Eco Process Assistance

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MELISSA

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Characterisation of the anaerobic biodegradation process

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1. Introduction

The MELISSA demonstration reactor is responsible for the degradation of faecal material. From previous experiments can be concluded that the overall conversion efficiency of the organic matter in the MELISSA reactor at a pH of around 7 and a temperature of 55°C was 40%. It appeared that protein were more easy to biodegrade (60%) than other components such as polycarbohydrates (20%). The fibrous fraction of the human faeces is the most resistant part to biodegrade. This fraction consists of cellulose, xylan and lignin components.

The production of methane must be inhibited in the MELISSA cycle, because it is of no use in the other compartments. Low pH values (6.5) in the demonstration reactor inactivated the methanogenic bacteria (TN41.2). Under these circumstances a conversion efficiency of only 30% could be achieved. Proteins were biodegraded for about 70% and non-protein material for only 10%.

The combination of two demonstration reactors, the first one operated at pH 6 and fed with faecal material and the second one operated at pH around 7 and fed with MELiSSA cake pretreated with cellulase and xylanase, resulted in a total conversion efficiency of around 53%. For this efficiency the CO_2, CH_4 and volatile fatty acids productions are taken into account. Proteins were converted for 70% and fibres for 44% (TN 43.2).

Conversion efficiencies were calculated during the operation of the demonstration reactor. Four different conversion efficiency can be distinguished. The total conversion efficiency encloses the production of VFA, carbondioxide and methane. Methane is of no use in the MELISSA-loop and therefore a second conversion efficiency is calculated. In the MELISSA conversion efficiency only the conversion of organic matter into volatile fatty acids and carbondioxide is taken into consideration. At pH 6.5 the total conversion efficiency will be identically to the MELiSSA conversion efficiency. The conversion efficiencies of fibre and protein were also calculated.

In this technical note, the results of the thermohilic anaerobic demonstration reactor at pH 6-6.5 and fed with faecal material are represented. The data of this reactor will be used by the University 'Blaise Pascal' to perform simulation experiments.

2. Reactor 1

2.1 Set-up

The demonstration reactor had a wet volume of 1.6 litre and a temperature of 55°C. The reactor was set at a pH of 6.5 in order to inhibit the methane production and was continuously stirred with a magnetic stirrer. The reactor was fed with faecal material collected from 8 different persons between age 24 and 40. The characteristics of the faecal material are represented in Table 2-1. Every two days 150 ml of feed was fed into the reactor after sampling 150 ml from the reactor. The hydraulic retention time obtained in the reactor was about 21 days. The reactor was automatically flushed with N_2-gas after every feeding and two times a day. In this way the produced biogas and H_2 was removed from the reactor. The gas was trapped in a solution containing 1 N KOH in order to capture the produced carbondioxide. The amount of CO_2 was measured by titration. Gas was frequently measured with a gasanalyser.

Table 2-1 Reactor 1: Characteristics of the faecal material

Parameter	Unit	Mean value
pH		7.1
Dry matter	g/l	23
Ash	g/l	3.4
Total nitrogen	mg/l	1091
Ammonium nitrogen	mg/l	73
VFA	mg/l	544
Acetic acid		261
Propionic acid		106
Iso Butyric acid		17
Butyric acid		97
Iso valeric acid		28
Valeric acid		23
Caproic acid		12

2.2 Results

2.2.1 pH and EC

The pH was set at 6.0 in order to inhibit the growth of the methanogens and therefore to prevent methane production. The EC was measured to have an idea about the dissolved salts present in the reactor. The value fluctuated between 7 and 8 mS/cm, which is normal for anaerobic reactors.

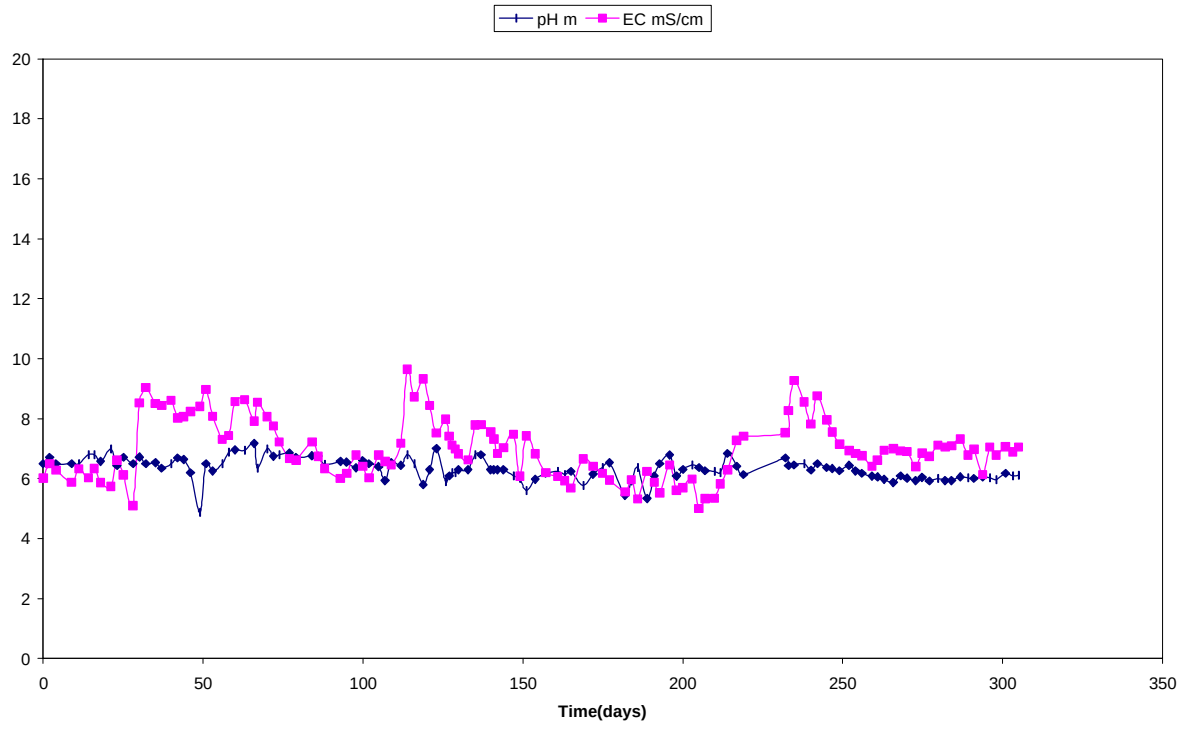

Figure 2-1 pH and EC in reactor

2.2.2 Dry matter, organic matter and ashes

At day 35 the DW increased due to the feeding of different faecal material. This faecal material had a higher DW content. At day 102 the DW decreased. At that time the reactor was fed with faecal material with a lower DW content.

It was difficult to take a homogenous sample and therefore small fluctuations are noticed. The ash concentration stabilised at a value of around 2.7 g/l.

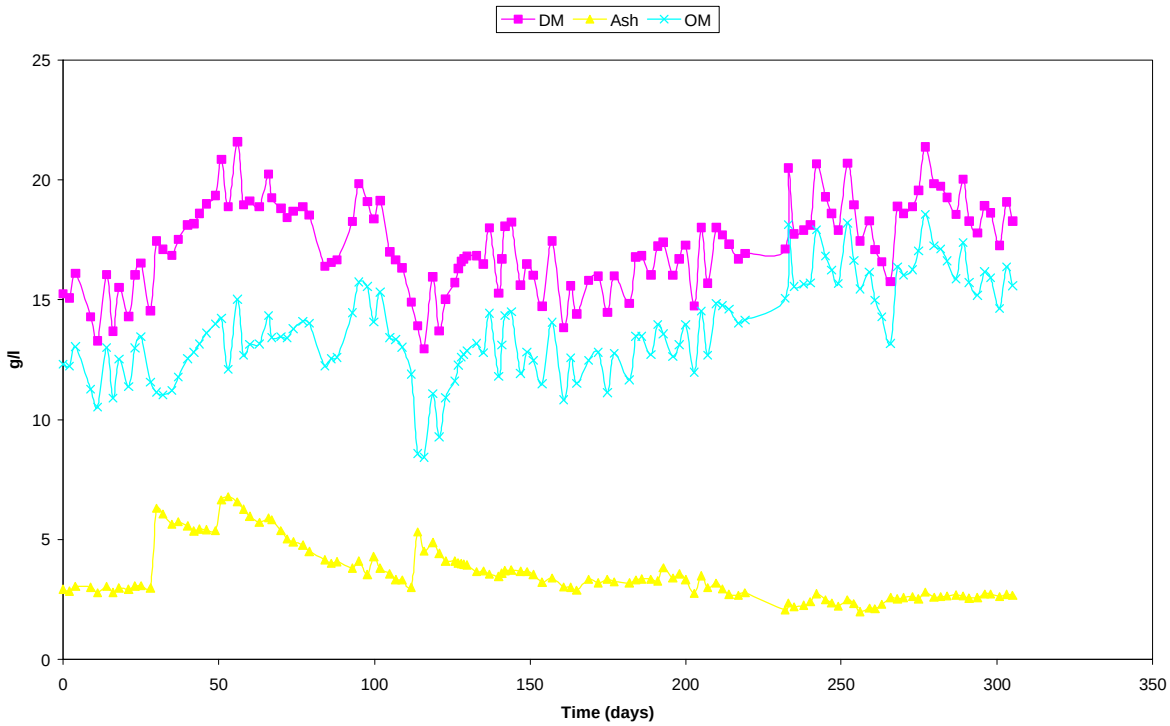

Figure 2-2 Dry matter, organic matter in reactor

2.2.3 NH_4 -N and N-org

The increase of NH_4-N at day 95 was due to a different feed. This faecal material contained a higher ammonia percentage than the previous feed. During the Christmas period gelatine and starch were fed into the reactor. The increase of NH_4-N was due to a easy conversion of gelatine into NH_4-N. The amount of gelatine fed into the reactor during Christmas was probably to high because not all N-tot was converted into ammonia. After the Christmas period the NH4-N concentration decreased and reached a stable value of around 600 mg/l. The fluctuations in N-org are due to the difficulty to take a homogenous sample since particles float in the solution.

2.2.4 Volatile fatty acids

In Figure 2-4 the volatile fatty acids are represented. The increases noticed at day 67 and 150 were due to a different feed fed into the reactor. This feed contained a higher amount of volatile fatty acids. At day 219 the reactor was fed with gelatine and starch. The increase of VFA at that time is due to the fact that starch is good degradable by the autochtonous bacteria of faecal material. The volatile fatty acids composition is represented in Figure 2-5. The majority of produced VFA was acetic acid due to the inhibition of the methanogenesis.

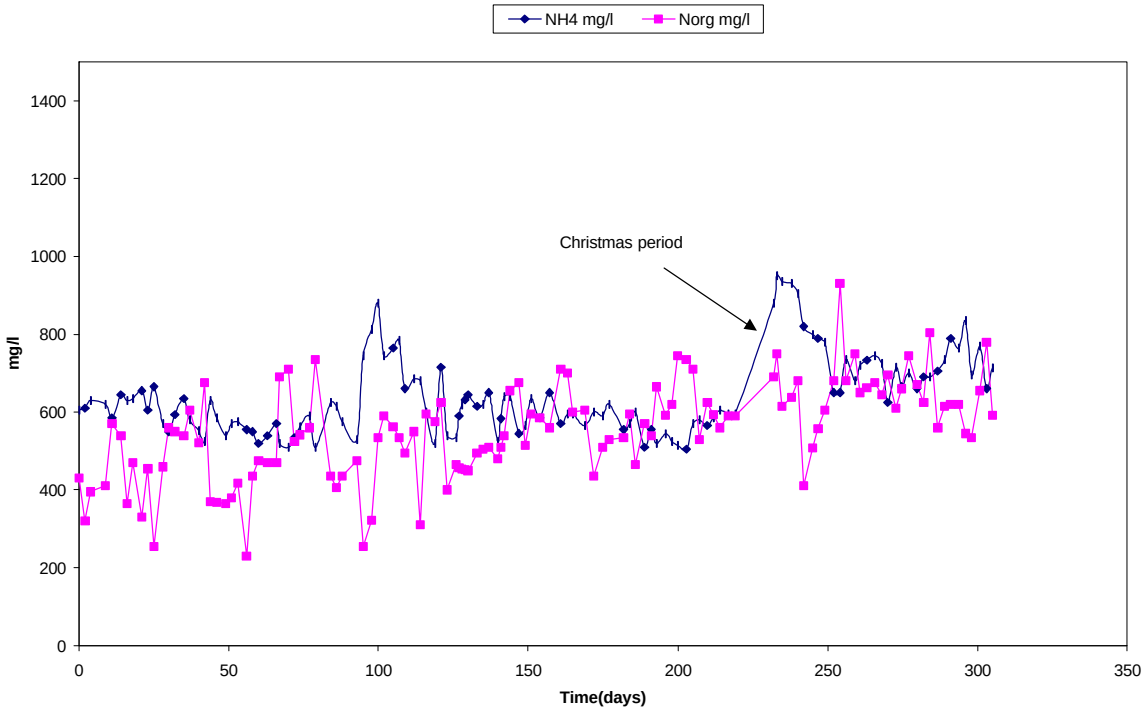

Figure 2-3 NH_4-N and N-org in reactor

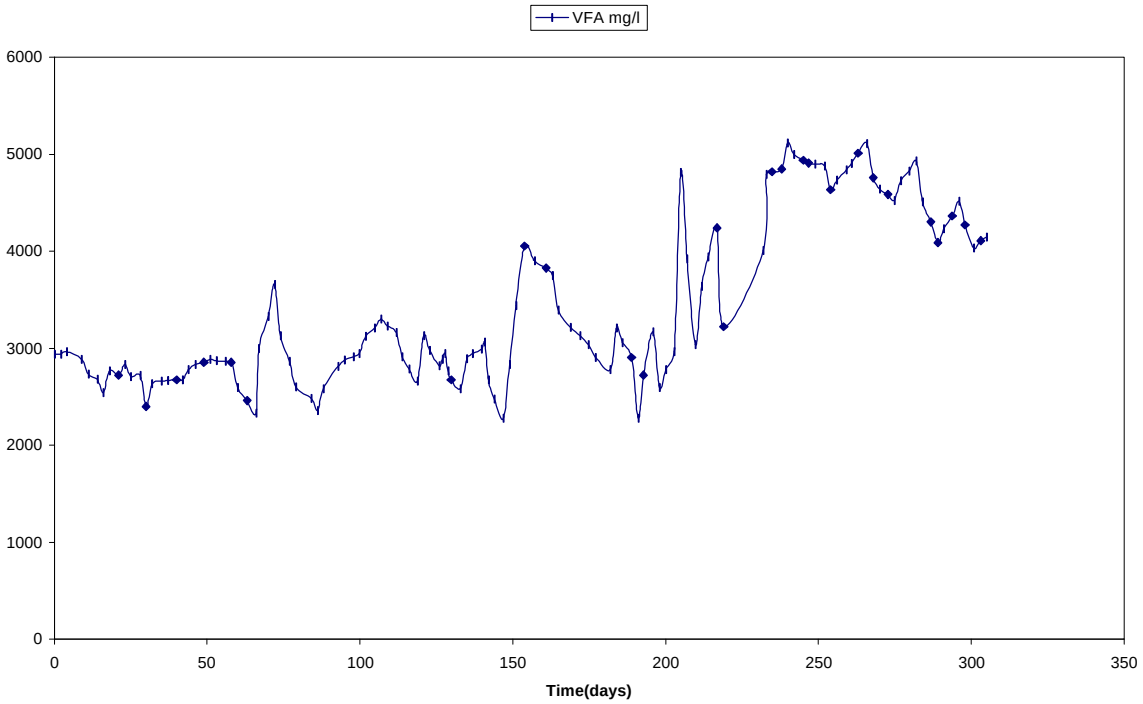

Figure 2-4 Volatile fatty acids in reactor

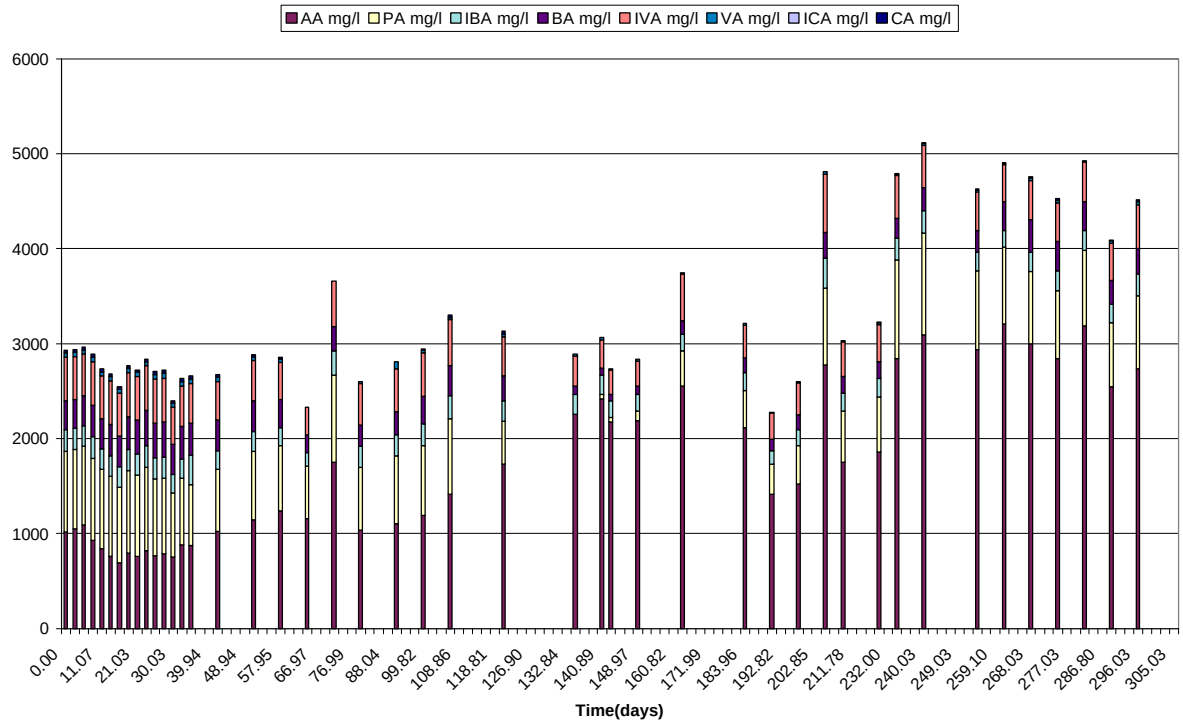

Figure 2-5 Volatile fatty acids composition in reactor

2.2.5 Biogas production

The cumulative biogas production is represented in Figure 2-6. At low pH, the methanogens were inhibited and only CO_2 was produced. The gas production during the Christmas period was not measured.

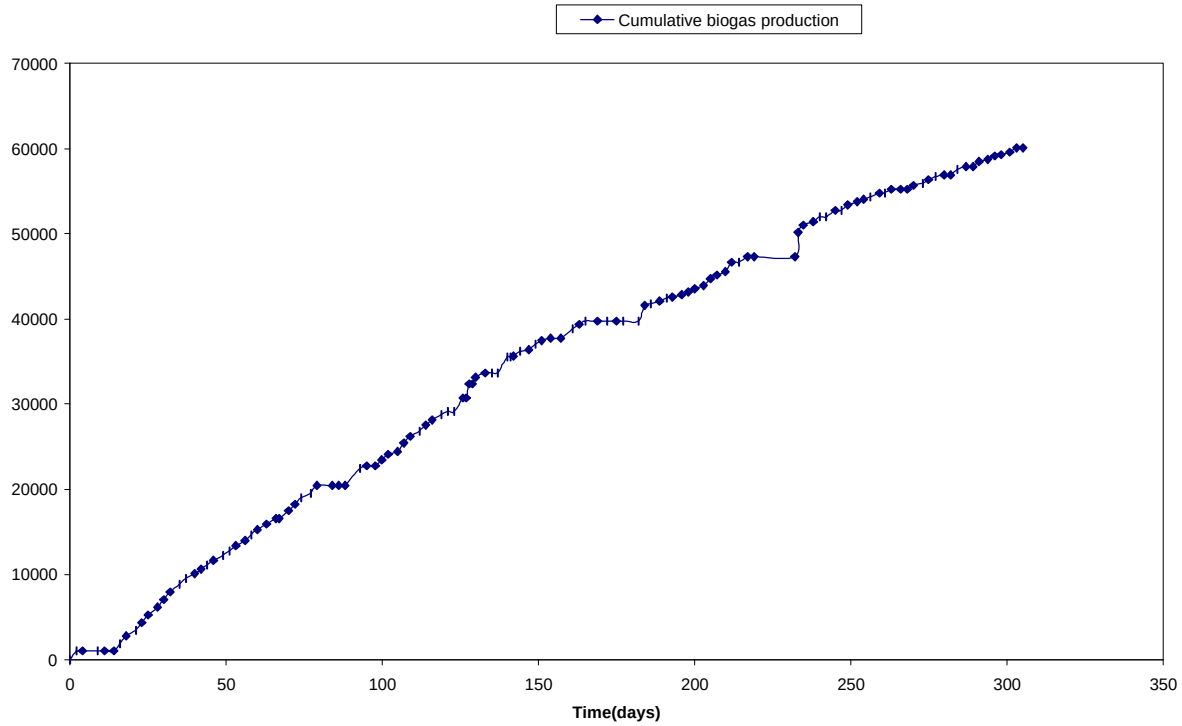

Figure 2-6 Cumulative CO_2 production of reactor

2.2.6 Conversion efficiency

The conversion efficiencies are represented in Figure 2-7. Three conversion efficiencies were calculated. The MELiSSA conversion efficiency encloses the production of VFA and CO_2 and was about 40%. Fibres were converted for about 28%. The protein conversion efficiency had a stable value of 60%.

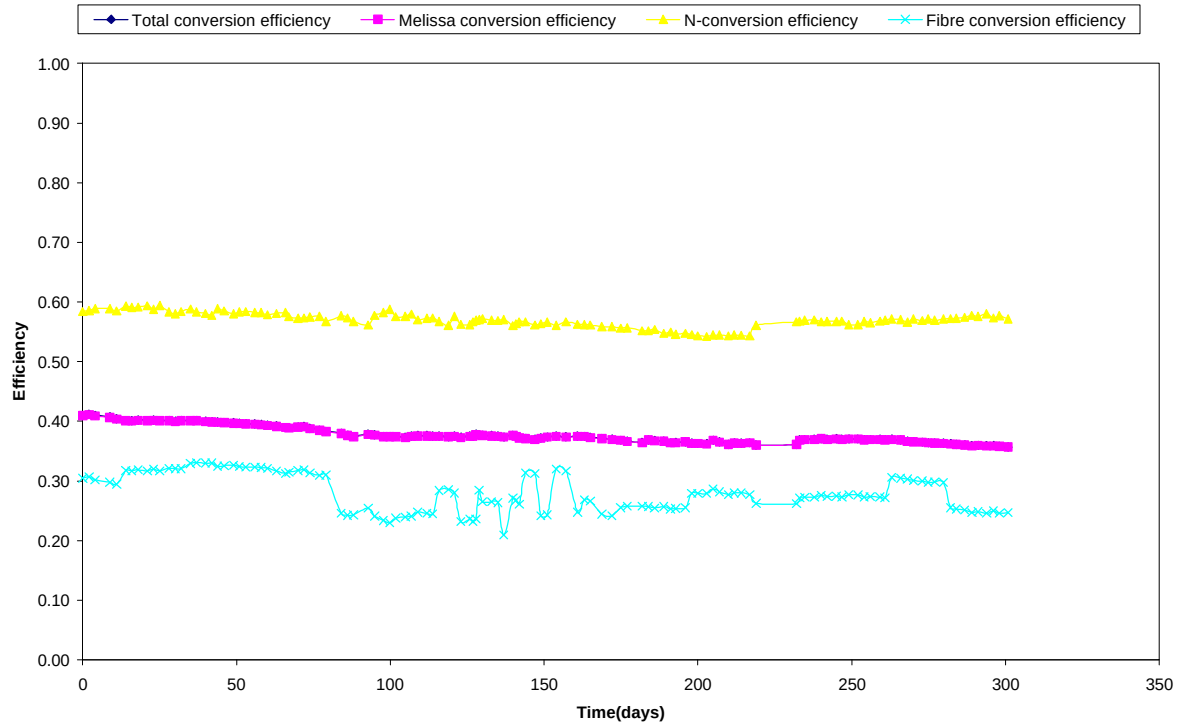

Figure 2-7 Conversion efficiencies

3. Conclusion

The conversion efficiencies of faecal material was investigated using a thermophilic demonstration reactor with autochtonous bacteria of faecal material. The reactor was operated at pH around 6.5 to avoid methane production, because it is of no use for the further loop. A total conversion efficiency of 40% was found. Proteins were converted for 60% and fibres for 28%. These results are similar to the results obtained last year (TN 43.2). The data will be used for the validation of the model of the anaerobic thermophilic reactor. It can be concluded that a stable inoculum was cultivated during the past two years.

ADDENDUM REACTOR

Feed of reactor

Date	Day	pH	DM	Ash	NH_4	Ntot	VFA	Amount
			g/l	g/l	mg/l	mg/l	mg/l	l
17-05-99	0.00	6.90	17.03	2.67	45	905	786	0.15
19-05-99	2.03	6.90	17.03	2.67	45	905	786	0.15
21-05-99	3.97	6.90	17.03	2.67	45	905	786	0.15
26-05-99	8.84	6.90	17.03	2.67	45	905	786	0.15
28-05-99	11.07	6.90	17.03	2.67	45	905	786	0.15
31-05-99	14.03	7.00	21.97	3.17	110	1025	877	0.15
2-06-99	15.99	7.00	21.97	3.17	110	1025	877	0.15
4-06-99	17.99	7.00	21.97	3.17	110	1025	877	0.15
7-06-99	21.03	7.00	21.97	3.17	110	1025	877	0.15
9-06-99	23.03	7.00	21.97	3.17	110	1025	877	0.15
11-06-99	25.03	7.00	21.97	3.17	110	1025	877	0.15
14-06-99	28.04	7.00	21.97	3.17	110	1025	877	0.15
16-06-99	30.03	7.00	21.97	3.17	110	1025	877	0.15
18-06-99	31.99	7.00	21.97	3.17	110	1025	877	0.15
21-06-99	34.99	7.24	23.39	3.85	42	910	388	0.15
23-06-99	36.97	7.24	23.39	3.85	42	910	388	0.15
26-06-99	39.94	7.24	23.39	3.85	42	910	388	0.15
28-06-99	41.97	7.24	23.39	3.85	42	910	388	0.15
30-06-99	43.84	7.24	23.39	3.85	42	910	388	0.15
2-07-99	45.97	7.24	23.39	3.85	42	910	388	0.15
5-07-99	48.94	7.24	23.39	3.85	42	910	388	0.15
7-07-99	50.90	7.24	23.39	3.85	42	910	388	0.15
9-07-99	53.05	7.24	23.39	3.85	42	910	388	0.15
12-07-99	56.01	7.24	23.39	3.85	42	910	388	0.15
14-07-99	57.95	7.24	23.39	3.85	42	910	388	0.15
16-07-99	59.96	7.24	23.39	3.85	42	910	388	0.15
19-07-99	62.99	7.69	30.92	5.99	58	1190	495	0.15
22-07-99	65.98	7.69	30.92	5.99	58	1190	495	0.15
23-07-99	66.97	7.69	30.92	5.99	58	1190	495	0.15
26-07-99	70.00	7.69	30.92	5.99	58	1190	495	0.15
28-07-99	72.00	7.69	30.92	5.99	58	1190	495	0.15
30-07-99	73.86	7.69	30.92	5.99	58	1190	495	0.15
2-08-99	76.99	7.69	30.92	5.99	58	1190	495	0.15
4-08-99	79.02	7.69	30.92	5.99	58	1190	495	0.15
9-08-99	84.03	7.22	25.21	3.69	80	1470	839	0.15
11-08-99	86.07	7.22	25.21	3.69	80	1470	839	0.15
13-08-99	88.04	7.22	25.21	3.69	80	1470	839	0.15
18-08-99	92.84	7.22	25.21	3.69	80	1470	839	0.15
20-08-99	94.91	7.22	25.21	3.69	80	1470	839	0.15
23-08-99	97.80	7.22	25.21	3.69	80	1470	839	0.15
25-08-99	99.82	7.22	25.21	3.69	80	1470	839	0.15
27-08-99	101.82	7.22	25.21	3.69	80	1470	839	0.15
30-08-99	104.86	7.14	17.86	2.54	39	1010	624	0.15
1-09-99	106.82	7.14	17.86	2.54	39	1010	624	0.15
3-09-99	108.86	7.14	17.86	2.54	39	1010	624	0.15
6-09-99	111.86	7.14	17.86	2.54	39	1010	624	0.15
8-09-99	113.85	7.14	17.86	2.54	39	1010	624	0.15
10-09-99	115.95	6.63	21.59	2.97	64	1020	677	0.15
13-09-99	118.81	6.63	21.59	2.97	64	1020	677	0.15
15-09-99	120.86	6.63	21.59	2.97	64	1020	677	0.15

Date	Day	pH	DM	Ash	NH_4	Ntot	VFA	Amount
			g/l	g/l	mg/l	mg/l	mg/l	l
17-09-99	122.89	6.93	16.03	3.32	54	920	402	0.15
20-09-99	125.82	6.93	16.03	3.32	54	920	402	0.15
21-09-99	126.90	6.93	16.03	3.32	54	920	402	0.15
22-09-99	127.81	6.93	16.03	3.32	54	920	402	0.15
23-09-99	128.81	6.63	21.59	2.97	64	1020	677	0.15
24-09-99	129.84	7.10	24.09	4.84	57	1175	270	0.15
27-09-99	132.84	7.10	24.09	4.84	57	1175	270	0.15
29-09-99	134.99	7.10	24.09	4.84	57	1175	270	0.15
1-10-99	136.89	7.10	21.65	3.06	52	1400	674	0.15
4-10-99	139.85	7.10	24.09	4.84	57	1175	270	0.15
5-10-99	140.89	7.10	24.09	4.84	57	1175	270	0.15
6-10-99	142.00	7.10	24.09	4.84	57	1175	270	0.15
8-10-99	143.95	7.00	18.43	2.59	78	655	716	0.15
11-10-99	146.95	7.00	18.43	2.59	78	655	716	0.15
13-10-99	148.97	7.00	19.19	2.38	320	1405	682	0.15
15-10-99	151.01	7.00	19.19	2.38	320	1405	682	0.15
18-10-99	153.84	7.00	18.43	2.59	78	655	716	0.15
21-10-99	157.10	7.00	18.43	2.59	78	655	716	0.15
25-10-99	160.82	7.00	19.19	2.38	320	1405	682	0.15
27-10-99	163.05	7.46	23.25	4.54	96	1180	144	0.15
29-10-99	164.97	7.46	23.25	4.54	96	1180	144	0.15
2-11-99	168.82	7.00	19.19	2.38	320	1405	682	0.15
5-11-99	171.99	7.00	19.19	2.38	320	1405	682	0.15
8-11-99	174.82	7.42	24.14	4.60	58	1230	219	0.15
10-11-99	177.07	7.46	23.25	4.54	96	1180	144	0.15
15-11-99	181.87	7.46	23.25	4.54	96	1180	144	0.15
17-11-99	183.96	7.49	20.64	4.21	113	1105	218	0.15
19-11-99	185.86	7.49	20.64	4.21	113	1105	218	0.15
22-11-99	188.82	7.49	20.64	4.21	113	1105	218	0.15
24-11-99	191.02	7.42	24.14	4.60	58	1230	219	0.15
26-11-99	192.82	7.49	20.64	4.21	113	1105	218	0.15
29-11-99	195.86	7.49	20.64	4.21	113	1105	218	0.15
1-12-99	197.97	7.07	25.61	2.79	64	1215	411	0.15
3-12-99	199.99	7.07	25.61	2.79	64	1215	411	0.15
6-12-99	202.85	7.07	25.61	2.79	64	1215	411	0.15
8-12-99	205.01	7.07	25.61	2.79	64	1215	411	0.15
10-12-99	207.03	7.07	25.61	2.79	64	1215	411	0.15
13-12-99	209.84	7.07	25.61	2.79	64	1215	411	0.15
15-12-99	211.78	7.07	25.61	2.79	64	1215	411	0.15
17-12-99	214.01	7.07	25.61	2.79	64	1215	411	0.15
20-12-99	216.89	6.82	20.17	2.25	45	980	699	0.15
22-12-99	219.01	6.82	20.17	2.25	45	980	699	0.15
4-01-00	232.00	6.82	20.17	2.25	45	980	699	0.15
5-01-00	233.03	6.82	20.17	2.25	45	980	699	0.15
7-01-00	234.78	6.82	20.17	2.25	45	980	699	0.15
10-01-00	237.89	6.82	20.17	2.25	45	980	699	0.15
12-01-00	240.03	6.82	20.17	2.25	45	980	699	0.15
14-01-00	242.01	6.82	20.17	2.25	45	980	699	0.15
17-01-00	244.98	6.82	20.17	2.25	45	980	699	0.15
19-01-00	246.82	6.82	20.17	2.25	45	980	699	0.15
21-01-00	249.03	6.82	20.17	2.25	45	980	699	0.15
24-01-00	252.03	6.82	20.17	2.25	45	980	699	0.15
26-01-00	254.05	6.82	20.17	2.25	45	980	699	0.15
28-01-00	256.03	6.82	20.17	2.25	45	980	699	0.15

Date	Day	pH	DM	Ash	NH_4	Ntot	VFA	Amount
			g/l	g/l	mg/l	mg/l	mg/l	l
31-01-00	259.10	6.82	20.17	2.25	45	980	699	0.15
2-02-00	260.79	6.82	20.17	2.25	45	980	699	0.15
4-02-00	263.01	6.83	27.47	2.73	49	1000	488	0.15
7-02-00	265.82	6.83	27.47	2.73	49	1000	488	0.15
9-02-00	268.03	6.83	27.47	2.73	49	1000	488	0.15
11-02-00	270.03	6.83	27.47	2.73	49	1000	488	0.15
14-02-00	272.84	6.83	27.47	2.73	49	1000	488	0.15
16-02-00	274.80	6.83	27.47	2.73	49	1000	488	0.15
18-02-00	277.03	6.83	27.47	2.73	49	1000	488	0.15
21-02-00	279.82	6.83	27.47	2.73	49	1000	488	0.15
23-02-00	282.02	7.28	24.59	3.15	60	1220	437	0.15
25-02-00	284.04	7.28	24.59	3.15	60	1220	437	0.15
28-02-00	286.80	7.28	24.59	3.15	60	1220	437	0.15
1-03-00	289.10	7.28	24.59	3.15	60	1220	437	0.15
3-03-00	291.02	7.28	24.59	3.15	60	1220	437	0.15
6-03-00	293.81	7.28	24.59	3.15	60	1220	437	0.15
8-03-00	296.03	7.28	24.59	3.15	60	1220	437	0.15
10-03-00	298.03	7.28	24.59	3.15	60	1220	437	0.15
13-03-00	300.82	7.28	24.59	3.15	60	1220	437	0.15
15-03-00	303.07	7.28	24.59	3.15	60	1220	437	0.15
17-03-00	305.03	7.28	24.59	3.15	60	1220	437	0.15

Volatile fatty acid composition in feed

Date	Day	VFA	AA	PA	IBA	BA	IVA	VA	ICA	CA
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
17-05-99	0.00	786	343	167	30	127	38	49	0	32
19-05-99	2.03	786	343	167	30	127	38	49	0	32
21-05-99	3.97	786	343	167	30	127	38	49	0	32
26-05-99	8.84	786	343	167	30	127	38	49	0	32
28-05-99	11.07	786	343	167	30	127	38	49	0	32
31-05-99	14.03	877	376	138	27	217	47	40	0	33
2-06-99	15.99	877	376	138	27	217	47	40	0	33
4-06-99	17.99	877	376	138	27	217	47	40	0	33
7-06-99	21.03	877	376	138	27	217	47	40	0	33
9-06-99	23.03	877	376	138	27	217	47	40	0	33
11-06-99	25.03	877	376	138	27	217	47	40	0	33
14-06-99	28.04	877	376	138	27	217	47	40	0	33
16-06-99	30.03	877	376	138	27	217	47	40	0	33
18-06-99	31.99	877	376	138	27	217	47	40	0	33
21-06-99	34.99	388	149	82	24	71	39	22	0	0
23-06-99	36.97	388	149	82	24	71	39	22	0	0
26-06-99	39.94	388	149	82	24	71	39	22	0	0
28-06-99	41.97	388	149	82	24	71	39	22	0	0
30-06-99	43.84	388	149	82	24	71	39	22	0	0
2-07-99	45.97	388	149	82	24	71	39	22	0	0
5-07-99	48.94	388	149	82	24	71	39	22	0	0
7-07-99	50.90	388	149	82	24	71	39	22	0	0
9-07-99	53.05	388	149	82	24	71	39	22	0	0
12-07-99	56.01	388	149	82	24	71	39	22	0	0
14-07-99	57.95	388	149	82	24	71	39	22	0	0
16-07-99	59.96	388	149	82	24	71	39	22	0	0
19-07-99	62.99	438	214	80	32	57	55	0	0	0
22-07-99	65.98	438	214	80	32	57	55	0	0	0
23-07-99	66.97	438	214	80	32	57	55	0	0	0
26-07-99	70.00	438	214	80	32	57	55	0	0	0
28-07-99	72.00	438	214	80	32	57	55	0	0	0
30-07-99	73.86	438	214	80	32	57	55	0	0	0
2-08-99	76.99	438	214	80	32	57	55	0	0	0
4-08-99	79.02	438	214	80	32	57	55	0	0	0
9-08-99	84.03	839	400	118	32	160	50	42	0	38
11-08-99	86.07	839	400	118	32	160	50	42	0	38
13-08-99	88.04	839	400	118	32	160	50	42	0	38
18-08-99	92.84	839	400	118	32	160	50	42	0	38
20-08-99	94.91	839	400	118	32	160	50	42	0	38
23-08-99	97.80	839	400	118	32	160	50	42	0	38
25-08-99	99.82	839	400	118	32	160	50	42	0	38
27-08-99	101.82	839	400	118	32	160	50	42	0	38
30-08-99	104.86	624	317	88	18	129	16	26	0	31
1-09-99	106.82	624	317	88	18	129	16	26	0	31
3-09-99	108.86	624	317	88	18	129	16	26	0	31
6-09-99	111.86	624	317	88	18	129	16	26	0	31
8-09-99	113.85	624	317	88	18	129	16	26	0	31
10-09-99	115.95	677	292	146	20	132	24	34	0	29
13-09-99	118.81	677	292	146	20	132	24	34	0	29
15-09-99	120.86	677	292	146	20	132	24	34	0	29
17-09-99	122.89	402	178	82	19	68	22	19	0	15
20-09-99	125.82	402	178	82	19	68	22	19	0	15

Date	Day	VFA	AA	PA	IBA	BA	IVA	VA	ICA	CA
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
21-09-99	126.90	402	178	82	19	68	22	19	0	15
22-09-99	127.81	402	178	82	19	68	22	19	0	15
23-09-99	128.81	677	292	146	20	132	24	34	0	29
24-09-99	129.84	270	162	48	0	37	24	0	0	0
27-09-99	132.84	270	162	48	0	37	24	0	0	0
29-09-99	134.99	270	162	48	0	37	24	0	0	0
1-10-99	136.89	674	346	120	23	123	30	33	0	0
4-10-99	139.85	270	162	48	0	37	24	0	0	0
5-10-99	140.89	270	162	48	0	37	24	0	0	0
6-10-99	142.00	270	162	48	0	37	24	0	0	0
8-10-99	143.95	716	357	176	18	117	27	21	0	0
11-10-99	146.95	716	357	176	18	117	27	21	0	0
13-10-99	148.97	682	304	189	20	113	28	28	0	0
15-10-99	151.01	682	304	189	20	113	28	28	0	0
18-10-99	153.84	716	357	176	18	117	27	21	0	0
21-10-99	157.10	716	357	176	18	117	27	21	0	0
25-10-99	160.82	682	304	189	20	113	28	28	0	0
27-10-99	163.05	144	88	21	8	12	15	0	0	0
29-10-99	164.97	144	88	21	8	12	15	0	0	0
2-11-99	168.82	682	304	189	20	113	28	28	0	0
5-11-99	171.99	682	304	189	20	113	28	28	0	0
8-11-99	174.82	219	128	35	11	15	21	8	0	0
10-11-99	177.07	144	88	21	8	12	15	0	0	0
15-11-99	181.87	144	88	21	8	12	15	0	0	0
17-11-99	183.96	218	130	33	9	31	16	0	0	0
19-11-99	185.86	218	130	33	9	31	16	0	0	0
22-11-99	188.82	218	130	33	9	31	16	0	0	0
24-11-99	191.02	219	128	35	11	15	21	8	0	0
26-11-99	192.82	218	130	33	9	31	16	0	0	0
29-11-99	195.86	218	130	33	9	31	16	0	0	0
1-12-99	197.97	411	204	88	12	67	20	20	0	0
3-12-99	199.99	411	204	88	12	67	20	20	0	0
6-12-99	202.85	411	204	88	12	67	20	20	0	0
8-12-99	205.01	411	204	88	12	67	20	20	0	0
10-12-99	207.03	411	204	88	12	67	20	20	0	0
13-12-99	209.84	411	204	88	12	67	20	20	0	0
15-12-99	211.78	411	204	88	12	67	20	20	0	0
17-12-99	214.01	411	204	88	12	67	20	20	0	0
20-12-99	216.89	699	372	136	12	111	17	32	0	19
22-12-99	219.01	699	372	136	12	111	17	32	0	19
4-01-00	232.00	699	372	136	12	111	17	32	0	19
5-01-00	233.03	699	372	136	12	111	17	32	0	19
7-01-00	234.78	699	372	136	12	111	17	32	0	19
10-01-00	237.89	699	372	136	12	111	17	32	0	19
12-01-00	240.03	699	372	136	12	111	17	32	0	19
14-01-00	242.01	699	372	136	12	111	17	32	0	19
17-01-00	244.98	699	372	136	12	111	17	32	0	19
19-01-00	246.82	699	372	136	12	111	17	32	0	19
21-01-00	249.03	699	372	136	12	111	17	32	0	19
24-01-00	252.03	699	372	136	12	111	17	32	0	19
26-01-00	254.05	699	372	136	12	111	17	32	0	19
28-01-00	256.03	699	372	136	12	111	17	32	0	19
31-01-00	259.10	699	372	136	12	111	17	32	0	19
2-02-00	260.79	699	372	136	12	111	17	32	0	19

Date	Day	VFA	AA	PA	IBA	BA	IVA	VA	ICA	CA
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
4-02-00	263.01	488	219	94	12	100	21	27	0	15
7-02-00	265.82	488	219	94	12	100	21	27	0	15
9-02-00	268.03	488	219	94	12	100	21	27	0	15
11-02-00	270.03	488	219	94	12	100	21	27	0	15
14-02-00	272.84	488	219	94	12	100	21	27	0	15
16-02-00	274.80	488	219	94	12	100	21	27	0	15
18-02-00	277.03	488	219	94	12	100	21	27	0	15
21-02-00	279.82	488	219	94	12	100	21	27	0	15
23-02-00	282.02	437	223	109	0	71	13	21	0	0
25-02-00	284.04	437	223	109	0	71	13	21	0	0
28-02-00	286.80	437	223	109	0	71	13	21	0	0
1-03-00	289.10	437	223	109	0	71	13	21	0	0
3-03-00	291.02	437	223	109	0	71	13	21	0	0
6-03-00	293.81	437	223	109	0	71	13	21	0	0
8-03-00	296.03	437	223	109	0	71	13	21	0	0
10-03-00	298.03	437	223	109	0	71	13	21	0	0
13-03-00	300.82	437	223	109	0	71	13	21	0	0
15-03-00	303.07	437	223	109	0	71	13	21	0	0
17-03-00	305.03	437	223	109	0	71	13	21	0	0

Parameters of reactor

Date	Day	Volume	pH	EC	DM	Ash	OM	NH_4	Ntot	Norg	CO_2	VFA
		L		mS/cm	g/l	g/l	g/l	mg/l	mg/l	mg/l	mg	mg/l
17-05-99	0.00	1.6	6.50	6.02	15.25	2.94	12.32	605	1035	430	1500	2933
19-05-99	2.03	1.6	6.70	6.50	15.07	2.84	12.23	610	930	320	1012	2935
21-05-99	3.97	1.6	6.50	6.28	16.10	3.05	13.05	630	1025	395	0	2962
26-05-99	8.84	1.6	6.50	5.88	14.28	3.01	11.28	620	1030	410	0	2887
28-05-99	11.07	1.6	6.50	6.32	13.30	2.77	10.53	585	1155	570	0	2729
31-05-99	14.03	1.6	6.80	6.03	16.06	3.05	13.01	645	1185	540	0	2680
2-06-99	15.99	1.6	6.80	6.34	13.69	2.80	10.89	630	995	365	862	2543
4-06-99	17.99	1.6	6.57	5.87	15.52	2.99	12.53	635	1105	470	933	2766
7-06-99	21.03	1.6	6.98	5.73	14.30	2.93	11.37	655	985	330	658	2724
9-06-99	23.03	1.6	6.43	6.61	16.04	3.06	12.99	605	1060	455	898	2835
11-06-99	25.03	1.6	6.71	6.12	16.54	3.09	13.45	665	920	255	898	2707
14-06-99	28.04	1.6	6.50	5.10	14.53	2.98	11.56	570	1030	460	898	2717
16-06-99	30.03	1.6	6.72	8.53	17.45	6.30	11.15	550	1110	560	898	2401
18-06-99	31.99	1.6	6.50	9.03	*17.10*	6.07	11.04	593	1143	550	898	2629
21-06-99	34.99	1.6	6.53	*8.50*	16.85	5.64	11.21	635	1175	540	898	2659
23-06-99	36.97	1.6	6.35	8.44	17.52	5.74	11.78	580	1185	605	684	2667
26-06-99	39.94	1.6	6.50	8.61	18.12	5.58	12.54	553	1075	522	577	2671
28-06-99	41.97	1.6	6.69	8.03	18.17	5.36	12.81	525	1200	675	523	2674
30-06-99	43.84	1.6	6.64	8.06	18.60	5.44	13.17	630	1000	370	469	2778
2-07-99	45.97	1.6	6.20	8.24	19.00	5.40	13.60	585	953	368	534	2830
5-07-99	48.94	1.6	4.87	8.41	19.35	5.37	13.99	540	905	365	591	2856
7-07-99	50.90	1.6	6.50	8.97	20.87	6.65	14.22	570	949	379	550	2882
9-07-99	53.05	1.6	6.25	8.08	18.88	6.79	12.09	575	992	417	599	2869
12-07-99	56.01	1.6	6.50	7.31	21.59	6.58	15.02	555	785	230	623	2862
14-07-99	57.95	1.6	6.88	7.44	18.96	6.27	12.69	550	985	435	635	2856
16-07-99	59.96	1.6	6.96	8.57	19.11	5.97	13.14	520	995	475	641	2593
19-07-99	62.99	1.6	6.94	8.63	18.88	5.73	13.16	540	1010	470	644	2461
22-07-99	65.98	1.6	7.17	7.92	20.25	5.91	14.34	570	1040	470	648	2330
23-07-99	66.97	1.6	6.35	8.54	19.25	5.83	13.42	520	1210	690	0	2993
26-07-99	70.00	1.6	6.98	8.06	18.82	5.37	13.45	510	1220	710	954	3325
28-07-99	72.00	1.6	6.74	7.76	18.44	5.03	13.41	535	1060	525	736	3657
30-07-99	73.86	1.6	6.80	7.22	18.70	4.91	13.79	563	1105	542	748	3128
2-08-99	76.99	1.6	6.85	6.67	18.88	4.78	14.10	590	1150	560	512	2863
4-08-99	79.02	1.6	6.71	6.62	18.53	4.51	14.02	510	1245	735	920	2598
9-08-99	84.03	1.6	6.76	7.22	16.40	4.16	12.25	625	1060	435	0	2478
11-08-99	86.07	1.6	6.74	6.74	16.55	4.01	12.54	615	1020	405	0	2358
13-08-99	88.04	1.6	6.48	6.33	16.67	4.08	12.59	575	1010	435	0	2584
18-08-99	92.84	1.6	6.57	6.00	*18.26*	3.81	14.46	530	*1005*	475	2048	2809
20-08-99	94.91	1.6	6.55	6.18	19.85	4.12	15.73	745	1000	255	244	2878
23-08-99	97.80	1.6	6.36	6.78	*19.10*	3.54	15.56	813	1135	322	0	2912
25-08-99	99.82	1.6	6.60	6.41	18.37	4.29	14.08	880	1415	535	742	2946
27-08-99	101.82	1.6	6.50	6.03	19.14	3.82	15.32	745	1335	590	655	3122
30-08-99	104.86	1.6	6.40	6.79	17.00	3.57	13.43	765	1328	563	294	3210
1-09-99	106.82	1.6	5.94	6.58	*16.67*	3.33	13.34	785	1320	535	1001	3298
3-09-99	108.86	1.6	6.54	6.45	16.34	3.31	13.03	660	1155	495	804	3230
6-09-99	111.86	1.6	6.44	7.19	14.91	3.01	11.90	685	1235	550	595	3162
8-09-99	113.85	1.6	6.80	9.65	*13.90*	5.32	8.59	680	990	310	691	2911
10-09-99	115.95	1.6	6.50	8.73	12.96	4.52	8.44	600	1195	595	637	2786
13-09-99	118.81	1.6	5.80	9.33	15.95	4.88	11.07	520	1095	575	584	2660
15-09-99	120.86	1.6	6.30	*8.43*	13.71	4.43	9.29	715	1340	625	405	3129
17-09-99	122.89	1.6	7.00	7.52	15.02	4.11	10.91	540	940	400	0	2973
20-09-99	125.82	1.6	5.90	7.98	15.72	4.12	11.61	535	1000	465	1555	2818

Date	Day	Volume	pH	EC	DM	Ash	OM	NH_4	Ntot	Norg	CO_2	VFA
		L		mS/cm	g/l	g/l	g/l	mg/l	mg/l	mg/l	mg	mg/l
21-09-99	126.90	1.6	6.10	7.41	16.30	4.03	12.27	590	1048	458	0	2883
22-09-99	127.81	1.6	6.20	7.12	16.60	3.99	12.61	618	1072	454	1658	2948
23-09-99	128.81	1.6	6.20	6.98	16.70	3.97	12.73	632	1084	452	0	2765
24-09-99	129.84	1.6	6.30	6.83	16.82	3.95	12.87	645	1095	450	814	2673
27-09-99	132.84	1.6	6.30	6.63	16.84	3.67	13.18	615	*1110*	495	475	2582
29-09-99	134.99	1.6	6.80	7.78	16.49	3.70	12.79	620	1125	505	0	2890
1-10-99	136.89	1.6	6.80	7.80	18.01	3.56	14.45	650	1160	510	0	2941
4-10-99	139.85	1.6	6.30	*7.56*	15.27	3.46	11.82	525	1005	480	1880	2991
5-10-99	140.89	1.6	6.30	7.32	16.70	3.59	13.11	583	1093	510	0	3061
6-10-99	142.00	1.6	6.30	6.84	18.06	3.72	14.35	640	1180	540	106	2676
8-10-99	143.95	1.6	6.30	7.02	18.23	3.73	14.50	640	1295	655	551	2476
11-10-99	146.95	1.6	6.10	7.48	15.61	3.68	11.93	545	1220	675	208	2276
13-10-99	148.97	1.6	6.00	6.08	16.49	3.67	12.82	565	1080	515	625	2834
15-10-99	151.01	1.6	5.60	7.43	16.02	3.55	12.47	635	1230	595	431	3443
18-10-99	153.84	1.6	5.97	*6.82*	14.73	3.23	11.50	585	1170	585	311	4053
21-10-99	157.10	1.6	6.17	6.20	17.45	3.40	14.06	650	1210	560	0	3901
25-10-99	160.82	1.6	6.24	*6.07*	13.85	3.02	10.83	570	1280	710	1077	3825
27-10-99	163.05	1.6	6.14	5.94	15.59	3.02	12.57	595	1295	700	549	3749
29-10-99	164.97	1.6	6.24	5.68	14.41	2.90	11.51	595	1195	600	348	3392
2-11-99	168.82	1.6	5.77	6.66	15.81	3.34	12.48	565	1170	605	0	3213
5-11-99	171.99	1.6	6.15	6.42	15.99	3.19	12.80	600	1035	435	0	3124
8-11-99	174.82	1.6	6.37	6.17	14.47	3.34	11.13	590	1100	510	0	3034
10-11-99	177.07	1.6	6.54	5.95	16.00	3.25	12.75	620	1150	530	0	2907
15-11-99	181.87	1.6	5.44	5.56	14.86	3.20	11.67	555	1090	535	0	2780
17-11-99	183.96	1.6	5.92	5.96	16.79	3.32	13.48	570	1165	595	1845	3209
19-11-99	185.86	1.6	6.37	5.32	16.84	3.36	13.48	600	1065	465	188	3058
22-11-99	188.82	1.6	5.34	6.24	16.04	3.34	12.71	510	1080	570	311	2907
24-11-99	191.02	1.6	6.08	*5.88*	17.24	3.27	13.97	555	1095	540	346	2278
26-11-99	192.82	1.6	6.50	5.52	17.40	3.82	13.58	520	1185	665	164	2722
29-11-99	195.86	1.6	6.78	6.46	16.02	3.39	12.63	544	1135	592	248	3165
1-12-99	197.97	1.6	6.08	5.61	16.70	3.57	13.13	525	1145	620	331	2596
3-12-99	199.99	1.6	6.31	5.70	17.28	3.33	13.95	515	1260	745	402	2779
6-12-99	202.85	1.6	6.46	5.99	14.74	2.76	11.98	505	1240	735	358	2961
8-12-99	205.01	1.6	6.38	5.00	18.02	3.50	14.52	570	1280	710	786	4810
10-12-99	207.03	1.6	6.27	5.33	15.69	3.00	12.70	580	1110	530	414	3922
13-12-99	209.84	1.6	6.24	5.35	18.01	3.18	14.84	565	1190	625	428	3033
15-12-99	211.78	1.6	6.20	5.83	17.70	2.94	14.76	585	1178	593	1065	3637
17-12-99	214.01	1.6	6.84	6.30	17.31	2.71	14.60	605	1165	560	0	3939
20-12-99	216.89	1.6	6.42	7.28	16.70	2.67	14.03	595	1185	590	655	4241
22-12-99	219.01	1.6	6.13	*7.41*	16.93	2.78	14.15	595	1185	590	0	3221
4-01-00	232.00	1.6	6.69	7.53	17.12	2.06	15.06	880	1570	690	0	4006
5-01-00	233.03	1.6	6.43	8.27	20.50	2.37	18.13	950	1700	750	2895	4790
7-01-00	234.78	1.6	6.46	9.28	17.74	2.19	15.55	935	1550	615	821	4818
10-01-00	237.89	1.6	6.49	*8.56*	*17.90*	2.26	15.65	930	1568	638	437	4845
12-01-00	240.03	1.6	6.28	7.83	18.11	2.41	15.70	905	1585	680	549	5114
14-01-00	242.01	1.6	6.49	8.76	20.67	2.75	17.92	820	1230	410	0	4996
17-01-00	244.98	1.6	6.38	7.96	19.30	2.49	16.81	800	1308	508	757	4937
19-01-00	246.82	1.6	6.33	7.56	18.60	2.36	16.24	790	1347	557	0	4908
21-01-00	249.03	1.6	6.27	7.15	17.90	2.23	15.67	780	1385	605	631	4893
24-01-00	252.03	1.6	6.44	6.93	20.69	2.50	18.19	650	1330	680	402	4878
26-01-00	254.05	1.6	6.25	6.84	18.96	2.33	16.63	650	1580	930	285	4629
28-01-00	256.03	1.6	6.17	6.76	17.46	2.00	15.46	735	1415	680	276	4731
31-01-00	259.10	1.6	6.08	6.42	18.30	2.14	16.16	680	1430	750	458	4833
2-02-00	260.79	1.6	6.06	6.62	17.09	2.11	14.99	720	1370	650	0	4903

Date	Day	Volume	pH	EC	DM	Ash	OM	NH_4	Ntot	Norg	CO_2	VFA
		L		mS/cm	g/l	g/l	g/l	mg/l	mg/l	mg/l	mg	mg/l
4-02-00	263.01	1.6	5.97	6.95	16.58	2.29	14.29	733	1395	662	414	5007
7-02-00	265.82	1.6	5.87	7.00	15.75	2.57	13.18	745	1420	675	0	5111
9-02-00	268.03	1.6	6.09	6.92	18.90	2.53	16.37	725	1370	645	0	4756
11-02-00	270.03	1.6	6.01	6.91	18.60	2.57	16.03	625	1320	695	469	4640
14-02-00	272.84	1.6	5.94	6.40	18.88	2.63	16.25	715	1325	610	260	4582
16-02-00	274.80	1.6	6.04	6.85	19.57	2.54	17.03	665	1325	660	414	4524
18-02-00	277.03	1.6	5.92	6.75	21.37	2.81	18.57	700	1445	745	346	4725
21-02-00	279.82	1.6	6.00	7.12	19.85	2.60	17.26	660	1330	670	224	4826
23-02-00	282.02	1.6	5.94	7.05	19.73	2.62	17.11	690	1315	625	0	4927
25-02-00	284.04	1.6	5.94	7.09	19.27	2.64	16.63	690	1495	805	642	4508
28-02-00	286.80	1.6	6.06	7.32	18.56	2.70	15.86	705	1265	560	346	4299
1-03-00	289.10	1.6	6.03	6.78	20.03	2.65	17.38	735	1350	615	0	4089
3-03-00	291.02	1.6	6.00	6.97	18.29	2.56	15.73	790	1410	620	590	4227
6-03-00	293.81	1.6	6.06	6.14	17.78	2.59	15.19	765	1385	620	248	4365
8-03-00	296.03	1.6	6.03	7.05	18.91	2.74	16.17	835	1380	545	399	4512
10-03-00	298.03	1.6	5.96	6.78	18.64	2.73	15.91	695	1230	535	153	4273
13-03-00	300.82	1.6	6.17	7.07	17.26	2.63	14.64	770	1425	655	286	4033
15-03-00	303.07	1.6	6.09	6.89	19.08	2.71	16.37	660	1440	780	516	*4107*
17-03-00	305.03	1.6	6.11	7.05	18.28	2.69	15.59	713	1305	592	0	*4144*

Volatile fatty acid composition in reactor

Date	Day	VFA	AA	PA	IBA	BA	IVA	VA	ICA	CA
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
17-05-99	0.00	2933	1012	852	230	303	461	46	0	29
19-05-99	2.03	2935	1046	838	221	302	451	47	0	29
21-05-99	3.97	2962	1090	831	213	314	439	46	0	29
26-05-99	8.84	2887	923	866	226	337	458	47	0	31
28-05-99	11.07	2729	841	837	214	316	450	43	0	28
31-05-99	14.03	2680	758	842	220	329	460	44	0	28
2-06-99	15.99	2543	691	797	213	325	447	43	0	27
4-06-99	17.99	2766	791	871	222	349	461	44	0	29
7-06-99	21.03	2724	756	857	225	355	462	42	0	28
9-06-99	23.03	2835	818	878	229	368	470	43	0	29
11-06-99	25.03	2707	764	810	225	366	461	47	0	34
14-06-99	28.04	2717	787	794	226	369	459	47	0	34
16-06-99	30.03	2401	750	678	193	318	389	42	0	31
18-06-99	31.99	2629	878	701	205	345	423	45	0	32
21-06-99	34.99	2659	875	639	309	338	418	45	0	33
28-06-99	41.97	2674	1020	658	198	319	406	46	0	27
7-07-99	50.90	2882	1142	722	212	321	425	38	0	24
14-07-99	57.95	2856	1235	688	192	294	394	34	0	19
22-07-99	65.98	2330	1161	548	142	189	289	0	0	0
28-07-99	72.00	3657	1752	915	251	263	476	0	0	0
4-08-99	79.02	2598	1032	664	219	224	440	18	0	0
18-08-99	92.84	2809	1103	716	224	241	447	78	0	0
25-08-99	99.82	2946	1188	735	234	288	461	22	0	19
1-09-99	106.82	3298	1414	792	247	317	482	24	0	23
15-09-99	120.86	3129	1729	453	213	267	411	28	0	28
29-09-99	134.99	2890	2255	0	208	94	309	25	0	0
5-10-99	140.89	3061	2417	44	206	77	293	24	0	0
6-10-99	142.00	2735	2175	47	175	67	257	14	0	0
13-10-99	148.97	2834	2191	98	177	85	266	17	0	0
27-10-99	163.05	3749	2557	366	174	142	493	17	0	0
17-11-99	183.96	3209	2114	391	189	153	348	14	0	0
24-11-99	191.02	2278	1413	316	145	117	277	10	0	0
1-12-99	197.97	2596	1520	403	173	153	336	11	0	0
8-12-99	205.01	4810	2774	810	314	275	613	24	0	0
13-12-99	209.84	3033	1750	538	191	172	365	16	0	1
22-12-99	219.01	3221	1859	576	195	182	388	17	0	4
5-01-00	233.03	4790	2845	1038	227	210	447	18	0	5
12-01-00	240.03	5114	3092	1073	233	244	445	21	0	6
26-01-00	254.05	4629	2939	826	194	229	405	23	0	13
2-02-00	260.79	4903	3205	810	176	304	386	14	1	7
9-02-00	268.03	4756	2996	761	203	342	414	26	0	14
16-02-00	274.80	4524	2843	717	205	312	408	25	0	14
23-02-00	282.02	4927	3188	790	212	300	422	15	0	0
1-03-00	289.10	4089	2545	676	196	246	395	21	0	11
8-03-00	296.03	4512	2736	766	228	276	459	30	0	18