Quantifying the Effects of Glycerol on Biogas Production

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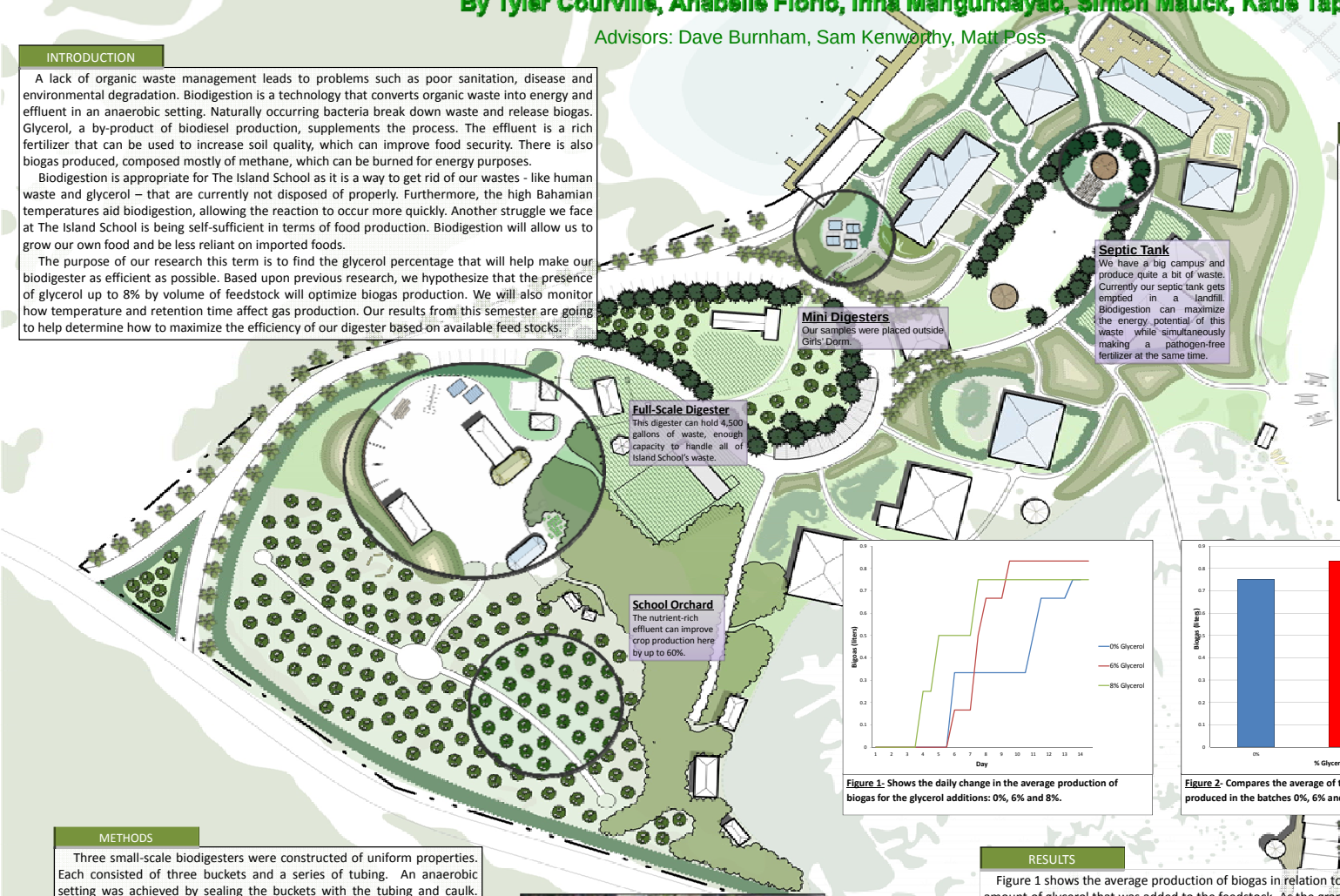
INTRODUCTION

A lack of organic waste management leads to problems such as poor sanitation, disease and environmental degradation. Biodigestion is a technology that converts organic waste into energy and effluent in an anaerobic setting. Naturally occurring bacteria break down waste and release biogas. Glycerol, a by-product of biodiesel production, supplements the process. The effluent is a rich fertilizer that can be used to increase soil quality, which can improve food security. There is also biogas produced, composed mostly of methane, which can be burned for energy purposes.

Biodigestion is appropriate for The Island School as it is a way to get rid of our wastes - like human waste and glycerol – that are currently not disposed of properly. Furthermore, the high Bahamian temperatures aid biodigestion, allowing the reaction to occur more quickly. Another struggle we face at The Island School is being self-sufficient in terms of food production. Biodigestion will allow us to grow our own food and be less reliant on imported foods.

The purpose of our research this term is to find the glycerol percentage that will help make our biodigester as efficient as possible. Based upon previous research, we hypothesize that the presence of glycerol up to 8% by volume of feedstock will optimize biogas production. We will also monitor how temperature and retention time affect gas production. Our results from this semester are going to help determine how to maximize the efficiency of our digester based on available feed stocks.



METHODS

Three small-scale biodigesters were constructed of uniform properties. Each consisted of three buckets and a series of tubing. An anaerobic setting was achieved by sealing the buckets with the tubing and caulk. Stage 1 was filled with a homogenous mixture of 11.4 L of water and 1.4 kg of pig waste that maintained an 8:1 ration of water to solids. The mixture contained an extra 36 grams of pig waste to account for any residual waste left after pouring the mixture into the bucket. Stage 2 was filled with five gallons of water that upon the production of gas was displaced into stage 3. Stage 3 was marked every 0.5 liters in order measure the amount of water displaced. It was elevated in order to prevent the flow of water without the production of gas.

There were three systems with the same percentage of glycerol simultaneously digesting, to maintain a precise measurement. The batches contained glycerol content of 0% (control variable), 4%, 6%, 8%, and 10% to compare the gas production in order to find the glycerol threshold.

The biodigesters were located in a sunny area where temperatures were higher. It has been found that warmer temperatures increase productivity. Data was recorded on the date, time, gas level, temperature and notable weather conditions twice a day.

Figure 3 – Shows one batch of the mini digesters, located outside of Girls' Dorm.

Figure 1- Shows the daily change in the average production of biogas for the glycerol additions: 0%, 6% and 8%.

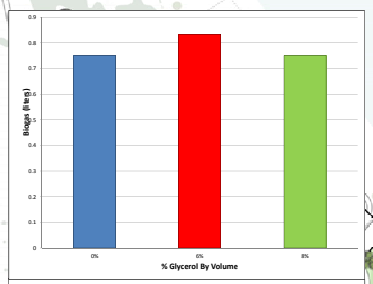


Figure 2- Compares the average of the total liters of biogas produced in the batches 0%, 6% and 8%.

RESULTS

Figure 1 shows the average production of biogas in relation to the amount of glycerol that was added to the feedstock. As the graph shows it took several days before biogas was produced, with 8% beginning most quickly. The graph shows that the batches with glycerol additions produced a steadier stream of gas for four days after gas was first produced, while the batch with no glycerol produced from day 5 until day 13.

Figure 2 shows the average amount of total liters of biogas in relation to the amount of glycerol added. It conveys that 6% glycerol produced the most biogas, averaging .833 liters between three digesters. Although 8% glycerol started producing sooner than 6%, it produced 0.75 liters while 6% .83 liters. After the data was run through an ANOVA test, a p-value of 0.1 was received, indicating that the addition of glycerol was not the only factor that affected the production of biogas.

DISCUSSION

The initial hypothesis stated that eight percent glycerol would optimize the production of biogas. The results from figure 1 show that 6% glycerol produced more biogas than both 8% glycerol and the control. The addition of 8% glycerol made gas production begin sooner.

There are many factors that could have altered the production of biogas. In order to dye the water, we added curry, which has been shown to inhibit the production of biogas. In addition, holes found in some of the digesters may have supported an aerobic environment which is not conducive to biogas production. Lastly, waste composition throughout the experiment was inconsistent as we collected waste on different days. The pigs' waste changes on a daily basis. All these possible sources of error may have had a remarkable impact on the experiment and our data statistically, but it does not remove the value of our data.

Most of the research papers we have read suggest the optimum glycerol level lies between 5% and 7%. The results support this statement however more research is needed to verify the optimal level of glycerol and to study the effects of abiotic factors such as temperature and waste composition.

For future research, students can experiment with different uses of methane on campus, the effects of effluent on plant growth and the composition of waste in relation to the production of biogas. Biodigestion has a lot of potential on the Island School campus and should be researched more because it is so appropriate and relevant for our campus.

WORKS CITED

- Adler, Ian 2006 "Turning Waste Into Fuel" Home Power 116 December 2006 and January 2007 92-95
- Amon, Th., et al. "Optimising methane yield from anaerobic digestion of manure: Effects of dairy systems and of glycerine supplementation." International Congress Series 1293, 2006.
- Chanakya, H.N., Reddy, B.V.V. and Jayant, Modak. "Biomethanation of herbaceous biomass residues using 3-zone plug flow." Renewable Energy (2008).
- Food and Agriculture Organization of the United Nations (FAO). "A system approach to biogas technology." 1997.
- Gary D. Meyers, Glen McLeod, Melanie A. Anbarci. "Waste Management Research." 2006. Sage Publications. <http://www.sagepublications.com>.
- Grushkin, Daniel. "A Hidden Cost of Farming." On Earth (2010).
- Kryvoruchko V., Amon T., Amon B., Gruber L. ,Schreiner M., Zollitsch W., "Influence of nutrient composition on methane production from animal manures and co-digestion with maize and glycerine."
- Stocking, M.A. "Tropical Soils and Food Security: The Next 50 Years." Science 302 (2003)
- Wahl, D. C. "Bionics vs. biomimicry: from control of nature to sustainable participation in nature." 2006