Biochemical Methane Potential of Fish Waste via Anaerobic Digestion at the Bay Mills Indian Community

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Abstract

Bay Mills Indian Community, an Anishinaabe Nation, is located at the junction of the Lake Superior and the St. Marys River. Commercial fishing is the second largest industry on local tribal lands and has culturally been a significant part of the traditional lifestyle. Regionally, an estimated 420,000 lbs. of fish (round weight) were captured by tribal fisherman annually. On average, 30-40 percent of the total weight of a fish is unusable for human consumption. Anaerobic digestion is being used in other regions to recapture fish waste via the creation of biogas and fertilizer. However, this technology has not yet been adapted for local use. Information on the viability of anaerobic digestion of freshwater fish species in a Northern climate is lacking. This project seeks to fill this knowledge gap and introduce the technology to the local community. To achieve this, the project has been divided into three phases. In phase one, bench-scale anaerobic digesters (500mL) were employed to investigate the necessary ratio between fish and other (local restaurant) waste streams to provide the highest biomethane potential. A ratio of 50:50 fish waste to restaurant waste yielded the largest average volume of biogas (935mL), compared to 924mL biogas create from a 25:75 fish to restaurant waste digestion. These values were 3-fold larger than the average volume of biogas produced through digestion of fish waste alone (368mL; $p<0.001$). This data is being used in phase two of the project: two outdoor (55 gallon) batch digestion processers, in which the biogas production of the previously mentioned fish to restaurant waste ratios will be compared and deployed during winter months. This will test the seasonal viability of anaerobic digestion of commercial fish waste on the Bay Mills Indian Reservation.

Background

- Bay Mills Indian Community
  - Anishinaabe tribe
  - Located on southern shore of Lake Superior
  - Traditional diet and present economy heavily dependent upon fisheries
- 420,000 lbs. of fish caught by local commercial fishermen annually
- 30-40% of total fish weight is not usable for human consumption
  - Disposal of fish waste presents economical and environmental problem
- Reclamation of fish waste through anaerobic digestion
  - Occurs when microorganisms break down biodegradable material under anoxic conditions
- Anaerobic digestion produces methane biogas and fertilizer
- Little to no data has been collected on biomethane production through anaerobic digestion of freshwater fish species in the Great Lakes region

Objectives

1. Establish methods for methanogenic bacteria cultivation
2. Determine biochemical methane potential for fish/restaurant waste variations
3. Create baseline data for future, large-scale research

Figure 1

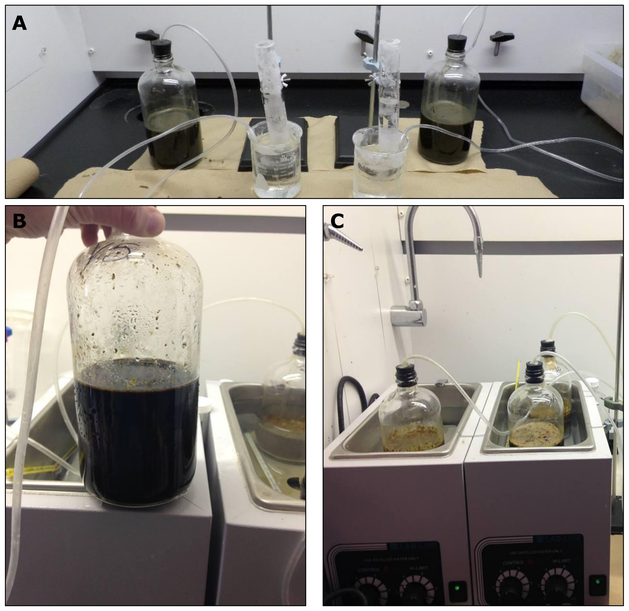

Figure 1. A) Preliminary batch of digestate., obtained from Michigan State University. 1L was grown into approximately 5L digestate to begin biochemical methane potential experimentation. This process began with two vials, and multiplied as bacteria colonies formed.
B) Close-up view of preliminary batch digestion.
C) Digestion vials were incubated at 90°C during experimental trials.

Figure 2

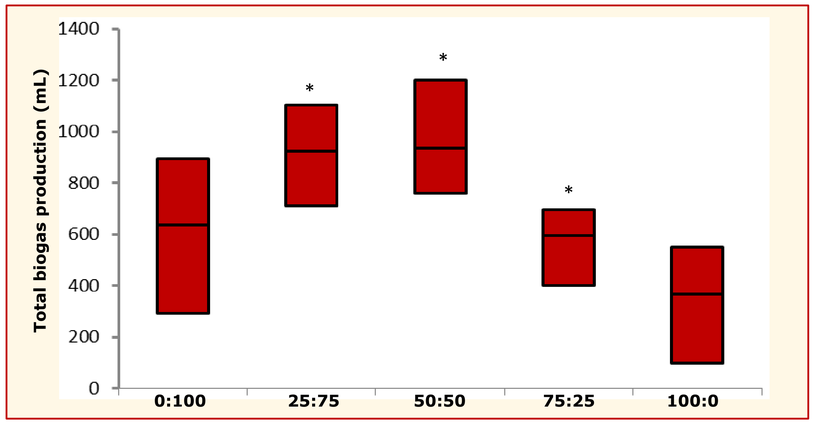

Figure 2. Total biogas production for 10-day biochemical methane potential trials. Fish waste and restaurant waste were combined in four experimental ratios (25% fish waste to 75% restaurant waste, 50% fish waste to 50% restaurant waste, 75% fish waste to 25% restaurant waste, and 100% fish waste) and compared to biogas production through digestion of 100% restaurant waste. Bars represent range of total biogas production during 10-day trial.; horizontal lines represent mean biogas produced. Asterisks denote ratios of fish to restaurant waste that produced significantly more biogas than digestion of fish waste alone.

Methods

- Local fish and restaurant waste were collected
- 1L batch digestions
- Varying ratios of fish to restaurant waste, by wet weight (total weight 50 grams)
  - 0:100
  - 25:75
  - 50:50
  - 75:25
  - 100:00
- Digestion carried out for 10 days under constant heat
- n=30 (10 per trial, 3 trials)
- Biogas volume measured via liquid displacement
- Methane detected using Bacharach Leakator (New Kensington, PA) combustible gas detector

Conclusions

- Bench-scale digestion and methanogenic cultivation techniques were established
- Digestion of fish and restaurant waste, in all ratios, produced methane
  - not significantly higher in digestion containing only restaurant waste compared to only fish waste
  - 2.5-times higher in digestion of 25% fish with 75% restaurant waste when compared to only fish waste ($p<0.001$)
  - 2.5-times higher in digestion of 50% fish with 50% restaurant waste when compared to only fish waste ($p<0.001$)
  - higher in digestion of 75% fish with 25% restaurant waste when compared to only fish waste ($p=0.017$)
- Next steps
  - Large-scale (55 gallon) anaerobic digestion
  - Ratios of fish to restaurant waste chosen from current study

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