Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

MONITORING AND RESEARCH DEPARTMENT

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CALUMET PHOSPHORUS TASK FORCE

TECHNICAL MEMORANDUM NO. 1

EVALUATION OF CARBON ADDITION TECHNOLOGIES FOR THE CALUMET WATER RECLAMATION PLANT – SUMMARY OF AVAILABLE CARBON ADDITION TECHNOLOGIES BASED ON LITERATURE INFORMATION

October 2014

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FORWARD

The Metropolitan Water Reclamation District of Greater Chicago (MWRD) recognizes the value of phosphorus as a non-renewable resource. In an effort to optimize the sustainable removal of phosphorus from its wastewater influents and the subsequent recovery of phosphorus in various forms suitable for use as an agronomic fertilizer, the MWRD initiated a Phosphorus Removal and Recovery Task Force in 2012. The Task Force initiated a study phase at several of the MWRD's Water Reclamation Plants (WRPs) to evaluate the feasibility of implementing enhanced biological phosphorus removal and to develop operational guidelines for optimizing its effectiveness. The Task Force has created WRP specific study workgroups that are focused on each of the WRPs that have been identified to participate in this initiative. As the workgroups complete various phases of their studies and evaluations they are documenting their findings and recommendations in technical memoranda. These memoranda are written by the WRP specific workgroups and vetted by the Task Force before being published. Their purpose is to capture the state of knowledge and study findings and to make recommendations for implementation of enhanced biological phosphorus removal as they are understood at the time the memoranda are published.

DISCLAIMER

The contents of this technical memorandum constitute the state of knowledge and recommendations developed by the MWRD's Phosphorus Task Force at the time of publication, and are subject to change as additional studies are completed and experience is attained, and as the full context of the MWRD's operating environment is considered.

Evaluation of Carbon Addition Technologies for the Calumet Water Reclamation Plant

Technical Memorandum 1

Date: July 31, 2013

To: Phosphorus Task Force & Advisory Committee

From: Phosphorus Study/Planning Team

Subject: Summary of Available Carbon Addition Technologies Based on Literature Information

1.0 Purpose

This Technical Memorandum describes the available carbon supplementation technologies that were considered for use in providing additional carbon for the enhanced biological phosphorus removal (EBPR) process at the Calumet Water Reclamation Plant (CWRP). While the primary focus is on CWRP, other plants may also benefit from carbon addition, and the review may serve as a springboard for those plants as well. Additionally, while looking at carbon initially for EBPR, the carbon supplementation technologies can also be considered to encourage denitrification as nitrate is inhibitory to the EBPR process. The available technologies were reviewed for applicability, and based on this review, a 'short list' was created for further evaluation.

2.0 Description and Applicability of Technologies

Each technology was evaluated for applicability by reviewing academic research and results from other plants. Information obtained from these sources included such items as amount of carbon produced, use at other WRPs, safety, how the technology works, maturity of technology, systems needed, and any other pertinent information required to evaluate whether or not the technology would be applicable for CWRP. Brief descriptions of each technology and their applicability are detailed in the following sections. These technologies are described by their respective science behind the technology, advantages, disadvantages, and information on existing installations.

2.1 Sludge Fermentation

Principle of Technology

The fermentation process involves the breakdown of sludge. In the first step of the process, hydrolysis, enzymes from anaerobic bacteria break-down the organic material in the sludge into smaller molecules which are dissolved in the liquid portion. The next step, acidogenesis, involves the uptake of these dissolved compounds by fermentative bacteria. The compounds are excreted as simple organic compounds, such as volatile fatty acids (VFAs), alcohols, lactic acid, and a variety of off-gases. A third step, acetogenesis, converts the products of acidogenesis to acetate, propionate, hydrogen, and carbon dioxide.

Advantages

Because of the mixture of acids produced from fermentation, it is often found to be more effective in terms of the needed COD:N ratio for denitrification or COD:P ratio for EBPR; mixed VFAs are best for EBPR. Additionally, about 70 percent of the COD originally present in the sludge can be converted to acetic and propionic acids through fermentation, making it a promising source for additional carbon. While some of the other technologies do not target carbon supply for EBPR as the primary goal, fermentation has been used for this purpose many times.

Disadvantages

Using fermentation as a carbon supplementation technology has some disadvantages. For one, fermenting sludge for carbon supplementation would decrease the carbon available for biogas production, as would be the case at CWRP. In such a situation, a cost-benefit analysis would have to be performed to determine where the carbon would be most beneficial. Additionally, fermentation can be corrosive and odorous making protective coatings and covers necessary in design of a system. While there is potential for the system to be retrofitted to existing infrastructure, other construction, such as mixers, mechanisms for sludge collection and scum removal, pumping, and piping would also have to be taken into consideration. Lastly, if the fermentation process carries on for too long, methanogenesis, in which methane is produced from acetate, can occur. For this reason, fermentation can be a difficult process to control, and operators must be adequately trained.

2.1.1 Primary Sludge Fermentation

Primary influent or primary sludge from the primary clarification process are two possible sources for fermentation. Both types of fermentation have been employed in BNR plants worldwide for over 20 years, making it a very mature technology. In practice, primary fermentation can be used with multiple configurations.

2.1.1.1 Activated Primary Tanks

Activated Primary Tanks (APTs) have raw wastewater as the influent feed to the tank. APTs generate VFAs by allowing a sludge blanket to build on the clarifier floor. A portion of the sludge is recycled back to the beginning of the primary clarifiers. At times, this design can also involve a mixing tank built in prior to the primary clarifiers. Typically, the tanks are simply gravity thickeners, and the equipment for the tank is similar.

Advantages

One major advantage of using an APT is a lower capital construction cost due to lower space requirements. Generally, while they do require a clarifier that allows sufficient sludge blanket depth to be maintained, these are easy to retrofit to existing facilities, and are easy to operate.

Disadvantages

As the VFA production potential is dependent upon the volatile solids in the process, the effluent from an APT is impacted by wet weather flows, and VFA production could suffer. In addition, due to the recirculation of solids and higher concentrations, the aeration tanks will also experience a higher solids loading using this type of technology. Lastly, the sludge plow capacity in the tanks can also be a limiting factor, and care would have to be taken to protect them.

Installations

There are likely more installations, but only the Baviaanspoort plant in South Africa was identified in the literature review.

2.1.1.2 Fermenters

Complete Mix Fermenters, Static Fermenters, or a combination of the two operate as side-stream fermenters and are the most common fermentation tanks utilizing primary sludge from the primary clarifiers as the feed. Essentially, complete mix fermenters are mixing tanks while static fermenters are gravity thickeners that allow the primary sludge to ferment while being mixed or thickened. In a complete mix fermenter, the overflow is returned to the primary clarifier influent for solid-liquid separation, which can also work as a disadvantage to the system as it can add additional solids to the process. Static fermenters convey the supernatant to either the anoxic or anaerobic zones in the BNR process.

Advantages

A major advantage of a side-stream configuration is that it allows greater operational flexibility, such as the ability to adjust to variable flows and to bring the supernatant directly to the zone where it would be most needed. This flexibility allows for VFA production to be better controlled than APTs. Another advantage static fermenters have over APT systems is that there is no increase in solids loading rate to the primary clarifiers. Lastly, with a static fermenter, the primary sludge is also given a chance to thicken, typically to 5 to 8 percent, which means less primary sludge volume needing further processing.

Disadvantages

While being one of the simplest designs, the VFA production is on the lower end and a higher concentration of suspended solids will enter into the secondary treatment stream.

Installations

There are numerous installations of primary sludge fermentation including the Westside Plant in British Columbia, Canada (operates with an SRT of 8 days and no internal recycling of bottom flow); Eagle's Point Plant in Minnesota; Durham Advanced Wastewater Treatment Plant in Oregon; Mason Farm WWTP in Carrboro, North Carolina; Water Pollution Control Facility in Las Vegas, Nevada; Douglas L Smith Middle Basin Treatment Plant in Johnson County, Kansas; and Kalispell WWTP in Montana.

2.1.2 Return Activated Sludge Fermentation

Fermentation of the return activated sludge (RAS) streams has not been as widely used as primary sludge, but it is still a viable technology. RAS fermentation usually consists of a completely mixed reactor incorporated into the process train, either as a mainstream or sidestream reactor.

Advantages

With RAS fermentation, although the yield of VFAs per VSS concentrations can be lower, there is a large potential load available because of the large RAS volumes typically available at plants. In addition, because the technology could be applied as sidestream treatment, there is flexibility to add the supernatant where it would be the most beneficial.

Disadvantages

Although this can be used with any nutrient removal plant, it has been used more widely with processes that do not have primary clarifiers. Another disadvantage of fermenting RAS solids is that the nutrients in the solids (P and N) can be released to the fermentate, causing a high nutrient concentration in the carbon rich stream. However, the overall benefit of the additional carbon can potentially outweigh the negative effect of additional nutrient release.

Installations

Although not as widespread, there are some installations of RAS fermentation discussed in literature. These include Pinery Water, Colorado (where there is no primary sedimentation); Truckee Meadows, Nevada; and Cedar Creek WWTP in Olathe, Kansas.

2.2 Sludge Disintegration

Disintegration of sludge is a technique that has historically been used to accelerate the sludge digestion processes, increase biogas production, and decrease sludge mass production. However, an increase in VFA content has also been observed when employing such techniques. There are a number of technologies that employ sludge disintegration. Among these are physical, focused pulse, ultrasound, thermal, and alkaline means to breakdown the cells into smaller particles.

2.2.1 Physical Sludge Disintegration

Principle of Technology

This technology works similar to a batch reactor, with a relatively short hydraulic retention time. The sludge is loaded, the mechanism is turned on, and the sludge is physically broken into smaller pieces through physical means. Typically, the feed sludge is WAS which is thickened prior to disintegration.

Examples of such physical technologies include:

- *Stirred Ball Mills* consist of a cylindrical chamber filled about 85% with grinding beads of differing materials and diameters. A rotor forces the beads into rotational movement, and the cells are disintegrated between the beads by shear and pressure forces. Centrifugal forces and an additional sieve hold the beads back.
- *Crown Sludge Disintegration Systems* pressurize the WAS and forces it through a disintegration nozzle, causing the cell structure to rupture. The cycle is repeated before the sludge is pumped back.
- *MicroSludge Process Systems* use a combination of chemical and mechanical processes. The WAS flows through a coarse filter, is dosed with NaOH, passes through a high shear mixer, and experiences a sudden pressure drop to rupture the cells.
- *Lysate Thickening Centrifuges* use centrifugal forces to destroy cells. The destruction takes place using a lysate ring on the centrifuge effluent following thickening. A study comparing disintegration methods ranked the degree of disintegration by lysate-centrifuge as very low.
- *Deflakers* are traditionally used in the paper industry. Sludge can be forced through moving and stationary discs, similar to a maze of teeth shredding the sludge as it exits.

In two studies examined, a motorized deflaker was used for the mechanical disintegration. Increases in VFA and solCOD were directly correlated with disintegration time and specific energy input to the sludge. Maximum concentrations of VFA and solCOD occurred at longer processing times and were as high as 30 times the initial concentrations. After 15 minutes, the solCOD was increased by 7.7 – 20 times. The rate of solCOD increase was higher in the beginning and increased as specific energy increased.

Advantages

The advantages of these types of technology include the decrease in ultimate sludge disposal quantities and the decrease in volume necessary to produce the extra solCOD, especially compared to fermentation. There are also no added safety concerns with handling chemicals associated with this technology. In another research study, the disintegration technologies produced a constant quality of effluent based upon the influents.

Disadvantages

In general, physical treatment of WAS is considered complicated and expensive. Along with an increase in solCOD, an increase in ortho-P returning with the liquid will also be observed. The P release from literature suggests that there is a similar correlation between P release vs treatment time as solCOD release vs treatment time. This technology will also place an additional energy burden on CWRP as well as maintenance of the moving parts involved with the mechanical means to disintegrate the sludge.

Installations

The physical sludge disintegration techniques have not been installed for the purposes of adding carbon to an EBPR process. However, there are various installations of the example technologies above for other purposes.

- *Stirred Ball Mills* – Unable to find any full-scale installations.
- *Crown Sludge Disintegration System* – Three full-scale installations in Germany and New Zealand.
- *MicroSludge Process* – Recent pilot testing completed in Des Moines Wastewater Reclamation Facility. No full-scale installations.
- *Lysate Thickening Centrifuges* – Ten pilot-scale installations in Germany and the Czech Republic (2001).
- *Deflakers* – Used more commonly in paper industry.

2.2.2 Focused Pulse Treatment of WAS/Open Cell Lysis

Principle of Technology

Open Cell Lysis is a technology that has been primarily employed in producing additional digester gas. However, recent research has shown that it can also be applicable in supplementing carbon for BNR. The Focused Pulse technology uses controlled pulses of high voltage electricity (20 to 30 kV at 2000 to 3000 Hz) to break down cell membranes of sludge flowing between two electrodes. The solids are broken into small molecules and the sludge is reduced in volume.

Advantages

Advantages of such a technology for carbon supplementation are that the reactor volume is small as the treatment time is on the order of microseconds; there is no significant increase in odors; there are no moving parts in the reactor; digester performance should improve; and the overall greenhouse gas emissions are reduced. While a portion of the sludge is diverted from the digesters, the value as a carbon source might outweigh the sludge's value in making biogas; a thorough evaluation would have to be conducted to determine where the sludge would add greater value. According to papers on the company website, efficiency of anaerobic digestion is improved by making sludge more vulnerable to destruction, and this ultimately corresponds to an increase in biogas production. Similar to other disintegration and hydrolysis technologies, savings would also be realized through a reduction of biosolids trucked from the plant. As there are no added chemicals, the safety risks for plant personnel are alleviated. Lastly, the literature suggests the denitrification efficiency was greatly improved using focused pulse treated WAS over traditional denitrification carbon supplements, such as methanol.

Disadvantages

Potential disadvantages of this technology include the simultaneous and proportional release of NH_3 with solCOD. The effectiveness of using this technology with WAS is greatly reduced if the released NH_3 is too great. Similarly, focused pulse technology increases concentrations of all of the other semi-soluble components, including phosphorus. However, the release of this additional phosphorus cannot be oxidized biologically when returned with the treated WAS. This release would also have to be evaluated. At this time, papers on the use of the solCOD released from focused pulse treated WAS for carbon supplementation with phosphorus removal cannot be found. In addition, this technology would incur additional energy usage.

Installations

This is not a yet a widespread technology as there is only one full-scale installation in the United States at the 10 MGD Plant in Mesa, Arizona. Other upcoming installations include Racine, Wisconsin; Orange County, California; and Riverside, California.

2.2.3 Ozonation

Principle of Technology

Ozonation uses the strong oxidative potential of ozone to affect and accelerate the lysis of bacterial cells. The system generally sees a portion of the RAS pass through a contact tank with ozone injected into the influent flow. Ozone also reacts with organic compounds that are less biodegradable and oxidizes them into smaller compounds which are more bio-degradable. Ozone rates are based on the concentration of solids in the RAS; around 0.17 g O_3/g MLSS appears to produce an affective VFA source for both denitrification and EBPR. This system additionally requires a storage tank for oxygen and an ozone generator.

Advantages

Similar to the other disintegration technologies, the degradation of cells is sped up by the ozone addition, making the reactor times and, hence, the reactor volumes less than those necessary for fermentation alone. Additionally, the ozone treatment can reduce the volume of wasted sludge. Improvements in the sludge settling behavior and foam reduction have also been seen during operations.

Disadvantages

Although it may be a less expensive addition, a key disadvantage of this technology is that it does require a constant addition of oxygen as an operating cost. Potential disadvantages of this technology also include the simultaneous and proportional release of NH_3 and P with solCOD. The effectiveness of using this technology with WAS is greatly reduced if the released NH_3 is too great. Finally, there is a potential that the ozonated sludge could have high levels of oxygen which could be detrimental to the anoxic/anaerobic zones established for EBPR depending on overall flow of this carbon addition.

Installations

Again, the majority of installations are not for purposes of carbon addition to a system. In the Bulgarograsso wastewater treatment plant, the ozonation technology has been successfully used since 2006 for sludge reduction.

There has also been recent research reporting the effective use of ozonated sludge as a carbon source for both EBPR and denitrification. The denitrification potential of ozonated sludge was reported to be comparable to that of acetate. On the Wedeco website (a subsidiary of Xylem), installations are noted for this purpose.

2.2.4 Hydrolysis (Alkaline or Thermal)

Principle of Technology

Thermal technologies typically work with WAS as a feedstock. The sludge is subjected to elevated pressures (6 – 25 bar) and temperatures (150 – 200°C). Cell destruction is achieved through a sudden pressure drop.

Research has begun on the use of thermally hydrolyzed sludge as a carbon source. In one paper, the solCOD from this process increased by about 28% and was useful as a carbon source for denitrification. Most of the increase of solCOD was due to increased VFA concentrations.

Advantages

There are no added chemicals which could result in sludge production. Excellent dewatering properties are obtained and the sludge is hygienized and stabilized.

Disadvantages

The hydrolyzed sludge from this process, as with the others, contains an additional nitrogen and phosphorus load. Theoretically, this additional load could be removed with a process to recover ammonium through stripping or precipitation, but this would add an additional step and equipment to the process.

Installations

Cambi and Kruger are two manufacturers of thermal hydrolysis equipment for wastewater sludge. Both have installations in Europe, but none in North America. These installations are for sludge treatment, rather than as an additional carbon source.

2.2.5 Ultrasound

Principle of Technology

Ultrasound technology also works to break down the size of the sludge particles in WAS or RAS streams into smaller particles. Essentially, the impact of ultrasound waves on the liquid causes the eventual cavitation when intensity rises above a given threshold. When gas bubbles are created, they grow in size and then collapse. The collapse produces the hydromechanical shear forces on the bulk liquid. Macromolecules with molar masses above 40,000 are disrupted by these forces.

Ultrasound systems typically consist of three major components – a generator to supply high-frequency voltage, a ceramic-crystal of piezo-electrical material to transform electrical into mechanical impulses, and a sonotrode to transmit the impulses into the fluid.

Advantages

Advantages of this technology are similar to other technologies presented that breakdown the size of the sludge particles. These include a decrease in sludge volume needing additional treatment and a corresponding reduction in polymer; lower disposal costs for the wasted sludge; increased biogas production due to enhanced anaerobic digestion and degradation of the volatile solids; improvement of secondary clarifier sludge settling characteristics; and a very small footprint with modular design capabilities easily adapted to different sludge quantities and existing infrastructure. This technology can also work in conjunction with fermentation to reduce the hydraulic residence time necessary for fermentation. It is also considered to be reliable in operation, does not produce additional odors, has no problems with clogging, and is relatively easy to implement.

Disadvantages

The drawbacks include an economical and environmental cost for electricity to power the ultrasound. Additionally, while there are multiple installations of this technology abroad, there are no full scale ultrasound installations in the US. Lastly, with the release of solCOD from the sludge, there is a corresponding release in phosphorus, the effects of which would have to be studied.

Installations

As stated above, there are full-scale installations of this technology in Germany, Spain, and the Netherlands, ranging from 40,000 – 725,000 population equivalent sized plants. Full-scale demonstration trials were completed in the city of Riverside and the Orange County Sanitation District. The purpose of these trials was for increased biogas production and volatile solids destruction. The results showed negligible changes for these purposes; full-scale installation was not pursued.

The Sonolyzer™ Ultrasound Sludge Disintegrator by Ovivo is one ultrasound system. Their website does mention that ultrasound can be used for the purpose of adding carbon to an EBPR system, although the locations were not specified on the website.

2.3 Chemical Addition

General

Chemical addition is by far the most straight-forward, understood, and developed method to meet carbon needs for biological nutrient removal; it is a reliable and proven technology that is usable in any operating condition and largely independent of fluctuations in sludge characteristics. However, the high cost of chemicals and transportation, the lack of environmental sustainability associated with resource usage of the chemicals, and the added mass to wasted sludge from adding chemicals are among the disadvantages.

Below are some of the traditional chemicals that have been used for carbon supplementation with associated advantages and disadvantages.

CHEMICAL	COD (mg/L)	ADVANTAGES	DISADVANTAGES
Methanol, 100%	1,188,000	• Widespread use as a carbon source for denitrification.	• Highly flammable. • Highly toxic. • Subject to wide fluctuations in pricing. • 90% of methanol consumed is imported. • Not as efficient for denitrification as other substrates – pertinent if anoxic zone is limited in volume. • Unusable by P accumulating organisms.
Acetic Acid, 100%	1,121,000	• Widespread use as a carbon source for denitrification. • Can also be used as a carbon source for EBPR. • Higher denitrification rate than methanol.	• Highly corrosive – can cause skin burns and permanent eye damage. • Expensive. • Addition of acetic acid to the post-anoxic zone of a BNR system can potentially result in release of stored P. • Flammable and high freezing point – 62°F – design must meet code requirements for flammable liquids that include measures to avoid freezing. • 316SS necessary for construction of feed system.
Propionic Acid, 100%	1,494,900	• Better for long-term health of PAOs.	• Highly corrosive – can cause skin burns and permanent eye damage. • Necessary to keep the sludge acclimated to propionate as a carbon source as poor efficiency can result without acclimatization. • Less removal seen for batch experiments – cannot add for short term or intermittent carbon shortages.
Sucrose (Sugar Solution)	274,000 – 685,000	• Chemical feed system is not a safety hazard.	• Attract rodents and insects. • Variable COD content.
MicroC	630,000	• Commercially made from agriculturally derived compounds and methanol or glycerin – consistent in makeup.	• Dependent upon limited producers.

Research suggests that a mix of acetic and propionic acids is optimal. For longer term selective advantage for PAOs over GAOs, propionate may be a more suitable substrate than acetate. If the choice in the end was made for chemical addition, these two acids and a mixture thereof would seem the optimal choice for further testing.

2.4 Imported Organics or Food Waste

Alternative carbon sources have been investigated, as well, as a more environmentally friendly and cost effective alternative to traditional chemical usage. Additionally, imported wastes are safer in terms of operating handling and feed systems than their chemical counterparts.

The challenge to utilizing alternative carbon sources is finding and developing a relationship with an industry that will be beneficial for both the wastewater utility and the industry. Additionally, the industry would have to maintain a constant level and makeup of waste for it to be a reliable feed for nutrient removal.

There a variety of industries that have wastes which can be utilized. Food and beverage manufacturers are the most obvious of the choices. There could also be potential waste streams from pharmaceutical manufacturers of any other industry using acetic or propionic acids.

For comparison sake, the following table shows values for a few of the alternative carbon sources and any specific advantages and disadvantages that were found.

SOURCE	COD (mg/L)	ADVANTAGES	DISADVANTAGES
Brewery Waste	1,250 – 3,000	• Does not contain additional TP. • Los cost.	• Contains additional TN, approximately 15 mg/L, which must be taken into consideration.
Dairy Waste	5,000 – 11,000	• Low cost.	• Contains additional TN, approximately 27.5 mg/L, which must be taken into consideration. • Contains additional TP, approximately 5.5 mg/L, which must be taken into consideration. • Low pH of waste (4.4) may require additional system adjustments.
Soft Drink Waste	68,500	• Effective for both denitrification and EBPR. • Low cost.	• Variable COD content.
Beet-Sugar Waste	9,250	• Low cost.	• Low pH (1.1) which could upset system. • Contains additional TN, approximately 230 mg/L, which must be taken into consideration. • Contains additional TP, approximately 6.2 mg/L, which must be taken into consideration.
Winery Waste	230,000	• No additional TP or TN. • Low cost.	• Low pH (3 – 6) which could upset system.

As seen, these carbon sources have the potential to meet the needs of CWRP, as well. Assuming that industrial matches can be found in the CWRP vicinity, it seems to be a technology worth pursuing. The biggest challenge will likely be finding a large enough flow stream to meet the entire carbon demand load. This technology would more feasibly be a part of a solution, rather than being able to solely supply this demand.

Various plants have used alternative carbon sources, including McDowell Creek WWRP in Huntersville, North Carolina (soft drink waste), and North Carolina's Long Creek WWTP and Crowders Creek WWTP (waste sugar solution).

3.0 Short List of Carbon Supplementation Technologies

Physical disintegration technologies produce the same results as other disintegration technologies, but also have more moving parts, higher maintenance requirements, and considerable specific energy put into the system. For these reasons, these technologies will not be pursued.

It also seems unnecessary to further consider four different types of similar technologies. Ozonation, thermal hydrolysis, ultrasound, and focused-pulse technologies are all similar technologies. As less information was available for ozonation and thermal hydrolysis with respect to nutrient removal, these technologies will not be further reviewed.

Of the technologies studied, the following will be further reviewed for potential in the next Technical Memoranda:

- Primary Sludge Fermentation
- RAS Fermentation
- Focused-Pulse
- UltraSound
- Chemical Addition
- Imported Wastes