Biorenewables Development Centre

Plants • Processes • Products

Report developed for:

Espazyme UK

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Effect of microbial addition on gas yield in Anaerobic Digestion

Contact details

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1. Our methodology

1.1. Feedstock analysis

The feedstock used for this experiment was pig slurry sourced from a local farm running an anaerobic digester. The source digester also uses ensiled maize. The change from slurry and maize to slurry alone could be detrimental to the microbial community so a small amount maize was added in the early stages of the experiment.

1. 1. 1. Total solids

Total solids of the feedstock is measured by taking a known quantity of material and drying in a furnace at 105°C until a constant weight is achieved.

1. 1. 2. Volatile solids

Volatile solids is measured by taking a known amount of material and heating in a furnace at 550°C until a constant weight is achieved. The solids lost on ignition the volatile solids content.

1.2. Experimental set up

The experiment is carried out in two 30 litre digesters with a programmable feed pump and passive digestate collection. The gas is passed through a flow meter (measuring Standard Cubic Centimetres per Minute (SCCM)) via a moisture trap. The gas volume is logged using Windmill data logging software collecting one data point per second. pH and temperature are monitored via a Hach pH/temperature probe.

The digesters are filled with 50:50 digestate (obtained from the same source as the feedstock) and water. The feed pump is programmed to deliver 100ml of pig slurry every 2 hours.

The microbial supplement (supplied by Espazyme uk) is added to one of the digesters as per manufacturer's instructions see table 1. The supplement is added to an appropriate amount of process water them made up to 100ml with pig slurry. The mix is added to the digester with the remaining pig slurry.

Table 1. Timetable for the addition of the supplement giving daily dosage and quantity of process water required.

Days	Daily dose (g)	ML of water from process
1	20	50
2	20	50
3	10	25
4	10	25
5	10	25
6	8	20
7	8	20
8	8	20
9	8	20
10	8	20
11	7	20
12	7	20
13	7	20
14	7	20
15	7	20
16	6	15 or 20
17	6	15 or 20
18	6	15 or 20
19	6	15 or 20
20	6	15 or 20
21	5	15 or 20
22	5	15 or 20
23	5	15 or 20
24	5	15 or 20
25	5	15 or 20
Weekly maintenance	5	15

1.3. Biochemical oxygen demand

The biochemical oxygen demand (BOD) of the digestate was determined using the BodTrak II respirometer from Hach uk. The sample was run for 5 days according to manufacturer's instructions. The sample was seeded with Polyseed to ensure microbial digestion.

1.4. Gas composition

The gas composition was determined using an SRI gas chromatograph with Haysep D, molecular sieve and TMX columns. The carrier gas used was Argon. The detectors were Thermal conductivity detector, Flame ionising detector with a Metheniser and a flame photometric detector with a sulphur filter. Peak areas were determined and measured against a standard curve of known gas concentrations. Data was collected using SRIs PeakSimple software.

1.5. Total nitrogen and ammonium

Total nitrogen and ammonium were determined using the Hach DR3900 spectrophotometer with appropriate test kits and in accordance with manufacturers instructions.

Total nitrogen was tested using the LCK 138 test kit

Ammonium was tested using the LCK 302 test kit

2. Key finding

2.1. Total and volatile solids

Table 2. Shows the total and volatile solids of the digester feedstocks.

Sample	Total solids (%)	Volatile solids (% of dry solids)
Pig Slurry	2.8	72
Maize	31	96.2

The maize was used for the first 10 days to aid in the transition from a complex feedstock to pig slurry alone. For the first 10 days the feedstock was added at a rate of 2.37 kg volatile solids per m^3 per day. After 10 days the feedstock was switched to pig slurry alone which was added at a rate of 0.8 kg volatile solids per m^3 per day.

2.2. Gas production

The gas production was measured over a 90 day period. Figure 1 shows the rate of gas flow at an hourly rate. This shows that there is a lot of fluctuation in the rate of gas flow especially in the first 20 days of the experiment. This is only to be expected in a digester that has not been running and has not had the chance to develop a steady pattern. Once the digester settles into a pattern it can be seen that the digester with the microbial additive consistently exhibits a higher rate of biogas flow.

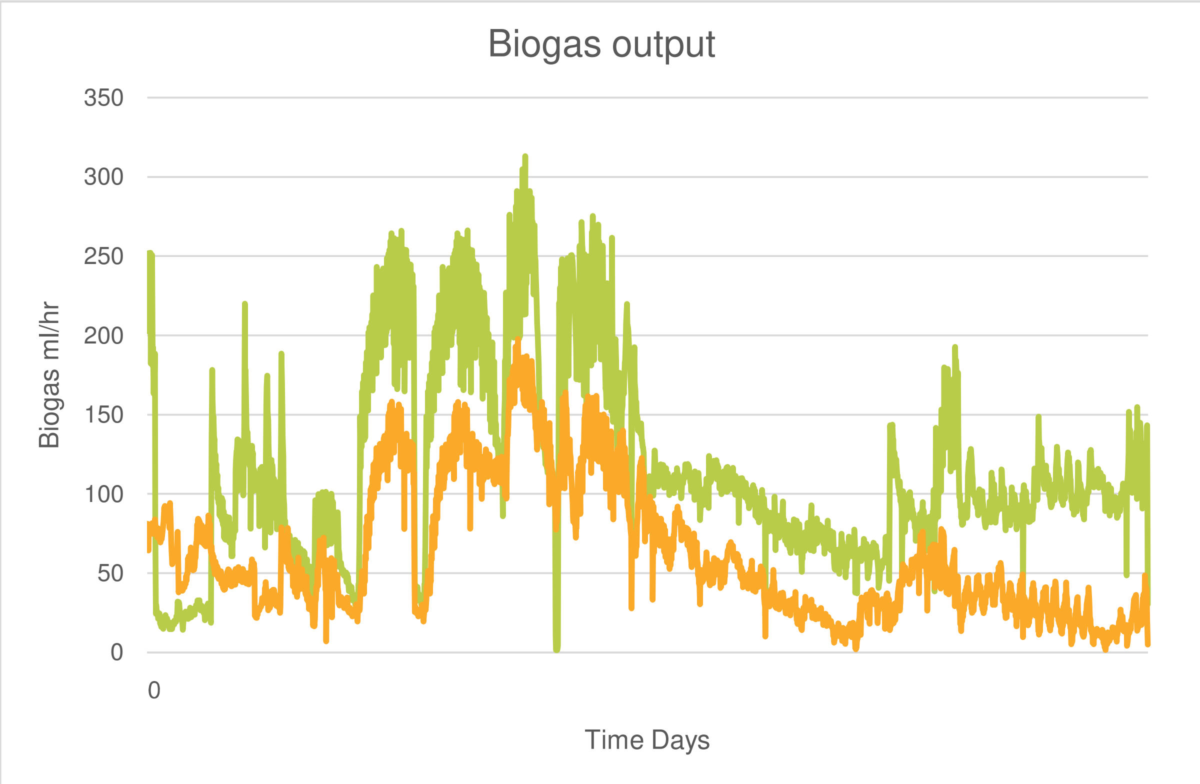

Figure 1 . Rate of biogas production in ml/hr over the period of the experiment. Comparing the treated and untreated digesters.

Figure 2 shows the cumulative biogas output over the course of 90 days. This clearly shows the effect of the increased rate of biogas flow due to the microbial addition. The chart indicates that in the early stages, as the digesters are conditioning, there is no difference in the biogas output. By day 10, however, the supplement is starting to have an effect and is improving biogas output. Total biogas output without supplement is 137 litres and with supplement is 257 litres.

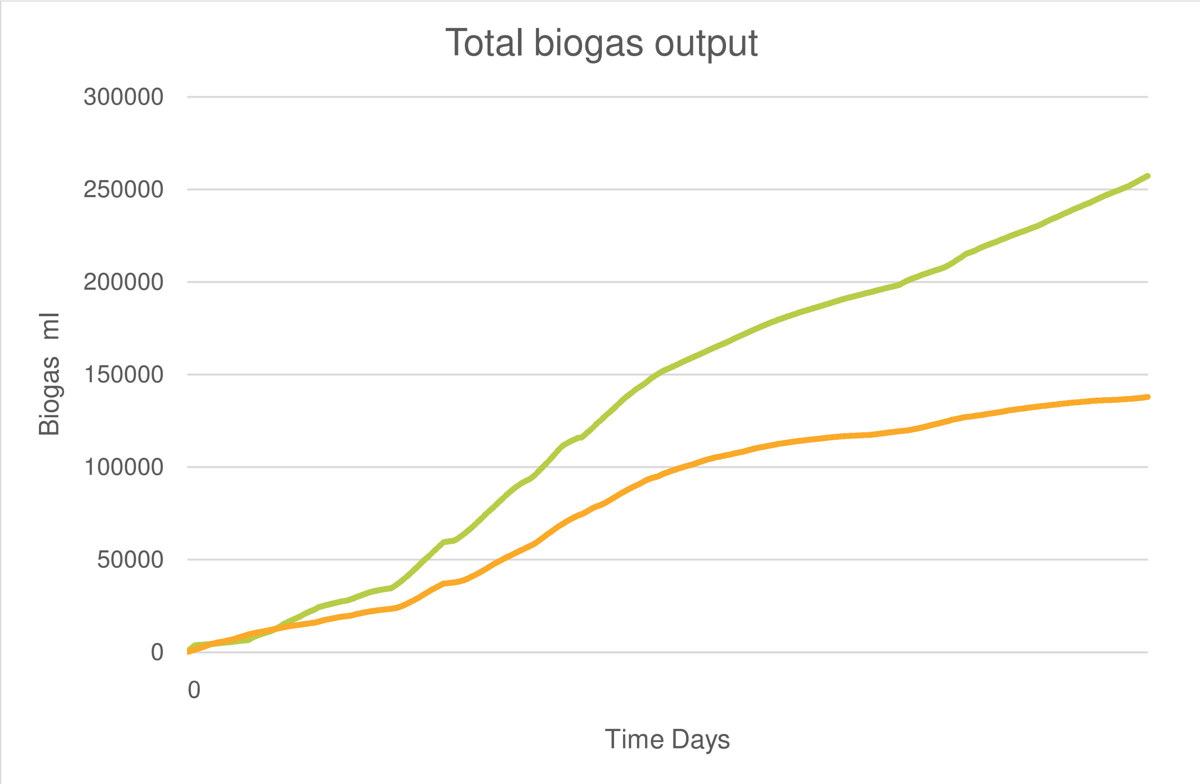

Figure 2. Cumulative biogas output comparing treated and untreated digesters.

2.3. Total and volatile solids

The digestate was analysed for total and volatile solids content to ascertain if the additive led to a significant reduction in solid material in the digestate. Figure 3 shows the result of this analysis and indicates a reduction in the solid material in the digestate of 14%.

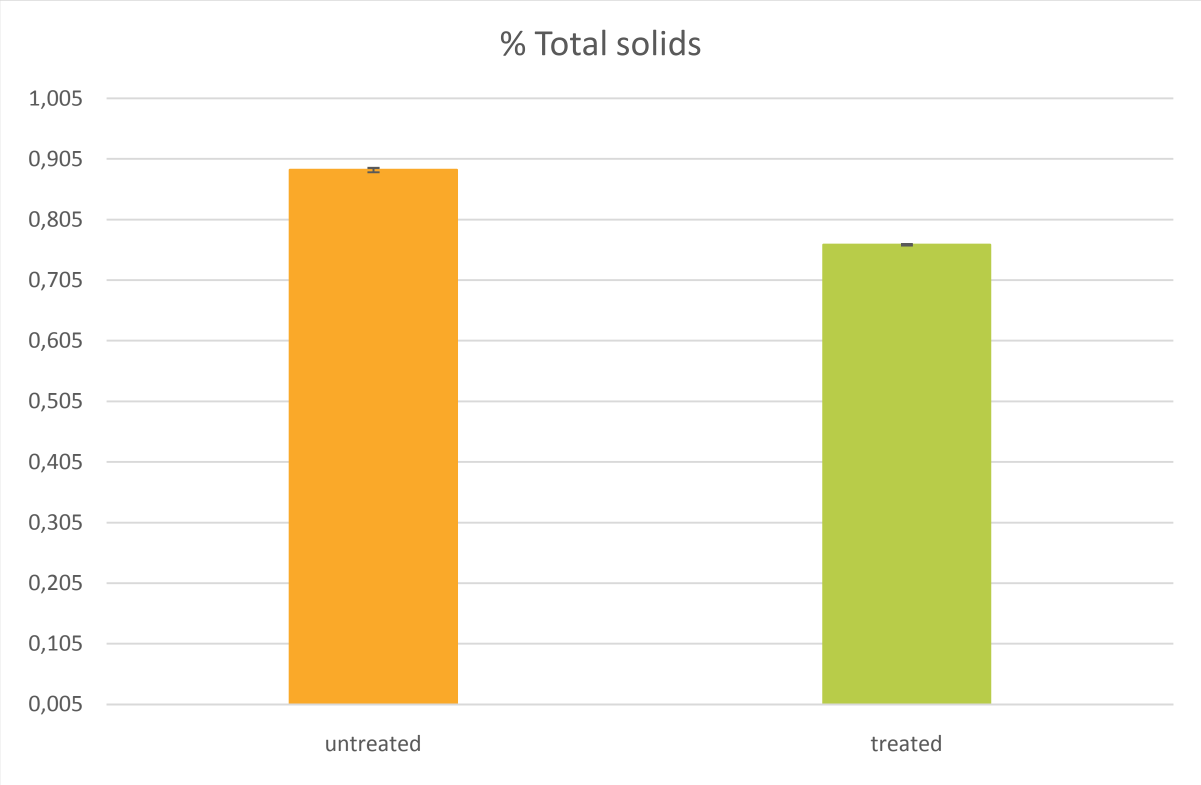

Figure 3. Total solids of the digestate

It should be noted that this is a low solid concentration for industrial digestate as at this stage of the experiment we are using only pig slurry which had a starting concentration of 2.8%. Volatile solids of the samples were 48.79 % and 41.86 % of the dry solids of the untreated and treated respectively.

2.4. **Gas composition**

Sample	Hydrogen sulphide concentration %	Methane concentration
Untreated	0.09 (se 0.002)	48.15 (se 1.05)
Treated	0.07 (se 0.019)	46.93 (se 2.1)

Table 3. Concentration of hydrogen sulphide and methane in the biogas se is one standard error

Table 3 illustrates the composition of the biogas showing levels of methane and hydrogen sulphide. We can see a reduction in the hydrogen sulphide concentration in the digester with the additive. As with the total solids data it should be noted that these are small concentrations and the standard deviation for the treated sample is relatively high.

2.5. Biochemical oxygen demand

The biochemical oxygen demand of the digestate was assessed to see if there is a reduction in the degradable material in the digestate. This can have a significant impact with respect to water courses near where the digestate is spread. The results of this test indicate that there is little difference in the BOD between the digesters giving figures of 545 mg/l and 541 mg/l for the treated and untreated digesters respectively.

2.6. Total nitrogen and ammonium

Table 4 shows the results of the nitrogen and ammonium analysis

Sample	Ammonium (NH_4-N) mg/l	Total Nitrogen g/l
Treated	50.83 (se 0.03)	1.62 (se 0.006)
Untreated	53.13 (se 1.21)	1.50 (se 0.008)

3. Conclusions

The results of this short study show that the addition of the microbial additive supplied by Espazyme UK has a positive effect on the biogas yield from pig slurry. The results show totals of 257 litres of biogas from a treated digester compared to 137 litres from an untreated digester over the course of 90 days.

The total solids indicate a reduction in dry solids of 14 % with a reduction in the volatile solids percentage. Similarly, a small reduction in hydrogen sulphide is observed but the standard errors in these results suggest this may not be significant. As the quantities measured are already small it may be that these differences are significant when scaled up or when using higher yielding feedstocks such as energy crops or crop residues. Methane concentrations are slightly different but the standard error would indicate this is not significant.

There is no discernible difference in the BOD of the digestate but again this could be due to the low solids nature of the feedstock and subsequent digestate.

The nitrogen analysis indicates a very slight decrease in the ammonium content of the treated samples and a higher value for total nitrogen. This is likely due to some of the nitrogen being in a different form.

4. Further Work

As pig slurry is not used in isolation and is generally a poor source of biogas we would recommend using a feedstock which gives a better representation of an industrial situation. With the addition of another feedstock, in co-digestion, such as straw, maize or grass the differences in H_2S and total solids concentration may well become more defined. In addition, any potential differences in BOD would be seen.

A more comprehensive nutrient analysis as well as trace element analysis would be beneficial to determining the full effect of the microbial addition to the system. This would give indications of trace element usage and requirements as well as determining if more nutrients are released into the liquid portion rather than being retained in the fibre.

Disclaimer

This document has been prepared as a result of a short study and should be considered as an early stage piece of work on the topic.

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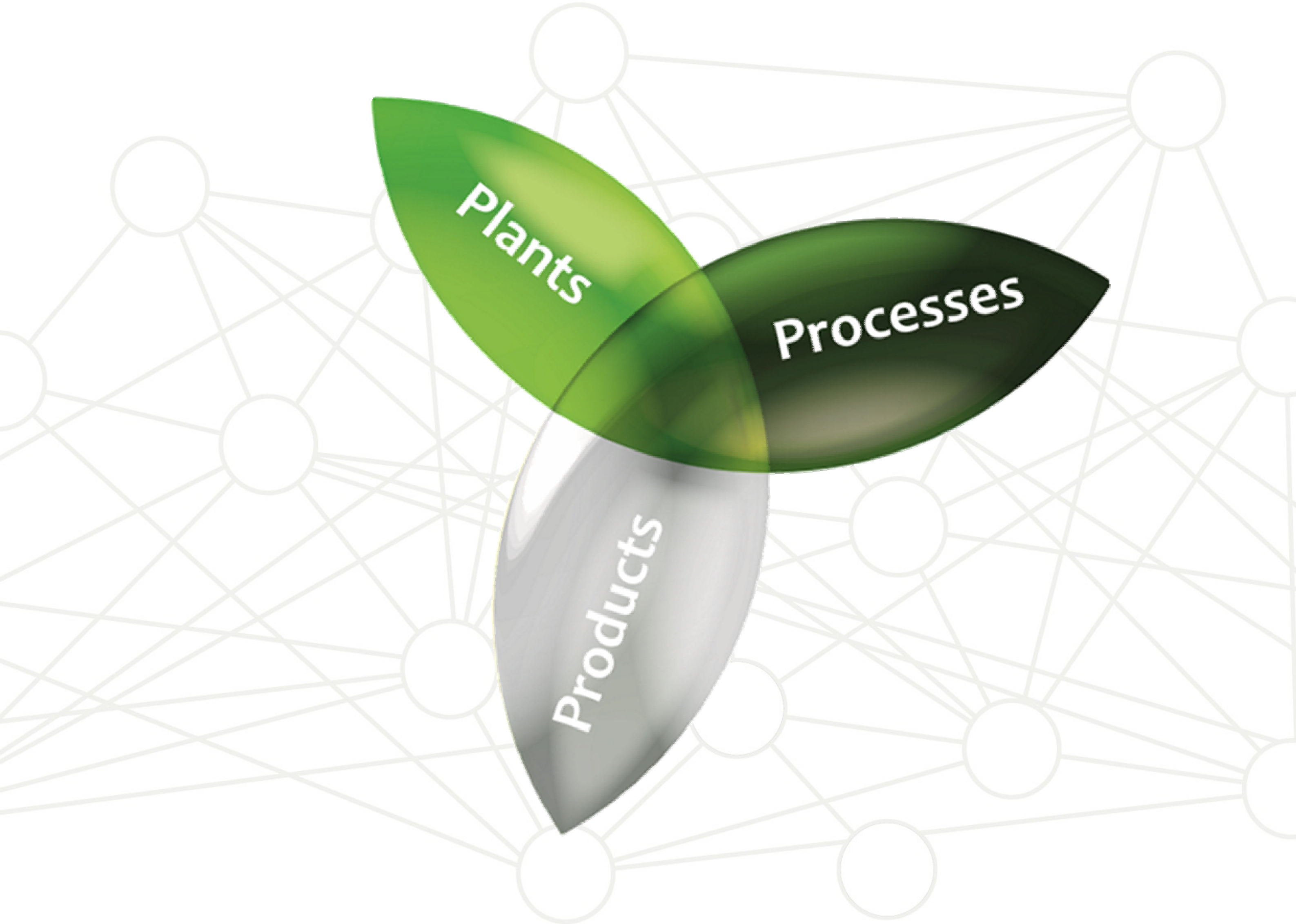

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The Biorenewables Development Centre (BDC) is a not-for-profit company, based at the University of York that helps businesses develop ways to convert plants, microbes and biowastes into profitable biorenewable products. Using cutting-edge science and technology, we bridge the gap between academia and industry to assist companies both in development and scale-up of new greener processes and products. Established through a collaboration between the world-renowned Green Chemistry Centre of Excellence and the Centre for Novel Agricultural Products, our expertise, services, open-access facilities and access to academic scientists across the fields of chemistry and biology put the BDC in a strong position to help develop bio-based projects.

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