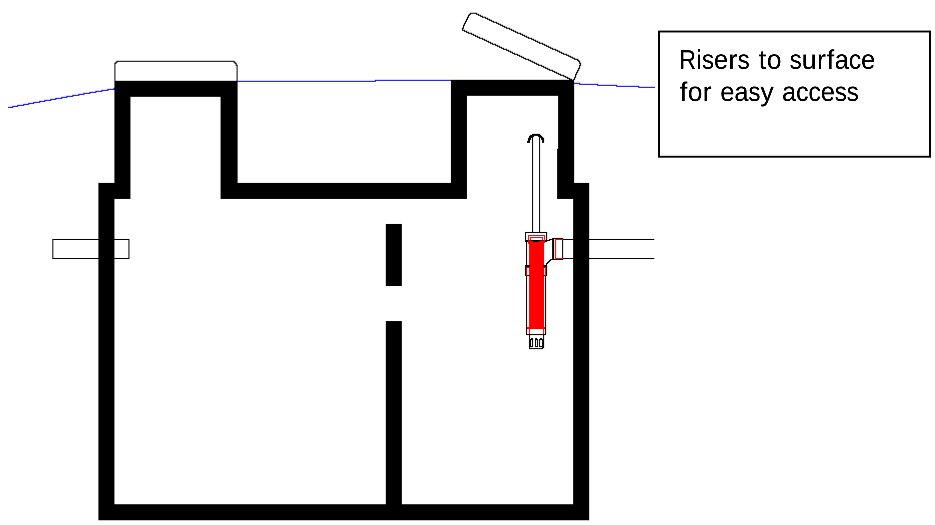

Figure 1

The effluent filter on the outlet of the septic tank is typically comprised of a fine screen that traps large solids in the septic tank, extending the lifetime of a tile bed by keeping solids out. Effluent filters require periodic cleaning by pulling out a slotted screen cartridge out of its case (**Figure 2**). Thus it is imperative that the maintenance provider can get access to the effluent filter. A handle of adequate length should be installed on the effluent filter so that a maintenance provider can open the lid of the riser and reach the handle from ground surface.

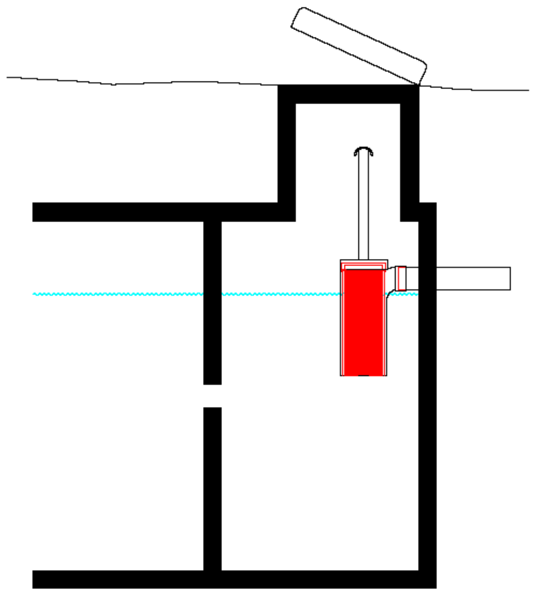

Figure 2

There are also many conventional septic systems that require pumps. Again, any buried tanks that contain pumps should have risers to surface so that maintenance personnel can gain access. Although there are many pumps in the marketplace that will operate for very long periods, they will fail sooner or later. Another important issue surrounding the design and installation is providing adequate plumbing and electrical connections, to better facilitate pump replacements. A poor plumbing layout is shown in **Figure 3**, where the pump does not have a quick disconnect and is buried deep in the tank. This layout requires a maintenance provider to climb inside a tank and cut the plumbing with a hacksaw just to be able to pull the pump out of the chamber. Not only does this take more time to do, but can also be very dangerous in the confined space.

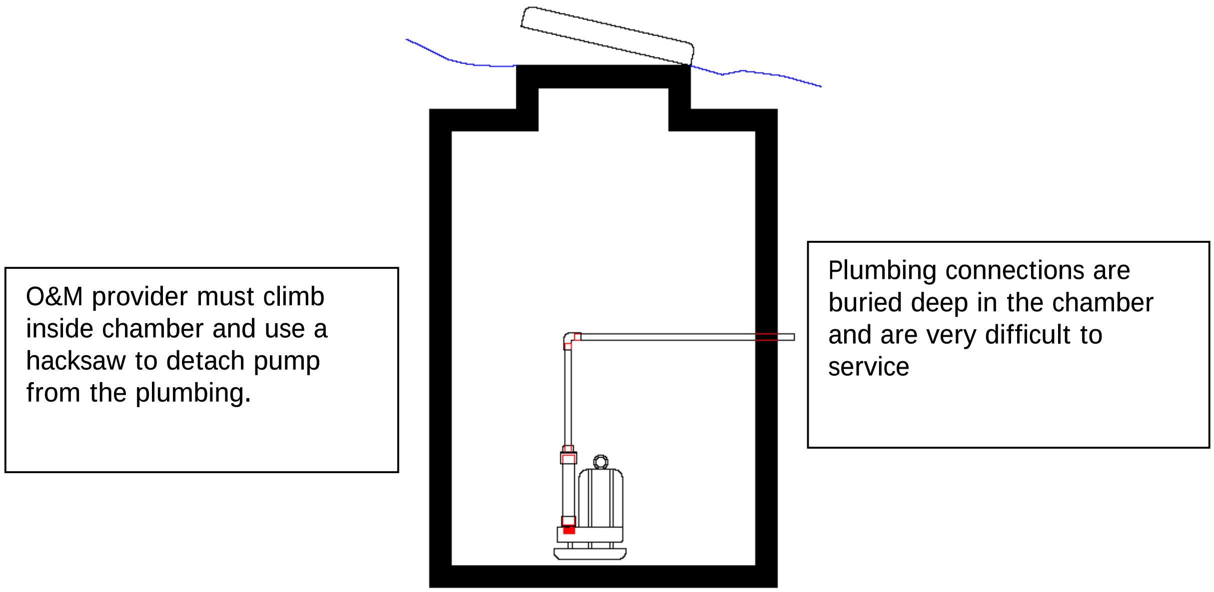

Figure 3

A plumbing layout that would make pump replacements much easier is shown in **Figure 4**. This plumbing layout shows the plumbing coming up into the riser, with a quick disconnect and a pull rope attached to the side. In this setup, the maintenance provider can detach the pump by simply unlocking the quick disconnect. The pump can now be pulled out of the chamber much more easily using the handle created by the unlocked quick disconnect and with the pull rope. This type of setup can save much time on-site for pump replacements. Slide rails are also available to make pump replacements, easier but are usually too expensive for most residential applications.

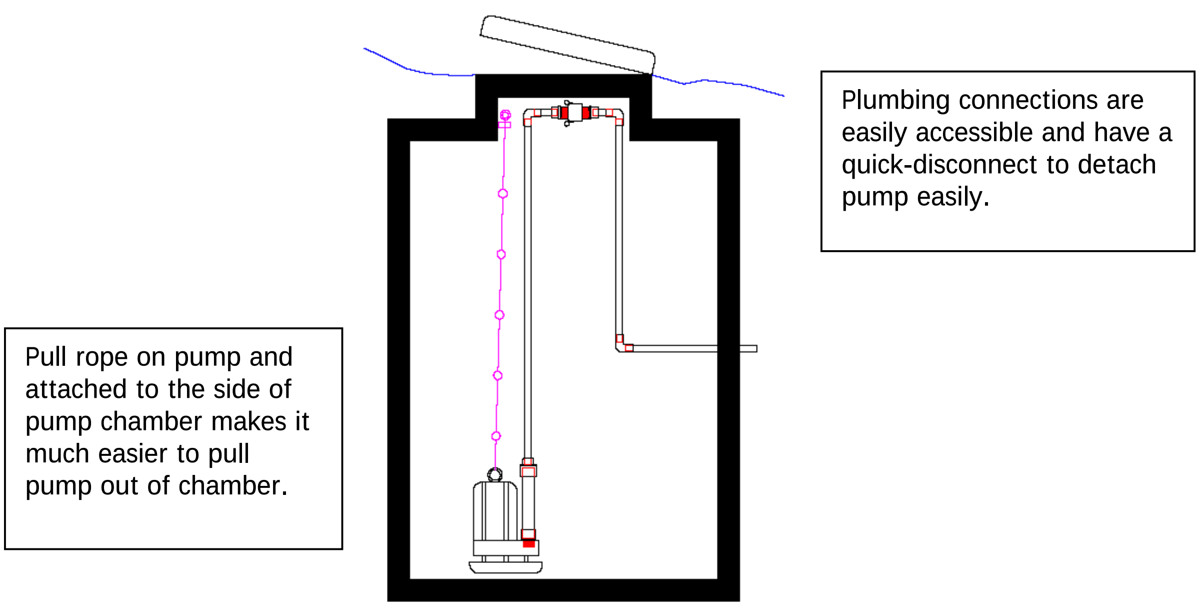

Figure 4

Figure 5 shows a pump electrical layout in which the wires of the old pump must be cut off to detach from the electrical power. The new wires from the new replacement pump are then installed using waterproof shrink-wrap to prevent water and gases from entering the wire, which can cause explosions and short-circuiting. This type of electrical setup makes pump replacement difficult and can be very unsafe as it is impossible to guarantee that the shrink-wrap would produce a 100% seal.

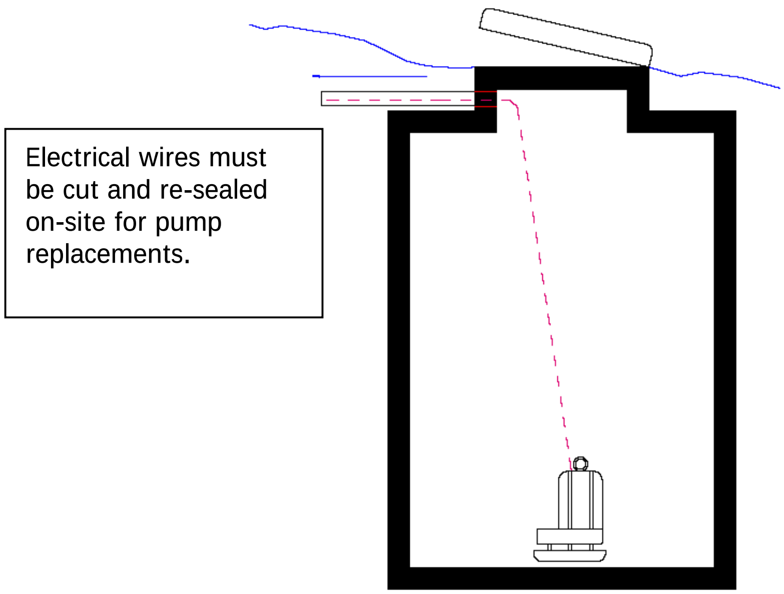

Figure 5

Electrical junction boxes can be used to make pump replacements much easier and safer. An electrical junction box is a weatherproof box installed at ground level, isolating electrical wires from gases and moisture. In this type of setup (**Figure 6**), the electrical connections are much easier. Electrical connections are accessed through the junction box, where the wires from the old pump can be detached and the wires from the new pump can be attached to the power right at the junction box. This type of setup guarantees that the electrical connections are isolated from moisture and gases.

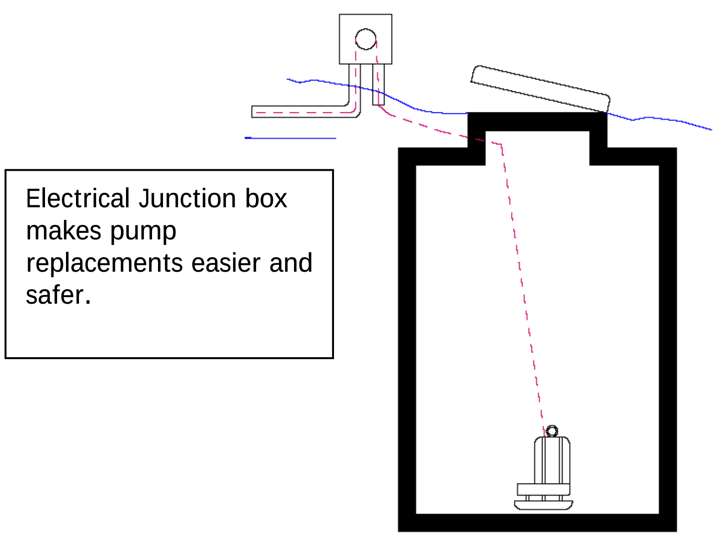

Figure 6

Operating with Maintenance in Mind

Operation of an on-site system begins with the owner. It is the owner's responsibility not to dump harsh chemicals and cleaners down the drains. On-site systems are living systems, containing beneficial microbes to break down the wastes. Disinfectants and bleaches are designed to kill microbes and can be used only in moderate amounts and sparingly. If large amounts of disinfectants are used, there is a good chance that it will destroy the microbes in a septic system. If the septic system biology is constantly destroyed, the results can be very costly, such as increased frequency of pump-outs, breakout and failed absorption beds. Thus an integral part of O & M is educating the owner of their on-site system.

DURABILITY AND CORROSION OF CONCRETE TANKS

Concrete septic tanks are the most commonly used in Ontario, and they are required to meet CSA-B66 standard for structural strength and water-tightness. Although this standard is adequate for mechanical rigidity, it does not address concrete porosity/permeability and chemical resistance and therefore durability when exposed to sulfurous compounds in the source water.

Durability and Impermeability of Concrete Tanks

After the Walkerton event in 2000, in which the municipal well water was contaminated by farm animal wastes (maintenance of the chlorinator was also a major issue), new requirements under the Nutrient Management Act, 2002 were made for animal waste storage on farm property (OMAF/MOE Staff, 2003). These changes deal with the construction requirements of concrete (and other) enclosures with respect to freeze/thaw and to exposure to manure gases. These requirements for animal wastes differ from B66 in that they prescribe 'durability' as well as just strength. Durability should be considered to be as important for containing human wastes (i.e., septic tanks) as they are for farm animal wastes.

Whereas CSA B66 requires only 25 MPa for concrete septic tanks, the OMAF 2003 requires this only when not exposed to manure gases, and requires 35 MPa for concrete exposed to manure gases.

10.3 Concrete properties
10.3.1 Strength - Concrete used for permanent nutrient storage facilities should have a minimum 28 day compressive strength of:

a. 25 MPa for plain unreinforced concrete not in contact with manure or manure gases;
b. 30 MPa for reinforced concrete without freeze/thaw exposure;
c. 32 MPa for reinforced concrete with freeze/thaw exposure; or
d. 35 MPa for reinforced concrete exposed to severe manure gases with or without freeze/thaw exposure.

Whereas B66 does not refer to 'durability', the OMAF 2003 requires a water-cement ratio of 0.40 when concrete is exposed to manure gases. A prescribed water-cement ratio in turn automatically controls the strength, and also the permeability and porosity of the concrete so that corrosive gases cannot penetrate the concrete as much. A mechanically strong concrete can be made that is still permeable to sewage gases.

10.3.2 Durability - Concrete used for permanent nutrient storage facilities should have a maximum water/cementing material ratio of:

a. 0.45 for concrete exposed to freezing and thawing and/or manure; or
b. 0.40 for concrete exposed to severe manure gases in poorly ventilated spaces.

The OMAF 2003 report also encourages the use of water-reducing admixtures to improve performance of the concrete.

10.5 Admixtures - Products for concrete mix enhancement such as high-performance concrete, fly-ash and chemical admixtures may be used to improve the structural design and performance. Chemical admixtures should meet the requirements of CSA A23.1.
Note: The use of water-reducing admixtures is recommended to improve workability and the overall performance of the concrete.

Although human sewage might be considered to be lower in strength than manure, it is the amount of sulphur as sulphate or sulphide in the source water for human wastes that controls the amount of corrosion in the exposed concrete, as detailed below.

Sulphuric Acid Attack on Concrete

Sulphate-rich soil attacks concrete in contact with the soil, and is important mainly in Western Canada. Sulphuric acid can form in the septic tank and attack the concrete from within. Parts of Ontario have high sulphur in the source water, either as sulphate or sulphide, which forms hydrogen sulphide in the septic tank, and in turn forms sulphuric acid in the air space in septic tanks and pump tanks. The sulphuric acid reacts with the concrete, decreasing the structural strength and durability, and increasing the permeability. This problem is recognized in OMAF/MOE (2003) for animal wastes, but not in CSA B66 for human wastes. Three methods in which concrete tanks can be attacked include:

1. *Corrosion by Sulphate-Rich Soils*

Through a series of chemical reactions, sulphate ions (SO_4^{2-}) in the soil react with calcium aluminate hydrates (C-A-H) present in hardened cement to form hydrogen calcium sulfoaluminate ($C_3A{\bullet}CS{\bullet}H_{32}$) also known as ettringite (e.g., Collepardi, 2004). Since ettringite is over twice the volume of calcium aluminate hydrate, this process causes expansion of the concrete inflicting serious damage and can ultimately lead to failure of the concrete structure.

Depending on the amount of sulphur in contact with the concrete, it may be necessary to protect the concrete with a plastic liner, sulphate resistant concrete mix, or a protective coating. Sulphate-resistant concrete tanks are dealt with in CSA B66, but it is the responsibility of the local regulatory authority to determine where soils require the use of sulphate-resistant concrete.

2. *'Direct Acid' Corrosion*

In the direct acid attack, sulphuric acid (H_2SO_4) in the wastewater source reacts with calcium compounds in the concrete (eg. $Ca(OH)_2$), ultimately to produce calcium sulphate ($CaSO_4$) and water (H_2O) as shown in **Figure 7** (Thomson, 2000)**.** In this reaction, calcium is removed from the concrete, which can ultimately damage its structural integrity (Crites and Tchobanoglous, 1998).

$$\mathbf{H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + H_2O}$$

Figure 7

This type of sulphur attack is rare in most common in industrial wastewaters, and less so in residential septic systems. However, bacterial sulphuric acid attack from sulphur-rich source water is important in parts of Ontario (see below).

3. <u>'Bacterial Acid' Corrosion</u>

Bacterial acid corrosion is caused when anaerobic bacteria in the septic tank convert sulphate (SO_4^{2-}) into sulphide (S^{2-}), which in turn combines with hydrogen (H^+) to form hydrogen sulphide gas (H_2S). In the presence of oxygen from incoming water or from the air space in the septic tank or pump tank, exsolved hydrogen sulphide gas is converted to sulphuric acid (H_2SO_4) as shown in **Figure 8** (Metcalf and Eddy, 2003). Sulphuric acid is highly reactive and attacks the concrete in the same way as the direct acid attack shown in **Figure 7.**

$$\text{Organic matter} + SO_4^{2-} \rightarrow \mathbf{S^{2-}} + H_2O + CO_2$$

$$\mathbf{S^{2-}} + 2H^+ \rightarrow \mathbf{H_2S}$$

$$\mathbf{H_2S} + 2\,O_2 \rightarrow H_2SO_4$$

Figure 8

This type of sulphur attack is the predominant one in septic systems. The septic tank is a biochemical reactor, where anaerobic (without oxygen) reactions occur to break down solids into gaseous compounds, which are primarily CO_2 (carbon dioxide) and CH_4 (methane). In wastewaters high in sulphate or sulphide, anaerobic bacteria produce hydrogen sulfide (H_2S) gas, which rises into the open air space of the septic tank and pump tank (Thomson, 2000). Moisture on the sidewalls of the concrete tank allows aerobic or facultative bacteria to thrive and convert hydrogen sulphide into sulphuric acid, which corrodes the concrete.

This kind of attack can be protected by concrete liners and coatings as well, but it is important to remember that the areas that are most susceptible are the concrete walls at the waterline and in the air space of the septic tank and pump tank. To be more cost effective, the liner or coating can be applied above the waterline, which includes any concrete risers and manholes located in the air space. Another option is to improve the overall quality of concrete tanks with a low water-cement ratio (OMAF, 2003) which in turn decreases permeability to resist corrosion.

THE IMPORTANCE OF GREASE TRAPS

Exterior grease traps are an essential component in septic systems that service cooking facilities such as restaurants, golf clubhouses, etc. Exterior grease traps are multi-compartment tanks as shown in **Figure 9**. The role of the grease trap is to detain kitchen wastewater long enough to allow fats, oils, and greases (FOG) to cool, solidify and rise to the top before the clearer effluent goes to the septic tank. The reason why grease traps are used is because FOG is very difficult to breakdown in the septic system. In a septic tank, FOG rises to the surface, forming a heavy scum layer. If the scum layer grows too thick, decreasing the effective volume of the septic tank, retention time is decreased and treatment is in turn compromised. This in turn can cause wastewater to hydraulically short-circuit through the septic tank and carry solids to the tile bed.

FOG can also carry over to the tile bed or treatment unit and cause problems. FOG tends to cling to the infiltrative surface (biomat) of the tile bed or treatment unit (foam, sand filter, etc.), reducing its absorption capacity (Septic-Info.com, 2004). FOG accumulates on the surface because the enzymes required to break them down are less active in low temperatures, like those found in the soil. This ultimately leads to breakout of sewage to the surface and can treatment units or disposal beds to clog.

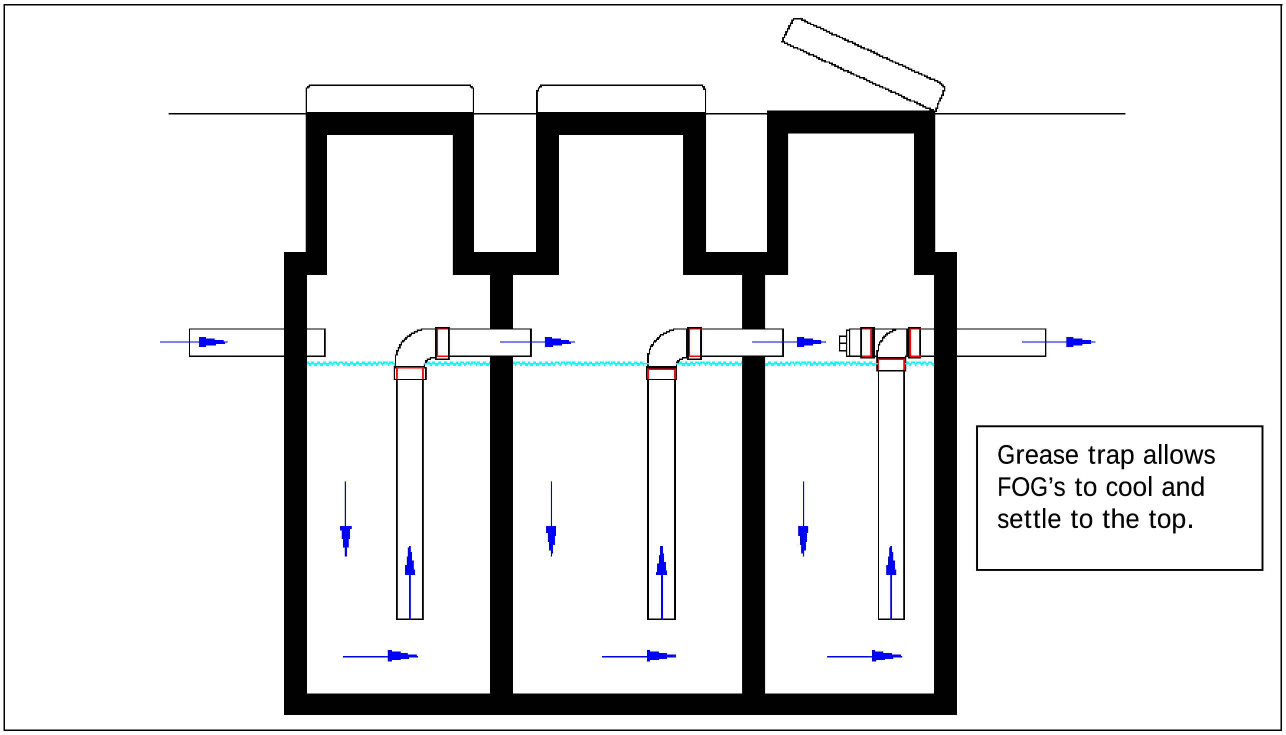

Figure 9

The OBC specifies that all kitchen wastewater from a restaurant must pass through a grease trap prior to entering a septic system. However, there are many on-site systems that have an interior grease trap, which may be too small to accommodate cooking facilities that serve a lot of fried foods. Since exterior grease traps are not specifically mentioned in the OBC, septic system designers, regulators, installers and owners may put in only an interior grease trap to satisfy the OBC requirement. Being inside the facility, and needing frequent servicing, the interior grease traps tend not to be operated well by the facility staff, and do not fulfill their function if not maintained.

For a septic system to function properly, an adequately sized exterior grease trap should be installed to intercept kitchen wastewater. Grease traps should be monitored and inspected frequently by professional service personnel for regular pump outs and successful treatment.

CONCLUSIONS

Ontario needs a professional O & M industry to look after the various components of on-site treatment and disposal systems. In order for it to be a financially viable business opportunity, on-site systems must be properly designed and installed with ‘maintenance in mind’, with regulations in place that prescribe ongoing maintenance contracts for all systems, no matter how passive. The team players in the industry should be informed on all maintenance issues, particularly on accessibility, water tightness of tanks, sulphuric acid attacks, and grease traps so that on-site treatment and disposal systems are sustainable and safe.

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