SAN DIEGO STATE UNIVERSITY

Sludge Characterization and Bio-Methane Production.

Estefania Palacios Pacheco

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1. ABSTRACT

Sludge Activity and Substrate biodegradability is important to identify because the measurement of the activity of microorganisms involved in wastewater treatment delivers information about biochemical processes responsible for substrate utilization or how fast can a substrate be converted to Methane. Therefore, the goal of the research is to characterize the ABR sludge and know more about the degradation kinetics of both ABR sludge and ABR Wastewater. Methane produced by the anaerobic digestion of the ABR can be measured and studied by performing a Bio-methane Production (BMP) test. The findings after implementing this test show that complete mixing increases the contact time of microorganism to substrate which increases the methane production rate. Moreover, acetate was used as a standard due to its high biodegradability ABR wastewater is less digestible than acetate and the total fraction of wastewater has a higher biodegradability than the soluble wastewater fraction.

2. INTRODUCTION

Anaerobic digestion is the process of converting organic matter into biogas. It is a multi-step biological process (fig 2.1) where the originally complex and large organic solid wastes are progressively transformed in simpler and smaller sized organic compounds by different bacteria strains up to have a final energetically worthwhile gaseous product, called biogas and a semi-solid material rich in nutrients. Anaerobic digestion can be easily performed in a biological reactor where mixers and heater exchanges could be the only technological and power consuming equipment needed. This process has therefore opened up interesting perspectives not only for the treatment of the organic solid wastes but also for the production of renewable source of power that is cheap and easy to obtain.

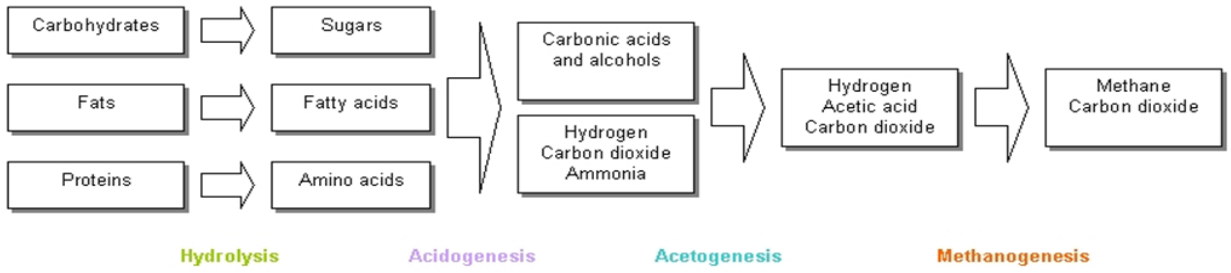

Figure 2.1 Multi-step biological process of anaerobic digestion.

The bio-methane potential test (BMP) is relevant thanks to the useful information it provides. The relevance of the BMP tests is a useful tool to improve the knowledge on the anaerobic digestion process to treat organic wastes. The information obtainable from their results, such as the biodegradability of the substrate, the relative specific rate of bio-methane production, the theoretical production of bio-methane and the disintegration process kinetics, can be studied using BMP tests. Hence, the tests are conducted in batch conditions and in bench scale, measuring the maximum amount of biogas or bio-methane produced per gram of volatile solids (VS) contained in the organics used as substrates in the anaerobic digestion process. Furthermore, relevant elements coming from the conduction of such tests are mainly the

environmental and operational condition that could lead the process to failure, the time needed to have a complete substrate degradation, the average rate of bio-methane production for each substrate, the proper functioning of equipment in order to evaluate the digestion kinetics by coupling the BMP tests results (Esposito et., al 2012).

Temperature affects the bio-methane production rate because the enzymatic reaction speeds up or slows down with temperature change. Usually higher temperatures imply greater methane yields in a shorter digestion time. Nevertheless sharp increases of temperature should be avoided because they can cause a decrease in bio-methane production due to the death of specific bacteria strains, particularly sensitive to temperature changes. To keep constant the temperature during BMP tests it is needed to submerge the reactors in a water bath kept at constant temperature (Esposito et., al 2012). Methane produced by the anaerobic digestion of the ABR can be measured and studied by performing a Bio-methane Production (BMP) test. Therefore, the goal of the research is to characterize the ABR sludge and know more about the degradation kinetics of both ABR sludge and ABR Wastewater.

3. MATERIALS AND METHODS

3.1 Sampling

Sludge and wastewater samples were collected from the DEWATS system using manual grab sampling. Sludge is collected using a large cylinder that reaches the bottom of the reactor, at the bottom of the cylinder a stopper is open when collecting the sludge and closed before removing it from the chamber. The sludge collected then is placed on a beaker. Inlet wastewater and sludge samples were taken from ABR 1 for street one.

3.2 BMP test

Each BMP test was performed under controlled and reproducible conditions in a 500 ml glass bottle. Each bottle was partially filled with inoculum and substrate ratio according to the COD equivalent to sodium acetate which is the standard substrate in this experiment in order to estimate the maximum methanogenic activity of the samples. The bottles were immersed up to three quarters of their high in a water bath at 35 C°. In order to enable gas transfer through the two bottles, each bottle cap was connected through a tube to an inverted 250 ml bottle containing NaOH solution and caped in the same way as done for the reaction bottle. To measure the liquid displaced from the gas produced, a graduated cylinder was placed under each inverted bottle. The volume displaced from the inverted bottles into the graduated cylinders was considered equivalent to the methane gas produced by the reaction bottles. The liquid volume displaced was recorded every five minutes until the digestion stopped.

3.2.1 Sludge Characterization and Wastewater biodegradability.

For sludge characterization, ABR 1 sludge was compared to the brewery sludge. Reaction bottles were filled with 100 ml of sludge and filled up to 500 ml with tap water. A volume of 0.5 ml of 250 g/l of Sodium Acetate was added to each bottle in order to have a final concentration of 0.25 g/l and it was run through the set up until the digestion stopped. In order to determine the volume of wastewater in the reaction bottle, the wastewater COD equivalent to the acetate COD was used. In order to obtain the soluble COD fraction of wastewater, the sample was filtered using a 0.45µm filter and for the total COD fraction the sample was used unfiltered.

3.3 COD analysis

COD analysis was performed on every sample before and after running through the BMP set up. Total COD samples for sludge were diluted to with deionized water by one milliliter of sample per 10 milliliters of solution. Measuring range of 100 - 1500 mg/I COD. 0.3 mL of solution A, 2.3 mL of solution B, and 3 mL of the sample are added to the cells. The tubes were digested for 2 hours into Spectrophotometer is turned on and set to mode 51 and the wavelength is set to 605 µm. Moreover, COD biodegradability from ABR1 inlet wastewater was determined by splitting a sample in 4 different glass bottles and placed in a water bath at 35 C to then analyze the COD every two days.

3.4 Total Solids and Volatile Solids

Total solids and volatile solids analyses were also performed for each sample. Placed in the oven at 105°C for 2 hours and to calculate the fraction of Total Solids the following formula was used TS = [W_2 - W_1]/Vol. of sample (W_1=Mass of filter, W_2=Mass after oven).

4. RESULTS

4.1 Sludge Characterization and Comparison.

Results show that stirring provides the maximum rate due to contact of the substrate to organism ratio (Figure 4.1). The change in rate happens at the same point for both curves illustrated with a black dotted line, after the identical amount of substrate has been converted. From this point on the rate shown is microbial decay. The non-stirring curve shows a diffusion limitation due to the lack of contact between the substrate and organisms. Moreover, ABR and Brewery sludge were compared (figure 4.2) after run through the BMP setup and the results show that the brewery sludge has the highest active digestion rate compared to the linear rate of the ABR sludge with a slope of 0.238 and 0.08 respectively. The sludge slope shows when the sludge is adapted to the substrate and the digestion occurs at the maximum speed. Once the slope decreases, it shows that the ideal substrate availability drops and the digestion rate decreases. Wastewater Biodegrability.

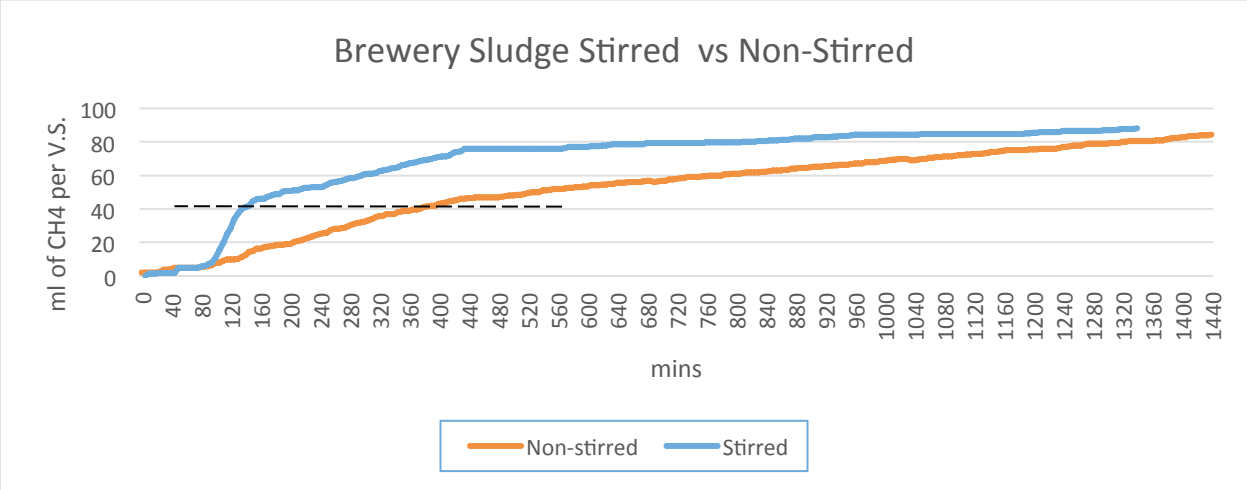

Figure 4.1 Brewery sludge stirr.ed vs non-stirred

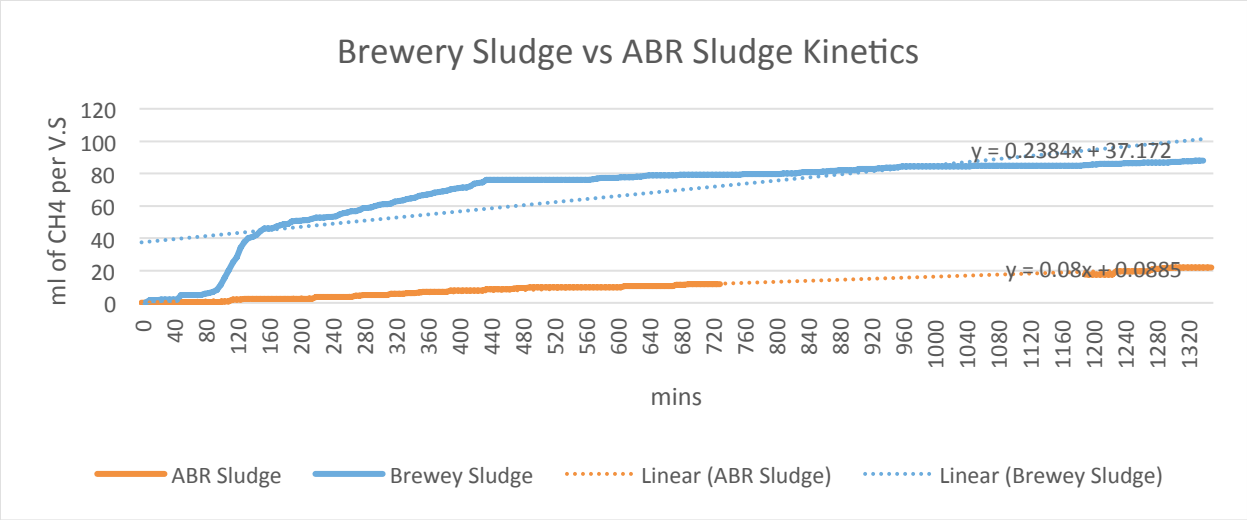

Figure 4.2 Brewery sludge vs ABR sludge kinetics

4.2 Wastewater biodegradability.

When comparing the wastewater total fraction to the soluble fraction (figure 4.3) the results show that the total fraction has a higher digestion rate than the soluble fraction when looking with a slope of 0.40 and 0.13 respectively. In addition, the COD decrease of ABR inlet wastewater (figure 4.4) showed that what decrease can be achieved with the water bath at 35 C˚.

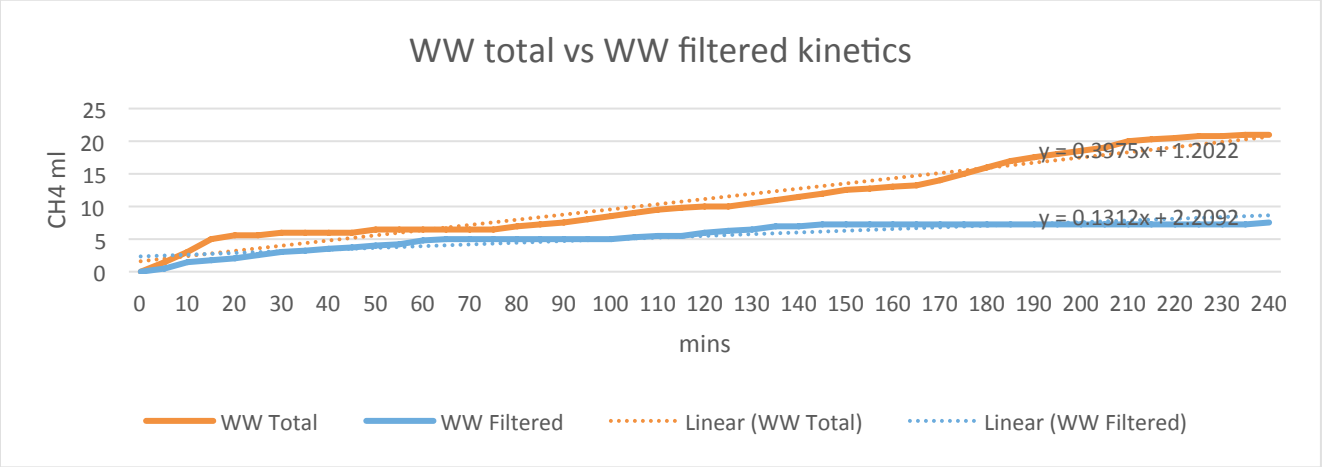

Figure 4.3 Wastewater total vs Wastewater filtered kinetics.

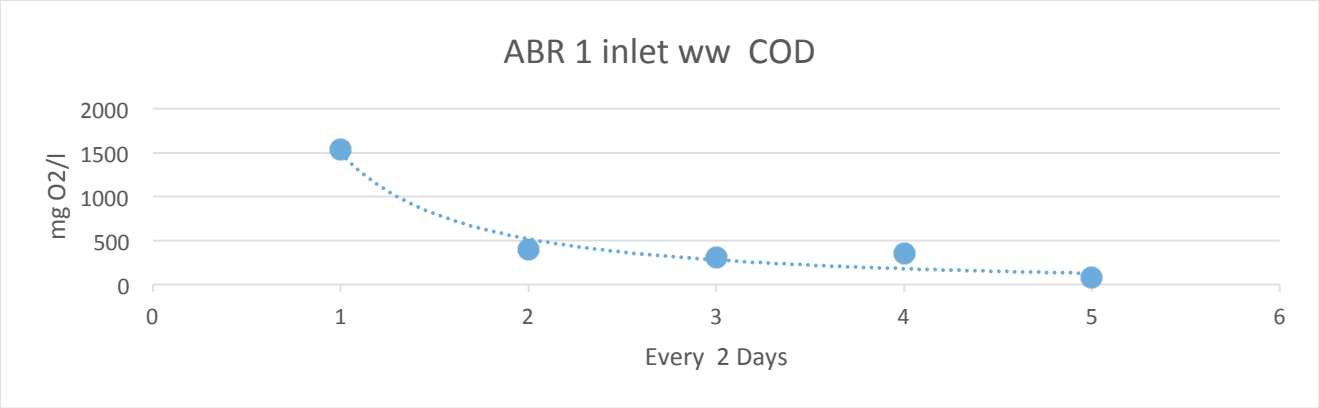

Figure 4.4 COD decrease of ABR inlet wastewater in a week.

CONCLUSION

Altogether, anaerobic digestion with complete mixing is most ideal because it increases the contact time of microorganism to substrate ratio which rises the methane production rate unlike non-stirred conditions which limitation is diffusion. In like manner, this limitation of diffusion is closer to ABR real conditions where there is less than optimal methane gas production. Moreover, ABR wastewater is less digestible than acetate and the total fraction of wastewater has a higher biodegradability than the soluble wastewater fraction probably due to the difference in particulate matter.

References

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