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Anaerobic digestion of seafood processing residues, sludge and algae from Greenland

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Introduction

In Greenland the fish industry is the main contributor to the BNP. Most of the fish processing plants in Greenland deposit their seafood-processing residue (SPR) of at seabed with consequential environmental impacts and loss of potential value. Conversion of SPR into biogas through anaerobic digestion (AD) is an option, which might be feasible at large-scale all-year production sites. The resources available are primarily SPR of shrimp, cod, halibut, lumpfish and crab (Statistics Greenland 2020). Though a number of studies mapped the biogas potential of various SPRs, none of the species important in Greenland have so far been studied. The aim of this work was therefore to investigate the biogas potentials of shrimp, halibut and crab residue. The biomethane potentials (BMP) of the residues were determined separately, as well as in combination with locally available carbon sources: the algae species *Saccharina latissimi* and *Ulvaria Fusca*, and sewage sludge. To evaluate the environmental performance of the digestate as soil amendment material, the content of toxic elements in the substrates was also investigated.

Materials and methods

Shrimp and crap residue samples were collected from the seafood-processing plant in Sisimiut, Greenland. Crab and Halibut residues were collected from the seafood-processing plant in Uummannaq, Greenland. Algae were harvested by hand from the marine coastline in Sisimiut, Greenland, and sewage sludge was collected from a pilot scale test plant with chemical mechanical treatment in Sisimiut, Greenland. All samples were stored and transported frozen until grinding and use.

Ash, protein, lipid and elemental content was analyzed in all samples in triplicates as a minimum, with controls and blind samples for method verification.

Lab scale batch experiments were made to determine single substrate methane potential. Combined samples of SPR and carbon rich substrates from Sisimiut were tested at different ratios. The samples from Sisimiut were tested at mesophilic conditions (35°C), in 1000mL glass bottles, each holding 100mL of inoculum, varying amounts of sample and water to add up to a total mixture volume of 200 ml with inoculum derived from a Danish mesophilic biogas reactor treating wastewater sludge. The samples from Uummannaq were tested at thermophilic conditions (55°C) in 500 mL glass bottles, each bottle held 160 ml of inoculum and 40 ml of substrate with inoculum originating from a Danish thermophilic co-digesting biogas plant digesting manure with industrial organic wastes. After inoculation, the bottle headspace was flushed with a mixture of N_2/CO_2 gas (80/20), sealed and placed in an incubator. The methane content in the headspace was regularly monitored by GC-FID to quantify the amount of methane accumulated during digestion. All batch tests were made in triplicates.

Results and discussion

The maximum biogas potentials obtained are visualized in figure 1. The potentials of shrimp, algae and sewage sludge were comparable to commonly used substrates such as manure, and that of other seafood products such as blue mussels (Nkemka and Murto 2013); tuna, sardine, needle fish and mackerel waste (Eiroa, *et al.* 2012); and bighead fish viscera, gills and scales (Xu et al. 2016). Co-digestion of shrimp and algea indicated a synergistic effect.

Crab and haliut residues had a higher potential of 500 and 598 mL/gVS respectively, which is comparable to potentials earlier found for mackerel cannery waste, cuttle fish cannery waste and unspecified fish market waste (Kafle et al. 2013), and only exceeded by salmon (Nges *et al.* 2012), which is otherwise the highest potential documented among seafood residues in the literature (828 and 742 mL/gVS for salmon heads raw and hydrolyzed, respectively).

The sewage sludge contained 564±85 ppm Cu and 712±143ppm Zn. As the limiting values for use of sludge as soil amendment according to Danish legislation are 500 ppm, both exceed, thus digestate resulting from co-digestion of sewage sludge should be monitored for compliance to environmental standards prior to utilization. None of the other substrates contained any of the investigated elements at environmentally concerning levels.

The shrimp processing facility in Sisimiut would be able to supply between 50 and 100% of its energy consumption by biogas derived from AD of their by-products. Development of an appropriate technological solution is however necessary before biogas production becomes feasible in small remote Arctic communities. Advanced thermophilic plants optimized for maximum energy production are sensitive towards changes in operating conditions; require highly specialized labor and high capital investments. Low-tech biogas plants as implemented on a single household/farm basis in third world countries on the other hand cannot run during winter periods. An intermediate solution designed for the remote Arctic, sufficiently isolated and simple to run at mesophilic conditions for higher process efficiency and stability may be feasible.

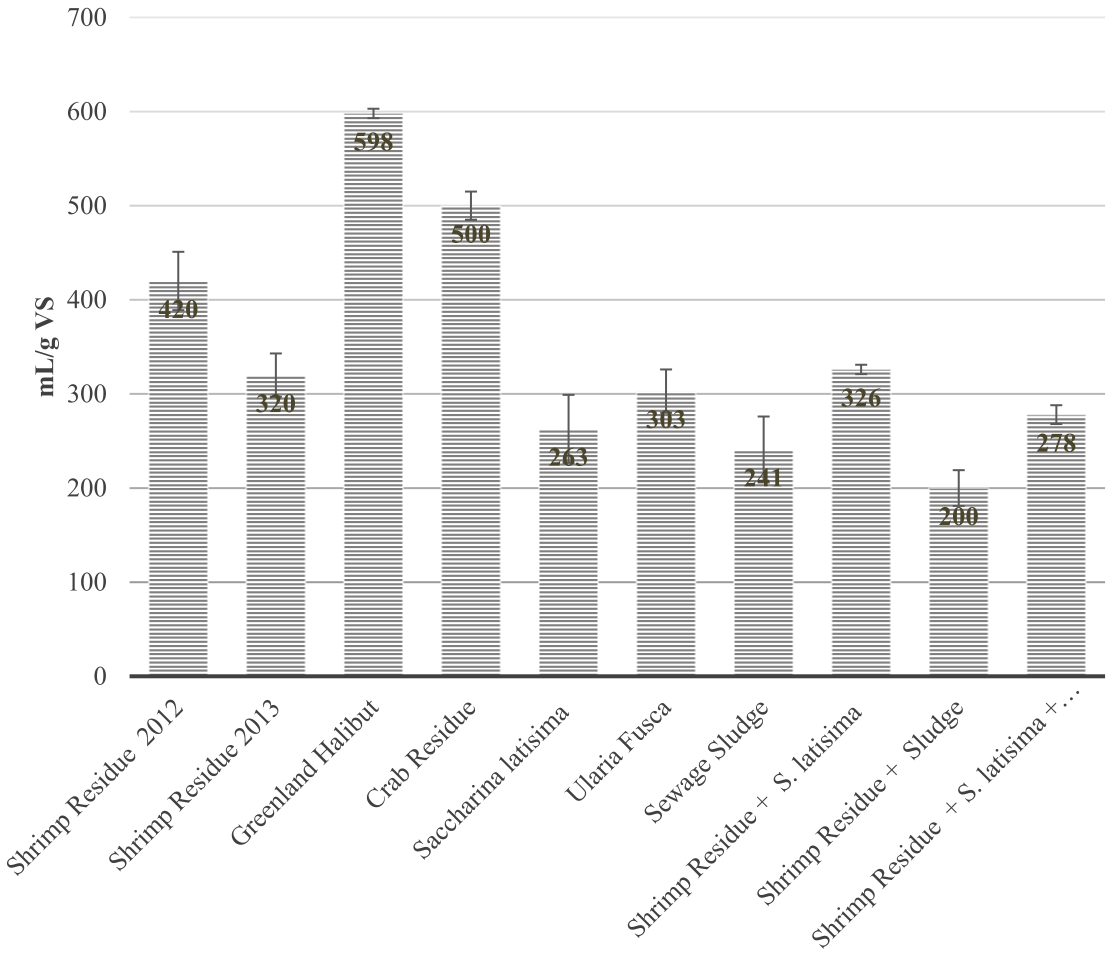

Figure 1: Biogas potential of SPR, algea and sludge from Sisimiut, Greenland – average values.

Conclusion

All residues had biogas potentials similar to or higher than conventional feedstock like manure and silage. The biogas potential of crab and halibut residues are high. The combined shrimp and algae digestion showed indication of synergistic effects. Currently, a significant energy potential is lost through todays practice. However, adaptation of AD technology to artic climate, substrates and infrastructure is necessary for a successful implementation.

References

Eiroa, M., Costa, J.C., Alves, M.M., Kennes, C., & Veiga, M.C. 2012. Evaluation of the biomethane potential of solid fish waste. *Waste Management*, 32, 1347-1352.

Kafle, G.K., Kim, S.H., & Sung, K. 2013. Ensiling of fish industry waste for biogas production: a lab scale evaluation of biochemical methane potential (BMP) and kinetics. Bioresource Technology, 127, 326-336.

Nges, I.A., Mbatia, B., & Björnsson, L. 2012. Improved utilization of fish waste by anaerobic digestion following omega-3 fatty acids extraction. Journal of Environmental Management, 110, 159-165.

Nkemka, V.N. & Murto, M. 2013. Two-stage anaerobic dry digestion of blue mussle and reed. Renevable Energy, 50, 359-364-

Xu, J., Mustafa, A.M., & Sheng, K. 2016. Effect of inoculum to substrate ratio and co-digestion with bagassse on biogas production of fish waste. Environmental Technology 10.1080/09593330.2016.1269837