Installation of SRS
(Sewage Recycling System)
at Aarle-Rixtel WWTP

A joint report with Waterschap Aa en Maas (WSAM)

Trial results and extrapolation to full scale system
April-June 2014

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Chapter 1: Abstract

Applied CleanTech (ACT) and Waterschap Aa en Maas (WSAM) conducted a trial of ACT's Sewage Recycling System (SRS) in Aarle-Rixtel WWTP during the period of April-June 2014. The success parameters set for the trial were:

1. Sludge reduction of 30%-50%
2. Recyllose™ production of up to 1 ton per day at 25%DM
3. Overall reduction of WWTP operating costs by 15-30%

All of which were successfully met.

In addition to the benefits to the wastewater treatment process, the by-product of the SRS – Recyllose™ was tested for different applications and was found suitable for many uses.

According to the trial results, a reduction of 36% TSS, 15% COD and 18% FOG was anticipated; an extrapolation to full-scale system has been made, with an expected reduction of 30% sludge and total savings on OPEX of 31%, which is very impressive and beyond the initial expectations (costs for sludge treatment, energy for aeration and SRS, and benefit from the Recyllose™).

The Recyllose™ production is projected to be 5,074 kg per day. The Recyllose™ was found to have many promising potential applications in the Dutch industry.

Extrapolation of the pilot results to the full scale WWTP shows that the SRS will result in a 12% decreased load (pollution equivalents) to the biology, which makes it an attractive technology to anticipated increase of the waste load to the WWTP Aarle-Rixtel.

No impact (positive or negative) on the full scale WWTP process was observed during the SRS pilot test.

We see this pilot and its successful results as a promising first step in a long and fruitful cooperation between ACT and WSAM. This cooperation will bring the vast benefits of the SRS technology not only to the waterboard, but also to the citizens, who will be able to benefit from the savings. The SRS technology also contributes to the environment, by reducing carbon footprint and GHG emissions.

The SRS system serving as a Recyllose™ factory creates new business opportunities in the area, develops new markets and positions the waterboard as an environmentally friendly company, and a promoter of green technology.

Chapter 2: SRS: How it Works

ACT's innovative Sewage Recycling System (SRS) is based on a ground-breaking technology installed at the pre-treatment stage of the water treatment cycle. ACT's SRS mines and recycles solids from wastewater before entering the biological reactor at a Waste Water Treatment Plant (WWTP), reducing overall operational costs by up to 30%.
ACT's patented technology traps the cellulose components and processes them into a clean, pasteurized, environmentally friendly product - Recyllose™ (recycled cellulose) - a valuable resource that is suitable for use in plastics, insulation, pulp & paper, construction, bio-fuels production, as well as in additional industries.

Following, in a nutshell, is how the system works:

1. The raw sewage, after pre-treatment (screening and grit removal) is pumped into the SRS. The pumped sewage passes through a primary cleaner to further remove grit.
2. Inside the SRS, the sewage passes through a Trapper to remove suspended solids, using the High Affinity Micro Trapping (HAMT) technology. Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), oil, grease, ammonia and phosphate are also reduced. No additives or chemicals are added in this process. No biological treatment is performed. Only hot air and occasionally hot water are used to clean the Trapper. Separation is based only on the physical properties of the suspended solids.
3. The cleaner sewage is then returned to the WWTP for further treatment. No alterations to the regular treatment in the WWTP are required.
4. The raw Recyllose™ from the Trapper, is then heated, cleaned and refined until it reaches less than 20% water content. The heating completely pasteurizes the product. Heating is self-produced inside the SRS and requires no external energy source.
5. The dried Recyllose™, now in pulp form, is further compressed to form pellets suitable for long term storage, transport and use.

Chapter 3: Installation at Aarle-Rixtel WWTP

The Aarle-Rixtel WWTP is designed to treat a load comparable to 272,000 inhabitants. Today it treats a load comparable to 300,000 people, and the forecast is that the load will further increase in the next few years. Although effluent quality has remained high so far, the WWTP eventually will have to undergo a costly upgrade to increase capacity.

One method to increase WWTP capacity without extensive civil works is the use of the micro-trapping technology incorporated in the SRS. The SRS reduces organic loads before they enter the reactor, reduces energy required for aeration, and prevents sludge formation.

The Aarle-Rixtel WWTP has a unique structure, making it ideal for a comparative trial.

After an efficient pre-treatment including 6mm screening, sand and silt sedimentation and FOG removal, the flow is separated into two identical streams, each treated independently in two different lines, named AT1 and AT2. Each line includes an aerobic reactor employing the m-UCT technology and five secondary clarifiers with independent return activated sludge lines and blowers for aeration. Each line is extensively monitored, therefore the performance of each line can be evaluated and compared during the trial period, and the effects of the SRS activity on the process can be measured.

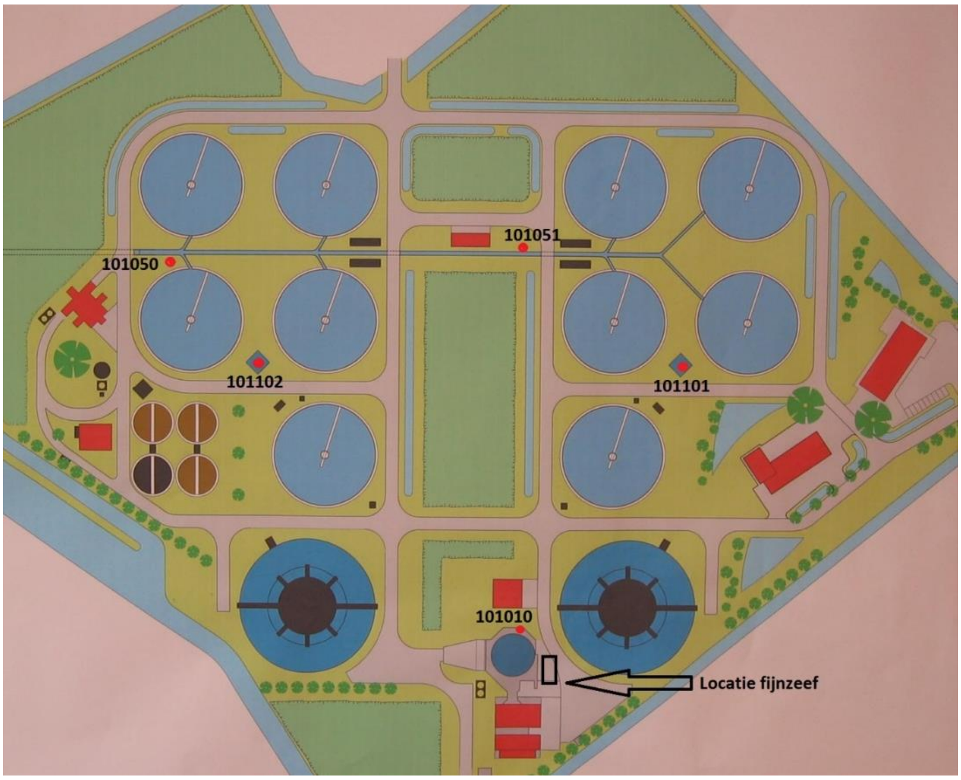

Figure 1 View of Aarle -Rixtel WWTP with location of SRS pilot

The SRS was installed at the Aarle-Rixtel WWTP from April 2014 till June 2014, a total of 73 days of 24/7 operation.
Sewage exiting the grit trap was pumped to the SRS, and the sewage after the SRS process was pumped to AT1. Recyllose™ mined from the sewage was stored in the WWTP and used for testing of various applications.
As an experimental step, the SRS was equipped with a secondary trapper to further reduce organic loads from the sewage. The sewage after the first trapper was pumped into the secondary trapper at an average flow rate of 50 m^3/h. The secondary trapper was operating for approx.5-10 hours a day. The solids concentrated from this trapper were not captured, but rather returned to the outlet flow after the sampling port. This allowed measurement of the secondary trapper's ability.

The trial has shown objectives that are considered as success criteria, as follows:

1. Sludge reduction of 30%-50%
2. Recyllose™ production of up to 1 ton per day at 25%DM, (20% of which is utilized for SRS operation) and application as energy or pulp source.
3. Overall reduction of WWTP operating costs by 15-30% (comprised of sludge transportation, treatment and disposal, electricity and polymer consumption, maintenance costs and increased capacity).

Additional parameters were checked during the trial:

1. Performance capacity of the SRS technology, for different components such as TSS, COD, BOD, O&G, N, P, energy and polymers/chemicals consumption.
2. Economic feasibility of the SRS performance for the WWTP, including potential revenues from the Recyllose™.
3. The impact of the SRS technology on the WWTP processes and performance (e.g. bio N and P-removal and sludge characteristics).

Chapter 4: Sampling Methodology

Two composite samplers were installed, one at the entrance to the SRS and the second on the outflow pipe of the SRS. The 24-hours composite samples were taken for testing once a day, or five times a week.
Analyses were executed almost daily in two labs, at the lab-facility of the WWTP Aarle-Rixtel, and about once a week at the Aquon laboratory (a joined laboratory for 9 waterboards).
Aa en Maas lab tested TSS, COD, fCOD, TN, and TP.
Aquon lab tested BOD, COD, TSS, VSS, NKj, and FOG. Additionally, Aquon tested for presence of heavy metals (mercury, nickel, lead, cadmium, chrome, copper, aluminum and zinc).

The following schedule plan was suggested:

Table 1 Sampling plan for SRS

frequency: x/ week			**SRS installation**	
Parameter	**Method**	**Lab**	**SRS influent**	**SRS effluent**
Flow	continuous	-	**c**	**-**
Electricity	continuous	-	**c**	**-**
TSS	stove	WWTP	5	5
Ash (inorganics)	stove	WWTP	2	2
COD	cuvet	WWTP	5	5
BOD5	NEN	Aquon	1	1
Nkj	NEN	Aquon	1	1
NH4-N	cuvet	WWTP	5	5
NO3-N	cuvet	WWTP	1	1
Total-N	cuvet	WWTP	5	5
Total-P	cuvet	WWTP	5	5
PO4-P	cuvet	WWTP	5	5
O&G	Gravimetric	Aquon	1	1
"metals"	NEN	Aquon	0.5	0.5

For some of the tests it was suggested to reduce frequency after the first few weeks of the trial.

Grab samples were taken 2-3 times a week and tested by Aa en Maas lab for TSS and COD. Grab samples were also taken before and after the secondary trapper, therefore the total reduction ability of the SRS could be determined (if the secondary trapper was operating at full flow).

Recyllose^{TM} was tested once a week by Aquon lab, and the following tests were performed: ash, water content, calorific value, chlorine, EOX (extractable organic halogens), contaminants (arsenic, mercury, nickel, lead, cadmium, chrome, copper, iron and zinc) and PAK-16 (polycyclic aromatic hydrocarbons).

Recyllose^{TM} was also tested once in Neve-Yaar laboratory in Israel for the following tests: ash, water content, phosphorus, calcium, magnesium, ammonia, cellulose, hemi-cellulose, lignin, ammonia, fat, protein, and nutritional value.

Recyllose^{TM} ash was tested once in Aquon lab for the following tests: chlorine, arsenic, mercury, nickel, lead, cadmium, chrome, copper, iron, zinc, EOX and PAK-16.

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Chapter 5: Data Collection

During the trial period, various data was collected from the SRS and the WWTP parameters. WWTP collected data as usual, through their automatic system and standard sampling schedule. Parameters for WWTP were inlet COD, TSS, TP, TN, NH_4, NKj, PO_4, inlet flow, electricity demand, sludge production, sludge water content and polymer consumption.
For each reactor the following data was collected: MLSS, SVI, WAS (flow and dry content), and electricity consumption for aeration.
Data was compared between AT1 and AT2, and data obtained during the trial period was compared to historical data, in order to find trends and to extrapolate for the full scale installation.
Historical data was collected for a year before the beginning of the trial.
The SRS collected inlet flow and electricity demand.
Recyllose™ weight and dry matter content were measured by WSAM personnel.
Recyllose™ internal consumption was recorded by ACT.

The following table summarizes the sampling schedule:

Table 2 Sampling schedule for WWTP

frequency: x/ week			Full scale										
Parameter	**Method**	**Lab**	**infl**	**infl1**	**infl2**	**effl**	**effl 1**	**effl 2**	**AT1**	**AT2**	**WAS**	**WAS 1**	**WAS 2**
Flow	continuous	-	c	c	c	c	-	-	c	c	c	c	c
Electricity	continuous	-	-			-	-	-	c, aer	c, aer	-	-	-
SS, MLSS, "DM"	stove	wwtp	2	2	2	-	2	2	2	2	-	1	1
		Aquon	1			1	-	-	1	1	0.25	0.25	0.25
Polymer consumption	operation	wwtp	-			-	-	-	-	-	c	-	-
Centrifuge work hours	operation	wwtp									c		
Ash (inorganics)	stove	wwtp	1			-	1	1	2	2	-	1	1
		Aquon	-			-	-	-	1	1	0.25	0.25	0.25
COD	cuvet	wwtp	3			-	3	3	-	-	-	-	-
		Aquon	1			1	-	-	-	-	-	-	-
BOD	NEN	Aquon	1			1	0.25	0.25	-	-	-	-	-
Nkj	NEN	Aquon	1			1	-	-	-	-	-	-	-
NH4-N	cuvet	wwtp	3			-	3	3	-	-	-	-	-
	continuous	-	-			-	-	-	c	c	-	-	-
NO3-N	cuvet	wwtp	1			-	1	1	-	-	-	-	-
	cuvet	Aquon	1			1	-	-	-	-	-	-	-
NO3-N	continuous	-	-			-	-	-	c, 2x	c, 2x	-	-	-
Total-N	cuvet	wwtp	3			-	3	3	-	-	-	-	-
P	cuvet	wwtp	1			-	1	1	-	-	-	0.5	0.5
	cuvet	Aquon	1			1	-	-	-	-	0.25	0.25	0.25
PO4-P	cuvet	wwtp	3			-	3	3	-	-	-	-	-
	continuous	-	-			-	-	-	c, 2x	c, 2x	-	-	-
O&G	Gravimetric	Aquon	1			-	-	-	-	-	-	-	-
"metals"	NEN	Aquon	0.25			0.25	-	-	-	-	0.25	0.25	0.25
SVI	Gravimetric	wwtp	-			-	-	-	3	3	-	-	-
O2	continuous	wwtp	-			-	-	-	c	c	-	-	-
aeration flow	continuous	wwtp	-			-	-	-	c, 2x	c, 2x	-	-	-
Dewatering: DS%, PE-cons.	operation	wwtp	-			-	-	-	-	-	0.25	0.25	0.25

Chapter 6: Trial Results

6.1 Sampling Tests Results:

The following table displays the various results obtained from the different labs and sampling methods:

Table 3 Summary of sampling results

	Composite samples								Grab samples				Final reduction rate for extrapolation**
	WSAM				Aquon				Aa en Maas				
	Inlet	Outlet	Reduction	n*	Inlet	Outlet	Reduction	n	Inlet	Outlet	Reduction	n	
Parameter	mg/l	mg/l	%		mg/l	mg/l	%		mg/l	mg/l	%		%
TSS	172	128	26%	42	225	131	42%	11	291	180	38%	23	36%
COD	492	463	6%	41	477	429	10%	11	689	572	17%	3‡	15%
BOD					161	157	2.8%	12					
N (NK)***	45	44	1.6%	27	41	40	2.8%	12					
P	6.7	6.5	3.7%	27	6.2			12					
FOG					30	24	18%	11					

* n= number of samples tested for each parameter.

** Final reduction rates for extrapolation; these are the reduction rates found to be representing numbers as a basis the estimation calculation of the performance of the SRS in a full scale installation.

*** WSAM lab tested for TN while Aquon tested for NKj.

‡ Since there only 3 samples for this parameter, the result is considered to have low representation.

Conclusions for the pilot test are based on both the Aquon and WSAM results, and are the basis for the full scale extrapolation.

6.2 TSS Measurements:

The following graph depicts the fluctuations in inlet and outlet TSS during the trial period for composite samples taken on the same day (n=10), and compared between the two labs:

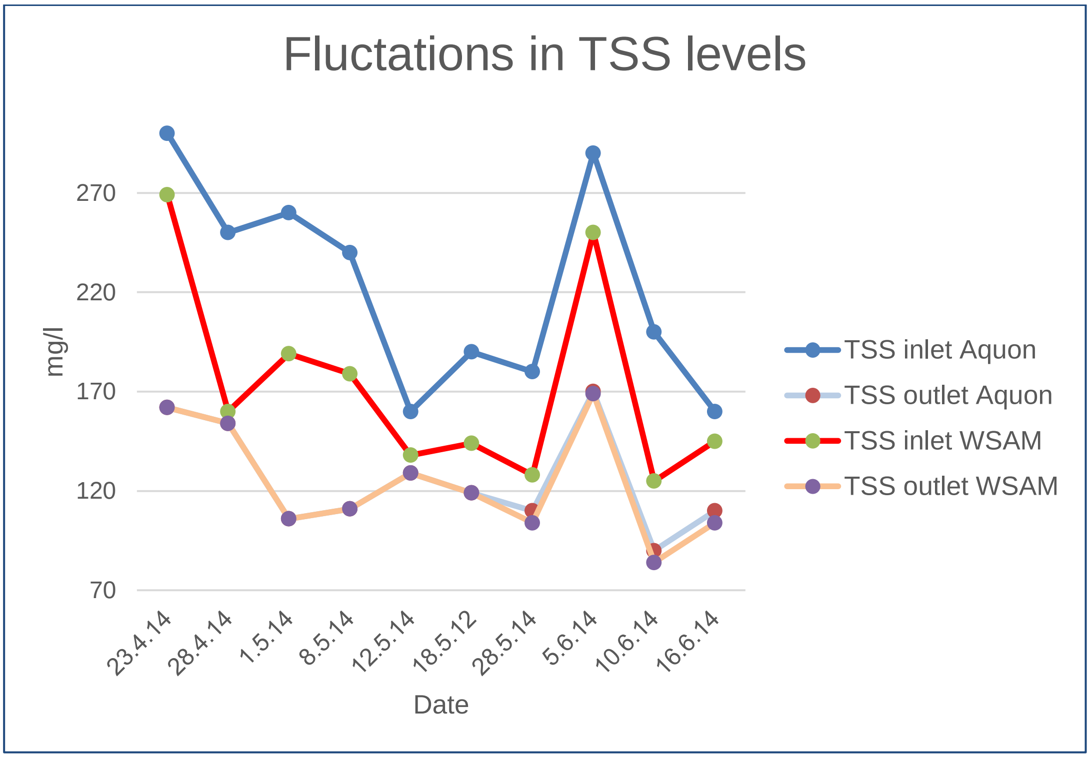

Figure 2 Fluctuations in TSS levels

The WSAM results and the Aquon results were comparable, the only striking difference was the TSS concentration of the influent samples. The results of Aquon were about 28% higher than the WSAM results.

We see three phenomena arising from the results:

1. Although the outlet TSS is almost identical for both labs and can barely be discerned, there is a large difference (average 28%) in inlet TSS between the two labs.
2. Parallelism between inlet TSS lines can indicate that the differences of the measurements between the two labs do not arise from random errors of sampling or storage.
3. Less parallelism between inlet and outlet lines are an indication that there is a correlation between TSS levels and TSS reduction, i.e. when inlet TSS levels are high then reduction rates are higher and vice versa.

The difference in influent TSS results between the two labs (phenomena 1) may arise from different measuring procedures between the two labs, but this has been checked and the procedures are identical. Currently there is no explanation for this difference.

The results of the average TSS reduction based on composite sampling for WSAM are 26% and for Aquon 42%. The average TSS reduction calculated from the WSAM grab samples is 38%.

6.3 COD Measurements:

The following graph depicts the fluctuations in inlet and outlet COD during the trial period for composite samples taken on the same day (n=10), and compared between the two labs:

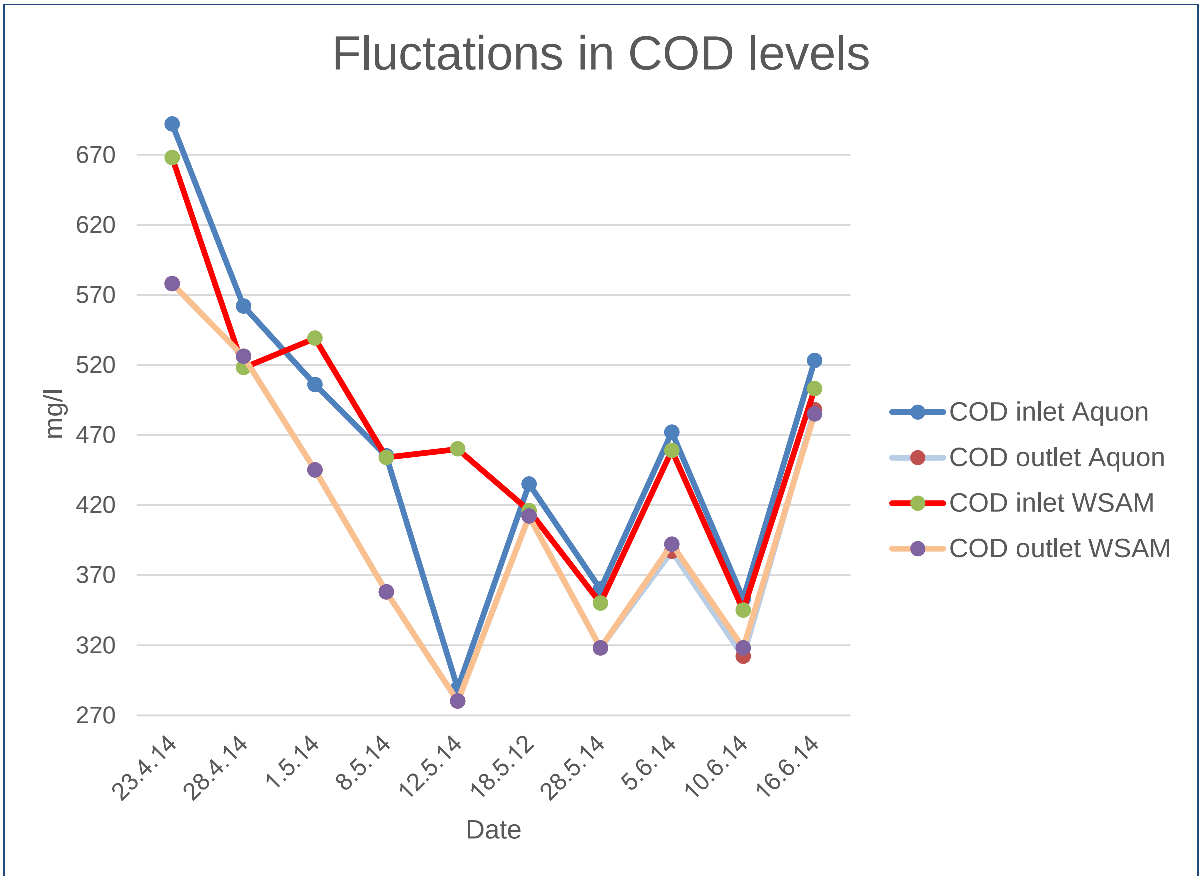

Figure 3 Fluctuations in COD levels

We see several phenomena from the graph:

1. Just as for the outlet TSS, outlet COD is nearly identical for the two labs giving a good indication of identical testing procedures.
2. As for inlet COD, if we ignore point number 5 (12.5.14), we get a good correlation between the lab results.

3. For the second period we see remarkable parallelism between the inlet and outlet lines. This can indicate good sampling repeatability and low correlation between COD level and COD reduction.

The results of the average COD reduction based on composite sampling for WSAM are 6% and for Aquon 10%. The average COD reduction calculated from the WSAM grab samples is 17%, based on 3 samples only.

6.4 BOD Reduction:

BOD reduction was quite low, average 2.8% according to Aquon tests. This is unusual for SRS installations, where it is common to get ~10-20% reduction of BOD, together with a 20-30% reduction of COD. This can be explained by a very low percentage of non-soluble BOD in the influent. Nonetheless, for the last 4 weeks of the installation Aquon tests showed a 12% reduction of BOD, which is more consistent with ACT experience. The reason for this change is unknown, but can be attributed to a change in composition of the industrial sewage reaching the WWTP, or the inherent inexactness of BOD tests.

The following graph shows fluctuations in BOD levels and BOD reduction, as measured by Aquon lab:

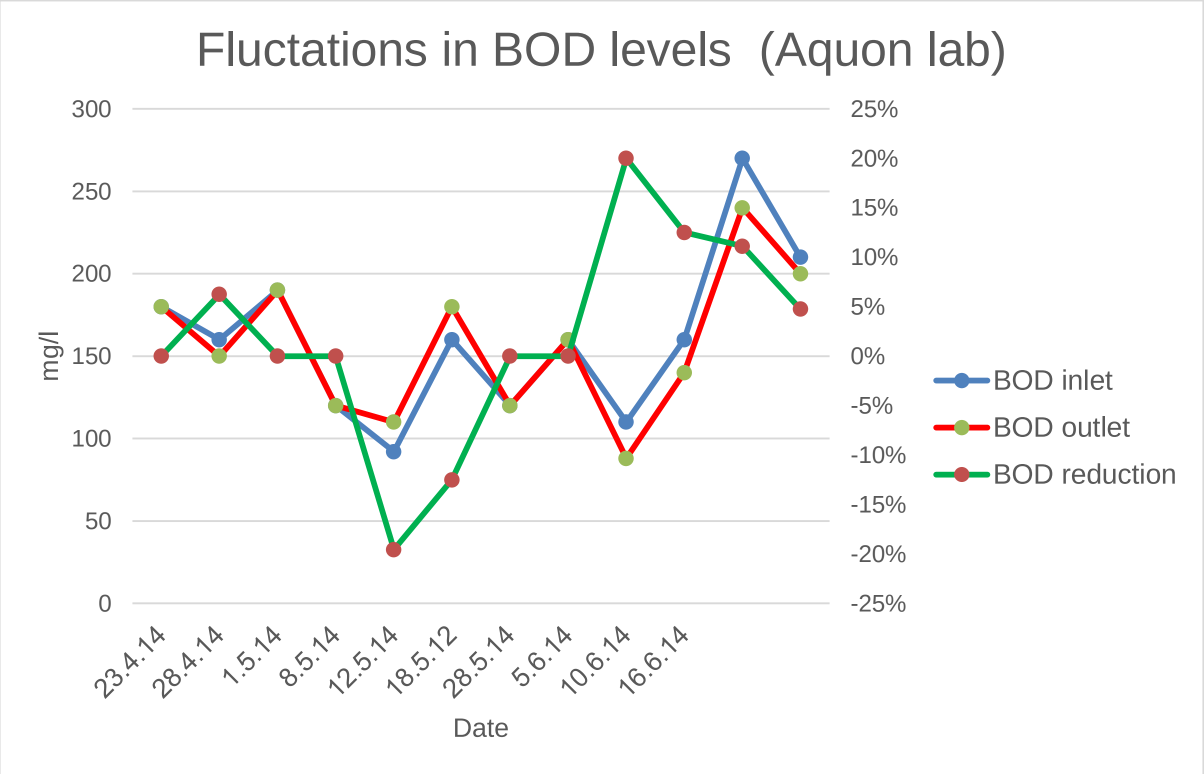

Figure 4 Fluctuations in BOD levels

6.5 N,P Reduction:

In general, TN and TP reductions were low. Aa en Maas measured TN and TP reduction at 1.6% and 3.7% respectively, while Aquon measured 2.8% reduction for NKj (Aquon didn't measure TN and TP). These results are within the error margins of the testing, and therefore weren't relied upon for the full scale system.

6.6 FOG Reduction:

FOG reduction was measured by Aquon to be 18%. Although FOG reduction influence for the full scale is not straightforward, it is anticipated to reduce foaming and slime buildup in the reactors, as well as reduce energy for aeration, otherwise spent on degrading the FOG.

6.7 Heavy Metals Reduction:

Concentration of several heavy metals was tested for the inlet and outlet flows. The results are summarized in the following table:

Table 4 Reduction of heavy metals by SRS

Metal	Symbol	units	Inlet	Outlet	n	Reduction
Mercury*	Hg	µg/l	<0.2	<0.2	12	0
Nickel	Ni	µg/l	13.8	11.8	12	14%
Lead	Pb	µg/l	16.5	14.3	12	14%
Iron	Fe	mg/l	2.0	1.8	12	12%
Cadmium*	Cd	µg/l	<1.0	<1.0	12	0%
Chrome	Cr	µg/l	19	12.9	11**	32%
Copper	Cu	µg/l	149	135	12	9%
Aluminum	Al	µg/l	922	788	12	15%
Zinc	Zn	µg/l	202	178	12	12%
					Average	12%

*Mercury and Cadmium were below detection limits.
** For Chrome one result was unreliable so removed.

As can be seen from the results, reduction of heavy metals by the SRS is moderate - around 12% on average. This may represent the percentage of heavy metals that are incorporated in the TSS and not soluble.

6.8 Grab Samples:

Grab samples of the SRS influent and effluent gave much higher results for TSS and COD concentrations than the composite samples, and the reduction rates were 10% higher than the composite samples. TSS grab samples showed 38% reduction versus only 26% reduction for the composite samples.

COD grab samples showed 17% reduction versus 10% reduction for the composite samples, although there only 3 samples for COD, therefore the representation is low.

The higher TSS removal rates found when using grab samples can be explained from our experience with prior installations and from observations of the current installation, the higher reduction rates correlate with higher influent TSS concentrations. The higher TSS levels are explained by the varying TSS load that was observed during the day; much higher organic loads during day-time, in comparison to night-time, when most people are asleep and sewage contains relatively more leakage water. Another possible reason is that during the night, when flows are low, solids may settle in the pipes and pumping stations, and are re-suspended during the day. This doesn't mean that these solids have escaped the SRS- they are trapped preferentially during daytime after they have been re-suspended.

The grab samples were taken during day-time only. The higher reduction rates for these samples are due to the higher efficiency of the SRS when loads are higher. This feature will be taken into account when designing for a full scale system installation, when several trapping systems are installed in parallel. Some of them can be tuned to reduce low levels of TSS efficiently, working mainly during the night, while other trappers will be adapted to the higher loads and flow during daytime.

6.9 Results of the SRS:

SRS pumped a total of 288,769 m^3 of sewage during the trial period (or 3,620 m^3/day), which is ~11% of the flow entering AT1.
Recyllose^{TM} production: an average of 240 kg/d at 82%DM, which are ~200 kgdm/d. About 75% of the produced Recyllose^{TM} were used as fuel for the SRS; for the full scale, the internal fuel consumption is expected to be around 15-20%.
Average electric demand of the SRS was 411 kWh/d for the SRS installation, including two pumping steps (one to pump sewage into the SRS and the second to supply pressurized sewage for the secondary trapper). The first pumping stage is estimated to consume ~50% of the daily demand, while the second pumping stage (working 5-10 hours per day) consumed ~10-20% of the daily demand. As an estimate, the SRS consumes ~150kWh/d without the pumping stages.

6.10 Results of Recyllose™ Testing:

Results of Recyllose™ (n=7 for most analysis, n=4 for calorific value and n=12 for DM) and ash (n=6, except EOX: n=5 and ash: n=1) analysis by Aquon:

Table 5 Composition of Recyllose and ash

Parameter	Units	Recyllose™	Ash
Ash	%	13.5	
DM	%	81.7	99
Calorific value	Kj/g	16.0	
Calorific value	Kcal/kg	3824	
Cl	mg/kg	719	597
EOX	mg/kg	17	0.28
As	mg/kg	1.3	8.52
Cd	mg/kg	0.41	1.56
Cr	mg/kg	21.6	125
Cu	mg/kg	249	1305
Fe	g/kg	3.7	23
Hg	mg/kg	0.41	0.54
Ni	mg/kg	13.1	81
Pb	mg/kg	43.0	203
Zn	mg/kg	391.4	1692
PAK-16	mg/kg	3.1	4.1

- PAK-16 = Polycyclic Aromatic Hydrocarbons (sum of separate components).
- EOX = Extractable Organic Halogens.
- All parameters refer to dry weight.

6.11 Results of Recyllose™ Testing by Neve Yaar Lab:

A sample of Recyllose™ was sent to the Neve-Yaar laboratory in Israel for analysis. This lab specializes in testing fodder for farm animals. The results are similar to the results of Recyllose™ testing taken from other installations in Israel and worldwide. The table below describes the results with a comparison to the average results from other sources:

Table 6 Result of Recyllose™ composition- Neve-Yaar Lab

Parameter	Units	Aarle-rixtel WWTP	Average of Recyllose™ sources worldwide
Ash	%	8.3	13.7
DM	%	85	90
P	%	0.301	0.345
K	%	0.100	0.125
Mg	%	0.07	0.13
Cellulose	%	55.8	49.2
Hemi-cellulose	%	9.7	8.9
ADF*	%	60.3	53.9
NDF**	%	70	62.8
Lignin	%	4.5	4.8
NH4	mg/kg	13.0	47.5
Fat	%	9.2	10.9
Protein	%	9.9	11.6
Nutritional value***	Mcal/kg	1.42	
Calorific value****	Kcal/kg		4414

*ADF = Acid Detergent Fiber = cellulose + lignin.
** NDF (total fiber) = Neutral Detergent Fiber = cellulose + hemi-cellulose + lignin.
*** Nutritional value is the energy the animal can absorb from digesting the product.
**** Calorific value is the energy emitted upon combustion.

The Recyllose™ contains 70% total fiber, out of which 80% is cellulose and the rest is hemi-cellulose and lignin. It also contains 10% each of fat and protein, satisfactory levels of the P, K, Mg and NH_4, low levels of heavy metals and a high nutritional value. All of these results show that the composition of the Recyllose™ makes it an ideal fodder for bovines, especially young cows.

When comparing Aquon results to Neve-Yaar results, we see that the ash content was 8.3% in Neve-Yaar results, compared to 13.5% in Aquon results. Aquon result is probably more representing, since it is an average of 7 tests, and it is in comparison with ash content from other sources of Recyllose™.

When comparing analyzes of Recyllose™ from Aarle-Rixtel to Recyllose™ from other sources, we see that the total fiber content is higher, fat and protein levels slightly lower, and the elements (P, K, Mg) are similar. NH_4 is substantially lower. Calorific values measured by Aquon (3824 kcal/kg) are lower than the average results common for Recyllose™ (4414 kcal/kg). This may be due to a lower content of fat.

6.12 Comparison Between AT1 and AT2:

Small differences in performance of the two reactors AT1 and AT2 were observed during the pilot period. No detrimental effect observed on the process or on the effluent quality.

1. The differences in aeration energy consumption were within the normal fluctuations in the trends. The following graph portrays differences in energy consumption for aeration during the trial period, and in comparison to the year before the trial began:

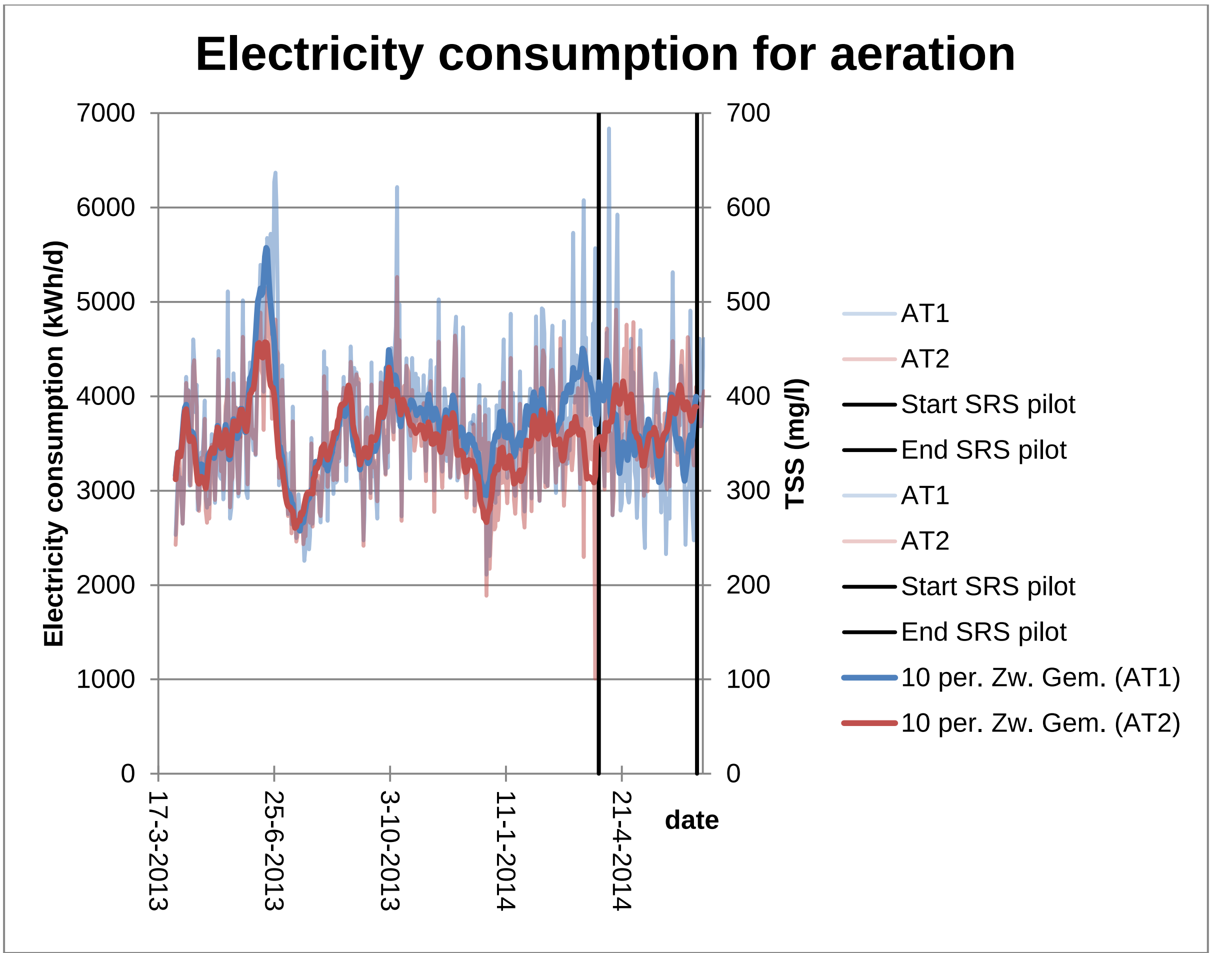

Figure 5 Fluctuations in energy for aeration

2. The differences in waste sludge production were within the normal fluctuations. Based on the observed TSS reduction of the SRS, it can be calculated that during the pilot test the waste sludge production in AT1 was approximately 2% lower than AT2, which is within normal fluctuations. The following graph portrays the fluctuations in daily amounts of surplus (waste) sludge removed from each reactor during the trial period, and the year before the trial began:

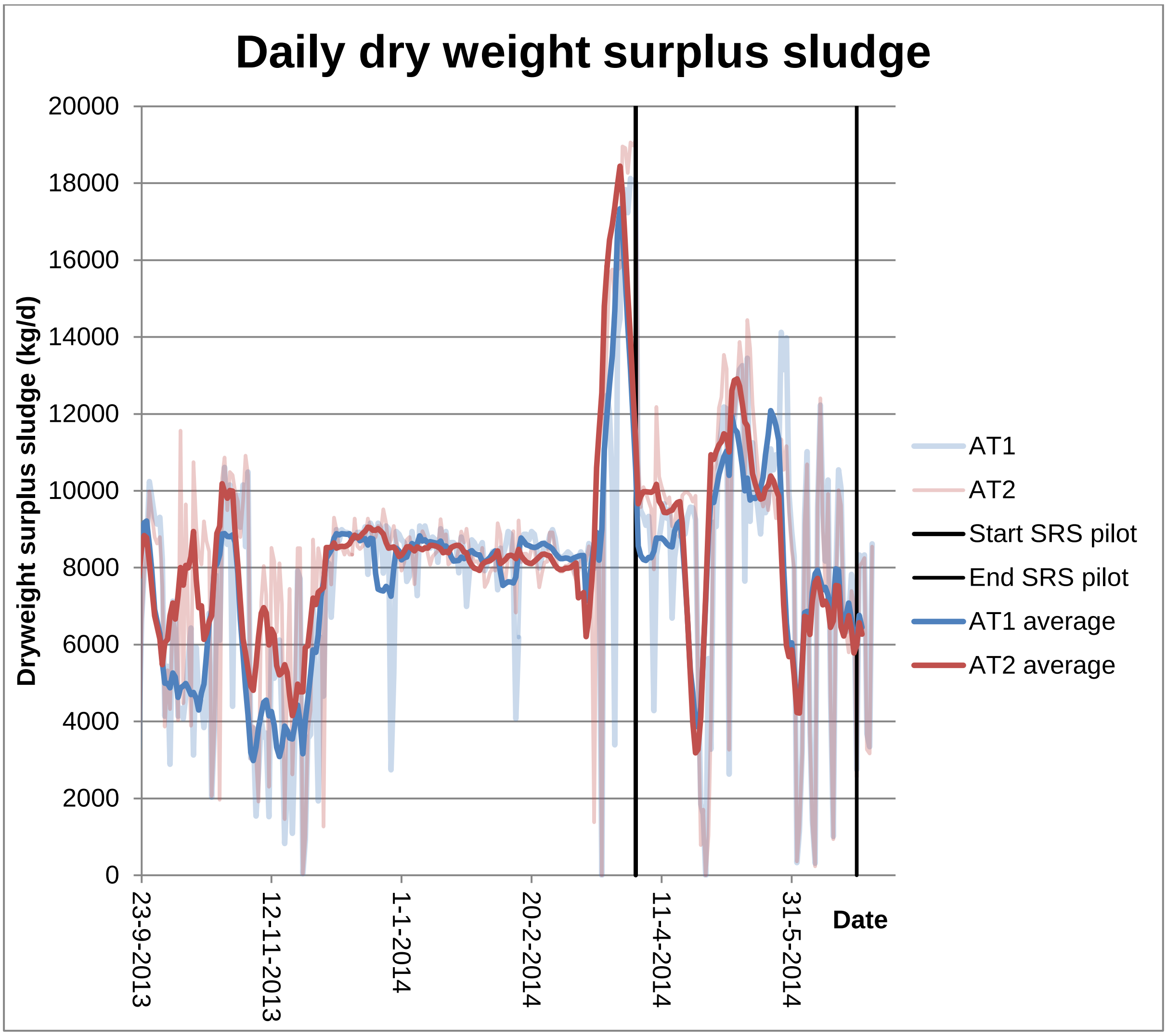

Figure 6 Fluctuations in daily surplus sludge

3. Sludge Volume Index (SVI) measurements:
   No significant difference was observed between AT1 and AT2.
   The following graph portrays the daily fluctuations in SVI levels during the trial period, and the year before the trial began:

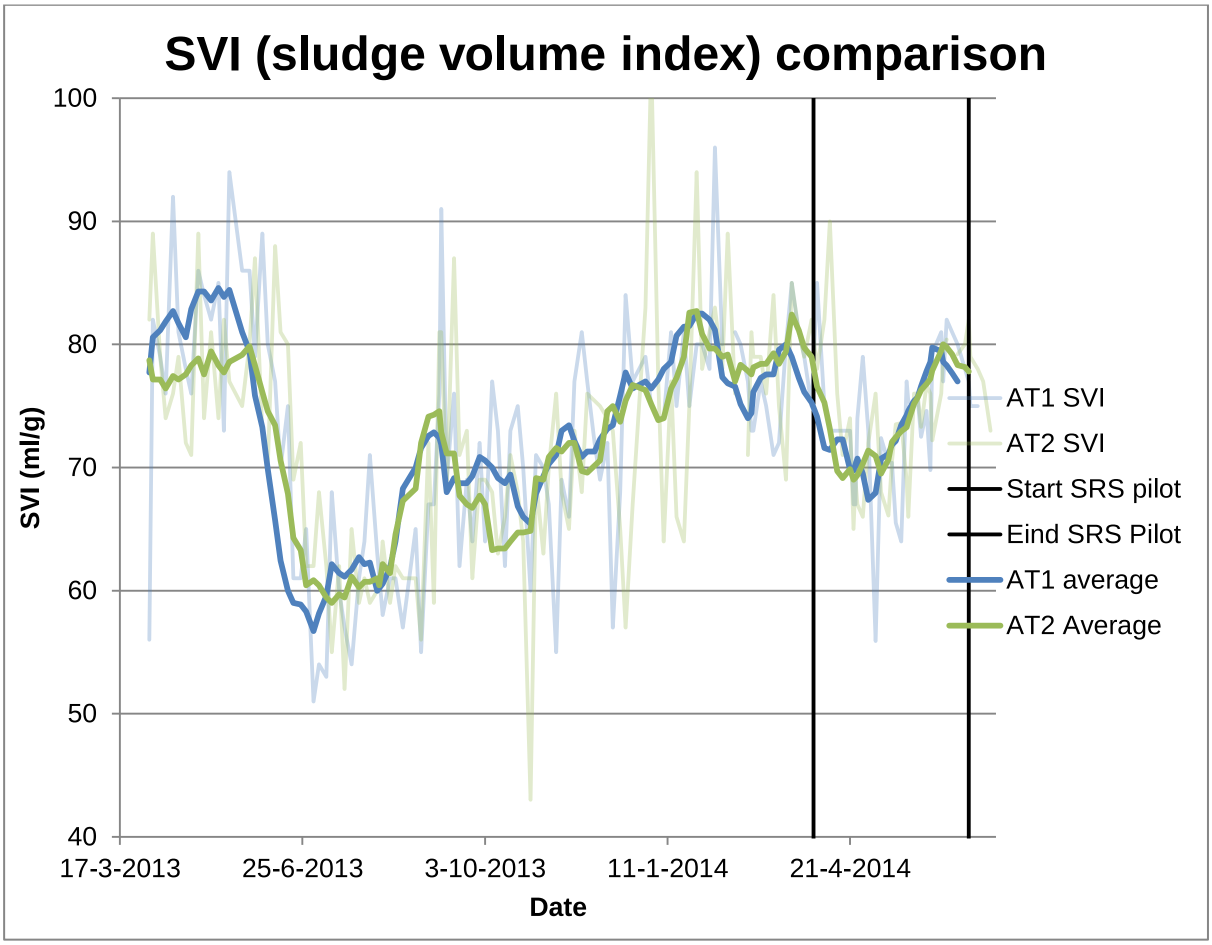

Figure 7 Fluctuations in SVI

4. Sludge dewatering: It was not possible to see significant differences in solid content, polymer consumption, or centrifuge working hours. During the trial there were several disturbances in dewatering operation (due to maintenance of the centrifuges), and the polymer type was changed. Amount of dewatered sludge for transport also contains sludge from Asten WWTP (dewatered in Aarle-Rixtel WWTP), therefore these were also not correlated to the SRS activity.

5. Effluent quality in both parallel lines was similar.

6.13 Recyllose™ Storage:

Weather conditions in the Netherlands during the trial were usually very humid. Under these conditions, the Recyllose™ can become moldy and smell bad. As a first step, ACT calibrated the SRS to produce drier pellets (above 85%DM), and produced a larger portion of Recyllose™ in fluff (windrow) form. The fluff form is less susceptible to mold. Nonetheless, since Recyllose™ contains mostly cellulose, which is a hygroscopic material, it may also absorb moisture from the air and start to mold.

During the trial, an experiment was performed to check this phenomenon. Recyllose™ pellets and fluff were thoroughly dried in the sun and then sealed in air tight containers. The material remained mold free for three weeks, and began to mold again only after it was opened. We concluded that Recyllose™ should be further dried and stored under humidity-controlled conditions.

As a consequence, for the full scale installation, an additional active drying unit will need to be installed to dry the product before storage, and storage of Recyllose™ in air-tight containers / bags or in humidity-controlled silos will need to be considered.

ACT experience from Israel, is that the Recyllose™ can be stored in open big-bags or sealed containers for several years, when it is sufficiently dry and protected from the weather and without any signs of biological activity.

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Chapter 7: Extrapolation to Full Scale System

The results of the pilot test were extrapolated to the full scale system. Representing numbers were assumed for the different parameters, based on the pilot results and on ACT's previous experience at other WWTP's, including the assumption that the full scale system will be further optimized in comparison to the pilot.

7.1 TSS reduction:

Results of TSS reduction for composite samples from Aa en Maas lab were on average 26%, and from Aquon 42%; the TSS reduction based on grab samples from WSAM lab were on average 38%. As a representing number we took 36%, which represents a realistic efficiency, based on ACT's previous experience. Other installations have shown average TSS reduction of 40-50%.

The average influent TSS load on 2013 was 14,095 kgdm/d, so with a removal efficiency of 36 % it can be calculated that the reduction in TSS load is 5,074 kgdm/d (see datasheet in chapter 11).

7.2 COD reduction:

COD reduction results for composite samples from the Aa en Maas lab were on average 6% (there were negative results as well), and for Aquon lab 10% (no negative results). The COD removal calculated from the 3 grab samples was 17%. In general, the calculated COD reduction in the pilot test seems to be relatively low, even in comparison to the TSS reduction. ACT's experience in other installations is a COD reduction in the range of 15-30%. Based on the ACT's previous experience and the pilot results, a realistic number for COD reduction was estimated to be 15%. The average influent COD load on 2013 was 32,732 kg/d, therefore, with a COD removal efficiency of 15% it can be calculated that the reduction in COD load will be 4,910 kg/d.

7.3 BOD reduction:

BOD levels were erratic during the trial period, averaging 2.8% for the entire period, with 0% reduction for the first 2 months, and 12% for the last month. For the full scale installation, it is expected to receive 6% reduction of BOD.

7.4 N,P Reduction:

In general, TN and TP reductions were low during the pilot test. Aa en Maas measured TN and TP reduction at 2% and 3% respectively, while Aquon measured 2% reduction for NKj (Aquon didn't measure TN and TP). These results are within the error margins of the testing, therefore they weren't relied upon for the full scale.

From ACT's previous experience in other installations. TN reduction rates are usually higher, around 10-15%, but these usually had much higher inlet TSS levels than Aarle-Rixtel. TP was not measured for representation number in other installations.

For extrapolation to full scale, TN-reduction of 3 % was assumed. This parameter is used only for calculating the impact on the WWTP capacity (pollution equivalents) in chapter 12.

7.5 FOG Reduction:

FOG reduction was measured by Aquon to be 18%. Although FOG reduction influence for the full scale is not straightforward, it is anticipated to reduce foaming and slime buildup in the reactors, and reduce energy for aeration, otherwise spent on degrading the FOG.

From ACT's previous experience, FOG can be reduced up to 40-50%, but these are for WWTPs that don't have a grease separator like in Aarle-Rixtel.

7.6 Recyllose™ Production:

Recyllose™ production for the full scale system is based on a ratio of 1:1 on TSS reduction. When we calculated based on data of 2013, the average daily flow was 66,800 m^3/d, TSS inlet was 211 mg/l which gives ~14,095 kgdm/d. With 36% TSS reduction, this results in a daily production of 5,074 kgdm/d of Recyllose™.

7.7 Reduction in Sludge Production:

Sludge production will be reduced, since inlet TSS and COD are reduced.

Sludge formation arises from two sources:

1. Non-biodegradable TSS.
2. Biomass growth in the reactor, due to degradation of COD.

In order to maintain a constant MLSS (mixed-liquor suspended solids) in the reactor, the operators of the WWTP pumped waste activated sludge (WAS) out of the reactors. It is estimated that 90% of the inlet TSS is non-biodegradable, and becomes a major component of the dewatered sludge for disposal. This number is based on theory and hasn't been checked in Aarle-Rixtel sewage. Although COD is also reduced by the SRS, the biomass yield in the m-UCT reactors cannot be reduced, since the biomass is required in order to remove phosphorus from the sewage. In order to maintain constant SRT (sludge retention time) in the reactor even though TSS and COD loads have decreased due to SRS activity, the operators will have to waste less sludge, less dewatered sludge will then be formed, and MLSS levels will be reduced.

Based on this rational, reduction in sludge production is calculated. It is assumed that for every kg of TSS there is a kg of BOD entering the WWTP. If the TSS is 90% non-biodegradable, then the remaining biodegradable TSS is digested in the reactor to give additional biomass with a yield factor of 0.25 [g sludge DM/g BOD].

BOD is also digested in the reactor with similar yield. The expected sludge produced from 1 kg TSS and 1 kg BOD entering the WWTP without the SRS is:

Sludge (no SRS) = 1 (kgTSS) X 0.9 + 1 (kgTSS) X 0.1 X 0.25 + 1 (kgBOD) X 0.25 = <u>1.175kg</u>

If the SRS is active and 36% TSS and 6% BOD is removed, the production of sludge will be: Sludge (with SRS) = 1 (kgTSS) X (1 - 36%) X 0.9 +1 (kgTSS) X (1 -36%) X 0.1 X 0.25 + 1 (kgBOD) X (1 - 6%) X 0.25 = <u>0.827kg</u>

The sludge will be therefore reduced by 1.175 - 0.827 / 1.175 = <u>29.6%</u>

7.8 Reduction in Sludge Dewatering Costs:

Sludge dewatering has additional costs: Polymer consumption and electrical energy for the centrifuges. Both of these parameters will be reduced in a ratio of 1:1 to sludge reduction. For 2013, energy for sludge dewatering was estimated at 1400 kWh/d, anticipated savings will be 29.6% X 1400 = 414 kWh/d.

Polymer consumption in 2013 was 226 kg/d (dry powder), therefore savings will be 29.6% X 226 = 67 kg/d.

7.9 Reduction in Energy for Aeration:

In the m-UCT reactors, air is introduced into the reactor via diffusers installed on the bottom of the reactor. Powerful blowers supply the pressurized air required. As the air bubbles ascend to the surface, oxygen diffuses from the bubbles into the water, allowing the formation of an aerobic bacterial colony. The daily amount of oxygen required is estimated to be in a ratio of 1:1 to the amount of COD entering the reactor, and the amount of energy required for aeration is assumed to be in a ratio of 1:1 to the amount of oxygen introduced. For estimation of the required energy for aeration it is therefore assumed to be in a ratio of 1:1 to the amount of COD entering the reactor.

Most of the COD, however, removed by the SRS is non-biodegradable and doesn’t influence aeration. The exact amount of particulate biodegradable COD separated from the sewage is hard to predict, we therefore used the reduction in of 6% in BOD (see section 7.3) instead. Energy for aeration is estimated to be reduced by 6%.

On 2013, the electrical energy required for aeration (excluding energy for mixing and pumping) was 7200 kWh/d. With a BOD-reduction of 6% this results in a saving of 6% X 7200 = 432 kWh/d.

For the full scale we expect a higher reduction rate in energy for aeration, since the biodegradable COD removed by the SRS is in the form of articulate, hence it is slowly biodegradable and requires a disproportionate ratio of aeration as compared to soluble biodegradable COD.

7.10 Total Savings in Energy Consumption

The total savings of electric energy are the sum of savings for sludge dewatering and savings for aeration. This is 414 + 432 = 846 kWh/d.

7.11 Energy Consumption of the SRS

During the trial period, the SRS consumed on average 411 kWh/d. This includes two stages of pumping, as described in the results chapter, and doesn’t include additional pumping from the SRS back to the reactor. The energy consumption of the SRS itself, was estimated to be 150 kWh/d.

For the full scale system, we anticipate that the energy consumption of the SRS would be around 1600 kWh/d, without any additional pumping.
Since the SRS requires ~1m of head for installation after the sand separator, and the WWTP doesn’t have enough head for this, the sewage will have to be pumped from the outlet of the sand separator to the SRS. The SRS will be installed in such a way, that the treated sewage will return gravitationally to the reactors. Pumping large volumes of sewage to very small heads requires specialized pumps with very low energy requirements, around 20-25kw. These pumps will allow 90% of the average flow to reach the SRS. This gives an additional ~500kWh/d and a total of 2100kWh/d for the SRS installation with pumping.

Another option is to install the SRS before the primary 6mm screens. This will not require an additional pumping stage, but can rely on the WWTP pumps to give the extra head. This installation form will have additional benefits since the load on the pre-treatment will also be reduced.
In conclusion, the SRS will expect to consume 1600-2100 kWh/d for the full scale installation.

7.12 Net Savings in Energy for Electricity:

The net savings for the SRS installation with pumping will be
846 – 2100 = -1254kWh/d, and without pumping 846 – 1600 = -754kWh/d.

Net electric energy consumption for the SRS installation is therefore expected be an additional energy consumption in the range 754 to 1254 kWh/d. This is an increase of 5-8% of total energy consumption of the WWTP (~15,000kWh/d).

7.13 Internal Recyllose™ Consumption:

Out of the ~200kgdm/d Recyllose™ produced by the SRS during the pilot test, approximately 150kgdm/d was consumed internally, producing heat energy required for the drying process. This corresponds to 75% internal consumption. Since the SRS 20K installed in Aarle-Rixtel can treat up to 1000kgdm/d of Recyllose™ using the same amount of fuel, the actual fuel consumption for a full scale installation should be in the range of 15-20%.

This can be calculated theoretically:
The material enters the dryer at **50**% moisture content and should leave the dryer at **15**% moisture content. This is the optimal moisture content for pellet production, and after cooling, may ensure the product will not mold.
For example, for every 100 kg Recyllose™ entering the dryer (or 50 kgDM) at 50%MC, 59 kg Recyllose™ will exit the dryer at 15%MC. The dryer should therefore evaporate 100 – 59 = 41kg water.
Evaporation energy is 2.26 MJ/kg and increasing the temperature of water needs an additional 0.29 MJ/kg. We disregard from biomass heating.
Altogether, 2.55 MJ/kg water evaporation is required. In order to dry 100kg Recyllose™, 41 x 2.55 = 105 MJ is required.
The dryer may have an efficiency of 70%, therefore we need 150 MJ per 59kg Recyllose™ exiting the dryer.
Dry Recyllose™ has a calorific value of 16 MJ/kg. At 15%MC it has the value of 13.6 MJ/kg. We therefore need to incinerate 150 / 13.6 = 11 kg Recyllose™ at 15%MC in order to dry 59 kg Recyllose™.
We need to burn 11 / 59 = **18.7**% of the material for drying. This falls within the range anticipated above.

7.14 Concentrated Results:

The following table summarizes the concentrated results for extrapolation to the full scale installation:

Table 7 Concentrated results for full scale installation

Parameter	Value
Energy reduction for aeration	6% reduction
Energy reduction for sludge dewatering	29.6% reduction
Sludge reduction	29.6% reduction
Polymer reduction	29.6% reduction
Recyllose™ production	5,074 kgdm/d
Total energy savings	846 kWh/d
SRS electric demand	1,600-2,100 kWh/d
Net electric demand	(-754) –(-1254)kWh/d (-5)-(-8)%
Increased capacity for the WWTP	10-15%

Chapter 8: Benefits for the WWTP

Due to SRS activity, besides the improvements mentioned above, additional benefits may arise, as follows:

1. Reduced maintenance for the WWTP - since the SRS eliminates all solids larger than 0.3mm, the WWTP personnel will not experience blockages in pumps caused by hairs, moist toilettes and hygienic items that can escape through the screeners. FOG is also reduced, so there is less foaming and scale buildup in pipes and passages.
2. The SRS acts as a second barrier to back-up the WWTP pre-treatment system in case of malfunction.
3. Increased sludge line capacity - postponement of upgrading this part of the WWTP, due to reduced organic loads in the sewage inlet.
4. Reduced load on the sludge dewatering system, means more time for maintenance and less risk of malfunctions that may require storage of sludge in the reactors. This may lead to increased MLSS and increased risk of effluent quality reductions.
5. Eligibility for CDMs (carbon credits).

Chapter 9: SRS Installation During Trial Period

The following scheme depicts how the SRS was installed during the trial period. Data is based on averages taken during the trial period.

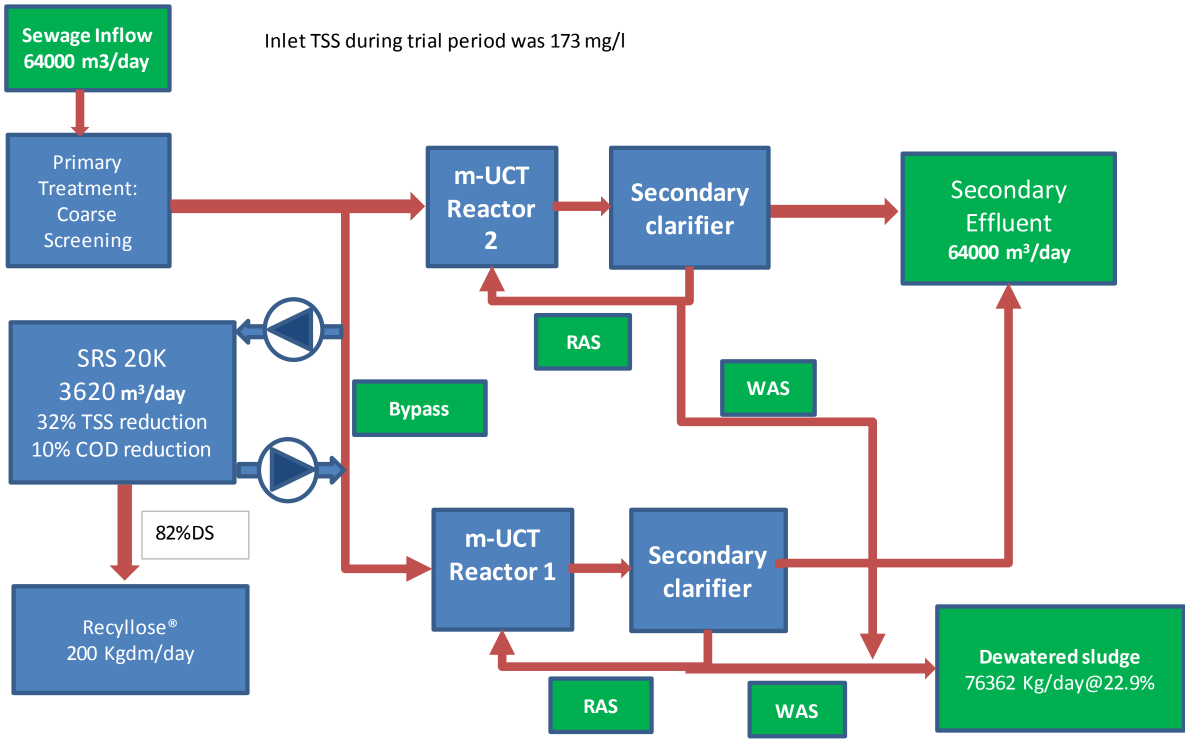

Figure 8 SRS installation during trial

Chapter 10: Scheme for Full Scale System Installation

The following scheme depicts how the SRS will be installed as a full scale system. Data is based on extrapolated values. WWTP parameters based upon data from 2013. All weights are based on dry matter.

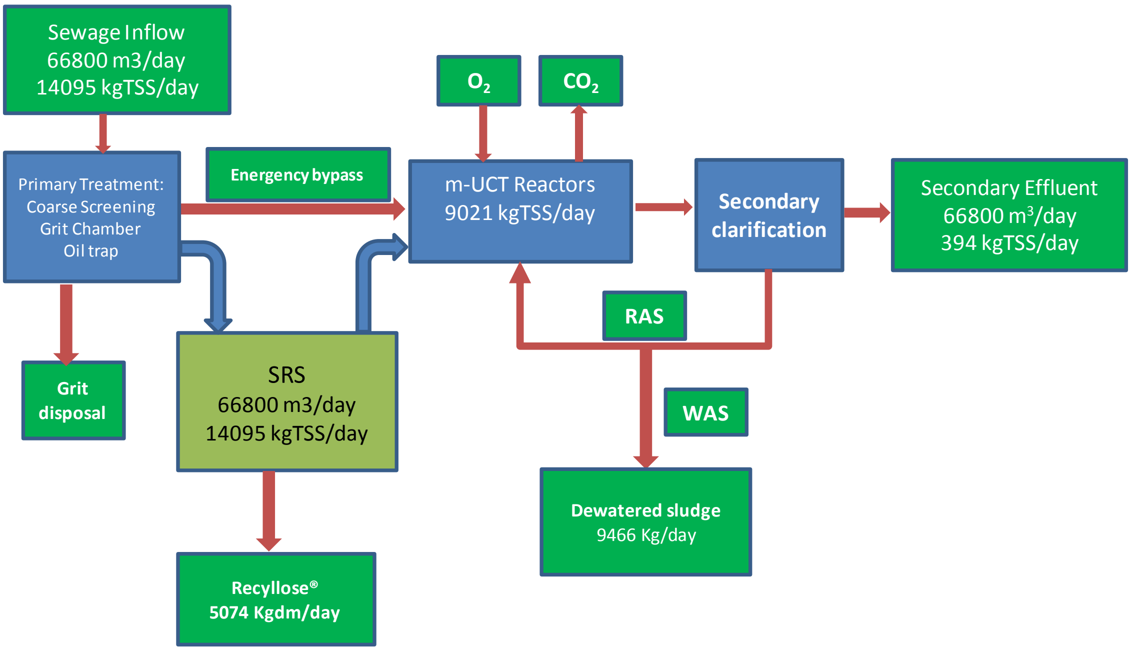

Figure 9 SRS full scale installation

Chapter 11: Mass Balance and Cost Calculation for the Full Scale System Installation

A mass balance was calculated for the full scale SRS system installation at the Aarle-Rixtel WWTP, based upon the extrapolated results. The data was based on the data received for the year 2013. The calculation appears in the attached file. The savings in cost for the WWTP were based on numbers received from the Waterschap.

Sludge dewatering costs include polymer consumption and energy for dewatering and exclude incineration.

Centrifuge daily load (in hours per day) was based upon the assumption of 25 m^3/h of sludge to the centrifuges.

The following table summarizes the savings, excluding labor, maintenance depreciation and interest:

Table 8 Calculations for daily savings with SRS

Calculation of amounts			100%	
Parameter	unit	Without SRS	With SRS	Reduction (%)
Dewatered sludge for disposal	kg/d	63421	44649	30%
Dewatered sludge	kgdm/d	13699	9644	30%
Energy for aeration	kWh/d	7,200	6,768	6%
Polymer for dewatering	kg/d	226	159	30%
Centrifuge daily load	h/d	19.7	13.8	30%
Expected Recyllose™	kgdm/d	0	5,074	

Cost Reduction assessment				100%	
Parameter	unit	cost (€)	Without SRS	with SRS	Daily savings (€)
Sludge dewatering costs*	€/tdm	98	1343	945	397
Sludge incineration (SNB)	€/ton	78.26	4963	3494	1469
Energy for aeration	€/day	0.10	720	677	43
SRS energy consumption**	€/kWh	0.10	0	160	-160
Expected Recyllose™	€/tdm	100	0	4,313	431
		Total (€/day)	7,026		2,181
				Savings	31%

* Sludge dewatering costs including polymer consumption and energy for dewatering (excluding incineration)

** Without additional pumping

It can be seen from the above tables that the main savings for the WWTP is due to reduction in sludge dewatering and disposal (84%), while the rest is due to energy consumption and commerce in Recyllose^{TM}.

Chapter 12: Increased Capacity

As explained above, due to the SRS activity, the entire load on the WWTP is reduced, less energy is required for aeration, and the load on the sludge dewatering system is drastically reduced. As a consequence, if the WWTP is currently overloaded and requires an upgrade, the upgrade can be postponed and the SRS can be installed instead, with significantly lower costs and footprint. Even if the WWTP is not currently overloaded, due to the growth of the population and industry, hydraulic and organic loads on the WWTP will slowly increase over time. The WWTP will eventually pass its design limit and require an upgrade. With the SRS, the date of this foreseen upgrade can be postponed.

The formula used in the Netherlands to calculate the load of a WWTP is based on the pollution equivalents (p.e.) formula:

$$Q * (COD + 4.57\ NKj) / 150,$$

With Q = flow (m3/d) and COD and NKj in mg/l.

Based on 2013 data we receive:
66800 m3/d * (490 + 4.57 * 41) / 150 = 302,000 p.e.

When SRS reduces COD and NKj by 15% and 3% respectively we receive:
66800 * (417 + 4.57 * 40) / 150 = 267,000 p.e.

This represents a 12% reduction in load on the WWTP. This means that the organic load on the WWTP can be increased above the design limit by 12%, without the need for an upgrade.

Another effect of the SRS is that the fraction inert material in the activated sludge will decrease, therefore, when operating the aeration tank at the same MLSS, the sludge activity is higher, resulting in larger WWTP capacity.

This calculation does not fully represent the load reduction of the sludge dewatering system due to reduction in sludge (mainly centrifuge working hours). Since sludge is reduced by 30%, centrifuge working hours are also reduced by 30%, therefore sludge load can increase by 30% without overpassing the sludge dewatering system design limit.

Chapter 13: Recyllose^{TM} Applications

Aa en Maas sent Recyllose^{TM} samples to numerous clients to test what are the available applications for commercial use of the Recyllose^{TM} as a new product as well as an economic substitute for cellulose. Some companies requested to remain anonymous. These are the results obtained so far:

1. **N+P Recycling**
   N+P is an intermediate company for waste disposal.
   Sludge from paper industry is used as **raw material in the ceramic industry**.
   Other application can be **fuel**.
   Test results:
   - Fluff is moldy, application in the ceramic industry is not likely because of bio-organics and smell.
   - For pellets application as fuel, a gate fee of approx. €20/ton is expected, excl. transport and documentation (approx. €15-20/ton) Costs will be €35-40/ton.

2. **TU Delft**
   Tests will be executed with Recyllose^{TM} for **dedicated digestion** under mesophilic and thermophilic conditions. Biodegradation will be determined for pellets and "untreated" cellulose (wet, before drying). Investigation of TU Delft is in cooperation with Waternet and KWR.

   Test results:
   - **Good results**. See Merle's presentation on cellulose symposium.
   - Aug 2012: anaerobic conditions screenings = 70% COD conversion as well as toilet paper, cellulose at 90% COD conversion.
   - General conclusion is that the Recyllose^{TM} is very well digested under mesophilic and thermophilic conditions.

3. **TU Delft**
   Tests will be executed with Recyllose^{TM} as component in **concrete**, to improve material properties.
   Test results:
   - Fibers have stabilizing effect on concrete mixtures, especially the liquid mixtures, which improve handling. Fibers have no negative effect on the concrete pressure strength. The effect of the fibers on pull strength is expected to be positive but will be tested when the concrete has hardened.
   - Ash can replace part of the cement in concrete mixtures.

4. **Estufa**

   Wood-burning boilers, biomass-fuels.

   Test results:

   - General: max 5% as "melting" should be higher than 1000 °C, otherwise slag formation.
   - 3-Oct 2014: Estufa has still not received the report from the test center. Attention point is the slag formation caused by the ash-content and low melting point, especially in smaller ovens this will result in higher frequency of manual cleaning, probably less problematic in larger ovens. Probably mix with other fuels. No info of emissions is currently available, it is probably at the test center.

5. **Warmteplan**

   Cellulose is used as in **insulation** material. Current product pays 50-100 €/ton.

   Test results:

   - In general: first visual impression of the material is OK.
     Potential disturbance parameters are present, like hairs, pieces of wood / grass, sand and smell. Mold on fluff.
     Material is relatively compact, not voluminous.
     Seems to have high moisture content (occurred during storage?).
   - Additional sample is sent to execute blowing, spraying.
   - Test is done on 8-Sept. 201. The fluff in 3 buckets was moldy, and the 4^{th} was OK for testing. There was insufficient material to conduct a blowing-test. Density is determined and is relatively high - 80 kg/m^3, while max. 30 kg/m^3 is used normally. Probably for application in horizontal insulation this is no problem. Smell and disinfection are attention points. Large amount of 2d fibers versus 3d fibers. Sensitivity for fire seems to be somewhat better (and therefore safer) in comparison to paper.

6. **Concrete company**

   Component in **concrete**, to improve material properties.

   Test results:

   - First impression is good.
   - Tests (pressure, tension) will be executed on hardened concrete (28 days).
     Material properties of cellulose containing concrete are comparable to the standard concrete, the company concluded that there were no advantages in using this product.

7. **NPSP**
   Cellulose fibers can be used to strengthen composite (**plastic**) material.
   Test results:
   - Recyllose^{TM} was tested for use as a composite.
   - Recyllose^{TM} fluff was mixed with polyester resin and set under pressure to form thin plates. Plates were tested for water absorption and tensile strength.
   - Water absorption results: Uncoated plate absorbs 9.4% water after 4 weeks while coated plate absorbs 2.6% water after 4 weeks.
   - Tensile strength: plates formed under high pressure have an average tensile strength of 20.6MPa; low pressure plates have an average tensile strength of 12.6MPa. Reference material has a tensile strength of 42MPa.
   - The material has good visual features and reasonable physical properties, and can be a good business opportunity.

8. **Alpha Enzymes**
   Investigate applications for **bio-materials**. Cellulose fibers can be used to strengthen composite (**plastic**) material.
   Test results:
   - Recyllose^{TM} has a lot of bio-activity: 6.8 * 10 ^ 5 counts.
   - Material becomes moldy in a few days, this property was used and stimulated. The cellulose is degraded to glucose when moldy. Then yeast is added, to produce ethanol. A mixture of alcohols is produced.
   - The ethanol - water separation can probably take place under reduced-pressure.
   - Mixture of Recyllose^{TM} (after drying) with PLA and starch was successfully prepared, with max. 30% cellulose in the mixture. in order to make a plant-pot, the wall is thick, making it economically unattractive. AE has plans for tests with pressing pure cellulose. Fluff to be sent to AE then. And AE has plans for executing a larger scale test (1000 liter) for the production of ethanol from cellulose, including purification step of ethanol.

9. **Verbruggen**
   Feed for **production of mushrooms**.
   Test results:
   - 4-Sept. 2014: update results requested.

10. **Nettenergy**

Production of **oil-products, gas, coal and water phase**.

Test results:

- First small scale lab **test is successful.** Gas burned continuously in yellow / orange flame.
    - Water will contain less "acetic" in comparison to wood; oil is black and solid at room temperature, smell differs from wood-oil because of less lignin (aromatics) ingredients.
    - Pellets are completely burned / coaled.
- Full scale: half bigbag is pyrolysed.
    - The produced oil burns well when diluted in diesel, the smell of the oil differs from wood-oil, the smell is not aromatic.
    - Water and oil is easily separated.
    - Gas was produced, and used in a gas-engine to produce electricity.
    - The pellets were transformed to coal with a lower rate in comparison to wood; the pellets were not completely coaled, and this will be investigated, probably because the pellets are pressurized, probably less problematic when smaller pellets are used....
    - Composition (of the oil) is not analyzed, if composition is known, applications of the raw material can be investigated.

11. **Enzymatic conversion company**

Enzymatic transition of cellulose to **sugar, bio-ethanol**.

Test results:

- Recyllose^{TM} fluff and pellets composition are analyzed and report is received. The cellulose content is circa 40% on DM basis, which is just acceptable for economics (tipping point) for enzymatic conversion. Cellulose % is lower than ACT's lab results from Israel, because of other analytical method. Important question now is the forecast for cellulose production in the future, that impacts the economics. First estimate is that the price is € 0,-

12. **Asphalt company**

Cellulose is used in certain types of **asphalt**, preventing de-mixing of the asphalt components, specifically bitumen and grit.

Test results:

- It works, but less efficiently than the standard product. Probably because of lower cellulose content. Advice to contact cellulose vendor for partial recycling. Current cellulose is bought at 485 €/ton.

Chapter 14: Carbon Credits

ACT's technology is eligible for Carbon Credits for the reduction of carbon emissions. These reductions occur in the different steps of the treatment process:

1. In the biological step there is less digestion and therefore less emission of methane and nitrous oxide, as well as less need for aeration.
2. In the solids treatment - less need for polymer, sludge transportation and sludge digestion.

The Recyllose^{TM} can be used by various industries, replacing trees timbering and fossil fuels.

Installing a permanent full scale SRS system in Aarle-Rixtel is expected to bring an annual saving of approximately 32600 ton/CO_2 (See example calculation below). This reduction is translated into CERs (Certified Emission Reduction units). There are carbon markets in many developed countries around the world that pay substantial amounts of money for such carbon reductions. Please note these calculations are only an estimate, and in order to get accurate numbers an appropriate methodology should be developed.

Links for the carbon trading market in the EU and the Netherlands:

https://www.emissieautoriteit.nl/english
https://www.pointcarbon.com/news/cme/
http://ec.europa.eu/clima/policies/ets/linking/index_en.htm

Data base:

Calculations:

Chapter 15: Conclusions

The SRS installation was successfully installed in the Aarle-Rixtel WWTP.
Out of the trial objectives, two were met successfully and the third one was nearly reached.

- ✓ According to anticipated reduction rates, sludge will be reduced for the full scale by 30%.
- ✓ The SRS produced 240 kg/d Recyllose™ at 82%DM which is ~200 kgdm/d. The production of 200 kgDM/d Recyllose™ attained is near the envisaged 250 kgDM/d.
  The Recyllose™ was partially (75%) burned by the SRS as an internal energy source; for the future, it is assumed that Recyllose™ consumption will be lower.
- ✓ According to the cost savings we calculated (see above), savings for the WWTP will be around 2,181 €/day which is 31% of the daily operational costs of the WWTP (excluding labor, maintenance, depreciation and interest) – a number that is beyond expectations.

The trial purpose was to explore the following success parameters:
1. Performance of the SRS technology. Performance indicators are removal efficiencies for different components like TSS, COD, BOD, O&G, N and P.
2. Economic feasibility of the SRS performance in the WWTP, including potential Recyllose™ revenues.
3. Impact of the SRS technology on the WWTP processes and performance.

All the performance indicators were investigated during the trial period and removal efficiencies were determined.
Economic feasibility and the impact on the WWTP was discussed above.

The mass balance and value proposition based on the agreed extrapolations for the full scale show OPEX savings of 31% for the WWTP.
Recyllose™ was found to be a valuable commodity, with many promising applications in the Dutch industry.
Based on the successful trial results and expected performance of a full-scale SRS system, ACT and Aa en Maas are discussing a full-scale installation of a 'tailored-made' SRS for Aarle-Rixtel WWTP.

Chapter 16: TNO letter of approval

TNO innovation for life

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Subject
Approval of report

Dear Sir,

As part of the SRS (Sewage Recycling System) pilot project for the extraction of solids from wastewater and the recycling into valuable commodities, Applied CleanTech (Israel) (ACT) has carried out a test using a pilot plant to recover solids from wastewater at the wastewater treatment plant of Aarle Rixtel (The Netherlands). As an independent expert witness I have visited the project location, attended project meetings, seen and studied the methods used, taken part in discussions on the outcome of the test and read the final report. As a result, I state that the conclusions drawn in *Installation of SRS (Sewage Recycling System) at Aarle-Rixtel WWTP, a joint report of Applied CleanTech and Waterschap Aa en Maas (WSAM); Trial results and extrapolation to full scale system*, final version, November 2014, by Nimrhod Becker, are justified on basis of the test results.

Yours faithfully,

J.W. van Groenestijn