Aqua-nova™

Why it is the best system!!

Aqua-nova™ Aerated Wastewater System is the best system that you can purchase in today's market. It provides our customers with a reliable sewage treatment system that can treat their domestic wastewater to a very high quality so that it can be used irrigate their gardens and lawns.

All Aqua-nova™ treatment systems are made in Australia by Everhard Industries. This is one of the most trusted names in Australian manufacturing and has been operating for since 1926. There are few businesses in Australia that have been as successful as Everhard Industries and still remain 100% Australian owned.

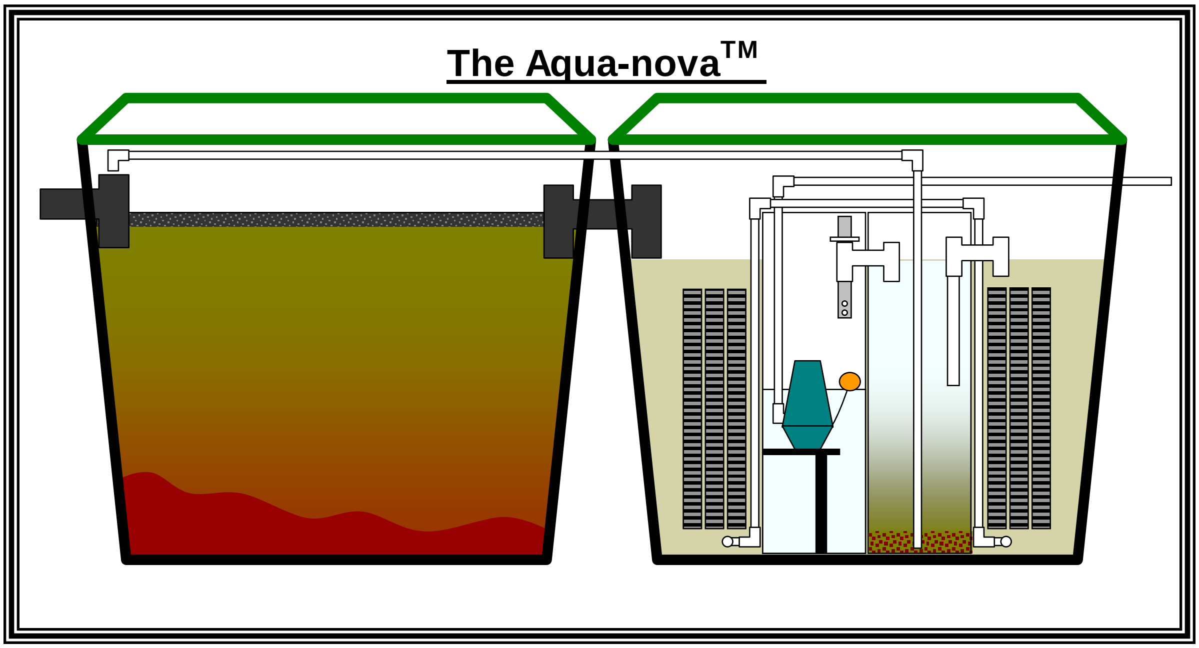
The simple truth is there are many systems on the market. However, many of these systems have only been on the market for a short period of time. Many of the companies who own and install these treatment plants have only been open for similar periods. To increase their sales or market share some of our competitors offer cash-back incentives or give extended warranties.

Over recent years many of our competitors have opened and closed their doors leaving the public without any warranty for the products that they have purchased. So when somebody needs to purchase a domestic wastewater treatment system with a 15-year warranty, we simply ask the buyer, "Who will be servicing this warranty in fifteen years?"

Further to this we do not give spurious claims to advance our business. Our treatment system efficiently treats wastewater by providing an environment suitable for bacteria to thrive. Most other treatment systems use similar technology. If certain chemicals are added to the system, the bacteria can die leaving the owner with untreated sewage being pumped over their lawn. In fact most treatment systems use chlorine to disinfect the treated water prior to irrigation. While people understand this, it is difficult to understand how some companies can make the claim that the owners of their treatment plant can dispose of any chemical into their system.

Trials for Domestic Wastewater Systems

All domestic wastewater treatment systems sold in Australia must be approved by the relevant state authority. To gain this approval, a system must be independently tested as required by the appropriate Australian Standard with testing performed over a period of 26-weeks in which samples are collected during nominated flow conditions.



Unfortunately this testing system does not take into account several operating conditions including –

- periods of no flow, when the occupants are on holiday or the house is untenanted.
- high flows, simulating discharges from baths or washing machines.

Our system is a 2-tank system which provides four treatment processes :

- Primary Sedimentation,
- Aerobic Digestion
- Clarification
- Disinfection

This arrangement provides significant advantages to other treatment processes.

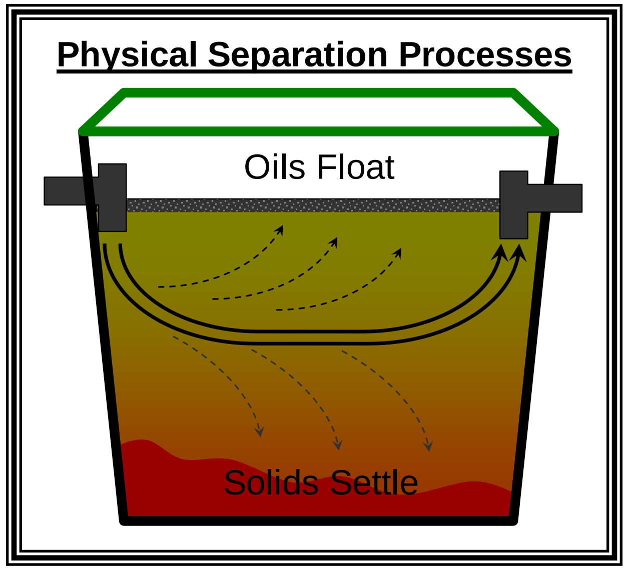
Sedimentation/Anaerobic Digestion

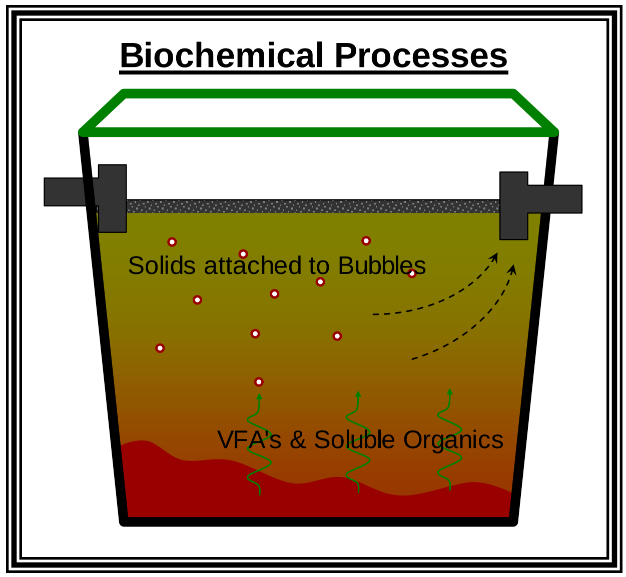
These physical and biochemical processes occur continuously in the primary tank. They work together to condition the water leaving the tank and allow the efficient operation of the treatment system during high flow and no flow conditions.

Sedimentation is the dominant conditioning process which occurs in the primary tank during periods when water is entering the treatment system. This is critical to the operation of the treatment system as it removes most of the suspended solids and oils.

While most manufacturers warn owners not to dispose of large objects (plastic bags, sanitary napkins, band-aids, etc) to the sewage system, this can inadvertently occur. These objects can work there way through a system and result in pump failures and blockages in the irrigation system. The primary tank significantly reduces the possibility of these types of failures[1].

The removal of oils, as a pretreatment phase to aerobic digestion, is also a critical aspect of this treatment process. Aerobic biofilms and bacteriological floc found in the aerobic phase of the treatment plant are porous allowing the survival of bacteria found beneath the surface of these systems. If a layer of oil is allowed to form over the bacteria, the porosity of a biofilm can be significantly reduced inhibiting the efficiency of the treatment process.





The sedimentation of solids and separation of oils combine to lower the BOD_5 (5-day Biochemical Oxygen Demand) by approximately 30%, reducing the organic load on the aerobic treatment phase.

When zero flow occurs, the Primary Tank acts as a *BOD_5 Bank* that allows a small amount of nutrients to be continuously feed into the aeration tank[2]. This is a result of soluble organics being produced in the breakdown of organic material and re-suspension of settled solids by gases produced in anaerobic digestion. A sludge return, which pumps water from the clarifier to the primary tank inlet, guaranties that a constant supply of nutrients to the secondary tank in zero flow conditions. This ensures that bacteria in the aerobic treatment phase are maintained in good condition.

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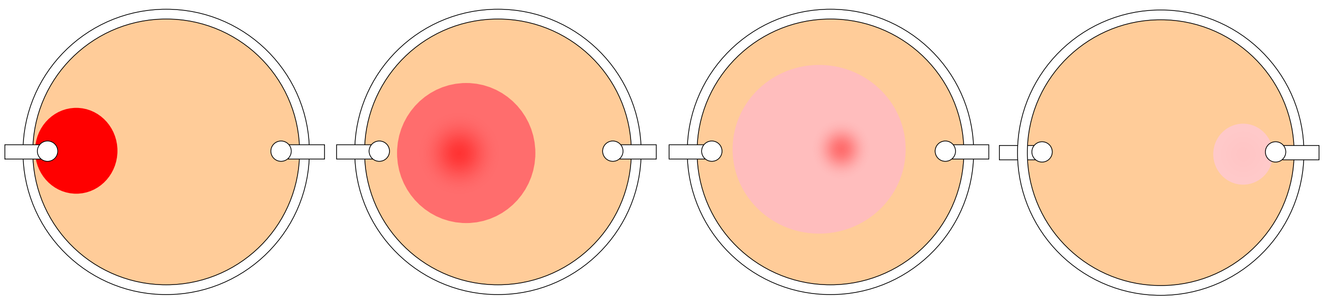
[1] Screened sewage is used in the Australian Standard test method.
[2] Zero flow conditions are not used in the Australian test method.

Failure to provide sufficient nutrients to the aerobic bacteria for extended periods of time can result in excessive endogenous metabolism (bacteria consuming bacteria). This can reduce the bacterial population necessary for treating wastewater in this process. Another problem which may occur is the generation of bacterial population that is predominantly filamentous bacteria. This bacteria has very poor settling qualities which can contribute to higher concentrations of suspended solids and BOD_5, and reduce the efficiency of the disinfection system.

The final important factor in having a primary tank is the dilution of raw sewage that contains elevated concentrations of soluble organic material[3]. This allows for a substantial dilution of organics though diffusion processes and currents in the tank.

Illustration of the Dispersion of High Organic Loads of in a Primary Tank



[3] This condition is not tested in the Australian test method.

Aerobic Digestion

In this process wastewater may be continuously or intermittently aerated, providing oxygen to aerobic life-forms in the wastewater. Bacteria growing in this environment will multiply to form biofilms and bacteriological floc. While most of these life-forms are bacteria it is important to know that other complex multicellular forms of life, including ciliates, nematodes and rotifers, are also found in aerobic treatment zone. Once established, this complex array of life provides a balanced environment which can efficiently treat wastewater to a very high standard.

Aerobic bacteria and these higher life forms can be compared to most other living creatures on earth animals. They require oxygen, carbon, nitrogen, phosphorous and trace elements to flourish. In many ways this system can be compared to many balanced natural environments witnessed on earth and, in a similar way, this balance can be upset through the use of chemicals, flow rates, a lack of oxygen and an imbalance of food.

Aerobic Treatment Systems

There are two types of systems that are commonly used to treat wastewater aerobically -

- Suspended Growth
- Fixed Growth

Suspended Growth is where bacteria grow in suspended clumps called **bacteriological floc**. This system is commonly used in large sewage treatment plants where operators regulate and manage the bacterial/sludge age. The management of sludge age is oextremely important as it ensures that the appropriate types of bacteria are maintained in the treatment plant.

A basic activated sludge system may comprise of exactly the same processes as our system however settled sludge must be returned to the inlet of the aeration chamber to seed the incoming wastewater with bacteria. A sludge wasting process to the Anaerobic Chamber is also necessary. There are two main problems that occur if sludge is not wasted:

- Aerobic bacteria will accumulate in the system inhibiting the settling process. If bacteria cannot settle (*see picture*) very poor quality effluent being produced.

- The wrong type of bacteria will accumulate in the treatment plant resulting in poor settling floc.

Activated Sludge Accumulation in SBR due to No Sludge Wasting

(30min Settled Sludge Volume)

The amount of sludge wasted may also need to be periodically altered to manage the amount of sludge in the treatment system. During periods when the amount of nutrients entering the system is low and a high concentration of bacteria in the system, filamentous bacteria can develop which can develop a scum on the top of the aeration tank and has poor settling qualities. If the reverse occurs, low bacteria / high nutrients, there will be insufficient bacteria to consume the impurities in the wastewater and poor quality water being discharged from the system.

<u>Activated Sludge</u>
<u>Poor Floc Formation due to Low Nutrient Loads</u>

Another type of activated sludge system in is a Sequential Batch Reactor (SBR). This is sometimes (incorrectly) referred to as extended aeration. In these systems the anaerobic tank would also act as a balance tank to manage the flow of wastewater into the aeration tank. This may be replaced with an aerobic tank but the total aeration required would be higher and appropriately designed to prevent limit large objects flowing through the system. Problems may result from this latter arrangement as there may not be a sufficient quantity of nutrients remaining in the system during zero flow periods and an anaerobic zone would still be necessary for managing the sludge age.

These systems typically operate on a three step timed process –

1. Aeration / Fill

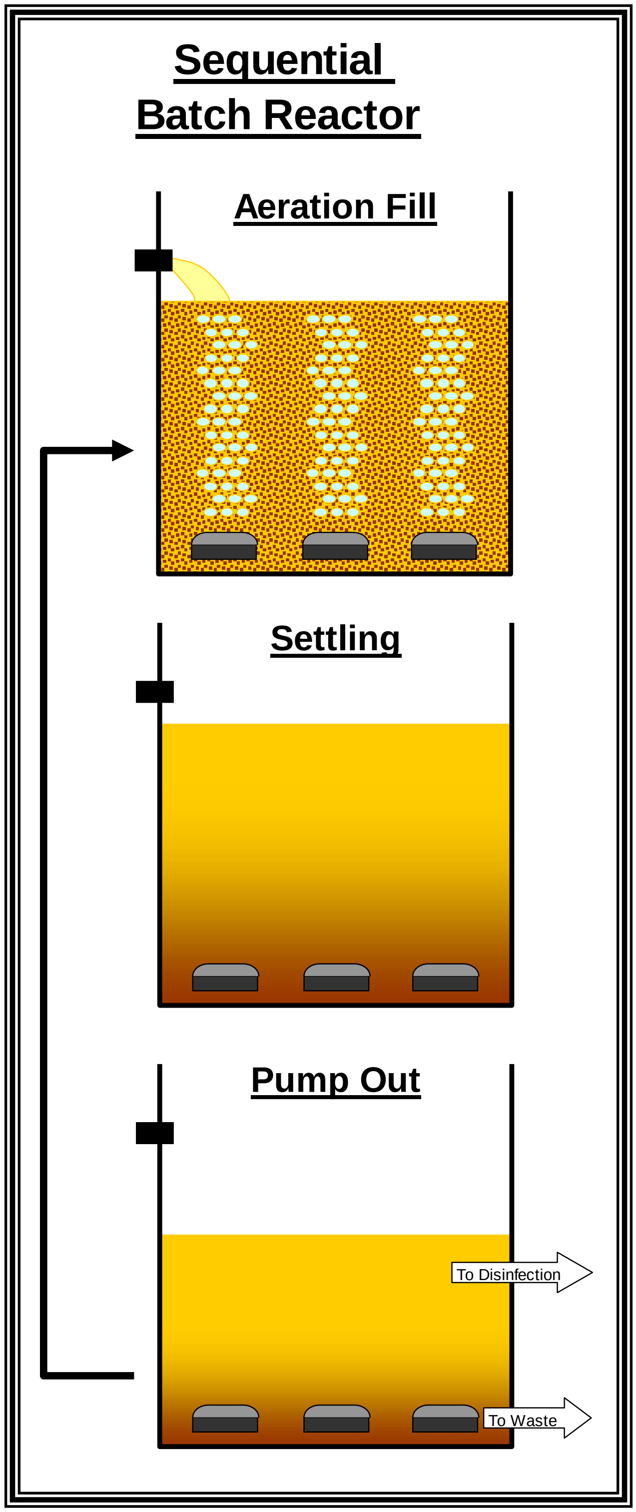
During this phase the Aeration Chamber is typically pumped from the balance tank to the aeration tank. This flow would be dependant on the water level in this tank. The water is aerated for a set period in which the nutrients are consumed by the bacteria.

2. Settling

The feed forward pump and aerators are turned off allowing bacteria to settle to the bottom of the chamber.

3. Pump Out

The clear water at the top of the tank is pumped out for disinfection and settled sludge is wasted. The wasting process may occur during the aeration cycle however requires a higher volume of effluent needs to be wasted.



The timing of these phases must be appropriately sequenced to ensure that sufficient aeration time is allowed to occur for the breakdown of impurities and that settling occurs in an efficient manner. If the aerators are turned off for an extended period of time filamentous bacteria can populate the sludge.

If a system is not constructed with a balance tank, raw wastewater can be discharged directly to the aeration chamber during the Settling Phase. This can re-suspend settled material leading to elevated concentrations of suspended solids and BOD_5 in the final effluent. This may subsequently decrease the efficiency of the final disinfection process. This problem may also occur when raw wastewater is discharged to the aeration chamber during the Pump Out Phase, however this may also see diluted raw sewage being pumped out of the tank.

As can be seen these systems are quite complex and the improper management of aeration, sludge wasting and hydraulic flows can detrimentally impact on the water quality leaving the treatment plant.

Fixed Growth wastewater treatment systems mimic water purification systems commonly witnessed in nature. These treatment systems incorporate media (plastic or rock) into the treatment system. This media provides an inert surface where bacteria can attach and grow. Over time bacteria will completely cover the surface of the media to form a **biofilm**. Examples of this phenomenon can be seen in shallow running creeks where bacteria grow on rocks to form a biofilm.

As these systems typically have a thicker biological growth than bacteriological floc, they are more resistant to harmful chemicals that could inadvertently put of down the sink.

There are two types of Fixed Growth treatment systems that are commonly used –

- Trickle Filters.
- Submersed Media

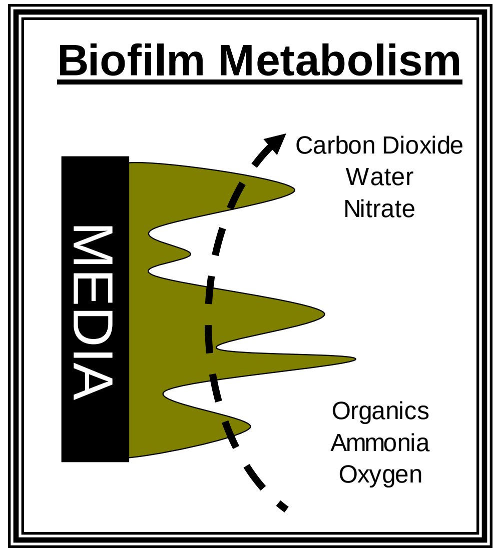
Both systems eliminate the need for careful management of sludge age and bacterial mass in the aeration chamber.

Trickle filters operate through irrigating wastewater over suspended media. As water flows over the media, bacteria attached to the media remove impurities. This hydraulic flow will slough bacteria off the media in large solid masses that easily settle in the final clarifier. During high flow periods this sloughing process will accelerate and can strip bacteria from the media, decreasing the amount of bacteria in the treatment system.

These systems often require more pumps than other systems, as wastewater is pumped from the primary tank onto the media and a recirculation pump is necessary to ensure the biofilm remain wet. Further to this as this system also requires continual irrigation of wastewater over the media, the media will eventually become blocked unless fine screens are used in the process.

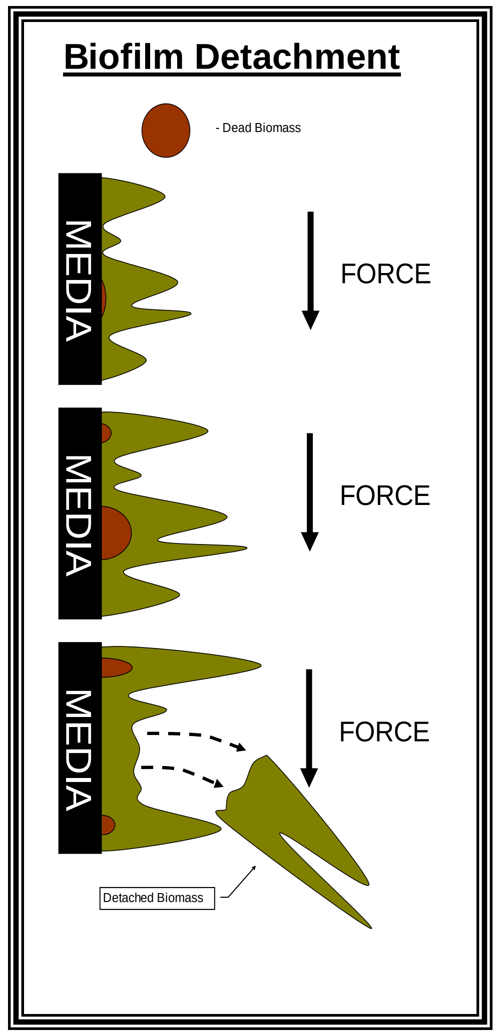
Fixed Growth Submersed Media is identical to activated sludge processes except that media is used. This is the technology used in the Aqua-nova™.

In the Aqua-nova™ bacteria grow on corrugated tubes that are fixed vertically within the aeration chamber. These tubes provide ample area for bacterial growth. Corrugations in the tubes provide excellent voids where the biofilm can establish.



The arrangement used in the Aqua-nova™ provides an environment which eliminates the need for sludge age management.

The bacterial population is self managed with the thickness of the biofilm being proportional to the nutrients available to the bacteria. During normal operating conditions the bacterial population on the media is relatively stable. As bacteria reproduce and the biofilm thickens. This decreases the nutrients and oxygen available to bacteria adjacent to the media. These bacteria can become stressed and can die, allowing bacteria at the surface of the biofilm to *slough* off the media. Most of the dislodged biofilm flows through to the system to the clarifier where it settles. Settled sludge is pumped to the primary tank where the bacteria die.



During zero flow periods, bacteria will survive on the nutrients that flow through with the recycled water and dead cellular material. Over a prolonged period there may be a small decrease in the biofilm however insufficient to affect the treatment process.

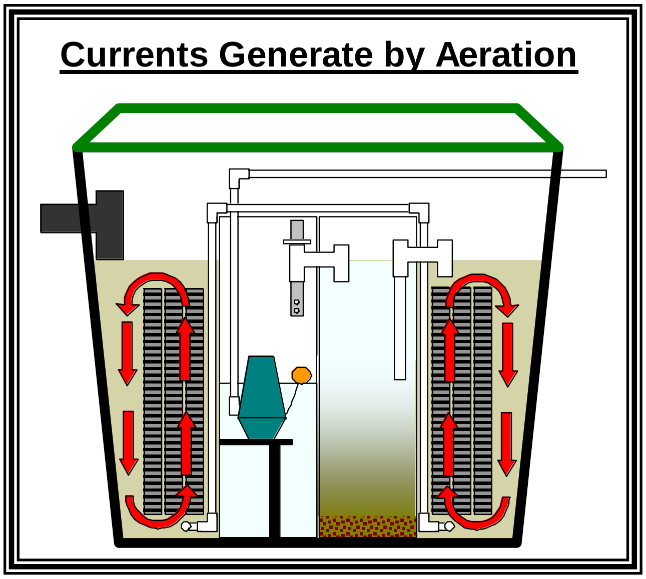
Aeration Equipment

Oxygen is an essential factor in the aerobic treatment process and it is essential that sufficient air is provided to drive the biological processes. Without oxygen the treatment process will not work.

The Aqua-nova™ uses compressed air to aerate the wastewater in the treatment system. This eliminates potential blockages of pumps and pipe work that can often occur in venturi systems. A pressure switch is linked to the pressurized air lines to immediately notify the owner of a fault in the system.

Air is delivered to the system via course bubble diffusers located directly below the fixed media to supply oxygen in the vicinity where the aerobic bacteria are attached. This also generates an internal current within the aerobic treatment zone that moves the wastewater across the biofilm for treatment.

While there are many factors which contribute to the ensuring sufficient oxygen is available for aerobic treatment, one of the most significant factors is the volume of air supplied to the system. The blower in our standard system delivers air at a rate of more than 100L/min. every minute of every day. This provides the Aqua-nova™ with approximately 25% more oxygen than other treatment systems, while treatment systems that use intermittent aeration may supply a net volume of air of less than 60L/min. The continuous supply of high volumes of air provides sufficient oxygen to treat wastewater with elevated organic loads.



To compensate for a reduced supply of oxygen, some treatment systems use fine bubble diffusers. Unfortunately these diffusers can block up, especially in intermittent aeration systems, reducing the volume of air delivered to the treatment system. The course bubble diffusers used in our system can be readily cleaned using hydraulic or pneumatic pressure.

<u>Other Treatment Technologies</u>

Aerated Sand Filters

This is a very simple technology where wastewater flows though a septic tank and then though a sand filter. Bacteria in the sand filter degrade organic impurities to produce the treated water.

Some of these systems that use the term "aerobic" are not aerobic systems as there is insufficient oxygen provided for aerobic treatment. Aerobic sand filters rely on the natural infiltration of oxygen and it is impossible for oxygen to naturally infiltrate a system surrounded by concrete.

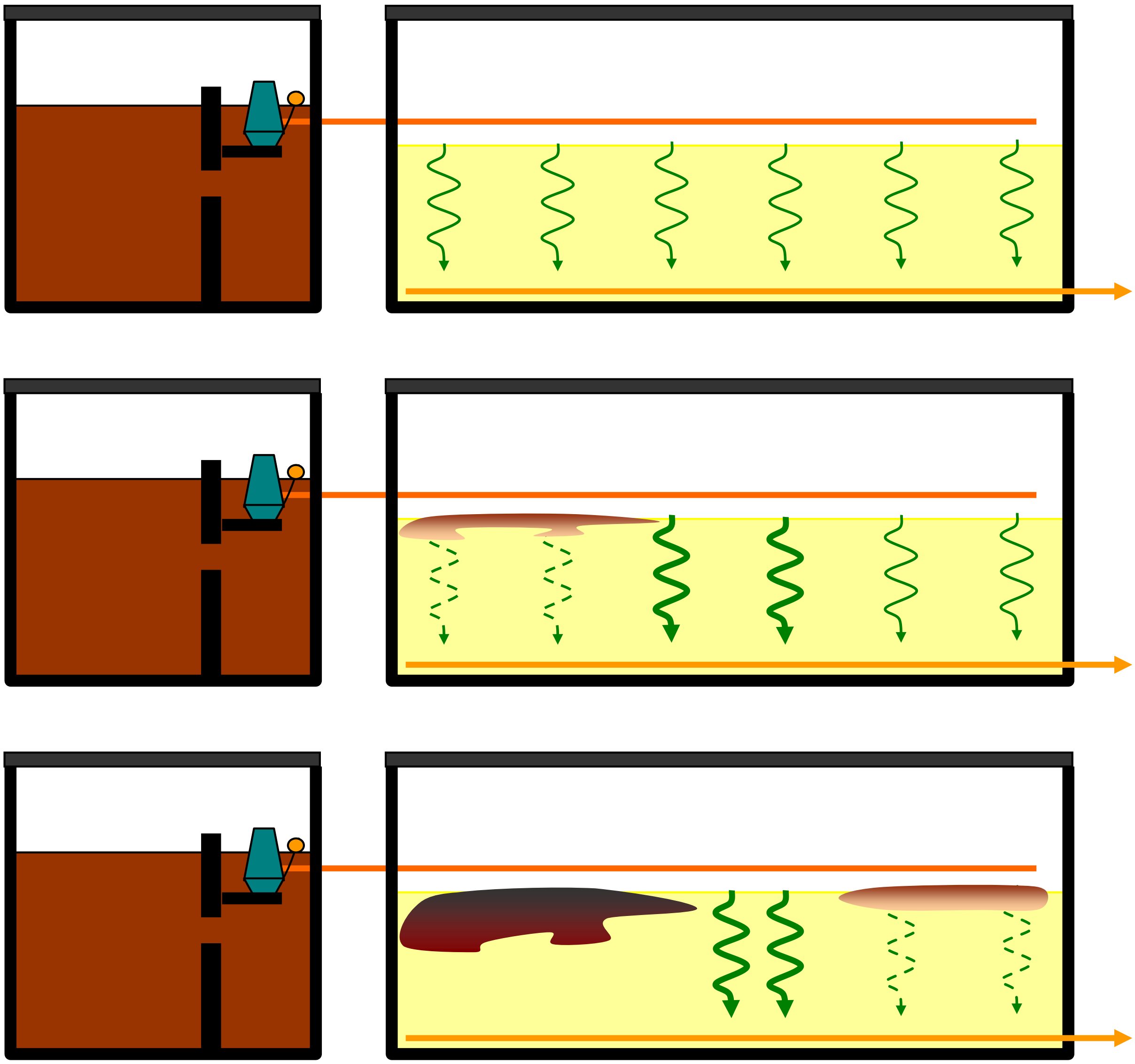
This technology has several disadvantages –

<u>Channeling and the Replacement of Sand Beds</u>

Small amounts sand, grit, hair and other non-biodegradable material are continuously carried through to the septic tank and then flow through to the sand bed. The concentration of this material in water leaving the septic tank is usually dependant on the concentration of solids entering the system, the hydraulic flow rate and how regularly the

septic tank is pumped out. As this material cannot be biodegraded, it is retained in the sand filter and block the small gaps between the sand particles.

Blinding of Aerated Filter



Initially this will result in the restriction of flow through effected areas causing the preferential flow of water through other areas of the filter. This phenomenon called channeling and can significantly reduce treatment efficiencies as not all the filter is used. Further to this, the blinding of areas can result in the reduced air flow through mounded sand filter systems further reducing treatment efficiencies.

While this can be managed through the periodic raking the surface of a submerged sand bed or the removal of sand (when access is available), it is more difficult to manage on mounded systems as the problem can be difficult to identify and the mounds are typically covered in grass.

Over time the entire sand filter can become blocked. This results in the flooding of a submerged sand bed or the ponding of untreated effluent around a mounded sand filter. While the time when this will occur does vary most sand beds only have a warrantee of approximately 5-years. Some manufacturers will '*solve*' this problem by driving star pickets or crowbars through blocked areas. While this will promote channeling and relieve the problem for a short period, the problem will inevitably return.

The only way to fix a blocked aerated sand filter is to remove, dispose of and replace the blocked sand. This can be an odorous, inconvenient and expensive operation as the affected sand will be anaerobic and should be disposed of to an appropriate landfill.

<u>Increased Power Costs</u>

Most aerated sand filters require two pumps. The first pump delivers water to the aerated sand filter while the second performs the irrigation. These pumps often draw significant amounts of power during their operation.

While most energy evaluations of systems will use standard operation, as the sand filter becomes blocked the run time of the primary pump will increase, increasing the cost of operating the system.

Pumping costs can also be effected when rainwater is allowed to infiltrate into the sand filter resulting in the irrigation of contaminated rainwater.

<u>Larger Area</u>

Most aerated sand filter systems require substantially more area than most other treatment systems.

Membrane Bioreactors (MBR's)

These systems can be extremely expensive to purchase often costing more than twice that of an Aqua-nova™. It has been reported that the full installation cost for one system can be more than $30,000.

The maintenance on these systems is also very expensive with servicing costs being more than $1,000/year.

While the membranes used in these systems provide an effective wastewater treatment option, their replacement can be an extremely expensive operation. This can cost more than $5000 and be required every 5-7 years.

Disinfection

Disinfection is the process in which we kill pathogens (disease-causing microorganisms). This should not be confused with sterilization where all microorganisms are destroyed. This is an essential part of all wastewater treatment processes as millions of microorganisms, including bacteria, viruses and cysts, can live in a single drop of wastewater and many of these can cause infection and diseases. Most government health officials believe that this is the most important part of the treatment process.

Chlorination

As standard practice, Aqua-nova™ uses chlorination to disinfect water leaving the clarifier. Clarified water flows over chlorine tablets into the pump well before being pumped to the irrigation area.

Chlorination works through the generation of Hypochlorous Acid which destroys the cell walls of bacteria. The reactions of chemicals used in chlorination are as follows.

$$\underset{\text{Chlorine Gas}}{Cl_2} + H_2O \Leftrightarrow \underset{\text{Hypochlorous Acid}}{HOCl} + HCl$$

$$\underset{\text{Sodium Hypochlorite}}{NaOCl} + H_2O \Leftrightarrow \underset{\text{Hypochlorous Acid}}{HOCl} + NaOH$$

$$\underset{\text{Calcium Hypochlorite}}{Ca(OCl)_2} + 2H_2O \Leftrightarrow \underset{\text{Hypochlorous Acid}}{2HOCl} + Ca(OH)_2$$

While individuals debate over what is the best disinfection process, it must be recognized that chlorination is the most common method used to disinfect water. This is because chlorine can quickly kill disease causing bacteria at low concentrations. Due to the proven reliability of chlorine, it is nearly always used in the disinfection of potable water, cooling tower waters, industrial water and wastewater. In most cases the treated water from an Aqua-nova™ will have a chlorine concentration less than that found in your drinking water and public swimming pools.

The reliability of our chlorine disinfection system was witnessed during testing required by the Victorian Government in 2006 when samples were collected from 20 installed systems by an independent agency. 60CFU/100mL was the highest result recorded which included a sample collected from a system that had been inadvertently turned off by the occupant. Faecal coliforms were not detected in 15 of the samples.

One of the most important features of our disinfection system is that it is automated and does not require electricity. In many instances where blackouts or power disruptions occur, other treatment plants will produce very poor water that cannot be effectively disinfected using other treatment methods.

Other wastewater treatment systems use different methods of chlorination to disinfect treated wastewater. This includes electrolysis where chloride ions in the wastewater are converted to chlorine gas.

$$2Cl^- \Leftrightarrow Cl_2 + 2e^-$$
$$Cl_2 + H_2O \Leftrightarrow HOCl + HCl$$

Unfortunately this process will also generate large quantities of hydrogen when sodium metal is formed on the negative electrode and reacts with water.

$$Na^+ + e^- \Leftrightarrow Na$$
$$2Na + 2H_2O \Leftrightarrow 2NaOH + H_2$$

If not vented properly, production of this gas will generate an explosive atmosphere in the headspace of the treatment plant.

While this process is commonly used to disinfect saltwater pools, these systems are specially built for disinfection with appropriate venting and require the use of high grade sodium chloride. Despite this scale will continue to accumulate on the electrodes from the formation of insoluble salts such as calcium hydroxide and magnesium hydroxide. This will also occur in wastewater but at a quicker rate due to the high level of impurities in the treated wastewater. Therefore the efficiency of chlorine generation is expected to decrease over time.

Ultraviolet Light

Ultra-violet Disinfection is used in some treatment systems. In most instances a fluorescent tube that produces UV light is placed adjacent to a clear tube through which the treated wastewater flows. Water flowing through that tube is irradiated with UV light. Bacteria adsorb this light, mutating the DNA in the cell. This prevents the bacteria from performing basic cellular functions and eventually the bacteria will die.

While these systems have passed their 26-week trial period, this technology has several flaws.

Penetration of UV Light

The efficiency of UV Disinfection system is severely reduced if the UV light cannot penetrate the final effluent. This is a fundamental problem associated with sewage treatment systems as all treated sewage has suspended solids and dissolved molecules that adsorb UV light.

During periods where the concentration of suspended solids in the water increases by a small amount, the bacteriological quality of the water can decrease significantly.

Another problem is the buildup of a biofilm and scale on the inside of the tube. This problem is inevitable and cleaning of the tube is often required.

Regeneration of Bacteria

If bacteria are irradiated with UV light, mutations in the bacterial DNA will occur. Unfortunately these mutations are reversible if bacteria are exposed to bright light immediately after disinfection. In systems that irrigate the irradiated water immediately, the damage caused to the bacteria by UV Disinfection can be reversed allowing disease causing bacteria to survive.

For UV Disinfection systems to work effectively the disinfected water must be stored for approximately 30-minutes in a dark area. As many bacteria are not affected by the UV Light, bacteria re-growth can occur in this area. For this reason, UV disinfection systems often fail in smaller sewage treatment plants and must often be supplemented by chlorination.

Cost of Operation

Unfortunately the bulbs in UV Disinfection systems have a finite life and must be frequently replaced. In most cases, replacements occur every 12-months which can cost more than $150.

The UV Disinfection unit's replacement cost can be more than $1,500.