AD101 – ANAEROBIC DIGESTION SYSTEM SELECTION CONSIDERATIONS

Nathan Clarke – Principal Wastewater Engineer, Beca Ltd

ABSTRACT

With increasing emphasis on low energy wastewater treatment, energy neutrality, carbon emission reductions, and alternative fuel sources, the need for anaerobic digestion as a treatment option is increasing, particularly in industrial wastewater and putrescible wastes applications.

Anaerobic bacteria are some of the oldest bacteria on earth, however while we think of the anaerobic processes as old and well established, this process is being developed constantly. Like the activated sludge process there are numerous configurations of anaerobic process and these configurations are often better suited to specific applications. With anaerobic digestion, a common problem has been that the appropriate configuration for an application is not well understood. The configuration of anaerobic digestion technology has a significant influence on the performance of the system, and it is common for inappropriate technologies to be selected resulting in poor treatment performance.

“When the only tool you have is a hammer, every problem is a nail”

In the context of anaerobic digestion, many suppliers are experts at one configuration of anaerobic digester and therefore seek to change the problem to suit their solution rather than use the technology most appropriate for the problem. They often state that their solution is appropriate and all you need to do is pre-treat the waste but fail to acknowledge the effects that occur if the pre-treatment doesn’t work effectively. Unfortunately, this can (and has often) resulted in digestion systems that don’t do what they are meant to do.

The paper will look at the various configurations of anaerobic digestion technologies, their benefits and disadvantages, and when and why the technologies might be appropriate.

This paper is intended as an informative presentation that shares the authors experiences with anaerobic digestion systems over twenty years designing and building anaerobic systems around the world.

A range different technologies will be discussed along with a range of constraints associated with the different configurations of anaerobic digestion system.

KEYWORDS

Anaerobic Digestion, System Selection, Process Configurations, Performance

PRESENTER PROFILE

Nathan Clarke is a principal wastewater engineer for Beca Ltd. He is passionate about wastewater treatment and has been working with anaerobic digestion systems for around 20 years as a consultant and design build contractor. He is keen to encourage the uptake of the technology and to share knowledge to assist potential owners to understand risks associated with the technologies.

1 INTRODUCTION

Anaerobic digestion (AD) is a proven technology and its use is widespread in wastewater treatment and renewable energy systems from wastes throughout the world. AD has several benefits over aerobic treatment technologies and as a treatment technology its adoption can be an excellent way to reduce carbon emissions and to recovery energy from waste materials. AD technology has however not been adopted significantly in NZ.

The current estimate of total biogas capacity in New Zealand is around 57 MW. The majority of this is used for electricity generation. Biogas can be a renewable substitute for natural gas and is suitable for use in homes and businesses for cooking, heating, electricity generation and can be used as a transport fuel, or as a feedstock for the production of other chemicals.

There are numerous configurations of Anaerobic Digester, with each configuration being suited to specific applications, and there is not one AD configuration that suits every application.

The selection of the configuration of anaerobic digester can result in the success or failure of an Anaerobic Digestion project.

There are numerous examples globally of digestions systems that have been installed that have failed to achieve effective performance due to the selection of a configuration that was not appropriate to the waste stream or the specific requirements of the site.

After more than 20 years in the industry, it is apparent that potential users of AD technology are still not well informed about the significance of the AD configuration selection on the successful implementation of AD systems.

One of the reasons for the number of systems that have failed to perform effectively is the fact that the AD industry is a technology centric industry where projects are typically undertaken as Design Build projects using a proprietary design. It is quite common for there to be very few personnel external to the supplier who have in-depth knowledge of the specific technical details associated with the particular configuration, and as a result therefore many clients select a technology based on supplier assertions, or on cost, assuming that they can rely on contractual remedies in order to make the supplier achieve compliance.

What is often overlooked is that suppliers of specific technologies are experts in their field, and they know and understand how to transfer risk to the client. It is very common for the owners of failed proprietary supplied AD systems to have no recourse on the supplier due to their wastewater being slightly outside the specified influent criteria. Even short-term aberrations are sufficient to give the supplier a means of voiding a warranty

In this paper a number of different configurations are outlined. The configurations are then compared for suitability for a range of waste characteristics.

In New Zealand the most common digesters are simple uncovered lagoons in dairy, pig and other farms, these digesters are not considered in this paper as they generate significant greenhouse gas emissions, can create odour issues, and can be a safety hazard. This paper only considers digestion systems where the gas is collected and can be managed without creating significant greenhouse gas emissions. For engineered digestion systems the most common in NZ are CSTR reactors for municipal biosolids digestion.

2 TYPES OF ANAEROBIC DIGESTIONS SYSTEMS

2.1 OVERVIEW OF AD SYSTEMS

There are numerous AD system configurations available, some of these are physically almost the same, however when run at thermophilic versus mesophilic temperature they are generally considered an alternative system configuration. For the purposes of this paper only physical differences are discussed.

There are numerous system configurations and each has benefits and disadvantages in each situation.

The different generic configurations include:

- Simple lagoon based systems
- Engineered lagoon-based systems
- Completely mixed Stirrer Tank Reactor (CSTR) systems, including mesophilic and thermophilic options, and multi stage systems.
- Anaerobic contact systems, including anaerobic MBR systems
- Granular sludge systems, including UASB, ECSB, IC, EGSB and similar systems
- Fixed film systems, including fixed and moving bed systems
- High solids systems with solids higher than 15%, including percolation bed systems, and mechanical drum systems

2.2 LOW RATE AD SYSTEMS

Low rate anaerobic digestion systems have a loading rate typically around 1 - 3 kg COD/m3.d The loading rate in these systems depends on the degree of mixing, or biomass contact with the incoming feedstock, and also on whether the system design is targeting the retention of solids within the reactor.

2.2.1 LAGOON STYLE SYSTEMS

There are a variety of lagoon based systems available on the market, with some very simple very low cost, and low performance systems to highly engineered lagoons with excellent treatment performance. Examples of lagoons processes that have been used extensively in the Asia Pacific region include simple anaerobic covered ponds, the CIGAR process, and the ADI-BVF system, and HRAL systems. Three of these systems are engineered to use the wastewater and gas production within the wastewater to provide a significant portion of the mixing and to have biomass recycles.

Traditional unmixed anaerobic lagoons typically accumulate sludge in the bottom of the reactor, resulting in process deterioration over time.

Engineered lagoons generally use sludge blankets with feedstock entering at the base of the reactor and flowing up through the biomass. This feeding profile enhances contact with the sludge, reduces the possibility of short circuiting, and separates the hydraulic residence time (HRT) from the Solid Residence Time (SRT) and creates a very stable system able to resist significant shock loads.

Photograph 1: Photo of feed and sludge removal pipe on an engineered lagoon digestion system.

2.2.2 CSTR

The CSTR system is the most common type of digestion system used in municipal biosolids, and animal waste and agricultural derived feedstock digestion. This system is used in many thousand installations world wide and is simple and robust. CSTR plants rely on having good mixing to prevent accumulation of solids and short circuiting. A key attribute of the CSTR is that the solid and liquid residence time in a CSTR is theoretically the same. The capacity of the CSTR is limited to the ability of the anaerobic process to sustain sufficient bacteria in the system, which requires the SRT to be long enough. CSTRs can be easily upgraded to have additional capacity by converting them to Anaerobic Contact systems, and therefore they offer significant flexibility to changes in wastes characteristics or capacity over time.

2.3 MEDIUM RATE SYSTEMS

Medium Rate Anaerobic Digestion systems are systems that have COD loading rates of around 3- 8 kg COD per m^3 per day. Typically, the loading rate for many of these systems would be in the 5 – 8 kg COD per m^3 per day range. A key attribute of these systems is that they rely on the separation of HRT from the SRT by either holding biomass within the systems, or capturing biomass in the effluent and recycling anaerobic biomass back into the system to enhance the SRT. This separation of the HRT from the SRT allows smaller tanks to be used from the same capacity.

2.3.1 ANAERBIC CONTACT SYSTEMS

Anaerobic Contact systems are typically a CSTR reactor followed by a separation device that captures and recycles anaerobic biomass. In New Zealand there are several Anaerobic Contact systems installed, although not all the systems operate as Anaerobic Contact systems. There are a range of separation devices that can be used in these applications, including Rotary Drum Thickeners, Gravity Belt Thickeners, Centrifuges, and Dissolved Gas Flotation systems. Additionally, microfiltration or ultrafiltration membranes can be used, however the generic name for a system with a membrane filtration system as the separator is an anaerobic MBR rather than an anaerobic contact system. Historically gravity separation and inclined plate separators were used, but these had poor separation efficiency and reliability due to gas buoying from ongoing gas formation and as a result operational performance can be variable. This is style of separator becoming less frequently used.

The type of separation system is often dependent on the suppliers experience, as well as on the quality of the effluent required. Care is needed to make sure that the separation technology is effective and reliable, as the performance of the AD system relies on the recycle of anaerobic biomass, and process failure can occur if the biomass recycle stops.

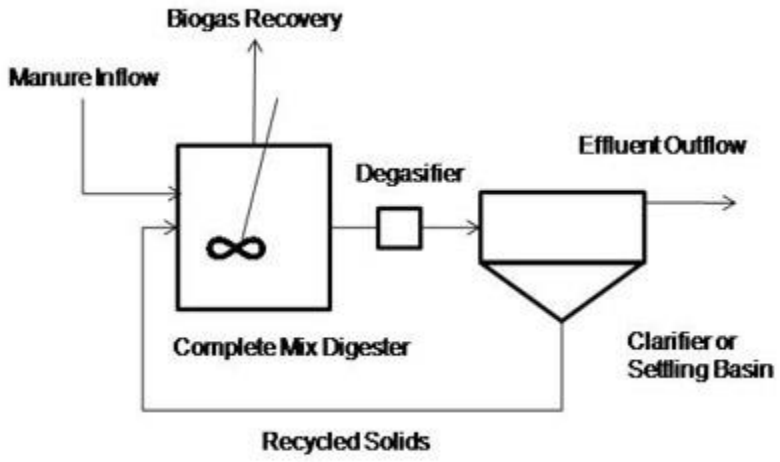

Figure 1: Schematic diagram of an Anaerobic Contact system

2.3.2 ANAERBIC MBR

Anaerobic Membrane Bioreactor (AnMBR) is an anaerobic contact system that uses microfiltration or ultrafiltration membranes as the separation technology. This system has some advantages over many other anaerobic contact systems because it can achieve very high quality effluent.

The AnMBR however can be more expensive to operated due to the additional energy and maintenance associated with the separation membranes.

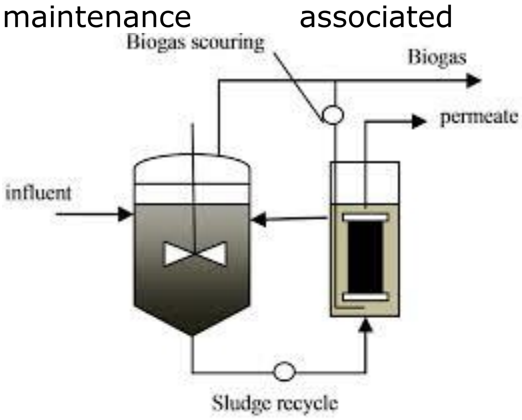

Figure 1: Schematic diagram of an AnMBR

Photograph 2: Example of the effluent (permeate) quality available from an anaerobic MBR system.

2.3.3 FIXED FILM SYSTEMS

Fixed film anaerobic digestion systems have media inside the reactor. Traditionally the media has been rigid media does not move within the reactor. Anaerobic bacteria can attach and grow on the media, and the waste material passes through the media coming in contact with the anaerobic biomass. These systems have excellent biomass retention properties and can be used on some difficult to treat wastes, as biomass can adapt to the waste resulting in improved ability to degrade particular chemical constituents. Anaerobic fixed film systems have a disadvantage in that they can develop channeling over time, and therefore performance can degrade over time. Newer versions of fixed film technology that has moving media, similar to aerobic MBBR, have been developed over time to reduce these issues, and however in these are not common at present.

2.4 HIGH RATE SYSTEMS

High rate anaerobic digestion systems are systems that have high loading rates. Typically high loading rates are considered loading rates between 10 and 30kg COD/m^3.d High rate systems are generally tall tank (often 20m tall) systems, and they are often preferred internationally due to the lower footprint area than low and medium rates systems. High rate systems however do have some significant disadvantages and are only suitable for a reasonably narrow range of wastes. In order to be used for other waste streams they can require significant waste pretreatment for the system to work effectively.

Generally, these systems are almost all based on granular anaerobic bacteria, and the waste is pumped up through the granular bacterial bed. They have a gas-solids separator inside to retain the granular bacteria in the reactor so that it does not wash out.

There are other very high rate systems which are significantly less common. An example is the relatively new downflow moving bed fixed film system. This system uses small moving media that are very slightly less dense than water as a carrier for bacterial culture. The raw wastewater is pumped into the system at the top of the tank and passes downward through the floating media, the media moves within the reactor to prevent channeling.

2.4.1 GRANULAR SLUDGE SYSTEMS

Granular sludge anaerobic digestion systems have been in service for around 40 years**,** with the first granular sludge system being the Upflow Anaerobic Sludge Blanket (UASB) system. Since this time additional developments in granular sludge systems have occurred, with the recent developments being very high rate. Many hundred granular sludge systems have been installed globally. This anaerobic digestion configuration very popular with industrial wastewater facilities with high soluble COD components.

A variety of variants are available for the granular sludge systems. Granular systems rely on the microorganisms growing into a hard granule, and the density and settling characteristics of the granules being high enough that the granules stay within the reactor. Different suppliers have different arrangements for their gas-solids separator design, and modern designs have more than one layer of settlers to improved solids recovery. These reactors have high to very high loading rates but have several constraints which can seriously affect their performance.

The technology suits waste streams with high soluble COD concentration and with low levels of suspended solids, low levels of fat, and low calcium concentrations. It is important to understand that many of these systems have had significant operational issues due to fat, high solids, or high calcium concentration in the wastewater.

The foot print and reactor size of these systems makes them attractive for system purchasers with constrained sites.

There are many systems globally that have had issues maintaining the granular bacteria in a healthy state. These systems often need ongoing bacteria seed culture to be added, and this can result in significant cost. In New Zealand there is no available source of granular anaerobic bacteria sludge, and only one system of this type has been installed at full scale. The system did not work effectively due to poor wastewater pretreatment and was abandoned by the client.


Photograph 3 and 4: A handful of granular sludge, and a representation of the gas solids separator in a high rate reactor.

2.5 HIGH SOLIDS SYSTEMS

High solids digestions systems are typically classified as systems having a solids concentration in the reactor of over 15 % solids. Often in these systems the waste material will have a total solids concentration of around 25% solids when it enters for the digestion process. They are regularly used for food waste and organic fraction of municipal solid waste digestion. There are several advantages of these systems including low water consumption, and the ability to accommodate high levels of contaminants.

2.5.1 PERCOLATION BED DIGESTION

A common configuration of high solids digestion system is the percolation bed. This system uses a mixture of pretreated material, coarse material to assist porosity, and recirculation of anaerobic liquid from the process to solubilise the organic material. The system is a batch system where multiple batches are processed offset in time, thereby allowing capacity to feed the system continuously. Normally system is a two-stage system with the percolation bed undertaking acidification and hydrolysis reactions, with methane production being undertaken on the leachate from the second stage reactor to remove additional soluble organic material.

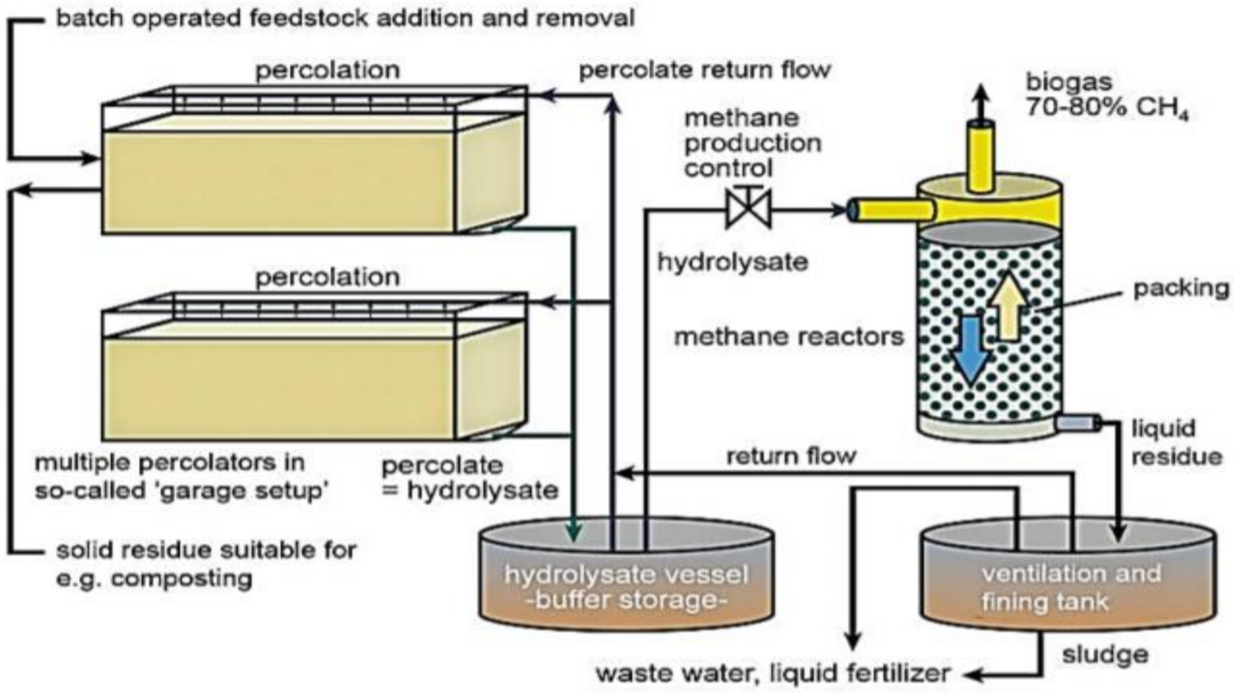

Figure 3 - Schematic of percolation bed high solids anaerobic digestion system.

2.5.2 VERTICAL TANK SINGLE TANK DIGESTION

Single tank high solids digestion systems are available (e.g Dranco) that use a recirculation of digested solid material with fresh feed material. The mixed feed material is added to the top of the reactor tank and recycle and discharge material are taken from the bottom of the tank.

This system uses a mixture of pretreated material mixed with the raw material, and recirculation of anaerobic treated material from the process to inoculate the feed material with bacteria. Some systems have a second stage reactor to remove additional soluble organic material.

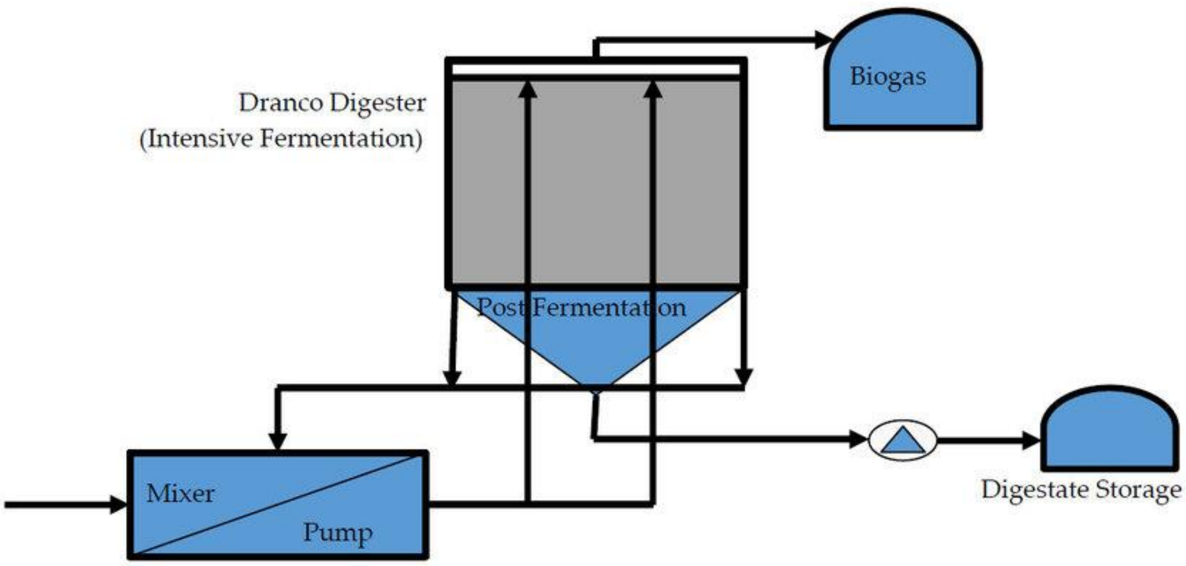

Figure 4 – Process schematic for high solids vertical tank digestion systems (schematic represents Dranco process)

2.5.3 MECHANICALLY MIXED HOROZONTAL DIGESTION

There are a range of suppliers of mechanically mixed horizontal reactor designs for high solids was streams, with the best known being the Kompogas system. This system feeds feed material along with a recycle stream to inoculate the feed with anaerobic bacteria into one end of a sealed reaction vessel. The vessel is mixed with a large slow turning mixing system and the mixer slowly moves the material inside the reactor. The material is degraded inside the system and moved toward the opposite end where it is discharged.

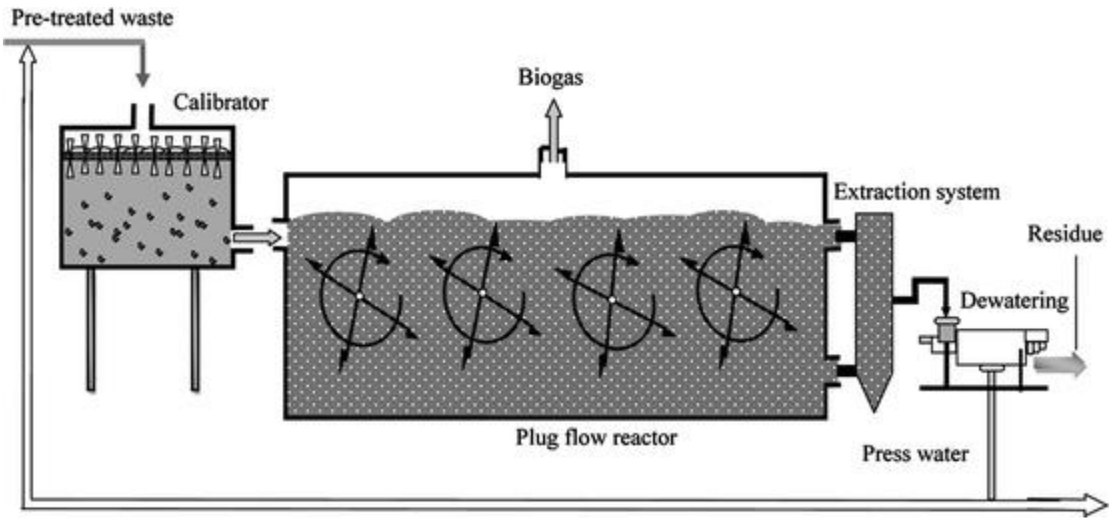

Figure 5: Schematic of horizontal high solids digestion system.

3 LIMITATIONS OF THE DIFFERENT SYSTEMS

All the different systems have some limitations, there is no system that is an answer to all situations. In a general sense the selection of a digestion system will have some overarching selection criteria which are the most important and that will override other less important considerations.

In the experience of the author, the most critical criteria are;

- the technical reliability,
- the robustness to changing feedstocks and process upsets,
- the ease of operation
- and the ability to accommodate changes over time are overarching critical aspects.

The cost of the system, while important, is secondary to getting a system that achieves the performance requirements. This consideration is because when AD processes fail to achieve their requirements from a technical basis significant extra money, time, and energy is expended in trying to get their performance to improve, and it often increases the cost to well above the costs that would have been spent if a more appropriate technology was selected initially. In the worst-case poor selection can result in the eventual abandonment of the system. This has happened with one high rate system in New Zealand.

3.1 LIMITATIONS OF THE VARIOUS CONFIGURATIONS

3.1.1 LAGOONS

Simple lagoons systems are a very low-cost way of getting some biogas from wastewater, reducing COD concentration, and reducing organic solids volume. They can be effective and are very easy to operate. Engineered lagoons are very effective at treating wastes and require little operator input.

The primary disadvantage of lagoon systems is the land area that they occupy. This is often considered an issue and is an area that the suppliers of other treatment technologies often emphasise. In the experience of the author the cost of land is seldom the reason for them not to be selected. The author has been involved with lagoon systems in many countries including European nations and land cost has only been an issue for factories located within large cities. More frequently a lack of available area, poor geotechnical conditions, or risks of solids accumulation due to high inorganic solids or calcium concentration are the actual reason for alternative technologies being selected.

Solids accumulation is an issue with unmixed or poorly mixed lagoon-based digesters. Unmixed anaerobic lagoons will generally fill up with sludge over time. Unmixed anaerobic lagoons in industrial waste treatment applications often fill up over 5 to 10 years, after which the treatment performance and effluent solids concentration will deteriorate significantly. When filled with sludge, the lagoon would require desludging.

Lagoons are not well suited to high calcium concentrations as sedimentation and scale formation can occur leading to inorganic solids accumulation. Inorganic chemical that are known to form deposits include Calcium Phosphate and Struvite.

For farm scale digesters where the solid material can be spread onto farm paddocks as fertiliser desludging is not typically an issue. With large industrial or municipal anaerobic lagoons, the sludge needs to be dredged out and then sent offsite for disposal. This can be an expensive exercise.

In New Zealand there is a large industrial wastewater anaerobic pretreatment lagoon system that has been operating for many years, which requires dredging nearly every year. Despite the dredging requirement it has provided the owner of the facility with a high level of reliable pretreatment for a very significant wastewater load. This example illustrates that solids accumulation and desludging does not necessarily mean that the technology is not appropriate, but care is required. Engineered lagoon systems such as the CIGAR process where high mixing energy is included with the feed stream at the bottom of the reactor has not been found to result in process performance issues due to accumulation of sludge

Lagoons are very robust technologies they provide good buffering for factories with variable waste streams. They are sufficiently robust that they can often tolerate significant variability in factory flows and loads without significant issues.

Systems such as the BVF reactor or the CIGAR process, where the waste is feed into the bottom of the lagoon reactor, the process can provide very high levels of treatment, with very low energy input.

With other reactors that include large unmixed settling zones some accumulation of sludge has occurred, and removal of sludge is occasionally required. Sludge removal on some systems is undertaken with the system in service using divers to suck the material out, whereas with other systems the removal of the cover is required to allow the system to be dredged.

These systems can also have good effluent characteristics if designed properly due to the ability to have internal settling zones. Effluent quality is dependent on the loading rate with loading rate above around 0.8 kg COD/m3.d resulting in sufficient biogas production that settling can be compromised due to gas buoying.

3.1.2 CSTR

CSTR is one of the most versatile anaerobic digestion configurations available. It can accept many waste streams however it has poor effluent quality and its capacity is often limited by hydraulic residence time.

Where the effluent quality is critical this configuration would not be acceptable.

CSTR is the most flexible technology available from a feedstock perspective and is applicable for a broad range of feedstocks. CSTR is often used for biosolids digestion, wastes with high solids concentrations, wastes with high fat content, and for very high strength wastes.

CSTR systems typically require high mixing energy, and mixing energy increases as the concentration of solids increases, this means that CSTR systems have a higher energy demand, which results in a lower net energy production than alternative technologies in some circumstances.

Maintenance of CSTR mixers has been an issue and it is important to consider the mixing system design in the selection of a CSTR. Where the mixers use gas to stir the fluid using a floatation effect, the gas mixing has been known to create foaming leading to operational issues.

Where ammonia is released into the anaerobic liquor, and there are other contaminants, (particularly phosphate and magnesium), then precipitates can occur which can cause significant scale formation within the reactor. This can create issues with pipe capacity, balance issues with mixers and pumps, and accumulation of unreactive solids within the digester. Struvite can be a serious issue for the operational costs and can significantly increase maintenance input to an anaerobic digester.

If mixing is insufficient, or larger particles settle into the base of a CSTR it is often possible for them to accumulate. The removal of the sediment can be difficult and occasionally will require the reactor to be emptied and cleaned. With an appropriate mixing system with sufficient mixing energy the accumulation of solids within a reactor can result in very low cleaning frequency for these systems.

Hydraulic Residence Time (HRT)/ Solids Residence Time (SRT) requirements for CSTR are very important as the anaerobic bacteria are slow growing an if the residence time is too short the process will "wash out" the bacteria. Typically, CTSRs are designed with a 18 – 25 day HRT. The minimum residence time will depend on a number of factors including; the level of mixing within the CSTR, the temperature in the CSTR, as well as the concentration of bacteria in the feedstock.

3.1.3 FIXED FILM ANAEROBIC DIGESTION SYSTEMS

Fixed film systems do not like high suspended solid concentrations, they cannot tolerate high levels of fat or high calcium concentrations and are best used for wastes that contain soluble difficult to treat waste constituents. The reason that they suit these wastes is due primary to their ability to adapt to difficult to degrade materials, and therefore provide improved treatment and reliability for these materials.

Fixed film systems require maintenance of the packing material, and it is common on fixed media systems that performance decreases over time as the packing material voids fill and the liquid starts to develop channels in the reactor. The author knows of systems where the media has become sufficiently blocked that it has floated in the reactor causing the significant issues. Maintenance is required to avoid this.

A newer development of the fixed film system is a system using media that can move within the reactor. This still has many of the limitations associated with fixed film systems but overcomes the channeling issues. This type of system can sometimes be used as a retrofit in a CSTR or similar tank to significantly increase the treatment capacity. The technology is not suitable for high TSS, high fat, or high calcium wastewaters.

3.1.4 TABLE OUTLINING CONSTRAINTS FOR VARIOUS AD TECHNOLOGIES

The following table is intended to outline some general limitations associated with different technologies. The table is not comprehensive, and expert advice should be sought when considering anaerobic digestion design. However, this table is intended to give a generic overview of the issues that should be considered.

	CONSTRAINTS FOR SELECTION FOR DIFFERENT GENERIC TYPES OF ANAEROBIC SYSTEM			
PARAMETER	Lagoon System	CSTR	Anaerobic Contact	Granular Sludge Systems
FOOT PRINT	Large	Medium	Medium	Low
TEMPERATURE	Mesophilic	Meso or Thermophilic	Meso or thermophilic	Mesophilic 25 – 40 C
COD CONCENTRATION	Limited in unmixed ponds typically ~ 15000 COD	No limit	No limit	Typical range between 1500mg/l - 30,000 mg/l
COD LOADING RATE	Typically up to 1kg COD/m3.d	Typically up to 3 kg/ m3.d	up to 6 kg COD/m3.d	up to 30 kg COD/m3.day
SULPHUR:COD RATIO	Must be greater than 7kg Cod COD:1 Kg sulphate Ideally greater than 10 kg COD to 1 Kg sulphate	Must be greater than 7kg Cod COD:1 Kg sulphate Ideally greater than 10 kg COD to 1 Kg sulphate	Must be greater than 7kg Cod COD:1 Kg sulphate Ideally greater than 10 kg COD to 1 Kg sulphate	Greater than 10kg COD : 1 Kg sulphate
SULPHIDE	<1000ppm free H_2S	<1000ppm free H_2S	<1000ppm free H_2S	<1000ppm free H_2S

CALCIUM	Depends on Specific system	High calcium results in increased maintenance risk	High calcium results in increased maintenance risk.	<500 ppm
NITROGEN	Ammonia-N < 2000ppm High nitrate concentration can also cause issues	Ammonia-N < 2000ppm High nitrate concentration can also cause issues	Ammonia-N < 2000ppm High nitrate concentration can also cause issues	Ammonia -N <1500 ppm High nitrate concentration can also cause issues
TSS	Can accept high solids concentrations	Can accept high solids concentrations	Can accept high solids concentrations	TSS <1500 ppm Organic TSS< 20% of sCOD
FAT	Fat can result in large floating fat layers and maintenance issues.	Above 10% fat as portion of feedstock COD care is required	Above 10% fat as portion of feedstock COD care is required	<100mg/l
CHEMICAL USE	Low	Low	medium	high
EFFLUENT QUALITY	Depends on system design	Poor effluent quality	Can have excellent effluent quality	High
COD REMOVAL	Depends on system design	Net COD removal low due to COD associated with bacterial solids in effluent	COD removal high to very high	COD removal high, but requires low suspended solids in feedstock.
FEEDSTOCK VARIABILITY	Robust to feedstock changes	Very robust to feedstock changes	Very robust to feedstock changes	Performance affected by feedstock changes
SLUDGE AVAILABILITY	Typically, readily available, but large volumes required.	Typically, readily available	Typically, readily available	Currently unavailable in NZ
ODOUR CONSIDERATIONS	Depends on Design, systems under negative pressure have	System under pressure, process upsets	System under pressure, process upsets	Depend on the system design.

	low odour issues	can cause odour	can cause odour	
OPERATIONAL SKILL	Low	Medium	Medium	High
WASTEWATER PH	Large range possible depending on waste characteristics.	Large range possible depending on waste characteristics	Large range possible depending on waste characteristics	6.6-7.8

Table 1: Typical constraints for different AD system selection

3.1.5 TYPICAL PERFORMANCE

The performance of anaerobic digestion systems is rated in a number of ways. The three primary ways depend on the reasons that the anaerobic digestion system is being used. For systems that are designed to produce power as their primary objective typically the primary performance objective would be gas yield.

For a digester with the primary purpose of biosolids degradation often the primary performance measure is volatile solids reduction. This measure is required to minimise the biosolids that needs to be transported to be further treated or disposed and gives an indication of the level of treatment and sludge stability that has been achieved.

The third measure of performance is often usually related to anaerobic digestion wastewater treatment applications. This is typically as industrial wastewater pretreatment systems. For wastewater treatment the performance measure is typically the removal percentage of COD and TSS within the digester.

	LAGOON	**CSTR**	**ANAEROBIC CONTACT**	**GRANULAR SLUDGE SYSTEMS**
GAS YEILD	Engineered systems can achieve very high gas yield	High	Very high	medium
VOLATILE SOLIDS REDUCTION (VSR)	Engineered systems can achieved high VSR	High	High	Low
WASTE WATER TREATMENT	Generally, requires post treatment.	Further treatment required	Can achieve excellent effluent quality	Generally, requires post treatment

Table 2: Typical AD configuration performance

It is very important to note that the performance of different technologies will depend on the waste stream they are treating and the waste characteristics. For example, the treatment of fruit juice wastes or starch processing wastes in well-designed and operated anaerobic digesters will often result in 99% removal of COD. However, for other wastes such as sugarcane molasses distillery wastes even very well designed and operated facilities will only remove around 65% of the COD.

Understanding of the waste streams is critical to the success of any wastewater treatment system, and this is just as important with anaerobic digestion as it is with any other system.

4 CARE REQUIRED FOR DIFFERENT SYSTEMS

Care is required for the selection of an anaerobic digestion systems as there are numerous technical considerations that have significant influence on the process performance. It is not wise to rely on the supplier of the technology for objective advice, as many suppliers only have one process option that they try to fix into every situation. The AD industry is technology centric industry and therefore it is suggested that potential owners find and get advice from an expert in the field to confirm that the system being offered to is actually suitable for their application.

Using purchase cost or relying of the assertions of the technology supplier are not good methods for deciding on the most appropriate process. Potential owners need to be able to discern what is a good and reliable solution and what isn't for themselves to avoid potentially purchasing an inappropriate system.

This paper outlines some generic constraints for different AD system configurations and is intended to assist a potential owner of facilities to understand the issues that need to be considered. This information is still high-level information, and it is strongly recommended that a prospective owner get expert advice to assist with the selection of the technology and making sure that there are no obvious issues with the waste specification that could void the supplier performance warrantees.

Generally, If the waste material has high levels of fat, oil or grease, or requires significant pretreatment to achieve consistent grease within the typical acceptance criteria for granular sludge system, then the risk to a granular sludge system is very high, and it is advisable to look for an alternative configuration.

Similarly, if calcium is high or TSS is high, then selection of a granular sludge system needs to be only undertaken after very serious consideration. This is one of the most important learnings. There are too many examples of granular sludge anaerobic systems have been selected and have been unable to perform due to the wastewater not being able to be treated to the level required for the process to be reliable

5 CONCLUSIONS

Anaerobic Digestion technology is well proven, but due to the large range of different configurations associated with AD, and the requirements for specific applications, it is necessary for owners to understand, or to get assistance from an expert, to avoid selecting an option that won't achieve their desired outcomes.

There are numerous suppliers of technology, many who have excellent product offering, but care is required due to the industry being technology supplier lead. There is a risk that suppliers will offer a process that is not well suited to the specific application, due to them not having knowledge or access to a better suited configuration.

Get advice from someone with experience with a range of different technologies.

REFERENCES

Wabnitz.G et al, 2011: Biogas 2010 to 2040, Bioenergy Association of New Zealand (BANZ), Biogas Interest Group.