ECOGI
Pre-treatment of biomass for anaerobic digestion

Mechanical pretreatment and separation of organic waste from households and industry to obtain a pulp for biogasification

Testreport

J.no.1004

Version 1, Feb 12th 2013
Revised version 5, may 6th 2013

Table of contents

1. Introduction

This test report is the result of a test carried out for verification of the performance of an environmental technology following the ETV method. The format used for reporting follows guidelines in EU general verification protocol version 1.0 December 15th 2011.

1.1. Name and contact of proposer

Proposer

Komtek Miljø af 2012 A/S, Drivervej 8, DK 6670 Holsted
Contact: Bjarne Larsen, phone: +45 7020 54 89, e-mail: Bjarne@komtek.dk

1.2. Name of test centre/test responsible

Danish Technological Institute, Verification Centre, Life Science Division, Kongsvang Allé 29, DK-8000, Aarhus, Denmark.
Test responsible: Bjørn Malmgren-Hansen (BMH), phone: +45 72201810, e-mail: bmh@teknologisk.dk.
Internal reviewer: Lotte Bjerrum Friis-Holm (LBFH), phone: +45 72201837, e-mail: lbfh@teknologisk.dk

1.3. Reference to test plan and specific verification protocol

The test plan is titled: Ecogi, Testplan J.no.1004
The verification protocol is titled: Ecogi, Verification Protocol J.no.1004

1.4. Deviations to test plan

There were minor deviations of the method in the test plan for the sorting procedure as described in part 1.10.

2. Test design

The test design is based on 3 repeated test runs of the ECOGI for each of two different kinds of waste in order to evaluate the customer claims concerning the following issues:

- Recovery of organic matter for biogas production[1] in pulp
- Purity of organic matter for biogas production in pulp
- Energy consumption per ton waste
- Water consumption per ton waste

[1] Organic matter is defined as material which can be converted into biogas within a normal period of operation approx. 25-30 days of mesophilic operation and 18-21 days of thermophilic operation . Wood pieces of size >5*5*5 mm are not included as they are not considered digestible within a normal operation period in a biogas plant.

The two types of waste are:

1. Organic fraction from household waste Vejle Kommune (waste sorting system).
2. Food waste from supermarket 25 %, 25% dairy waste and 50% of (1)

Every test run consists of 3 batch runs. The samples taken under the 3 batches are combined to one test run sample (Figure 1). Three tons waste is processed per batch.

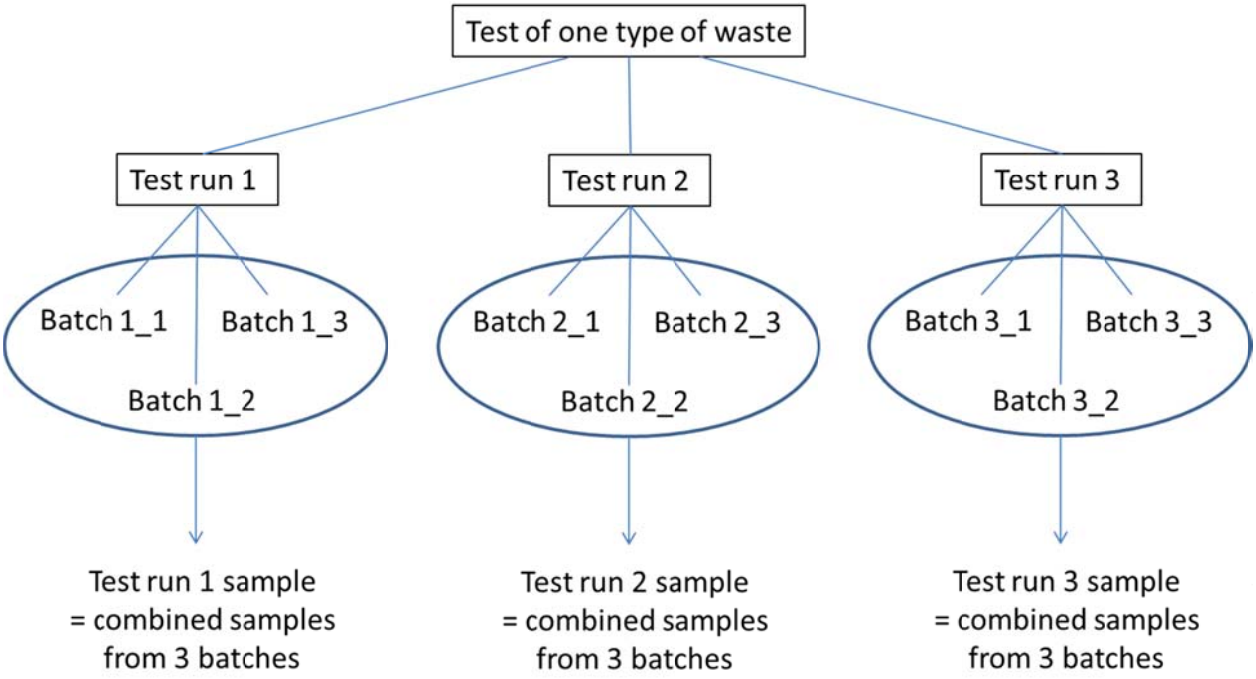

Figure 1: test runs and sampling for the two waste types

Calculation of purity:
Purity of biopulp is calculated as given in appendix 3
Recovery of biopulp:
Recovery of biopulp is calculated as given in appendix 3.

1.5. Test site

The test site is Komtek A/S, Drivervej 8, DK 6670 Holsted

1.5.1. Types of test sites

The site is a plant performing composting operation with a separate treatment of organic waste using the developed ECOGI process.

1.5.2. Addresses

Test site

Komtek Miljø af 2012 A/S, Drivervej 8, DK 6670 Holsted

1.5.3. Descriptions

The ECOGI plant is placed in a separate closed building at Komtek. All equipment in the building including necessary ventilation is run by electrical power which can be logged separately from other facilities at Komtek.

1.6. Tests

1.6.1. Test methods

Measurement of recovery and purity is based on measuring all mass flows during operation of the ECOGI shown in Figure 2 and analysis of a number of parameters of representative samples taken from some of the mass flows.

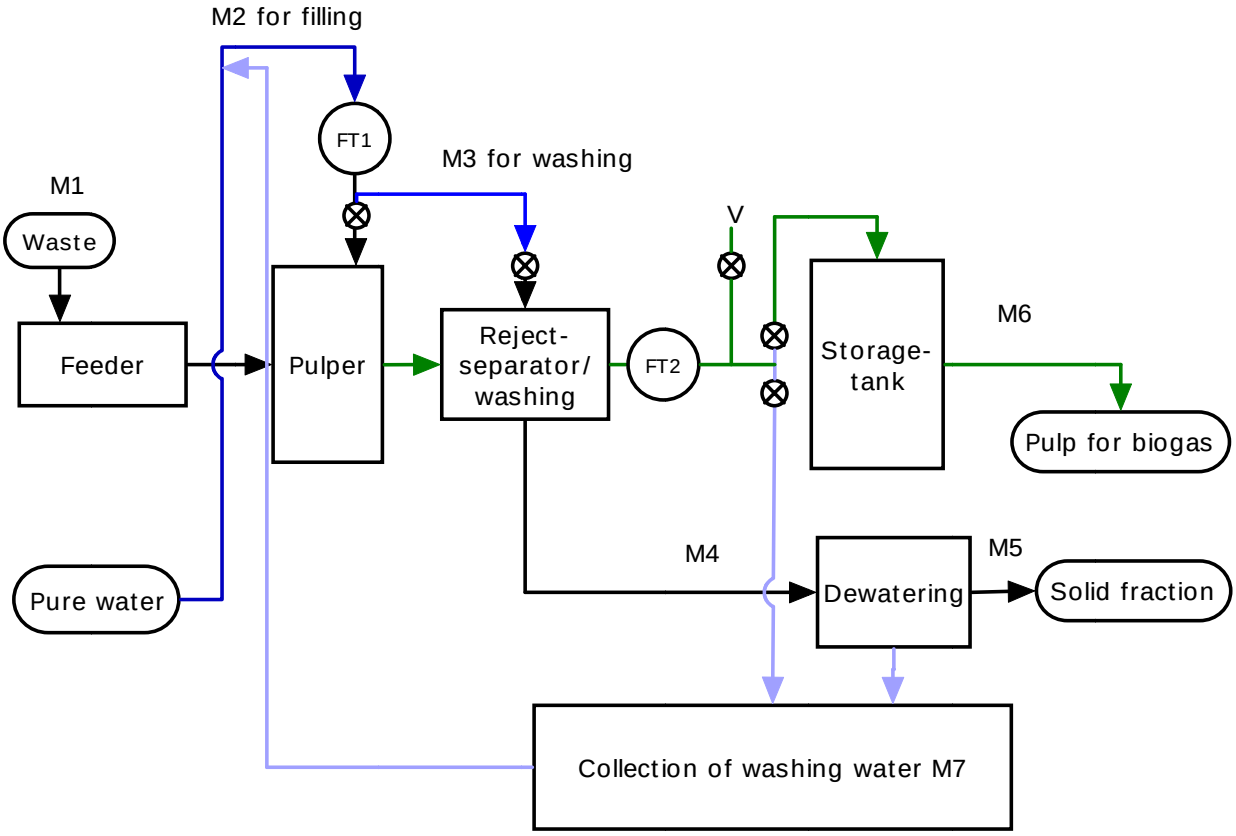

Figure 2 Mass flows in test

- M1 weight
- M2 weight (using FT1 - flow transmitter)
- M3 weight (using FT1 - flow transmitter)
- M4 weight will decrease during transport for drainage

- M5 weight will be recorded after drainage, 60 liter of the solid fraction per test run is sampled representatively for organic content test
- M6 weight, representative sampling of each batch while pumping for test of anorganic content in biopulp.
- M7 volume (by height measurement in tank) before and after a test run. Representative samples will be taken after each test run while pumping the washing water out of the reservoir after each test run.

The electricity consumption is measured by reading the electricity-meter of the hall, the ECOGI is operating in, before and after every test run. The ECOGI is the only operating machine in this hall.

Basically three tests are performed on the samples taken out during test for one waste type, see section 0 for detailed description of the tests and sampling:

Biopulp purity test (sampling position V)

This test determines the purity of the biopulp by sorting the inorganic residues out of the biopulp sample by sieving the biopulp, flushing with warm water and hand sorting of organic rests on the sieve. The inorganic residue is dried and weighed.

Organic content test in solid fraction (sampling position M 5)

This test determines the loss of organic matter in the ECOGI process, which is the biopulp not being washed of the solid fraction in the ECOGI process.

Automatic washing in a specially designed washer is performed repeatedly on the solid fraction following filtration in order to determine rest organic matter in the solid fraction. The subsamples will be dried, manually sorted for organic/inorganic matters and analysed for dry matter.

Organic content in washing water (sampling position V during recirculation of content from collection tank)
This test determines the organic residue in the washing water. This test is performed for mass balance reasons only and will not be included as loss of organic material in our calculations, because the washing water is recycled to the pulper in normal operation for reuse in next pulping step and thus the content of organic matter is not lost.

The TS (Total Solids) and VS (Volatile Solids) is analysed from representative samples.

The test methods are described in detail in appendix 3 of the test plan.

1.6.2. Test staff

The test staff is

Bjørn Malmgren-Hansen (BMH)	Sampling, data analysis and reporting (TI)
Sabine Lindholst (SBL)	Sampling, analyses, data analysis, reporting (TI)

1.6.3. Test schedule

Task	Timing
Application definition document	August 2012
Verification protocol with test plan	November 2012
Test	December 2012
Analysis phase	December 2012-january 2013
Test reporting	January 2013
Verification	January 2013
Verification report	April 2013

1.6.4. Test equipment

The test equipment includes besides the ECOGI sampling containers, buckets, sieves with different mesh sizes, small wheel loader, pitch-fork, sorting table with drain for water collection, small shovels, drying ovens, concrete mixer with attached 40 mm sieve, weights, flowmeters in plant. For further details see Appendix 3 in the test plan.

1.6.5. Type and number of samples

The types and number of samples per type of waste are summarized in the following.

sample	Sampling position	Number of batch samples	Number of test samples	Number of samples per waste type
biopulp	**V**	**9**	**3**	**3**
solid fraction	**M5**		**3**	**3**
Collection tank	**V**			**3**

In general the following practise for sampling, subsampling and sample handling of suspensions was used.

Sampling of main sample from inlet and outlet

The main samples are taken from valves with sufficient dimension (1") to ensure that no material is stuck in the valve. Before obtaining the sample at least 2 litres are discarded. A 10-15 litre bucket is used for sampling the main samples. For details see Appendix 3 in Test plan.

Preparation of subsamples

In all subdividing of samples care was taken to produce representative subsamples as some fibre material may float or sink.

Depending on type of the homogeneity of the biomass pulp the subsamples were obtained in the following way:

1) ***Homogenious pulps:*** a subsample was made by stirring main sample well during transfer to subsample
2) ***Inhomogenious pulps with floating layers or fast sinking layers***: Sieving of fibres was performed followed by proportional weigh of solid and liquid fractions into subsamples.

Used Methods
In the tests the biopulp was very homogenious and could be subsampled using method 1). This method was also used for washing water in the sorting step.

All other sampled material was solid.

Handling of samples
All fibre material was refrigerated if tests were performed within 2-3 days or freezed down for later analysis.

Used preservation and storage of samples:
Solid fraction samples were transported to Danish Technological Institute directly and dried there before VS analysis.

1.6.6. Operation conditions

Before each test run of waste, the whole system was flushed with clean water until no visible rest from the previous operation could be observed any longer. Further all conveyers for solid input and output waste was emptied. Each batch test uses 30 minutes pulping.

1.6.7. Operation measurements

- Total power consumption during treatment was recorded
- Water consumption during treatment was recorded

1.6.8. Technology maintenance

The test is a short term performance test of 2-3 days. Maintenance requirements are not covered in the test.

1.6.9. Health, safety and wastes

While testing, the personal wears a protective suit and gloves, safety glasses in case there is risk of splashes and if necessary breathing protection. The waste can be deposited in a general waste container. Based on low temperatures during test (0-5ºC) it was decided that sorting could be performed without breathing protection.

3. Test results

The test report will be included as an appendix in the verification report according to the DANETV Centre Quality Manual.

1.7. Test data summary

Target and measured values of tested parameters.

For the following types of waste the performance parameters in the table below were obtained:
A: Organic fraction from household waste Vejle Kommune waste sorting system.
B: Food waste from supermarket 25 %, 25% dairy waste and 50% of (A)

Parameters	Target	Measured value	Method/comment
Overall performance			
Capacity		5-6 ton organic waste /h	Based on test.
Chemicals		None	
Pure Water		approx. 1 ton water/ton wet waste	Based on test.
Energy			
Electricity consumption		20-30 kwh/ton waste	based on consumption in the tests
Treatment effects			
Purity of pulps (nondegradable particles plastic, glas, metal of 2-6 mm) % in a pulp with DM 15%	95 %	Test with A >99.86 % in pulp with 15% TS Test with B >99.96 % in pulp with 15% TS	
Recovery % VS	90 %	Test with A: 94.8 % with standard deviation of 0.7 % Test with B: 95.9 % with standard deviation 0.6 %	

It is concluded for ECOGI system:

- the purity of pulp is high (>99.8 weight %) when measuring the content of plastic, glass etc. >2 mm)
- the recovery is high (approximately 95% of the organic waste is recovered in the pulp in the two tests)

1.8. Test Performance observation

The test was designed to test the ECOGI equipment performance under realistic operating conditions and with two different sorts of waste. By choosing the amount of replicate operating cycles used in the test, the data observed can be judged as being representative for most operations of the equipment.

The plant operated well with no accidential operation stops during the 2 day test

1.9. Test quality assurance summary incl. audit results

For each batch run mass balances were calculated to validate the measured mass and flow measurements. Further mass balances were made for the sorting and washing procedure to validate the accuracy of the method.

1.10. Ammendments to and deviations from test plan

The test plan was followed except from minor adjustments in the sorting procedure

The following deviations were made from the test plan:

The hand sorting of the solid reject fractions was performed directly after washing (without drying) as this was judged a more secure sorting method because it was more easy to recognize the organic materials (etc. vegetables like carrots which loose color and form when drying).

The organic fractions from 2 - 40 mm were not crushed in the chain crucher, because there was not enough material for the chain crucher to work. Instead parts of the sorted out organic material was crushed in a mortar for subsampling.

4. References

Appendix 1Terms and definitions

Terms and definitions used in the protocol are explained in Table 4.1.

Table 4.1 Terms and definitions used by the DANETV test centres.

Word	DANETV	Comments on the DANETV approach
Analytical laboratory	Independent analytical laboratory used to analyse test samples	The test centre may use an analytical laboratory as subcontractor
Application	The use of a product specified with respect to matrix, target, effect and limitations	The application must be defined with a precision that allows the user of a product verification to judge whether his needs are comparable to the verification conditions
DANETV	Danish centre for verification of environmental technologies	
(DANETV) test centre	Preliminary name for the verification bodies in DANETV with a verification and a test sub-body	Name will be changed, when the final nomenclature in the EU ETV has been set.
Effect	The way the target is affected	The effect could be concentration reduction, decrease in treatment period, pH increase etc
(Environmental) product	Ready to market or prototype stage product, process, system or service based upon an environmental technology	The product is the item produced and sold and thus the item that a vendor submit for verification
Environmental technology	The practical application of knowledge in the environmental area	The term technology is covering a variety of products, processes, systems and services.
Evaluation	Evaluation of test data for a technology product for performance and data quality	None
Experts	Independent persons qualified on a technology in verification	These experts may be technical experts, QA experts for other ETV systems or regulatory experts
Matrix	The type of material that the product is intended for	Matrices could be soil, drinking water, ground water etc.
Method	Generic document that provides rules, guidelines or characteristics	An in-house method may be used in the absence of a standard, if

Word	DANETV	Comments on the DANETV approach
	for tests or analysis	prepared in compliance with the format and contents required for standards.
Performance claim	The effects foreseen by the vendor on the target (s) in the matrix of intended use	None
Performance parameters	Parameters that can be documented quantitatively in tests and that provide the relevant information on the performance of an environmental technology product	The performance parameters must be established considering the application(s) of the product, the requirements of society (regulations), customers (needs) and vendor claims
Procedure	Detailed description of the use of a standard or a method within one body	The procedure specifies implementing a standard or a method in terms of e.g.: equipment used
Producer	The party producing the product	None
Proposer	Any legal entity established in or outside the European Union presenting an innovative environmental technology for verification under the EU ETV pilot programme	None
Standard	Generic document established by consensus and approved by a recognized standardization body that provides rules, guidelines or characteristics for tests or analysis	None
Target	The property that is affected by the product	Targets could be *e.g.*. contaminant concentration
Test centre, test sub-body	Sub-body of the test centre that plans and performs test	None
Test centre, verification sub-body	Sub-body of the test centre that plans and performs the verification	None
Test/testing	Determination of the performance of a product for parameters defined	None

Word	DANETV	Comments on the DANETV approach
	for the application	
Vendor	The party delivering the product to the customer	Can be the producer
Verification	Evaluation of product performance parameters for a specified application under defined conditions and adequate quality assurance	None

Appendix 2 Test data report

Test

The test was performed as described in the test plan except minor deviation in sorting method (see 3.4).

Before the actual test, a prerun was performed on 10.dec 2012 for testing the method and calibrating the equipment.

Calibration

All weights used were calibrated using preweighed calibration bottles with water (129.08 g and 4.46 kg) which were weighed using DTIs calibrated laboratory weights.

Table 2 Test results

Weight	reference	measured
small weight (g)	129.08	129
20 kg weight (kg)	4.46	4.45
30 kg weight (kg)	4.46	4.4

All weights measured within the accuracy of reading.

The input amount of added waste and the output amount of reject was weighed using calibrated weighing cells on Komteks wheel loader.

Calibration of flow transmitters was performed by using the basin M7 for measuring the amount. The area of the basin was measured to 1.4*11.7 = 16.38 m^2.

Table 3 Test of flow transmitter FT1 by adding of water performed dec.10th 2013

test	added FT1 (m^3)	measured (cm)	Calculated addition (m^3)	Difference %
1	6.1	39	6.39	-4.5
2	2.4	14.8	2.42	-0.8

The result is acceptable within the uncertainty of height measurement of the basin (1 cm) and area measurement (1 cm height corresponds to a volume change of 0.164 m3).

Sorting test

Based on the prerun it was decided to run without the chain crusher, because there was not enough material for the chain crucher to work.

Based on drying trials and inspection of the waste it was decided to perform the hand sorting of the solid reject fractions directly after washing without drying as this was judged a more secure sorting method as materials were more easily recognized.

Tests performed

Tests were performed 11.december using organic waste collected from households in Vejle and on 12.december using 50 % waste from Vejle and 50% waste from industry.

The test included the following steps according to test plan:

- Recording all input and output weights as well as power consumption for each test run
- Sampling of produced pulp
    - analysis of VS and TS of pulp
    - analysis of purity of pulp (amount of non-degradable matter > 2 mm – glass, metal, plastic) by washing, sorting and weighing
- Sampling of reject
    - subsampling of reject for testing content of organic waste
    - washing of subsample in special machinery
    - sorting reject in non-degradable matter (plastic, metal, glass/stones) and degradable matter and weighing (wet)
    - drying subsamples of sorted reject and weighing for dry matter analysis
    - Analysis of Volatile solids content (organic matter)

Documentation photos from selected individual steps in the test are shown below.

Sampling of produced pulp

3 subsamples were taken during pumping to storage tank and transferred to a large bucket for mixing and subsampling while stirring.

Figure 3 Sampling of pulp

Analysis of purity of pulp

A 1 litre subsample of the pulp was washed on a 2 mm sieve as shown below before collection of particles for drying and weighing.

Figure 4 Washing of pulp to estimate purity

Sampling of reject

The reject was collected in a container with drainage of water to floor tank. The container with one batch was transferred to a clean storage facility for mixing and weighing.

Figure 5 Collection of reject from one batch in container

The 3 batches in a test run were mixed using a large wheel loader and weighed using the weighing cells of the wheel loader

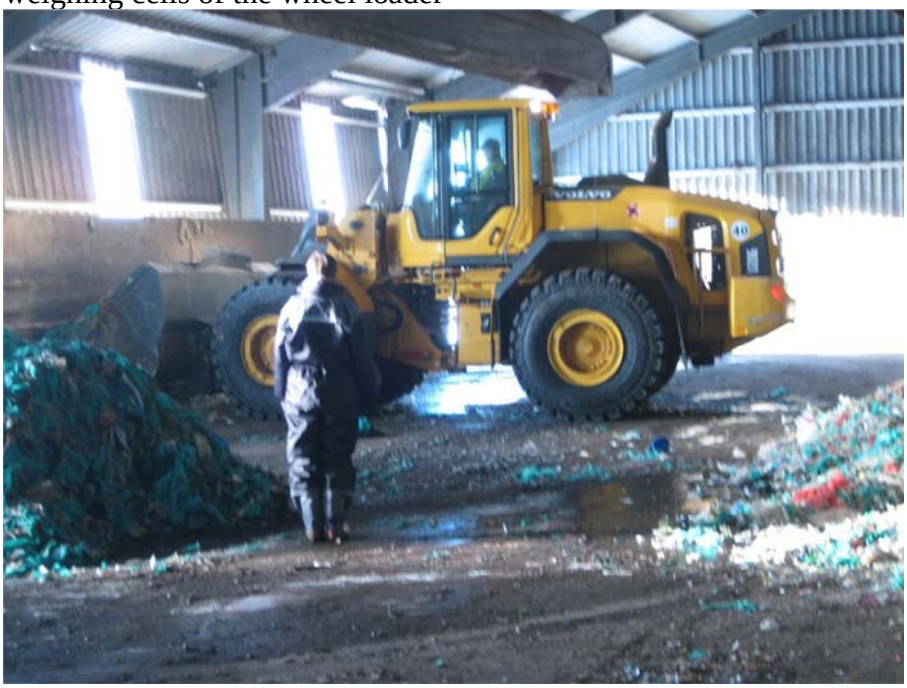

Figure 6 Mixing of 3 batches to one sample representing a test run and weighing with wheel loader

From the mixed 3 batches a representative sample was taken by using a grab randomly picking and filling a 60 litre square bucket.

The square bucket was now sorted according to the procedure in appendix 3 of the test plan.

The content was weighed and transferred to a cement mixer with a 40 mm screen in front together with washing water (Figure 7). The average weight was approximately 15 kg for each wash. The amount was washed in three steps while rotating.

The used sorting procedure (appendix 3, test plan) is summarized below
1: washing with 48 litre cold water for approx. 10 minutes, decanting of water by tilting into a collecting bucket with a 10 mm screen
2: washing with 20 litre cold water for approx. 10 minutes, decanting of water by tilting into a collecting bucket with a 10 mm screen
3: washing with 20 litre hot water (30-40ºC) for approx. 10 minutes, decanting of water by tilting into a collecting bucket with a 10 mm screen (Figure 8)
4: removal of >40 mm reject for sorting

- 4a: The reject fraction >40 mm was hand sorted in non-degradable material (plastics, metal, glass, bones and sticks with dimensions larger than 5*5*5 mm and organic material (Figure 10)
- 4b: The material was weighed (wet)
- 4c: The non-organic material was dried and weighed

5: The < 10 mm fraction including washing water was filtered on a 2 mm screen (Figure 9). The amount was small and it was sorted together with the 10-40 mm fraction.
6: removal of 2 - 40 mm reject for sorting

- 6a: Sorting a representative sample of approx. 20% of the reject fraction 2 - 40 mm by hand in non-degradable material (plastics, metal, glass, bones and sticks with dimensions larger than 5*5*5 mm and organic material (Figure 11)
- 6b: The material was weighed
- 6c: The non-organic material was dried and weighed

7: From the organic fraction > 40 mm and 2 - 40 mm proportional subsamples were prepared by thorough mixing for analysis of TS and VS.

8: Sampling of washing water
A representative sample was taken from washing water to further analysis of TS and VS

Figure 7 Washing in cement mixer with 40 mm screen

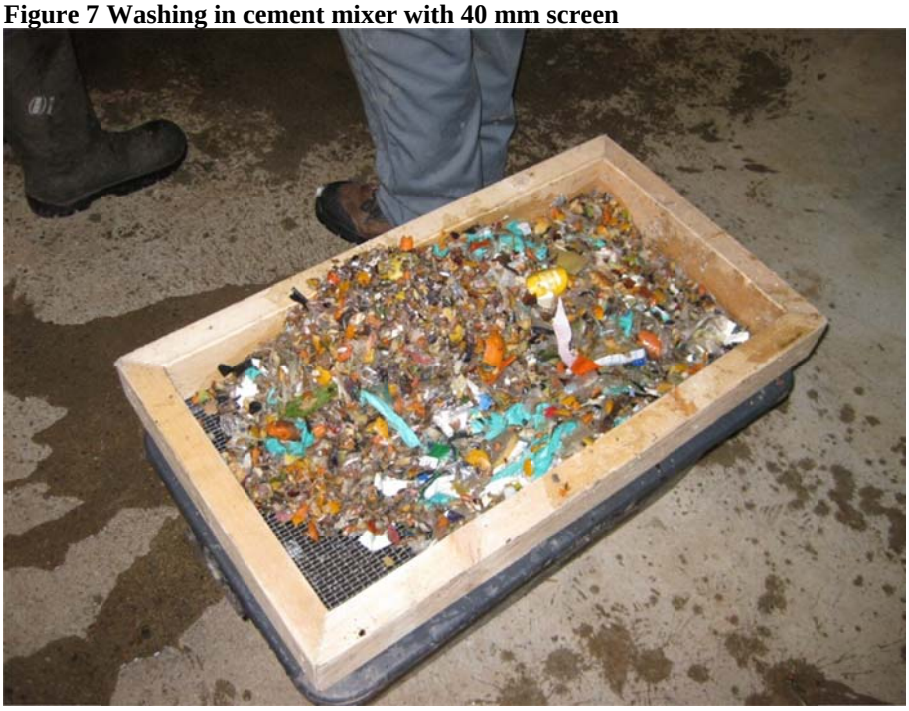

Figure 8 Collection of 10 - 40 mm reject from washing

Figure 9 Collection of 2 - 10 mm reject from washing

Figure 10 Sorting of > 40 mm washed reject fraction

Figure 11 Hand sorting of 2-40 mm fraction on sorting table

Total Solids and Volatile solids analysis

TS and VS was analyzed on organic samples that were manually homogenized as thoroughly as possible by using a mortar.

The drying method for organic fraction used was 103 °C for 4 days, as there still was loss of weight after 2 and 3 days. The low temperature option in test plan appendix 3 (50 °C) was not used, as the drying would have been too time consuming.

Test results and Mass Balances

During all tests the following parameters were recorded as shown in Table 4 to Table 9.

- Input of waste (waste in ton)
  The amount was only weighed for the sum of 3 batch tests and therefore has been distributed evenly between the 3 batch tests

- Amount of water to pulper
  The amount is added using FT1

- Total water for Reject separation
  The total amount for reject separation was measured by reading amounts added by flow transmitters. This amount is transferred to the pulp in the rejection step.

- Pulp to storage tank
  The amount is measured using FT2

- Washing water
  The washing steps is divided in 2 steps with approx. 1.5 m^3 in first step using technical water followed by 2.3 m^3 fresh water

- Reject
  The amount was only weighed for the sum of 3 batch tests and therefore has been distributed evenly between the 3 batch tests

- Power consumption
  The power consumption of the plant including ventilation was recorded by reading the kWh counter before and after the combined 3 batch tests in each test run

Table 4 Test A test run T1

11.dec.13 A-T1	batch 1	batch 2	batch 3	Sum or average
Waste input ton	2.233	2.233	2.233	6.7
Amount of water added to pulper (m^3) FT1	2	2	2	6
Water level after water addition (cm)	86	104	130	
Reject separation				
Total separation water added to pulp	6.5	6.7	6.5	19.7
Pulp to storage tank m^3 FT2	9.3	9.2	9.5	28
Washing				
other water washing (estimated) *	1.5	1.5	1.5	4.5
Pure water for washing m^3	2.3	2.3	2.5	7.1
Reject out				
Reject out ton	0.48	0.48	0.48	1.45
Mass balance				
Input waste + water	10.73	10.93	10.73	32.40
Output pulp + reject	9.78	9.68	9.98	29.45
error in mass balance %	8.85	11.43	6.99	9.1
kWh before	253515			
kWh after			253709	
Power consumption kWh			194	

Example calculation of mass balance A-T1, batch 1:

Input waste and water = 2.23 + 2 + 6.5 = 10.73 ton
Output pulp and reject = 9.3 + 0.48 = 9.78 ton

Table 5 Test A test run T2

11.dec.13 A-T2	batch 1	batch 2	batch 3	Sum or average
Waste input ton	2.333	2.333	2.333	7
Amount of water added to pulper (m^3) FT1	2	2	2	6
Water level after water addition (cm)	104			
Reject separation				
Total separation water added to pulp	7	6.1	6.55	19.65
Pulp to storage tank m^3 FT2	9.3	8.7	8.4	26.4
Washing				
other water washing	1.3	2	1.65	4.95
Pure water for washing m^3	2.3	2.3	2.3	6.9
Reject out				
Reject out ton	0.52	0.52	0.52	1.55
Mass balance				
Input waste + water	11.33	10.43	10.88	32.65
Output pulp + reject	9.82	9.22	8.92	27.95
error in mass balance %	13.38	11.66	18.07	14.4
kWh before	253752			
kWh after			253922	
Power consumption kWh			170	

Table 6 Test A test run T3

11.dec.13 A-T3	batch 1	batch 2	batch 3	Sum or average
Waste input ton	2.167	2.167	2.167	6.5
Amount of water added to pulper (m^3) FT1	2	2	2	6
Water level after water addition (cm)				
Reject separation				
Total separation water added to pulp	6.8	6.4	6.6	19.8
Pulp to storage tank m^3 FT2	9.5	9.5	9.4	28.4
Washing				
other water washing	1.4	1.5	1.3	4.2
Pure water for washing m^3	2.3	2.3	2.3	6.9
Reject out				
Reject out ton	0.49	0.49	0.49	1.46
Mass balance				
Input waste + water	10.97	10.57	10.77	32.3
Output pulp + reject	9.99	9.99	9.89	29.86
error in mass balance %	8.94	5.49	8.17	7.55
kWh before	253922			
kWh after			254086	
Power consumption kWh			164	

Table 7 Test B test run T1

12.dec.13 B-T1	batch 1	batch 2	batch 3	Sum or average
Waste input ton	2.267	2.267	2.267	6.8
Amount of water added to pulper (m^3) FT1	2	2	2	6
Water level after water addition (cm)	104.5			
Reject separation				
Total separation water added to pulp	6.9	5.6	7.4	19.9
Pulp to storage tank m^3 FT2	10.9	8.4	10	29.3
Washing				
other water washing	1.2	2.8	1.1	5.1
Pure water for washing m^3	2.3	2.3	2.3	6.9
Reject out				
Reject out ton	0.53	0.53	0.53	1.6
Mass balance				
Input waste + water	11.17	9.87	11.67	32.7
Output pulp + reject	11.43	8.93	10.53	30.9
error in mass balance %	-2.39	9.46	9.71	5.5
kWh before	0	254399		
kWh after			254493	
Power consumption kWh			141*	

* for this test the power consumption for the test run was calculated from two batch runs

Table 8 Test B test run T2

12.dec.13 B-T2	batch 1	batch 2	batch 3	Sum or average
Waste input ton	2.783	2.783	2.783	8.35
Amount of water added to pulper (m^3) FT1	2	2	2	6
Water level after water addition (cm)				
Reject separation				
Total separation water added to pulp	7	7	7.1	21.1
Pulp to storage tank m^3 FT2	10	9.9	10.6	30.5
Washing				
other water washing	1.3	1.3	1.2	3.8
Pure water for washing m^3	2.3	2.3	2.3	6.9
Reject out				
Reject out ton	0.50	0.50	0.50	1.5
Mass balance				
Input waste + water	11.78	11.78	11.88	35.45
Output pulp + reject	10.50	10.40	11.10	32
error in mass balance %	10.89	11.74	6.59	9.73
kWh before	254538			
kWh after			254693	
Power consumption kWh			155	

Table 9 Test B test run T3

12.dec.13 B-T3	batch 1	batch 2	batch 3	Sum or average
Waste input ton	2.633	2.633	2.633	7.9
Amount of water added to pulper (m^3) FT1	2	2	2	6
Water level after water addition (cm)				
Reject separation				
Total separation water added to pulp	7	7	7	21
To storage tank m^3 FT2	10	9.8	9.8	29.6
Washing				
other water washing	1.3	1.3	1.3	3.9
Pure water for washing m^3	2.3	2.3	2.3	6.9
Reject out				
Reject out ton	0.54	0.54	0.54	1.62
Mass balance				
Input waste + water	11.63	11.63	11.63	34.9
Output pulp + reject	10.54	10.34	10.34	31.22
error in mass balance %	9.40	11.12	11.12	10.5
kWh before	254706			
kWh after			254877	
Power consumption kWh			171	

The calculated mass balances for the 3 tests have average errors between 5 and 14 weight %. The error may be due to an error in reading of FT2 of approximately -10 % or a combination of reading errors in FT1 and 2. It was not practically possible to calibrate the flow transmitter FT2 on the pulp.

Table 10 shows waste in- and -outputs and power consumption for each test run.

Table 10 Waste amounts and power consumption

Test	test run	Input waste ton (wet)	Output Pulp ton(wet)	Output reject ton (wet)	kWh used	kWh/ton input wet
A	1	6.70	28	1.45	194	29.0
A	2	7.00	26.4	1.55	170	24.3
A	3	6.50	28.4	1.46	164	25.2
B	1	6.80	29.3	1.6	141	20.7
B	2	8.35	30.5	1.5	155	18.6
B	3	7.90	29.6	1.62	171	21.6

The water consumption of pure water is at present under improvement. In normal operation technical water (recycled from earlier pulpings) is used for new pulpings. The technical water is produced by dewatering of the pulp by a dewatering technology which is presently being optimised. Based on the test 2.3 ton of pure water was needed for washing the reject of each batch which is approximately the same as the added amount of wet waste.

Analysis results

Purity

In Figure 12 the content of residue (2-6 mm) in 1 liter pulp from the purity analysis is shown.

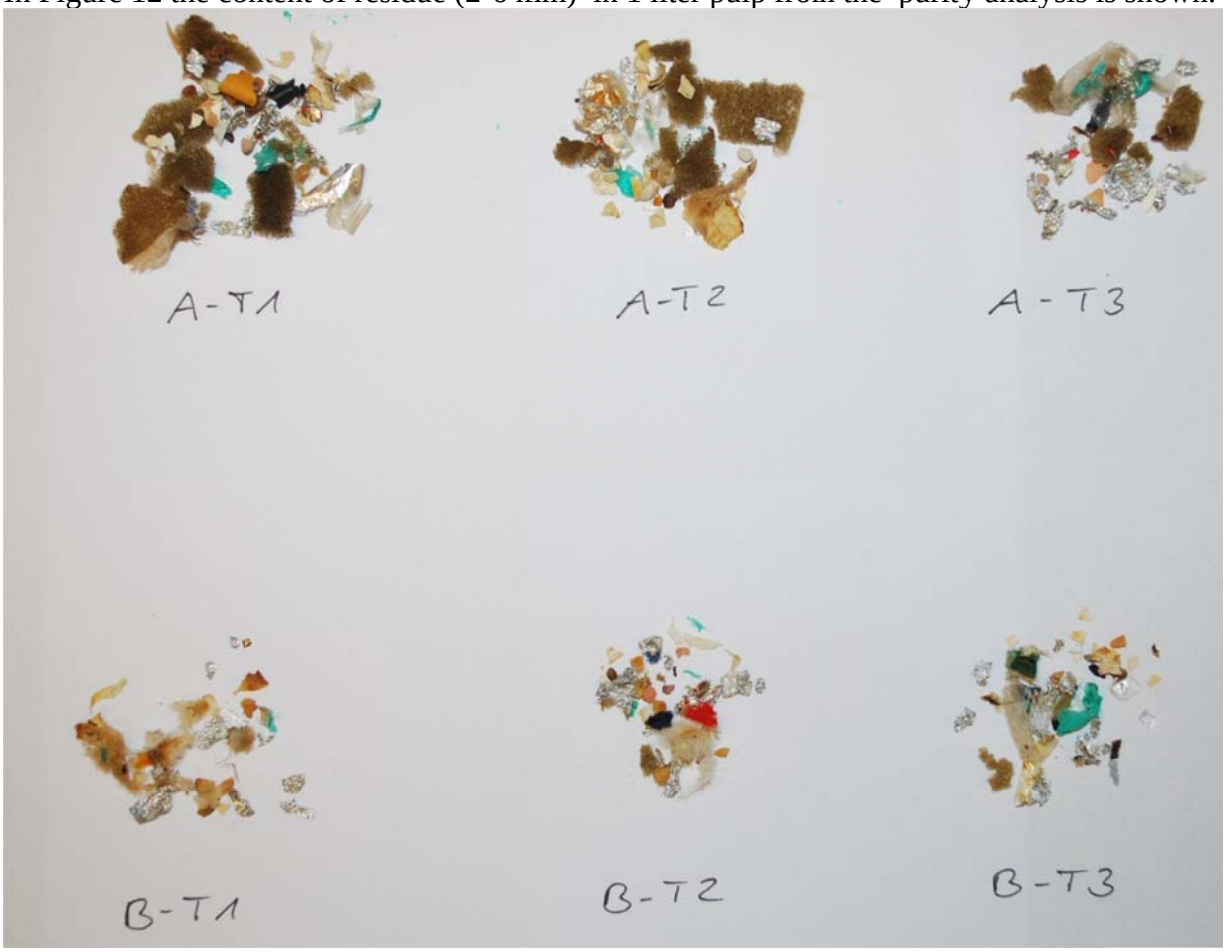

Figure 12 Inorganic dried residue (2 - 6 mm) of 1 liter pulp from test runs

The table below shows the analysis data for calculating purity. The purity is recalculated to 15 % TS as this is the typical product quality after dewatering using a screw press.

Test	test run	biopulp weighed (g)	TS pulp %	TS inorganic components 2 - 6 mm (g)	% inorganic in pulp	% inorganic in pulp with 15% DM
A	1	1000.00	4.99	0.4555	0.05	0.14
A	2	1000.00	5.88	0.7909	0.08	0.20
A	3	1000.00	6.13	0.3125	0.03	0.08
B	1	1000.00	6.41	0.1623	0.02	0.04
B	2	1000.00	6.93	0.1969	0.02	0.04
B	3	1000.00	6.8	0.1958	0.02	0.04

The impurities >2 mm amounts to

A average: 0.14 % standard deviation 0.06 %
B average: 0.04 % standard deviation 0.002 % when recalculated to 15 % TS.

The particles have to pass a 6 mm sieve in the rejection separator and therefore cannot be larger.

The purity (amount of non-degradable material like plastics, glass and metal) are
A > 99.86 %
B > 99.96 %
in a pulp with a calculated TS of 15 wt %

Recovery

The table below shows results from weighing of the reject samples. The samples were treated according to the procedure using washing and hand sorting of fractions larger than 40 mm and from 2 - 40 mm. The hand sorting produced a number of fractions which are nondegradable in biogasification and organic fractions which are degradable in biogasification. Further the washing water contained particles and solubilized organics < 2 mm.

In the sorting procedure the material is divided into :

Non degrable fractions in biogasification including:

- Metal
- Plastic, rubber and textiles
- other inorganic materials like stones ,ceramics and glass
- wood pieces, sticks and bones with dimensions >5*5*5 mm

Fractions degradable in biogasification including:

- organic waste from households and industry

Table 11Weighing of reject

					Non-degradable in biogasification (kg wet)		Degradable in biogasification (kg wet)			
Test	test run	Sample input (kg wet)	wash water input (kg)	Drained reject after washing (kg wet)	> 40 mm	2 - 40 mm	> 40 mm	2 - 40 mm	wash water drained off (kg)	organic wet (%)
A	1	15.1	79	17.42	9.27	3.01	0.52	4.57	72.60	29.3
A	2	14.1	76	17.49	6.82	4.54	0.26	4.65	72.10	30.2
A	3	14.1	75	17.10	4.76	4.60	0.29	5.74	73.30	39.2
B	1	10.95	75	12.70	5.24	3.03	0.29	2.79	70.60	27.1
B	2	13.95	75	15.20	6.18	3.16	0.48	3.12	73.30	27.8
B	3	13.1	79.5	16.52	5.02	4.30	0.38	4.56	72.53	34.6

The weights for 2 - 40 mm are based on sorting and weighing of 20 % of the wet sample.

There is a minor loss of water during drainage and sorting.

The mass balance of input (before washing) and output (after washing) shows the following deviations.

Figure 13 Mass balance before and after washing

testrun	batch	input	output	deviation %
A	1	94.10	89.97	-4.4
A	2	90.10	88.37	-1.9
A	3	89.10	88.69	-0.5
B	1	85.95	81.94	-4.7
B	2	88.95	86.24	-3.1
B	3	92.60	86.78	-6.3

The water loss of 0.6 -6 % is acceptable when taking into account the large number of operations in the sorting procedure.

An example of the sorted fraction > 40 mm, textile and plastics is shown in Figure 14.

In Figure 15 the non plastic and textile content in a >40 mm sorting fraction is shown.

Figure 14 Sorted fraction >40 mm textile and plastics

Figure 15 Sorted fraction >40 mm metal, organic residue and non biogas degradable woodsticks and bones

An example of the sorted fraction 2 - 40 mm is shown in Figure 16 to Figure 18

Figure 16 Sorted fraction 2-40 mm organic fraction

Figure 17 Sorted fraction 2-40 mm plastic fraction

Figure 18 Sorted fraction 2-40 mm textile, metals, bones and sticks

The content of sticks, bones with dimensions >5*5*5 mm was measured in test B. These are not considered to be degradable in biogasification without severe pretreatment which is yet not developed or installed at full scale biogas plants.

The content was between 6-12% of the organic food waste (wet weight) or between 2-3.3 % of the total amount of sorted waste (Wet weight).

In Table 12 Total Solids and Volatile solids of the sorted organic fractions and the washing water are shown.

Table 12 TS and VS of organic content in fractions

Biopulp	test run	TS %	Standard dev. %	VS %	Standard dev. %
A	1	4.99	0.52	88.43	0.17
A	2	5.88	0.44	88.48	0.09
A	3	6.13	0.06	88.36	0.92
B	1	6.41	0.09	90.33	0.66
B	2	6.93	0.11	90.42	0.61
B	3	6.80	0.11	90.27	0.46
Reject 2-40 mm					
A	1	14.49	1.12	81.37	4.15
A	2	15.63	0.16	83.37	4.61
A	3	15.38	0.62	90.60	3.09
B	1	14.71	0.09	87.05	0.24
B	2	15.10	0.51	92.26	1.89
B	3	15.36	0.45	87.84	5.05
Washing water					
A	1	0.16	0.00	69.63	0.53
A	2	0.17	0.01	74.86	2.16
A	3	0.22	0.01	73.84	1.96
B	1	0.18	0.01	74.25	2.72
B	2	0.14	0.00	73.66	2.67
B	3	0.15	0.00	76.60	2.06

Table 13 and Table 14 show calculations of recovery.

Table 13 Results for test A

Test run	1	2	3
Biopulp tons Input	28	26.4	28.4
TS %	4.99	5.88	6.13
VS %	88.43	88.48	88.36
Biopulp VS ton Input	1.23	1.37	1.54
Reject tons	1.45	1.55	1.46
Organic % (wet)	29.30	30.18	39.16
Organic ton (wet)	0.42	0.47	0.57
Organic DM %	14.49	15.63	15.38
Organic VS %	81.37	83.37	90.60
Organic VS ton excluding washing water	0.050	0.061	0.080
Organic VS ton including washing water	0.057	0.070	0.091
% recovery	95.41	94.93	94.07

% recovery for test A: 94.8 % with standard deviation = 0.68 %

Example calculation T1:

Biopulp in VS = 28 * 4.99 * 88.43/100/100 = 1.23 ton

Organic reject wet = 1.45 * 29.3/100 = 0.42 ton
Organic reject excluding washing water VS ton = 1.45*29.3/100*14.49*81.37/100/100=0.050 ton

Washing water addition T1
Input = 17.42 kg organic wet content 0.52 + 4.57 = 5.09 kg with DM 14.49% VS = 81.37%

washing water = 72.6 kg with TS = 0.16% VS = 69.63%

Organic content (excl. washing water) in VS = (0.52+4.57)*14.49*81.37/100/100 = 0.60 kg
Organic content washing water in VS = 72.6*0.16*69.63/100/100 = 0.081 kg

Thus for T1 we have additional 50 *0.081/0.6 = 6.75 kg VS to the 50 kg excluding washing water or in total 0.057 ton VS in the reject

As the biopulp contains 1.23 ton VS the recovery for batch 1 can be calculated to (1.23-0.057)/1.23*100 = 95.4%.

Table 14 Results for test B

Test run	1	2	3
Biopulp tons Input	29.3	30.5	29.6
TS %	6.41	6.93	6.80
VS %	90.33	90.42	90.27
Biopulp VS ton Input	1.70	1.91	1.82
Reject tons	1.6	1.5	1.62
Organic % (wet)	27.13	27.80	34.62
Organic ton (wet)	0.43	0.42	0.56
Organic TS %	14.71	15.10	15.36
Organic VS %	87.05	92.26	87.84
Organic VS ton excluding washing water	0.06	0.06	0.08
Organic VS ton including washing water	0.07	0.07	0.09
% recovery	95.96	96.49	95.31

% recovery for test B: 95.9 % with standard deviation = 0.6 %

Discussion and conclusion

The results show

- a high purity of the produced pulp with less than 0.14% particles of plastic, glass, metal larger than 2 mm.
- a recovery >94.8% of organic material

The organic material will be in the form of food waste from households. Based on the high recovery it is expected that the organic material is partly downsized in the pulping process to allow most of the material to pass the 6 mm screen holes in the sorting unit. Loosely bound paper like drying paper for kitchen use is also expected be disintegrated by the pulping process and no identifiable larger parts of paper was found in sorted fractions.

Some sticks and bones and wood pieces are too solid to be down sized in the process and are removed with the reject. The amount of these parts was limited in the tests but will of course depend on the composition of collected waste.

Appendix 3 Amendment and deviations report for test

No amendments and deviations are described here (deviations to test plan are given in part 3.4)