MEMBRANE THICKENING AEROBIC DIGESTION PROCESSES

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ABSTRACT

Sludge management accounts for approximately 60% of the total wastewater treatment plant (WWTP) expenditures and laws for sludge disposal are becoming increasingly stringent therefore much consideration is required when designing a solids handling process. A membrane thickening aerobic digestion process integrates a controlled aerobic digestion process with pre-thickening waste activated sludge using membrane technology. This process typically features an anoxic tank, an aerated membrane thickener operating in loop with a first stage digester and followed by second stage digestion.

Membrane thickening aerobic digestion processes can handle sludge from any liquid treatment process and is most ideal for facilities obligated to meet low total Phosphorus and Nitrogen discharge limits. Membrane thickening aerobic digestion processes offer many advantages including: producing a reusable quality permeate with minimal levels of total phosphorus and nitrogen that can be recycled to the head works of a plant protecting the performance of a biological nutrient removal (BNR) liquid treatment process without requiring chemical addition, providing reliable thickening up to 4% solids concentration without the use of polymers or attention to decanting, increases sludge storage capacities in existing tanks, minimizes footprint of new tanks, reduced disposal costs, and provides Class B stabilization.

KEYWORDS

Aerobic Digestion, Membranes, Nutrients, Solids Handling

INTRODUCTION

All wastewater facilities are going to generate solids and dealing with solids is a necessary evil. The processing, treatment, and disposal of sludge for beneficial use accounts for approximately 40% to 60% of total wastewater treatment plant expenditures. These costs will only continue to rise because the amount of sludge produced at wastewater treatment plants is continually increasing. The USEPA estimated the sewage sludge production in 1998 from publicly owned treated works (POTW) facilities in the United States was 6.9 million dry tons (US EPA, 1999) and was estimated at 8 million dry tons in 2005 (US EPA, 2006). Depending on economic factors, site conditions, regulatory requirements, stabilization goals, and solids disposal options there are many solids handling technologies wastewater treatment plants can consider before determining the appropriate solution for a wastewater treatment facility.

A membrane thickening aerobic digestion process is a controlled aerobic digestion process that utilizes a membrane for thickening waste activated sludge (WAS) which consistently provides reliable and improved thickening performance and sustainable nutrient management of a biosolids handling process by minimizing total nitrogen and phosphorus loading in side stream flows. A side stream is any process flow resulting from the treatment of biosolids that flows back to the liquid treatment process, and can account for approximately 20% of a WWTP total influent nitrogen and 30% of the total influent phosphorus load (Bilyk, Pitt, Taylor, Waunkmuller, 2011). Examples of side streams are filtrate or centrate from dewatering operations and supernatant from digestion processes. If a plant recycles very high concentrations of nitrogen and phosphorus in side streams of solids handing processes it can be difficult to remove in the biological process making it problematic to comply with any discharge permit requirements.

This process is suitable for handling waste activated sludge (WAS) from many liquid treatment processes such as a membrane bioreactor (MBR) and also conventional processes such as sequencing batch reactor (SBR), extended aeration such as an oxidation ditch, rotating biological contactors (RBC), and activated sludge processes such as a modified Ludzack-Ettinger (MLE).

Membranes are typically utilized in liquid treatment applications such as a MBR process therefore using membranes to pre-thicken sludge in an aerobic digestion process is a very unique approach. Although a membrane thickening aerobic digestion process is a relatively new solids handling approach to many it uses the same membrane equipment as an MBR process however thickens the sludge to three times greater concentration. This process offers outstanding operational, economical, and process benefits which include: the ability to reliably thicken sludge up to 4% solids concentration without the use of polymers or operator attention, provides a Class B stabilized sludge in a reduced tank footprint optimizing digestion performance reducing sludge disposal, and producing a reuse quality permeate effectively minimizing the impact of nutrients from solids handling side streams on a liquid treatment process. This process also provides continuous thickening allowing for operations to be independent of wasting schedules from the liquid treatment process. Currently, there are sixteen operating membrane thickening aerobic digestion process installations in the United States with several more in construction. The hydraulic flow of these plants is typically between 500,000 GPD and 2 MGD, with one installation designed for a 25 MGD flow.

METHODOLOGY: DESCRPTION OF THE MEMBRANE THICKENING AEROBIC DIGESTION PROCESS

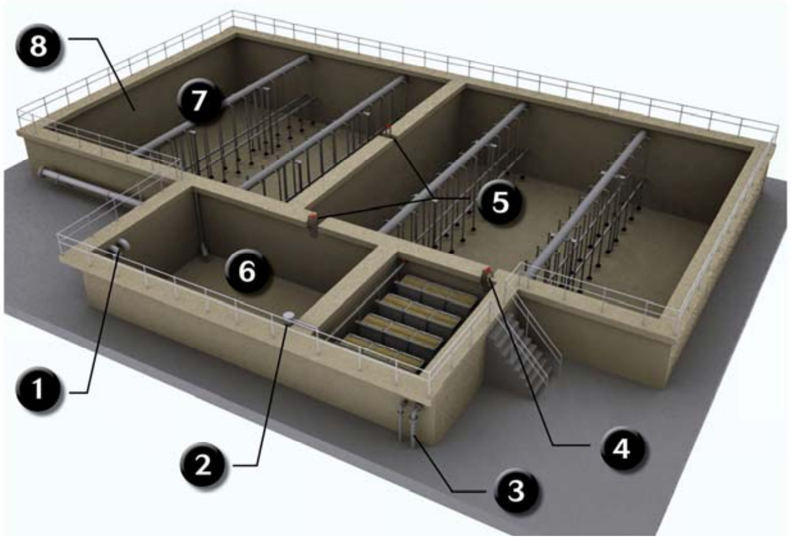


Figure 1: General Membrane Thickening Aerobic Digestion Process

The following are the steps of the membrane thickening aerobic digestion process shown above:

1. Waste Activated Sludge (WAS) is wasted from the activated sludge process and enters the Anoxic Tank at a rate of 1Q.

2. As the liquid level in the Anoxic Tank rises, sludge is pumped into the membrane thickening (MBT) tank at a recycle rate of 4Q, ensuring the solids remain at an optimum thickness.

3. As WAS is pumped into the MBT from the Anoxic Tank, permeate is extracted through the membranes and either goes to the head of the plant or to disinfection.

4. When the maximum liquid level in the MBT is reached, the addition of sludge to this tank causes a corresponding overflow into the In-Loop Digester for first stage digestion.

5. When the maximum liquid level in the In-Loop Digester is reached, the addition of sludge to this tank will cause a corresponding overflow of sludge to either the Isolation-Digester or to the Anoxic Tank, completing a continuous process loop.

6. Nitrified sludge transferred from the In-Loop Digester to the Anoxic Tank is mixed with the incoming WAS, which serves as a fresh carbon source allowing for denitrification without having to cycle the air on and off in the digester tanks.

7. The small portion of sludge that is transferred from the In-Loop Digester to the Isolation Digester is aerated and mixed for second stage digestion for further pathogen removal.

8. Sludge is transferred out of the Isolation Digester tank for final disposal.

As described above a membrane thickening aerobic digestion process utilizes a nitrification and denitrification process that removes nitrogen in both the solid and liquid phase.

Phosphorus removal presents a much more challenging and sophisticated concept in the membrane thickening aerobic digestion process than nitrogen removal. A membrane thickening aerobic digestion process is capable of minimizing the release of the three forms phosphorus: inorganic phosphorus, polyphosphorus, and organic phosphorus.

Although phosphorus is generally not soluble in water, aqueous phosphates are commonly found in wastewater. Under acidic conditions H^+ ions are present phosphate (PO_4^{-3}) and can be transformed into aqueous forms of hydrogen phosphate (HPO_4^{-2}), dihydrogen phosphate (H_2PO_4), and phosphoric acid (H_3PO_4). The dissolution of inorganic phosphorus is controlled by pH and described using the acid disassociation equilibrium constant (pK_a). Phosphoric acid is triprotic therefore the pKa values of hydrogen phosphate, dihydrogen phosphate, and phosphoric acid are 12.7, 7.2, and 2.12 respectively. Under pH conditions between 12.7 and 7.2 hydrogen phosphate and dihydrogen phosphate species are most present which can form bonds with minerals such as calcium, sodium, and magnesium. The bonds formed with these minerals and aqueous phosphate species form precipitates which remove phosphorus in solution and remain in the solids. Under acidic conditions phosphoric acid is the dominant species and cannot form bonds with minerals or metals so the phosphorus stays in aqueous form. The continuous nitrification and denitrification sequencing described above in the membrane thickening aerobic digestion process allows excellent pH control, preventing the dissolution of inorganic phosphorus by maintaining the pH to range between 6.0 to 7.5.

Polyphosphorus accumulating organisms (PAOs) can store carbon compounds as a source of energy in the absence of oxygen or nitrate, which are common energy sources in biological processes. The storage of carbon compounds by PAOs results in a polyphosphorus release. The incoming WAS into the Anoxic Tank provides a fresh carbon source for PAOs to release polyphosphate following the exhaustion of nitrate, which also occurs in this tank. The aerated MBT tank, where permeate is collected, allows for the PAOs to grow and uptake the released polyphosphorus while their stored carbon reserves are oxidized resulting in reduced phosphorus levels in permeate.

PAO decay causes organic phosphorus release into the permeate due substantial biomass destruction in a membrane thickening aerobic digestion process. However, organic phosphorus release in permeate is minimal since Van Haandel and Van der Lubbe found the decay rate of PAO is approximately six times slower than non-PAO bacteria, and there are approximately twice as many non-PAO bacteria than PAO in a typical biomass. Although non-PAO bacteria are more common in a biomass and have a faster decay rate they contain approximately fifteen times less polyphosphorus than PAO bacteria (Van Haandel and Van der Lubbe, 2007).

DISCUSSION: EVALUATING THE KEY ADVANTAGES OF A MEMBRANE THICKENING PROCESS

Improved Thickening Without the use of Polymers or Decanting

Membrane thickening aerobic digestion processes produces a Class B stabilized sludge with reliable thickening without using polymers or decanting, allowing wastewater facilities to expand solids storage capacity in existing process tanks and minimize the footprint of newly constructed tanks. According to the United States Environmental Protection Agency (USEPA) Class B sludge is stabilized where pathogens are significantly reduced but still present in large numbers. Class B sludge is can be used for application to agricultural or nonagricultural land. In order to meet Class B stabilization two criteria must be met per the EPA Title 40 – CFR Part 503 Regulations. The first criteria that must be met is Pathogen Reduction and this can be met by complying with one of these two requirements: 1) Pathogens in the sewage sludge containing less than 2,000,000 CFU per gram of total dry solids and 2) Meeting a time temperature requirement of 20^o C at 40 days SRT or 15^oC at 60 days SRT. The second criteria is the Vector Attraction and can be met by meeting one of these two requirements: 1) Volatile solids reduction of 38% or more or 2) Standard Oxygen Uptake Rate (SOUR) of 1.5 milligrams oxygen per hour per gram of dry solid (mg O_2/g VSS/hr) or less (US EPA, 1993). For example if a sludge sample has a SOUR of 1.49 mg O_2/g VSS/hr and pathogens of 1,999,999 CFU per gram of total dry solids then it is in compliance with Class B stabilization requirements.

Thickening with membranes is independent of the WAS settling characteristics in contrast to a standard aerobic digestion process where WAS is aerated in one or more tanks and periodically stopping aeration to allow the WAS to settle and excess liquid to be decanted. Using decant thickening methods is very common in aerobic digestion systems, however thickening performance can fluctuate greatly and can have high disposal costs especially without sludge dewatering. Sludge concentrations of WAS in aerobic digestion operations can range from 0.8% to 2.5% but typically 1.3% solids concentration (Burton and Tchobanoglous, 1991). Membranes are capable of thickening WAS up to 4% solids concentration because the higher solids concentration is a function of physically filtering permeate out of the sludge rather than relying on gravitational settling. Comparing membrane thickening to a standard aerobic digestion process that utilizes decanting to thicken WAS, membranes provide more than three times better thickening performance if typical solids concentrations are considered.

Many wastewater operators find dealing with polymers difficult and labor intensive. Membrane thickening aerobic digestion processes do not require any polymers for thickening and therefore substantially minimizes operator attention while thickening. It eliminates maintenance associated with polymer thickening such as start up, cleanup, and shut down time of mechanical equipment.

Thickening of WAS with membranes brings much value to a wastewater treatment facility such as reduced disposal costs, energy costs, operation and maintenance, and construction costs of process tanks. Reliable and improved thickening with membranes significantly reduces the volume of sludge minimizing footprint of process tanks resulting in reduced energy and concrete costs, improved digestion performance provides reduced quantity of sludge to be disposed, and as discussed previously lowers operation and maintenance costs. In addition a membrane thickening aerobic digestion process can be retrofitted in existing tanks which is critical for wastewater treatment plants that are limited in space.

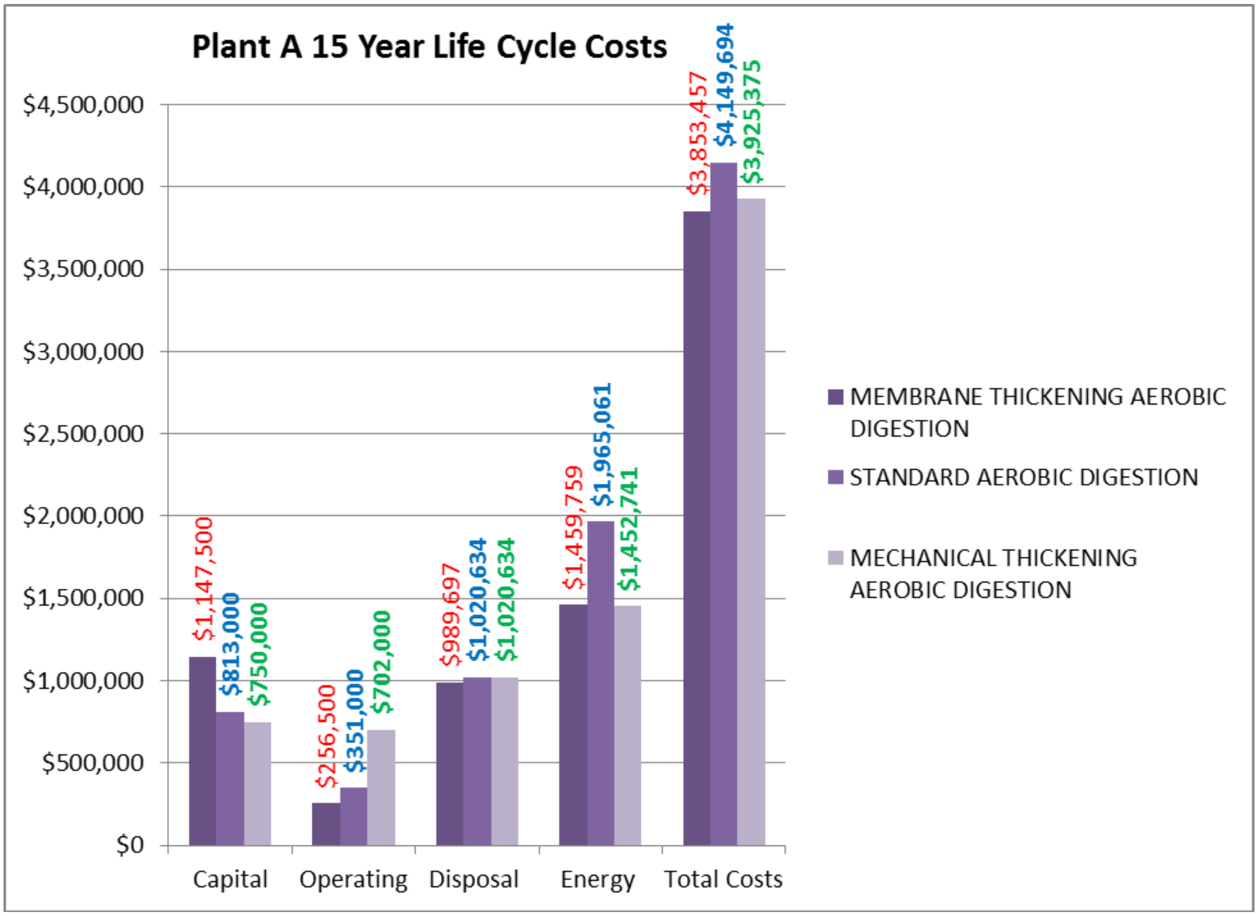
This example can help quantify the financial impact of the many advantages a membrane thickening aerobic digestion process can have. Let's consider a wastewater treatment plant that is considering a new solids handling facility, Plant A. Plant A is considering three Class B solids handling alternatives, a membrane thickening aerobic digestion process, mechanical thickening aerobic digestion process, and standard aerobic digestion process utilizing decanting to thicken WAS. Plant A is a municipal wastewater treatment plant, has a flow of 4 MGD (15,142 cubic meters per day), influent BOD concentration of 250 mg/L, and sludge yield of 0.7 lb WAS per lb of BOD. Table 1 shows a cost comparison of the solids handling alternatives over a 15 year life cycle which is the typical life of a WWTP is 15 to 20 years.

Table 1: Evaluation of Solids Handling Processes Considered for Plant A

DESIGN CONDITIONS		
Class B Biosolids		
Mixing Air Requirement of 30 scfm/1,000 cubic ft		
Process Air Requirement of 2 lb O2/lb VS destroyed		
15 Year Life Cycle		
Sludge is dewatered with belt press to 16% cake solids and land applied		
DESIGN PARAMETERS		
Plant Flow (MGD)	4	
BOD Conecentration (mg/L)	250	
Sludge Yield (lb WAS/lb BOD)	0.7	
WAS Loading Rate (ppd)	5,838	
Required SRT (days)	42	
STANDARD AEROBIC DIGESTION PROCESS DESIGN		
WAS Concentration (%)	2%	
WAS Volume (gpd)	35,000	
Volume Required (cubic ft)	196,524	
Airflow Required (scfm)	5,896	
Annual Energy Consumption (KWH)	1,871,486	
Concrete Required for Process Tanks (cubic yd)	1,326	Concrete Costs are $500/cubic yard
MEMBRANE THICKENING AEROBIC DIGESTION PROCESS DESIGN		
WAS Concentration (%)	4%	
WAS Volume (gpd)	17,500	
Volume Required (cubic ft)	98,262	
Airflow Required (scfm)	3,998	
Annual Energy Consumption (KWH)	1,390,247	
Concrete Required for Process Tanks (cubic yd)	695	Concrete Costs are $500/cubic yard
MECHANICAL THICKENING AEROBIC DIGESTION PROCESS DESIGN		
WAS Concentration (%)	5%	
WAS Volume (gpd)	14,000	
Volume Required (cubic ft)	78,610	
Airflow Required (scfm)	4,604	
Annual Energy Consumption (KWH)	1,383,563	
Concrete Required for Process Tanks (cubic yd)	678	Concrete Costs are $500/cubic yard
15 YEAR LIFE CYCLE COST COMPARISONS		
MEMBRANE THICKENING AEROBIC DIGESTION		
Capital	$1,147,500	Includes Equipment, Building, and Process Tank Costs
Operating	$256,500	Includes Chemical and Operating Costs
Disposal	$989,697	Based on $50/ton and $4/lb polymer
Energy	$1,459,759	Based on $0.07/KWH
Total Costs	**$3,853,457**	
Cost Per Ton Sludge Treated*	**$299**	
STANDARD AEROBIC DIGESTION		
Capital	$813,000	Includes Equipment, Building, and Process Tank Costs
Operating	$351,000	Includes Chemical and Operating Costs
Disposal	$1,020,634	Based on $50/ton and $4/lb polymer
Energy	$1,965,061	Based on $0.07/KWH
Total Costs	**$4,149,694**	
Cost Per Ton Sludge Treated*	**$281**	
MECHANICAL THICKENING AEROBIC DIGESTION		
Capital	$750,000	Includes Equipment, Building, and Process Tank Costs
Operating	$702,000	Includes Chemical and Operating Costs
Disposal	$1,020,634	Based on $50/ton and $4/lb polymer
Energy	$1,452,741	Based on $0.07/KWH
Total Costs	**$3,925,375**	
Cost Per Ton Sludge Treated*	**$265**	

*Capital costs are amortized over 15 year life cycle at an interest of 5%.

Figure 2: Chart of Plant A 15 Year Life Cycle Costs



As seen in the Table 1 and Chart 2 above, although a membrane thickening aerobic digestion processes have the highest capital cost and cost per ton of sludge treated than the other two alternatives it offers the lowest overall life cycle costs. Membrane thickening aerobic digestion processes provide more than a 60% reduction in operating costs when compared with mechanical thickening aerobic digestion. Based on these findings the operator attention costs associated with mechanical thickening equipment is quite substantial where membrane thickening aerobic digestion requires very minimal operator attention. In addition membrane thickening aerobic digestion has reduced costs in every category with exception of capital when compared with standard aerobic digestion. It is widely recognized that equipment associated with membrane processes have very high capital costs in comparison to other technologies, however as seen in the above example membrane thickening technology can be a very cost effective solution when 15 to 20 year life cycles are considered, the typical life of a wastewater treatment facility.

Impacts of High Nutrient Sidestreams

High nutrient concentrations in plant recycles or side streams from solids handling processes are widely recognized as a leading cause for high nitrogen and phosphorus in plant effluents of biological nutrient removal (BNR) facilities, therefore the selection of a solids handling process is very critical when designing a WWTP. Critical issues associated with high nutrient recycles from solids handling processes include the inability to comply with nitrogen and phosphorus effluent discharge limits, increased operating costs associated with chemical addition to remove nutrients, and depletion of carbon to nitrogen ratio in the liquid treatment process preventing denitrification to achieve complete nitrogen removal.

Solids handling processes such as anaerobic digestion or autothermal thermophilic aerobic digestion (ATAD) are known to generate hundreds or even thousands mg/L of total nitrogen and phosphorus in sidestreams recycled to the head of the plant. Sidestreams from dewatered anaerobic digested sludge can range from 900 to 1,500 mg/L of ammonia as nitrogen, which can increase ammonia concentration in the plant influent by 3 to 5 mg/L on an average day basis. If such a side stream is returned, it can have a profound impact on oxygen uptake and aeration design system of the liquid treatment process (Phillips, Kobylinski, Barnard, Wallis-Lange, 2006).

Nitrosomonas and Nitrobacter bacteria are temperature sensitive and will die at temperatures exceeding 49 °C. ATAD processes are typically operated at temperatures ranging from 45°C to 60°C which will inhibit the nitrification process resulting in increased ammonia accumulation. ATAD systems have similar sidestream ammonia concentrations to anaerobic digestion processes which range from 800 to 1,500 mg/L (Oerke, 2010).

Excessive nutrients from biological process sidestreams can have adverse economical impacts. In order to remove phosphorus and nitrogen from the effluent a separate sidestream treatment process, lime stabilization, and chemical addition of alum, acetic acid, or ferric chloride may be required. These alternatives can add substantial costs and the addition of chemicals or lime can increase sludge loads up to 40% which also increases the associated costs with dewatering and disposal. For example, acetic acid is a commonly used chemical used as a source of volatile fatty acid (VFA) to enhance biological phosphorus removal (BPR). Charlotte Mecklenburg Utilities (CMU) in North Carolina operates the 12 MGD BPR McDowell Creek WWTP and use acetic acid to enhance phosphorus removal. Since 1999 at a rate of 1,400 to 2,100 gpd of acetic acid the McDowell Creek WWTP has spent approximately $400,000 annually (Fiss, Fiss, Jr, and Rebodos, 2010).

In addition, if too much nitrogen from sidestreams are recycled back to the head of the plant it can deplete carbon to nitrogen ratios preventing the denitrification process to achieve complete nitrogen removal in the liquid treatment process. If carbon to nitrogen ratios are depleted an external carbon source such as methanol or Micro-C™ would need to be added to achieve complete nitrogen removal. There are nearly 200 wastewater treatment facilities in the United States that use methanol as a carbon source to achieve denitrification. Although methanol addition is widely used and is generally economical, it has disadvantages such as being highly flammable and highly toxic. Methanol addition can be expensive depending on how much needs to be added. Because most of the methanol used in the United States is imported prices can fluctuate greatly and typically costs range from $1.35 to $3.25 per gallon and to remove 1 lb of nitrate approximately 3.5 lb of methanol is required (Fiss, Fiss, Jr, and Rebodos, 2010).

Membrane Thickening Aerobic Digestion Process Produces Reuse Quality Permeate

The permeate produced from a membrane thickening aerobic digestion process is reuse quality containing a very minimal amount of total nitrogen, total suspended solids, and phosphorus. Recycling the permeate to the head of the plant will protect the effluent quality of the BNR biological process without requiring chemical addition, prevents the addition of external supplemental carbon sources or a sidestream treatment process. Because the permeate is reuse quality it can also be sent directly to disinfection or combined with the plant effluent.

Figure 3: Permeate produced from a membrane thickening aerobic digestion process

RESULTS: CASE STUDIES OF MEMBRANE THICKENING AEROBIC DIGESTON PROCESSES

Dundee WWTP, Dundee, Michigan

Dundee, MI WWTP required a process that could provide class B sludge for subsurface injection which wouldn't negatively impact their BNR activated sludge system. Since sub-surface injection timing was limited due to regular heavy snowfall, the facility was required to have a holding time of approximately 180 days with very limited sludge hauling. Compliance showing Class B stabilization is shown through pathogen results. Table 2 below shows the pathogen count in colony forming units (CFU) per dry gram the solids prior to subsurface injection. As seen in the table below the sludge stabilized by the membrane aerobic digestion system is well below the required pathogen count of 2,000,000 CFU/dry gram for Class B criteria.

Table 2. Dundee WWTP Pathogen Count of Sludge Stabilized by Membrane Thickening Aerobic Digestion Process

DUNDEE WWTP FECAL COLIFORM RESULTS		
Sludge Stabilized by Membrane Thickening Aerobic Digesiton System		
Date	**Geometric Mean (CFU/dry gram)**	**% Solids**
3/21/2006	57,270	3.29
4/19/2007	281,552	3.23
3/13/2008	78,125	3.13
3/18/2009	33,434	2.18
3/10/2010	146,602	2.32
11/1/2010	75,157	1.55
3/14/2011	110,940	3.63
9/14/2011	5,547	2.74
3/28/2012	101,430	1.77
10/9/2012	45,792	2.47
5/14/2013	57,859	3.08
Average	**90,337**	**2.67**

In order to increase the sludge retention time to 180 days, Arcadis Engineers integrated the membrane thickening aerobic digestion process with existing aerobic digester tanks. Only a new membrane thickening tank (MBT) was added to form a complete membrane thickening aerobic digestion process.

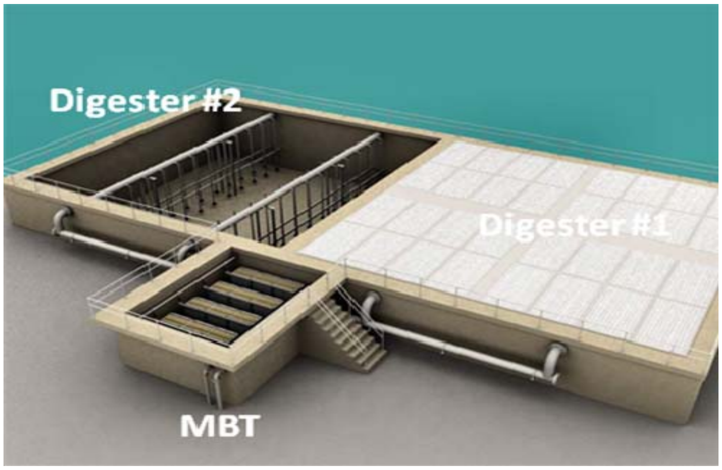


Figure 4: Dundee, MI WWTP Membrane Thickening Aerobic Digestion Facility

After implementing the membrane thickening aerobic digestion process, the plant was able to thicken from 2.5% to 5.5% solids prior to the season when sub surface injection was not possible, all without the use of polymers. Due to the improved performance, the 180-day storage objective was achieved and the facility was able to limit sludge hauling to twice a year. Direct results from this upgrade allowed the plant to double their capacity to 1.2 MGD, while reducing their sludge disposal costs by nearly 40%.

The high quality permeate from the membrane thickening aerobic digestion process allowed it to be rerouted to the head of the plant without compromising the performance of the BNR activated sludge process. The type of permeate quality shown in Table 3 below has been sustainable throughout the entire course of the operation of the Dundee membrane thickening aerobic digestion process.

Table 3. Dundee WWTP Membrane Thickening Aerobic Digestion Permeate Results

Parameter	**Results (mg/L)**
BOD	1.12
TSS	2.00
Total Phosphorus	1.09
NH_3-N	0.22
NO_3-N	0.03

Union Rome WWTP, Union Rome, Ohio

Since December 2009, Union Rome Wastewater Treatment Plant (WWTP) in Union Rome, Ohio currently operates a MBR activated sludge system followed by a membrane thickening aerobic digestion process.

CT Consultants which was contracted by Union Rome Sewer Authority to design a wastewater treatment facility to handle its municipal wastewater. The main objective of the Union Rome WWTP design was to minimize the footprint of the facility so that the entire operations could be constructed into one building. Membrane thickening aerobic digestion processes provided the smallest footprint out of all the aerobic digestion options CT Consultants considered which minimized construction costs of the building.

The Union Rome WWTP membrane thickening aerobic digestion process shown in Figure 5 below consists of a membrane thickening tank operating in-loop with an anoxic and aerobic digester tanks. During digestion, the aerobic zones (the membrane thickener and digester) provide nitrification with the anoxic basin provides built-in time for denitrification and stabilizes the pH. This continuous nitrification and denitrification sequencing eliminates nitrate and ammonia in the permeate which is critical in allowing the facility to comply with their ammonia effluent discharge limit of 1.0 mg/L and 0.3 mg/L for summer and winter operations respectively.

Figure 5. Union Rome WWTP Membrane Thickening Aerobic Digestion System (Membrane Thickening Tank shown on the left, Aerobic Digester shown on the right)

Sludge at the Union Rome WWTP is thickened up to 5% solids (average of 4.15% solids), which is consistently more than triple the concentration of the influent total solids wasted from the MBR biological process. The thickening performance of the Union Rome WWTP membrane thickening aerobic digestion process is shown in Figure 6 below.

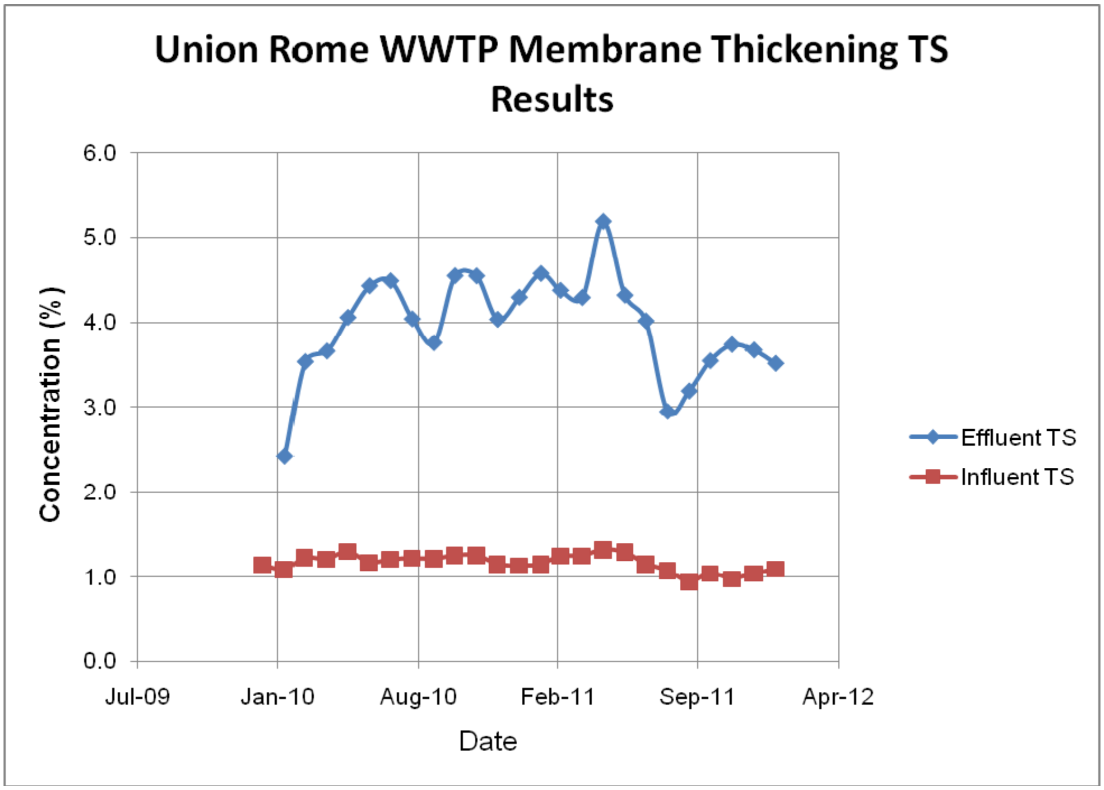


Figure 6. Union Rome WWTP Thickening Results of Aerobic Digestion System

Permeate produced from the membrane thickening aerobic digestion process at the Union Rome facility is combined with the MBR effluent which is sent directly to disinfection. As shown in Table 3 below the permeate from the membrane thickening aerobic digestion process contains less than 0.1 mg/L of ammonia which is well below the facility's effluent discharge limit mentioned above.

Table 3. Union Rome WWTP Permeate Results (February to January 2012)

Parameter	Result (mg/L)
BOD	< 1.0
TSS	< 1.0
Total Phosphorus	< 5.0*
NH3-N	< 0.1

*No biological phosphorus removal in MBR process upstream

After the WAS is processed in the membrane thickening aerobic digestion process process it is sent directly to a belt filter press for sludge dewatering for disposal to a sanitary landfill. Prior to incorporation of the membrane thickening aerobic digestion system, the Union Rome facility operated their belt press five days a week (260 days per year). Improved thickening achieved with the membrane thickening aerobic digestion process as described above substantially increases the capacity of the Union Rome facility, resulting in reduced belt filter press operations and decreasing the frequency of the sludge to be dewatered. The membrane thickening aerobic digestion process reduces the belt filter press operations at the Union Rome WWTP to three days every two and a half months (15 days per year). Since operating the membrane thickening aerobic digestion process the Union Rome facility has increased their belt press efficiency by using 40% less polymer to dewater the same amount of solids as the previous sludge handling process and reduces the quantity of sludge hauled to the landfill by more than 50%. This results in savings over $58,000 in hauling costs and over $3,000 in polymer costs annually since operating the membrane thickening aerobic digestion process.

CONCLUSIONS

Although membranes are more commonly applied in liquid wastewater treatment and water treatment processes, they can also be utilized in solids handling system. Membrane thickening processes are controlled aerobic digestion processes that integrate WAS thickening with membranes. Thickening with the membranes provides continuous, automated, and improved thickening that does not require the use of polymers or attention to decanting. Although a membrane thickening aerobic digestion process is considered a unconventional solids handling approach offers the lowest life cycle costs when compared to more conventional aerobic digestion systems. Membrane thickening aerobic digestion processes are suitable for handling WAS from many biological liquid treatment processes such as MBR and conventional processes but especially ideal for facilities that are obligated to meet strict nutrient discharge limits specifically total nitrogen and phosphorus. Membrane thickening processes feature outstanding permeate quality with reduced nitrogen and phosphorus which minimizes side stream nutrient loading to the head of the plant.

REFERENCES

Bernard, J., Kobylinski, E., Phillips, H., and Wallis-Lage, C. (2006) Nitrogen and Phosphorus-Rich Side Streams: Managing the Nutrient Merry-Go-Round, 2006 WEFTEC Proceedings, 5,282-5,304.

Bilyk, K., Pitt, P., Taylor, R., and Wankmuller, D. (2011) Process and Economic Benefits of Side Stream Treatment, 2011 NC AWWA-WEA Conference Proceedings, 1-11.

Burton, F., Tchobanoglous, G., (1991) Wastewater Engineering Treatment, Disposal, and Reuse, Third Edition, Metcalf & Eddy, Inc., 774

Fiss, E, Fiss, E.M., Rebodos, R., (2010) Alternative Carbon Sources for Achieving Biological Nutrient Removal at Municipal Wastewater Treatment Plants, 2010 NCWAA Conference Proceedings, 1-8

Oerke, D., (2010), Second Generation ATAD – A TAD Better? – Two Case Studies of Conversion from “First Generation to Second Generation” ATAD Systems, 2010 WEF Residuals and Biosolids Conference Proceedings, 1-14.

Van Haandel, A. and Van der Lubbe, J. (2007) Wastewater Treatment Design and Optimization of Activated Sludge Systems, Model of Biological Phosphorus Removal 5.1.3., 197-198.

US Environmental Protection Agency (1993) *Title 40 – Protection of the Environment Code of Federal Regulations (CFR) Part 503 “Standards for the Use or Disposal of Sewage Sludge”*, EPA-831-B-93-002b, Office of Enforcement and Compliance Assurance, Washington, D.C.