Anaerobic Digestion of Biological and Enzymatic Hydrolysed Dry Manure

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Dairy and beef industries represent a significant source of waste biomass produced all year round. Feedlot cattle can generate manure about 5–6% of their body weight each day, a dry mass of roughly 5.5 kg per animal per day. Full-grown milking cows can produce 7–8% of their body weight as manure per day, roughly a dry mass of 7.3 kg per animal per day. A dry mass of about 24 billion tones of dairy manure is produced per year in the USA (Carlin et al., 2009).

Slurry and solid manure have traditionally been directly applied onto land as fertilizers. However, these might be potential sources of air and water pollution. Therefore, proper manure management practices must be applied to minimize environmental impacts. Anaerobic digestion is one of the most popular approaches for manure management due to two major reasons:

1) Reduction of the associated methane emission into the atmosphere;
2) Production of biogas as a renewable energy source;

Anaerobic digestion (AD) is a biochemical process where several groups of microorganisms degrade organic matter into a gaseous mixture consisting mainly of methane and carbon dioxide called biogas and a digestate, in an oxygen-free environment.

Depending on the amount of solids present in feedstock, AD can be categorized as dry (high solid content, >20%), semi dry (medium solid content, 10%-20%), and wet (low solid content, <10%). The dry anaerobic digestion process has many advantages, such as reduction of water usage, decrease in energy consumption for heating purpose due to volume reduction, and the easier disposal of the digestate compared with the wet process, however, the biogas production efficiency is lower for the dry AD of manure than the wet process. Dry anaerobic digestion can decrease the mass transfer efficiency and affect the absorption of substrates by microorganisms. A high concentration of solids can cause various problems during dry AD, such as inhibition due to ammonia nitrogen (Xiao et al., 2019).

On the other hand, another challenge with livestock manure management is the extensive use of water. Dairy farms use approximately 435 L of water per cow per day (about 113 L for drinking and the rest for flushing manure alleys). This estimation does not take into account the water required for milking, cleaning, and irrigating the crops that feed the livestock (Font-Palma, 2019). This would results in generation of huge amounts of washwater in an animal farm that would result in more challenges for proper and safe disposal of the waste streams.

Considering the huge amounts of dry manure and washwater produced on a daily basis in an animal farm, dilution of dry manure by a waste stream such as washwater for the purpose of biogas production could have a great potential in improving the performance of an anaerobic digester. However, the presence of inhibitory agents such as hypochlorite in washwater could cause operational problems with anaerobic digestion of diluted manure. Another challenge will be the amount of dilution considering the rate of biogas production for an efficient performance of the digester. Therefore, the effects of dilution ratio on AD of dry manure were studied in this work. Three different dilution ratios (dry manure: washwater), i.e. 1:2, 1:3, and 1:5 were investigated. Samples were subjected to biomethane potential (BMP) tests for 30 days and biomethane yields were measured for each dilution ratio. According to the results, a proper dilution ratio to lower solid content of the feedstock would result in a higher biogas production rate.

Furthermore, and to enhance the digestibility of the dry manure, enzymatic hydrolysis of the diluted manure at the dilution ratio of 2:1 was studied in this research. Owing to its relatively high fibre content (up to 50%), manure falls into the category of materials that could be enzymatically fermented. Therefore, converting fibre to biomethane via a sugar platform provides an approach for this new level of manure application. This process involves hydrolysis of fibre components (cellulose and hemicellulose) into simple sugars, which can be converted to methane via biological processes such as AD. Therefore, effects of enzymatic hydrolysis of cow manure on AD process and biomethane production were investigated.

Two commercial enzymes, A and B, manufactured by Amapex at two different concentrations, i.e. 2.0 and 5.0 g/L were used for enzymatic hydrolysis of dilute manure before AD. This makes it possible to compare the enzymatic and biological hydrolysis of diluted manure for a higher biomethane yield.

For the biological hydrolysis, diluted manure at a dilution ratio of 2:1 was incubated at 40 °C for 4 days. However, enzymatic hydrolysis of the diluted manure at the same ratio was performed in the presence of certain amounts of enzymes (2.0 and 5.0 g/L) for 36 h. Glucose content was measured as the hydrolysis advancement indicator and it was observed that glucose released in the hydrolysed samples with a higher rate in the presence of the enzymes. Also, samples with a more concentration of glucose as a result of enzymatic hydrolysis demonstrated a higher biomethane production rate. According to the results, hydrolysis rate increased at higher enzyme concentrations led to a higher biogas production rate after 30 days. It should be noted that the biogas produced from the diluted manure at different dilution ratios contained 60-70% methane and the balance was carbon dioxide.

References

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