Optimization of Biogas Production from sewage sludge

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Abstract— It is widely known that the degradation of waste activated sludge is a slow process with a low extent of degradation. Improvement methods with regards to bio-methane yield were investigated in this study using a laboratory batch anaerobic digester. Mono-digestion of sludge with a C: N ratio of 15.47 resulted in a lower accumulation of gas volume than co-digested sludge even though the pH decreased rapidly in both cases. The thermophillic anaerobic digestion of sludge and co-digested sludge also produced higher bio-methane yield than mesophillic digestion of waste water sludge. Gas accumulation volume in the digesters during thermophillic digestion increased from 50 Nml to 100 Nml, 200 Nml to 600 Nml and 600 Nml to 750 Nml for sludge, cow dung and sludge and sludge and food waste respectively as the temperature was increased from 37°C to 45°C.

Keywords— Anaerobic digestion, Co-digestion, Mesophilic temperature, Waste Activated Sludge

1 Introduction

South Africa and certain Eskom supplied countries in Africa are currently going through an energy crisis. The process of load shedding and the promoted energy efficiency programmes serves to illustrate the current energy situation. Furthermore, the situation is aggravated by the increases in energy prices. South Africa is becoming one of the higher costing energy suppliers in the world. Additionally, South Africa is one of the highest GHG emitters in the world therefore all efforts must be made in order to reduce its GHG emissions. Treating sewage is a water recycling service. A large variety of disposal routes are possible, however anaerobic digestion proves to be more eminent for its abilities to further transform organic matter into biogas (60–70 volume% of methane, CH_4), which can then be used to generate electricity or used as it is (Gunaseelan, 1997).

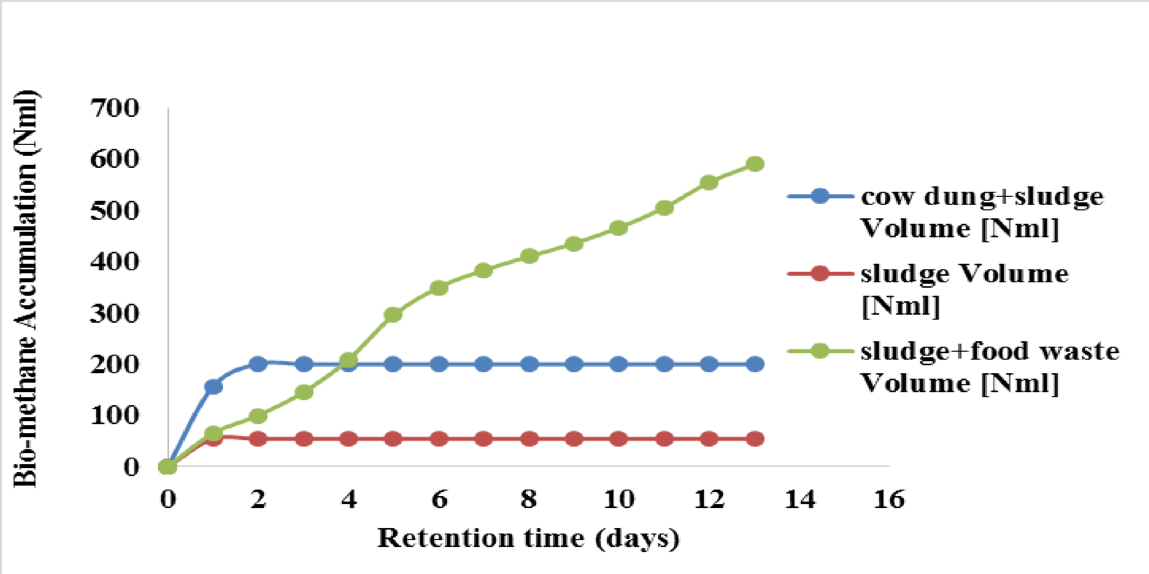


Figure 3: Mesophilic temperature 37 °C on co-digestion of bio-methane production

The graphs do not have a lag phase indicating that substrates started producing gas on the first day. This is due to the fact that the digesting system had agitators, and the cow dung was crushed to allow for optimum surface area for reaction. The mono-digestion of sludge shows the lowest gas accumulation of 45 Nml which stopped after one day. If a substrate has a low C:N ratio, it results in accumulation of ammonia and a pH that is higher than 8.5 (Matheri, 2015). However, this was not the case with sludge. The C:N ratio of sludge was initially 15.47 but as soon as the experiment started, the nutrients in the substrates rapidly produced acid which resulted in a pH of 4.15. The problem of pH creating a toxic environment for bacteria could be solved by introducing other substrates by co-digestion. Co-digestion of sludge with cow dung showed a slight increase in gas production with a gas volume of 200 Nml. However, the process of accumulation stopped on the second day. This was due to an increase in C:N ratio which took place within the first two days and resulted in a low pH of 4.15. Co-digestion of sludge with food waste shows continuous increase in accumulation for the 15 days with a final gas volume of about 600 Nml on the 15th day and a pH of 6.40. Thermophilic bio-methane was then investigated as another alternative for optimum bio-methane production.

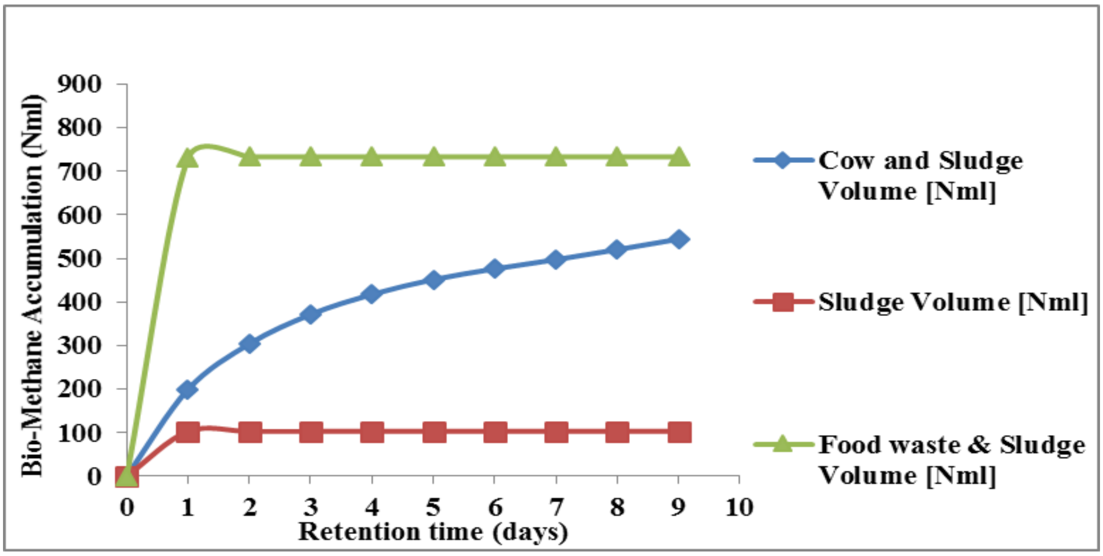
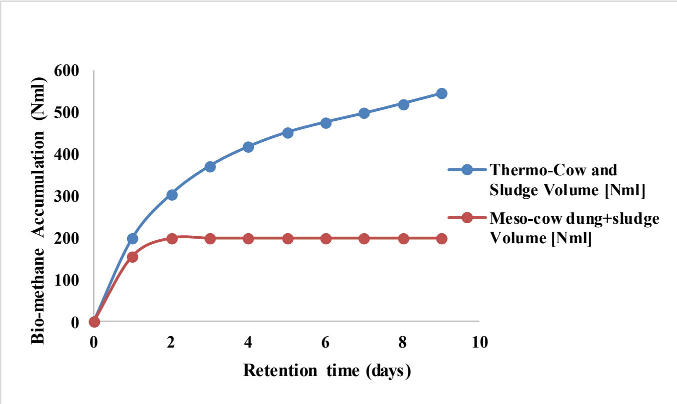


Figure 4: Thermophilic temperature 45 °C on co-digestion of substrates in bio-methane production

3.3 Effect of temperature on bio-methane production

Digestion that took place under thermophillic temperature resulted in a slight improvement in the accumulation of bio-methane gas as opposed to gas produced under mesophillic temperature. Mono-digested sludge has a gas accumulation of 100 Nml which stopped increasing in a day. However, this is twice the gas produced in mesophillic temperature. Co-digestion of sludge with cow dung has a gas accumulation of about 600 Nml within two days and a pH of 5.32. The pH having decreased from 7.83. Moreover, the co-digestion of food waste and sludge resulted in a gas accumulation of about

750 Nml. This is more than the gas accumulation obtained in a mesophilic anaerobic digestion of sludge.



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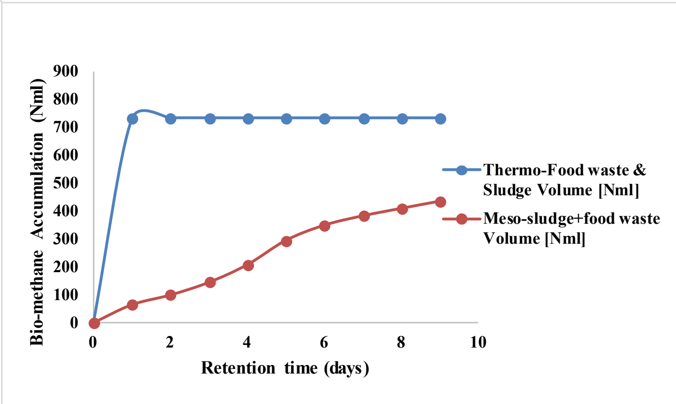

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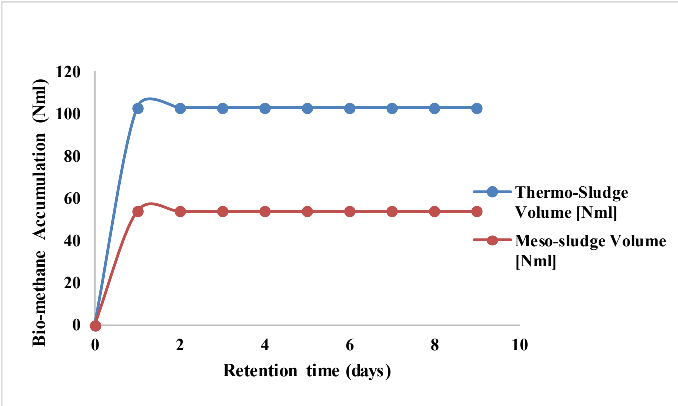

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Figure 5: Influence of digestion temperature on the bio-methane production

The Figure 5 show mono-digestion and co-digestion of sludge. Higher biogas production was observed under thermophilic temperature compared to mesophilic condition with lower retention time. There were more mesophiles than thermophiles; they are also more resilient to changes in the conditions of their environment in comparison to the thermophiles. Therefore, mesophilic digestion and systems are considered to have more stability than thermophillic systems. On the contrary, even though thermophillic digestion systems are said to be less stable, they have a higher methane yield. Since their heat energy input is higher which allows for removal of biogas from the substrate at a retention time that is the same as that of a mesophillic system. Furthermore, it is known that high temperature results in fast movement of molecules which then results in a fast rate of reaction and thus faster gas production. Another advantage is that the high temperature facilitates greater reduction in pathogens in the digestate.

4 Conclusion

Anaerobic digestion of a substrate conducted under thermophilic temperature resulted in a higher bio-methane yield than mesophilic range with lower retention time. Therefore, thermophilic can be used as an alternative to mesophilic temperature, although the drawback would be the costs involved in the energy input that comes with a higher temperature. The co-digestion of the substrate enhanced increased in biogas production than the mono-digestion with control of pH and distribution of the nutrients.

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