final report

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Demonstration and monitoring of in-vessel anaerobic digestion and reduction of abattoir, and other regional food industry wastes to produce renewable energy

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Abstract

On 25 September 2013, a 1000L upflow anaerobic sludge blanket (UASB) reactor was inoculated with 300L of onsite anaerobic lagoon sludge (i.e. outlet from Pond E) and filled to a working volume of 900L with untreated abattoir effluent i.e. 'saveall'. The digester operated under batch conditions for approximately 48 hours before start-up under shock load conditions with an initial hydraulic retention time (HRT) of 24 hours during weekly operations receiving 3 x 300L feeds per day during abattoir operational hours. The digester then operated under batch conditions during weekend periods to reflect onsite start/stop of inputs into effluent treatment system.

Initially, organic removal efficiencies and conversion to biogas containing methane were high, however after 13 days of operation the methane content had reduced to approximately 10%. The HRT was increased to 72 hours to allow the biomass to acclimate to a significantly different organic and hydraulic loading environment. Within a few days, the methane content of the biogas had increased and was on average 35%. Despite variable methane content in the biogas generated, the OLR removal efficiencies reported as chemical oxygen demand (COD) was consistent throughout this period being on average 50% reduction.

After 62 days of steady state operation, the HRT was reduced to 48 hours causing an increase of 50% in the organic loading rate (OLR) to the digester which resulted in an increase in methane content to on average 40-45%. The OLR removal efficiencies remained consistent throughout this period at 50% indicating the processes of organic conversion to biogas containing methane was improved with the change in operation.

After 35 days under this operating regime, the HRT was further reduced to 36 hours causing an increase of 50% in OLR to the digester which resulted in an increase in methane content initially on average 55-60%. Under this operating the methane content steadily increased and after 30 days of operation, was on average 65-70%. An onsite operational issue occurred at day 13 of operation with higher loading of oils and greases (O&G) into the effluent treatment system and subsequently the digester which resulted in a reduction in methane content to 45-50%. The issue was resolved

on day 17 with a steady increase in methane content over the next few days of operation before peaking above 70% on day 24. By day 30 of operation, the biomass had recovered from the disturbance and improved organic conversion with methane content being on average 65-70%. The digester has been operating for a cumulative total of 167 days with four phases from start-up through steady state and step-wise reductions in HRT to optimise organic content conversion to biogas containing methane.

The successful start-up and operation of the digester demonstrates that:

- Unamended abattoir effluent can be successfully treated using a high-rate digester such as the UASB with consistent organic removal efficiencies and conversion to biogas containing high methane content;
- Onsite anaerobic lagoon sludge can be used as inoculum for anaerobic digestion of abattoir effluent;
- After a period of acclimation to significant changes in hydraulic and organic loading, the biomass was able to successfully treat unamended abattoir effluent with a highly variable organic loading;
- The biomass was able to successfully recover from operational issues resulting in changes in composition to organic loading;
- Despite, the variable organic content, the methane content of the biogas generated steadily increased over time and each step-wise reduction in HRT resulted in an increase of approximately 10% eventually peaking and remaining on average 65-70%.

With respect to bioenergy potential, the volume of biogas generated was not captured during operation for two reasons:

- Primarily, over time, and particularly after periods of batch operation, the digester sludge became increasingly thick and densely settled with significant reduction in physical volume within the digester. This physical property of the sludge resulted in an increase in headspace in the reactor from 100L up to 400L. This is a large volume of gas to be expected to be generated from a 900L working volume digester; and
- Re-configuration of the digester to operate as a UASB meant a compromise with an inefficient gas collection system and the data that could be collected that would be representative of operational results.

Project objectives

The project outcomes will be as follows:

1. Identify who/where co-digestion is being undertaken and the results in terms of system performance and gas production.
2. Install trial Micro Digester.
3. Establish potential/confirmed waste suppliers of co-digestion feedstock
4. Operate micro digester trial unit and report on performance – input materials, methane, digestate, water quality, FOG levels etc
5. Conduct trials and measure effectiveness of in tank anaerobic treatment of abattoir wastes and various blends with external wastes
6. Identify regulatory requirements for a full AD installation
7. Provide a full final report for dissemination to the industry

Success in achieving milestone

The continuous operation of the 1000L UASB for 167 days with consistent organic removal and increasing methane content in biogas generated to a final average of 65-70% demonstrates that unamended abattoir can be successfully treated using high rate anaerobic digestion. Additionally, the use of onsite anaerobic lagoon sludge to inoculate and its ability to acclimate to a significantly different hydraulic and organic loading environment to generate consistent biogas with high methane content has not been reported. Being able to source biomass from onsite material to inoculate/maintain an anaerobic digester is of value at industrial-scale treatment with reduction in potential costs and down-time in operations in the event of a disturbance that results in biomass loss.

Overall progress of the project

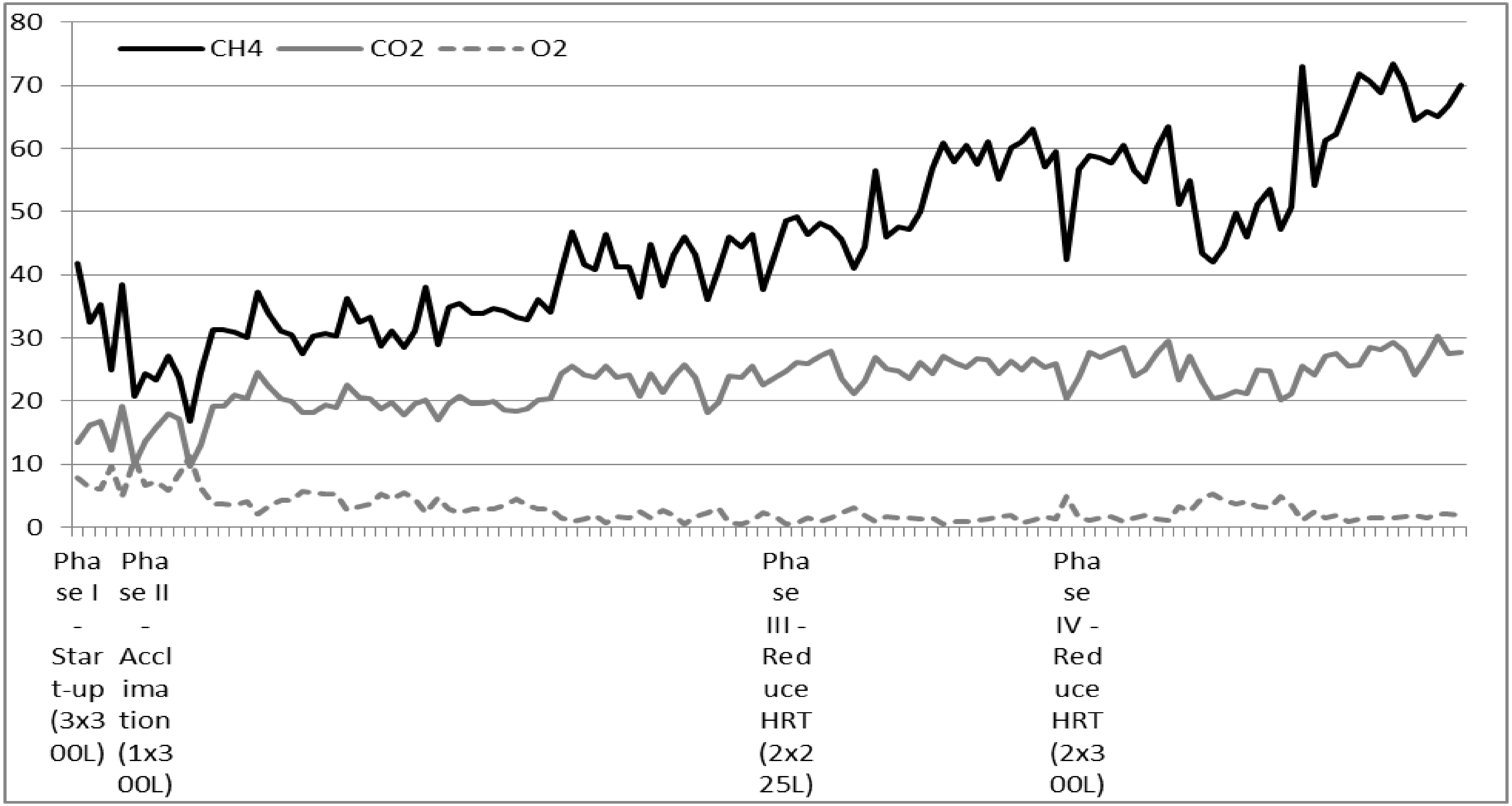
The project is progressing with respect to milestone operation and reporting requirements.

Recommendations

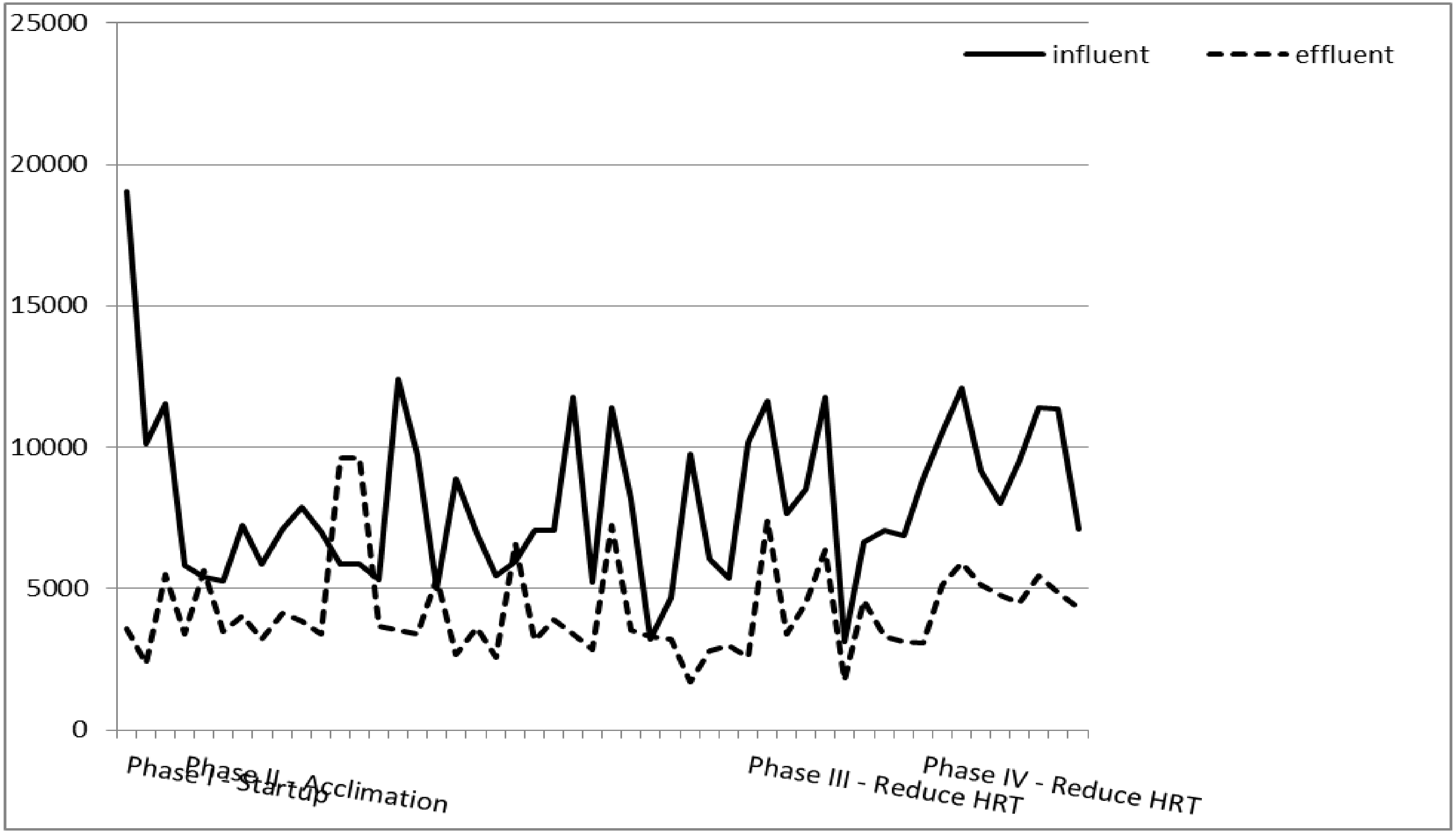
To be discussed.

Appendices

Below is the graph of the biogas content (i.e. methane, carbon dioxide and oxygen) through 4 phases of operation (I) start-up, (II) acclimation and (III) & (IV) methane content optimisation.



Below is the COD loading over the 4 phases of operation



Below is the organic loading rate (OLR) kg/day during the 4 phases of operation