Long Term Solids Handling Alternatives for New York City Water Resource Recovery Facilities (WRRFs)

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Abstract

New York City Department of Environmental Protection, (DEP), owns and operates 14 water resource recovery facilities (WRRFs) which treat a combined average dry weather flow of 57 m^3/sec. DEP in association with the City College of New York, (CCNY), has embarked on a long term project to assess thermal hydrolysis pretreatment of the combined sludge to enhance production of anaerobic digester gas, (ADG), and take advantages of improve reduction of volatile solids and sludge dewatering. This paper will focus on the initial phases of thermal hydrolysis.

Keywords: Thermal Hydrolysis, resource recovery, anaerobic digestion, dewaterability

1. Introduction

The current practice among the 14 WRRFs in New York City includes gravity thickening of the combined primary/secondary sludge to three percent solids, followed by anaerobic mesophilic digestion to produce ADG, and then dewatering the digested sludge to a cake of approximately 30% solids for disposal into landfills. Currently ADG averages at 1.02 x 10^8 m^3/year, of which 35% is used beneficially satisfying 15% of DEP's total energy usage. The long term objectives include enhance ADG production and utilization, reduction of solids produced while improving the quality of the dewatered cake for beneficial use. A key component in fulfilling these objectives and which is the subject of this paper is pretreatment of the combined sludge using thermal hydrolysis.

The study is structured to be a multi-prong approach that consists of assessing thermal hydrolysis within a range of temperatures and contact times of 80°C to 200°C and 10 to 60 minutes, respectively, followed by ADG production rates using the biochemical methane potential, (BMP), method. These findings will be the basis for further evaluation using multiple semi-continuous flow anaerobic digesters.

2. Materials & Methods

All experiments were carried out at the Environmental Engineering laboratory at CCNY. The thermal hydrolysis was achieved in a batch process using a 1-liter non stirred Pressure Vessel System Provided by Parr Instrument Co., Wisconsin, US. The heating cycle of thermal hydrolysis batch process was divided into three stages that consists of heating time to reach the desired temperature, followed by a holding time, i.e., the contact time, and then cooling to room temperature prior to analyzing the hydrolyzed samples. The BMP were measured using 150-ml serum bottles.

Phase 1. Relate thermal hydrolysis temperature and contact time to different sludge sources

The goal of a series of batch experiments simulating temperatures of 80 and 200 °C. and contact times of 5 and 60 minutes were performed. Thermal hydrolysis was conducted on different batches of pre-thickened sludge from the Wards Island WRRF to 4.5% TS, and calculated in terms of the increase in soluble COD (sCOD) as described by Sapkaite, et al, 2017.

Phase 1A. was designed to select the optimum contact time for hydrolysis and **Phase1B. to assess** temperatures of 80, 120, 160, and 200 °C. using the optimum contact time on the following types of sludge: Activated Sludge (WAS); Anaerobic Digested Sludge (DS), Primary Sludge (PS), and a mixture of WAS and PS collected from the gravity thickener underflow (TUS), all from the Wards Island WRRF.

Phase 2. Biodegradability of thermally hydrolyzed sludge tested using the BMP method

Biodegradability was evaluated in terms of ADG produced by the hydrolyzed samples based on the BMP method in accordance to Angelidaki, I. et al., 2009, using serum bottles filled with seed, substrate, and DI water as needed. The serum bottles were then placed in a shaker table set at 150 RPM and housed in an incubator set at 35°C.

3. Results & Discussion

Phase 1A: Figure 1 shows the increase in hydrolysis reaching a plateau over time with an insignificant increase beyond 30 minutes. Thus 30 minutes was selected as the optimum contact time for all future experiments

Phase 1B: Table 1 shows that for the selected contact time of 30 minutes, the degree of hydrolysis differs in the two temperature ranges tested, 20 – 120°C, and 120 – 200 °C. In both ranges, WAS showed the largest degree of hydrolysis and primary sludge the slowest. Though DEP at this time is considering thermal hydrolysis for the combined sludge, the maximum benefit in terms of ADG produced would be from hydrolyzing the WAS.

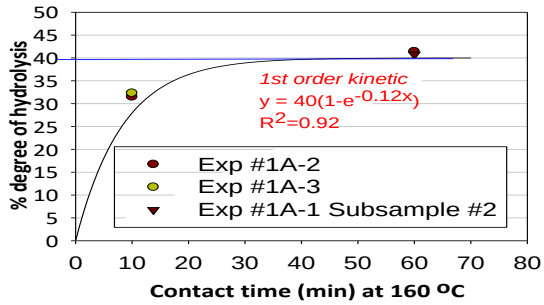

Figure 1. Degree of hydrolysis achievable with Temperature of 160 °C. at different contact time

Table 1. Rates of degree of hydrolysis per °C. appear to differ within two temperature ranges

Temperature ranges	WAS	ADS	TUS	PS
20 – 120 °C.	0.168	0.128	0.092	0.048
120 – 200 °C.	0.374	0.429	0.287	0.222

Phase 2

The BMP showed in Figure 2 that the maximum ADG production coincided with the hydrolysis of sludge at 160°C and 30 minutes contact time, which conditions will be used in all future experiments. At the temperature of 200°C, though hydrolysis increased, ADG production decreased. These findings are in agreement with results reported by Bougrier, et al., 2008.

4. Conclusions

Summary of relevant findings:

- Thermal hydrolysis accelerates at temperatures above 120°C but ADG production decrease at 200°C.
- Thermal hydrolysis increases the availability of readily biodegradable COD (rbCOD) for ADG production.
- ADG production from the hydrolyzed fraction compared to that in the remaining particulate COD fraction were equal at 160°C. Thus, the temperature of 160°C and a contact time of 30 minutes was selected to conduct the long term Phase 3 study.

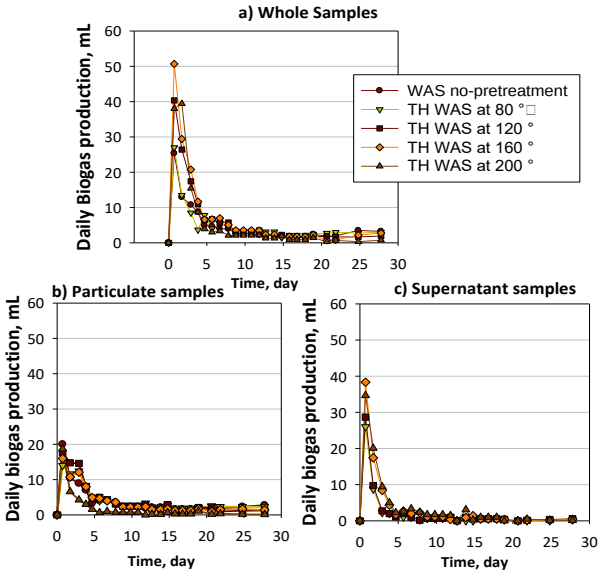

Figure 2. Daily raw biogas production from a) Whole Samples, b) Particulate Samples, and c) Supernatant Samples

Acknowledgements

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