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COMPARISON BETWEEN TWO TECHNIQUES FOR SLUDGE DEWATERING – TRIALS AT SJÖLUNDA AND KLAGSHAMN WWTPs

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Abstract

The cost for disposal of the dewatered sludge is dominating among the operational costs for sludge handling at municipal wastewater treatment plants. This, in turn, is affected by the dryness of the sludge. In this paper the results from parallel trials with two different dewatering techniques, at two different wastewater treatment plants (Sjölunda and Klagshamn in Sweden), are presented and discussed. The dewatering equipment tested is a high-speed centrifuge and a hydraulic filter press.

In general, at both treatment plants, the press delivered drier sludge than the centrifuge, about 30 % DS contra 28 % DS at Sjölunda and 33 % contra 29 % DS at Klagshamn, at relatively moderate polymer doses (7–10 g polymer /kg DS).

Another general observation was that both the press and the centrifuge delivered drier sludge at Klagshamn than at Sjölunda. It was noted, during the trials with the press at both plants, that the dewatered sludge cake needed more or less manual help to detach from the press and fall into the collecting tray under the press.

Key words – Sludge dewatering; Bucher press; Westfalia separator; economy

Introduction

One of the most costly parts of the wastewater treatment process is disposal of the treated sludge. In Sweden, this cost varies between 220–600 SEK/t wet weight (Svenskt Vatten, 2010), depending on sludge quality and local regulations. Thus, if the DS concentration in the dewatered sludge is 25 % or 30 % the disposal cost per ton DS can be calculated to vary between 880 and 2400 SEK/t DS (25 %), or between 700 and 2000 SEK/t DS (30 %). The polymer (120–140 SEK/t DS) and electricity (12–60 SEK/t DS) used in the dewatering process are the other significant operational costs. The disposal cost, which dominates markedly among the operational costs, is of course affected by the dryness of the dewatered sludge. It is often hard to say in advance what a dewatering technique can achieve, with respect to dryness and polymer consumption, on a specific sludge. Therefore trials are needed. Since the sludge quality may change with time, parallel trials is a good method if different dewatering techniques are to be evaluated.

In Malmö, Sweden, the municipal wastewater is treated at Sjölunda (308,000 population equivalents, p.e. (70 g BOD_{7}/ (p.e.*d)) and Klagshamn (70,000 p.e.) WWTPs.

As both plants need to renew their mechanical dewatering equipment, an investigation of the available dewatering techniques has been conducted. During the autumn of 2009 some diagnostic trials in bench-scale with sludge from Sjölunda and Klagshamn were performed. The results suggested that it might be possible to achieve higher DS concentrations with a new press technology than with the existing centrifuges at the plants.

Since a new method for sludge dewatering from

Bucher AG has been paid attention (Boehler *et al*, 2003, 2004; Thunberg 2010), trials with the HPS 207 filter pilot-press were conducted parallel to trials in full scale with a high-speed centrifuge by Westfalia Separator. The existing centrifuges, at both plants, represent traditional equipment, i.e. operating at relatively low speed and thus with a relatively large diameter. Since more and more manufacturers tend to produce centrifuges operating at relatively high speed and thus with a relatively small diameter, it was considered interesting to compare the new press technique with a high-speed centrifuge. The trials could also give a first hint about the performance of a high-speed centrifuge compared to the existing ones at the plants.

In this paper the operational results from the parallel trials with respect to the dryness of the dewatered sludge, but also with respect to polymer consumption and other parameters, are presented and discussed.

Materials and methods

Sjölunda and Klagshamn WWTPs

About 25 300 t/year sludge with DS content of 23 % (equivalent to 5 895 t/year of 100 % DS) and about 4 400 t/year with DS content of 20–22 % (equivalent to 959 t/year of 100 % DS) are produced and deposited from Sjölunda and Klagshamn
WWTPs respectively.

The origin of the sludge at the plants varies mainly due to the different process configurations, the operational mode and to the different industrial loads at the plants.

At both plants phosphorus is mainly reduced by pre-precipitation with iron chloride products.

At Sjölunda, the biological treatment is taking place in a high-loaded activated sludge plant (ASP), operated with sludge age about 2–5 d, followed by nitrifying trickling filters and a moving bed biofilm reactor (MBBR) process for denitrification. The final separation of particles is performed in a dissolved air flotation (DAF) plant.

Table 1. *Operational data for the digesters at the plants.*

Digestion, parameters	Sjölunda	Klagshamn
Detention time, d	21–22	25
Organic load, kgVS/m^3×d	1,2	0,5–2,0
Temperature, °C	35	37
SS conc in digester, % DS	2,2	2
kgVS/kg DS influent, %	77	75
kgVS/kg DS effluent, %	59	60

At Klagshamn, the ASP is designed for organic material removal and nitrification with sludge age about 14 d. Here also the denitrification takes place in a MBBR process, but the final treatment step is dual-media, downstream filter for particle separation and further phosphorus reduction.

The resulting sludge at the plants (primary sludge, excess sludge and sludge from the DAF and dual-media filter respectively) is thickened in clarifiers before it is digested (mesophilic) and dewatered in low speed centrifuges.

Collected data for the sludge and the digestion processes are presented in Table 1.

Trial equipment

Bucher hydraulic filter pilot-press HPS207

The Bucher hydraulic filter pilot-press HPS 207, Figure 1, consists of a rotating cylinder with a volume of 0.2 m^3. A drainage system and a piston are assembled in the cylinder. The filter system contains 11 drainage elements with an area of about 1.1 m^2. Each of the drain elements consists of a drainage core over which a filter sock is fitted. This sock holds back the solids of the sludge when pressure is applied (up to 10 bar) while the filtrate water escapes via channels in the drain elements into a collection chamber in the cylinder and then to the collection tank. The system is closed.

Each filtration batch contains four steps, Figure 2. The sludge is filled into the cylinder in several steps. After each step, pressure is applied as the piston reduces the volume. The filtrate is drained, and the sludge forms a filter cake. When the piston is drawn back, the pressure is released and the drainage elements stretched, breaking the filter cake. The whole filtrating process

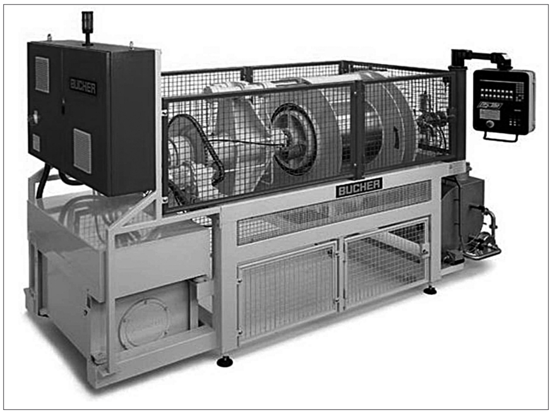

Figure 1. *The Bucher hydraulic filter pilot-press HPS 207 used in the trials.*

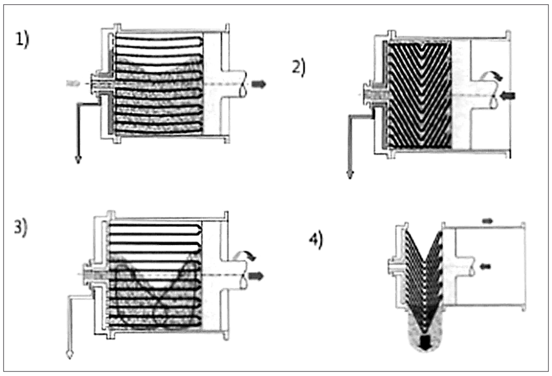

Figure 2. *The dewatering process with HPS 207 Bucher filters press. 1) Filling phase – the sludge is fed into the rotation cylinder. 2) Squeezing – pressure is applied and the piston moves forward. 3) Loosening up – the pressure is released. 4) Emptying – the sludge is discharged.*

contains about 30 compressions. By the last compressions no sludge is fed, in order to achieve high DS.

Westfalia Separator

The centrifugal separator from GEA Westfalia separator used in the trials is UCF 466 with a drum diameter of 460 mm, L/D 4,0 and a speed of 2000–3850 rpms, Figure 3.

The separator contains a rotating drum and an independently rotating screw inside. Sludge is fed through the stationary feed tube (9) together with flocculent. The flocked sludge enters the separating chamber (8) and the solids phase settles on the bowl wall. The scroll and the bowl rotate in the same direction at different speeds thus the solid phase is fed to the conical part of the bowl, dry zone. The sludge is dewatered and discharged at the outlet (12). The centrate is led to the other end of the bowl and discharged at the outlet (11).

Conditions at Sjölunda WWTP

At Sjölunda the digested sludge was pumped from a fairly good mixed tank to the test equipment. The feed sludge was analyzed every two hours. The DS content varied between 1.7–1.8 % and the flow to the centrifuge between 30–45 m^3/h. The high flow (45m^3/h) was applied only during the capacity trials. The feed sludge to the Bucher press, which needed 400–500 L per batch, was analyzed in every new batch. No differences in DS content in the feed sludges to the two machines were noted.

Conditions at Klagshamn WWTP

For best performance, the centrifuge needs a load of 500–600 kg DS/h. At Klagshamn, the sludge feed to the test equipment was unexpectedly thin. The concentration of DS varied between 1.1–1.7 %. Due to the limited amount of digested sludge available and the low concentration of DS in the sludge, the trials had to be performed in intervals, when there was enough sludge available. For the trials with the centrifuge this only meant that the different settings were run with a time gap (1–2 hours) in between. For the trials with the press, which was believed to be more sensitive to low initial DS concentration in the feed sludge, sludge was pumped to a tank where it was thickened to about 2 % DS. For verification, samples were taken and analyzed before each new dewatering batch.

Polymers

The polymers for the trials were chosen by a polymer supplier making diagnostic trials in bench scale, and by taking into account only the sludge properties and not

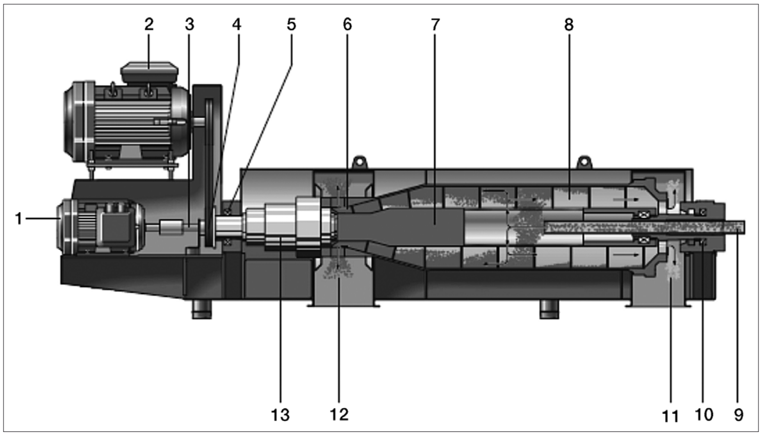

Figure 3. *Westfalia separator UCF 466 used at the trials. 1) Secondary motor (scroll). 2) Mainmotor (bowl). 3) Drive scroll. 4) Drive bowl. 5) Bowl bearing. 6) Bowl. 7) Scroll. 8) Separating chamber. 9) Inlet. 10) Bowl bearing. 11) Outlet centrate. 12) Outlet sludge. 13) Gear.*

Table 2. *Polymers used at the trials at Sjölunda WWTP and Klagshamn WWTP.*

	Product name	Charge	Supplier	Name
Sjölunda	CE 89	20%	SNF Nordic AB	S 20
Sjölunda	CE 149	50%	SNF Nordic AB	S 50
Sjölunda	CE 169	60%	SNF Nordic AB	S 60
Sjölunda	E64LH	60%	Reifloc Abwassertechnik GMBH	R 60
Sjölunda	C121*	5%	SNF Nordic AB	S 5
Klagshamn	CE 59	10%	SNF Nordic AB	S 10
Klagshamn	CE 109	30%	SNF Nordic AB	S 30
Klagshamn	E64LH	60%	Reifloc Abwassertechnik GMBH	R60
Klagshamn	CE 169	60%	SNF Nordic AB	S 60
Klagshamn	C 122*	5%	SNF Nordic AB	S 5

* The polymer used in full scale (C121 and C122 are very similar).

the technique. Furthermore, both suppliers of dewatering technique had the opportunity to choose one polymer at will. Also the polymer used in the existing dewatering processes at the plants (S5) were compared. All polymers used in the trials are presented in Table 2.

The trials

Samples were taken from the sludge feed and from the dewatered sludge, and analyzed according to the standard methods issued by the Swedish Standards Institute (SIS, 2005) and The Swedish Water- and Wastewater Treatment Plants Association (VAV, 1984).

The digested sludge used in the trials was taken from the bottom of the gravity thickener at Klagshamn and from the digested sludge storage tank before the centrifuges at Sjölunda. The aim was to imitate the conditions for the dewatering equipment at the two plants.

The trials with the press were preceded by flocculation tests in laboratory scale both at Sjölunda and Klagshamn, since the press was believed to be more sensitive to the type of polymer. Only the two strongest charged polymers, R60 (best) and S60, showed satisfying results, and therefore R60 was used in all the test runs. One test run was performed with one of the other polymers, but then almost no sludge cake at all was formed. This is an important limitation for the press. A similar limitation was not found for the centrifuge, and therefore all the polymers were tested in the centrifuge runs.

For each setting during the trials with the centrifuge, three samples from the dewatered sludge and three samples from the reject water were taken out and analyzed. The samples were taken out with an interval of about 20 minutes. For each setting during the trials with the press, three samples from the dewatered sludge cake were taken out and analyzed. Since the press produces most of the press water (reject) early during the pressing phase, the samples from the reject were collected during this phase.

Results and discussion

The Trials with Westfalia Centrifuge

The results from the centrifuge trials at Sjölunda and Klagshamn are presented in Figure 4 and Figure 5. It should be pointed out that each data-point is an average

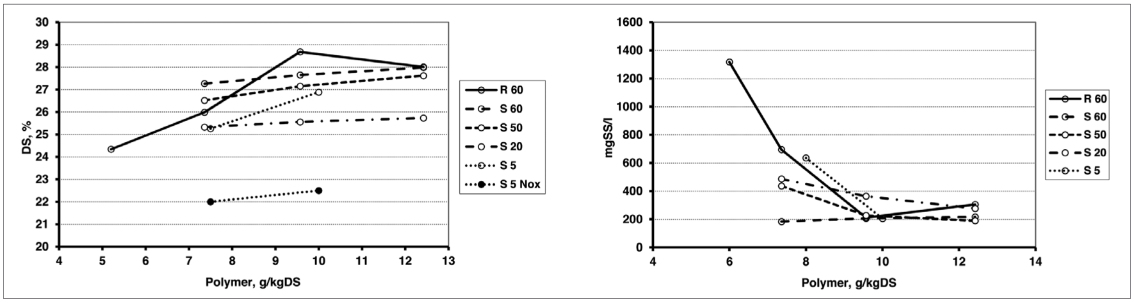

Figure 4. *Results from Sjölunda WWTP with the centrifuge. A) The DS concentration as a function of the polymer dose B) The SS concentration in the reject water as a function of the polymer dose.*

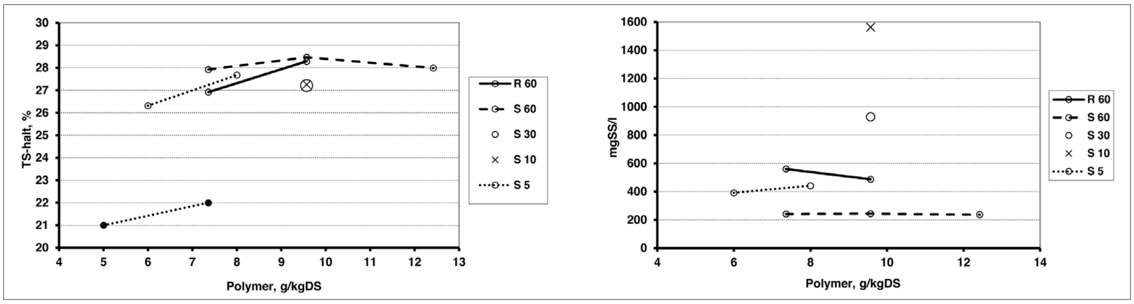

Figure 5. *Results from Klagshamn WWTP with the centrifuge. A) The DS concentration as a function of the polymer dose B) The SS concentration in the reject water as a function of the polymer dose.*

value from the results of the three samples that were taken out from that specific setting. Since the DS concentration from the three samples from one specific setting could differ as much as 2 % (highest-lowest) this probably was a good procedure.

Generally it can be noted that the higher the polymer charge, the higher DS concentration can be expected (Figure 4A). A maximum DS content of 27–28 % could be achieved by using moderate polymer dosage (7–10 g polymer/kg DS). The polymer type used in full scale at Sjölunda (S5) showed good results in comparison to the charge. The "S5 Nox"-line presents results, 22–22.5 % DS, from the dewatering process with the same polymer and the existing full scale low-speed centrifuges at Sjölunda. The quality of the reject water seems to improve (decreasing SS concentrations) with polymer doses up to 10 g polymer/kg DS. Further increase in dosage showed no improved results.

At Klagshamn, due to practical problems with the equipment installation and time restriction, fewer trials could be performed.

The same trend of higher DS content using strong charged polymers could be seen also at this plant (Figure 5A). In comparison to Sjölunda, somewhat higher DS concentrations could be achieved, 28–29 %. Similar trials with the existing polymer (S5) as at Sjölunda were performed. The high-speed centrifuge, at similar dosage as the low-speed centrifuge, could reach about 6 % higher DS concentration in the dewatered sludge.

At Sjölunda the quality of the reject water could be improved by increasing the polymer dose up to 10 g polymer/kg DS (Figure 4B). At Klagshamn, most of the samples showed good results expect those from the trials with the low charged polymers S10 and S30, Figure 5B. However, it must be pointed out that at Klagshamn the centrifuge during much of the time, including during the trials with S10 and S30 was loaded only with 400 kg DS/h, which may have influenced the results negatively.

Maximum capacity trials at both plants with a feed flow of 45m^3/h were conducted. The DS load at this flow was about 800 kg DS/h at Sjölunda and 640 kg DS/h at Klagshamn. The polymers used were R60 at Sjölunda, 9.3 g polymer/kg DS, and S60 at Klagshamn, 12.4 g polymer/kg DS. The achieved DS concentration at Sjölunda was 26 % DS and at Klagshamn 28 % DS. An energy consumption of 0.7–0.8 kWh/m^3 was registered at both plants.

The Trials with Bucher Press

The results from the trials with the press are presented in Figure 6 (Sjölunda) and Figure 7 (Klagshamn). Also here the data points are average values of three samples for each adjustment. Each press cycle lasted 120 min and the batch volume varied between 400–580 l for Klagshamn and 470–630 l for Sjölunda, although most of the test runs were performed with a 550 l batch volume, which also gave the best performance.

It was expected to find a spatial distribution of the results, depending on from where on the circular sludge cake the samples were taken out. To achieve a representative result, three samples for each adjustment were taken out – one near the centre, one at the middle of the radius and one at the periphery of the sludge cake. Since the DS concentration from the three samples from one specific setting could differ as much as 3 % (highest–lowest) this probably was a good procedure. No clear pattern could be seen regarding from which point the sample with the highest or the lowest DS concentration was taken.

The results from the trials with the press at Sjölunda (Figure 6A) show a more irregular pattern than in the trials with the centrifuge (Figure 4A). However, also here the results suggest that the DS content increases with increasing polymer dose. It should be noted that the scale on the x-axis in Figure 6A contains significantly higher values than in Figure 4A. At similar polymer doses as in the trials with the centrifuge, the press seems

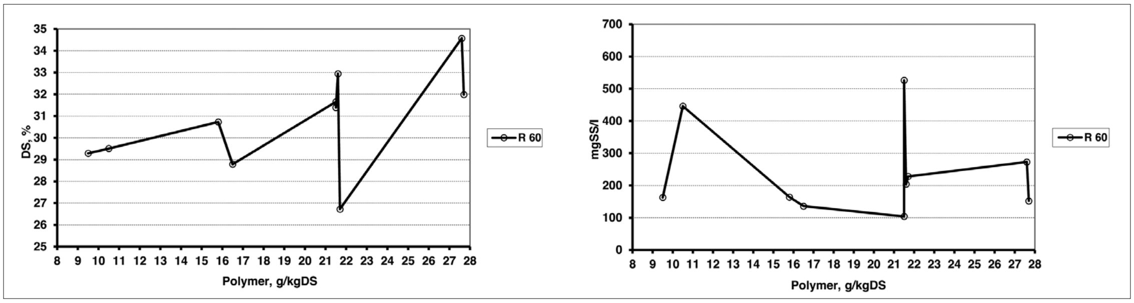

Figure 6. *Results for Sjölunda WWTP with the press. A) The DS concentration as a function of the polymer dose B) The SS concentration in the reject water as a function of the polymer dose.*

able to achieve about 30 % DS. The reason for several test runs being performed at almost the same polymer dose was that the results seemed best at this dose, and the fact that the results were uneven.

The results from the trials with the press at Klagshamn (Figure 7A) show a more coherent pattern than the results from Sjölunda (Figure 6A). Also here the DS concentration seems to increase with increasing polymer dose. It should be noted that the press achieves higher DS concentrations, and at smaller polymer doses, with the sludge at Klagshamn than with the sludge at Sjölunda. At similar polymer doses as in the trials with the centrifuge, the press seems able to achieve about 33 % DS concentration at Klagshamn.

The quality of the press water (Figure 6B and 7B) seems to be roughly the same as the quality of the reject water (Figure 4B and 5B) at both plants.

To get an idea of if the press could perform better if the DS concentration in the feed sludge was higher, an experiment was carried out at Klagshamn. The (thin) feed sludge was pumped into a container and 3 g polymer /kg DS (R60) was added. Next day sludge from the bottom of the container was used as feed sludge, now with a DS concentration of 3.1 %. An additional dose of 10 polymer g/kg DS (R60) was added. A DS concentration of 33 % was achieved, which was within the same range as the other results.

An experience worth noting from the trials with the press, at both plants, was that the dewatered sludge needed more or less manual help to detach from the press and fall into the collection chamber after the dewatering process. It was noted that the sludge detached somewhat easier at Klagshamn than at Sjölunda, perhaps because of the higher dryness. It could be speculated that a full scale application might work slightly different in this sense.

Conclusions

In general, at relatively moderate polymer doses (7–10 g polymer /kg DS) at both plants, the press delivered drier sludge than the centrifuge, about 30 % DS contra 28 % DS at Sjölunda and 33 % contra 29 % DS at Klagshamn.

Another general observation was that both the press and the centrifuge at Klagshamn could deliver drier sludge than at Sjölunda.

The trials with the centrifuge showed that the sludge became drier and the quality of the reject water better with increasing polymer doses and with increasing

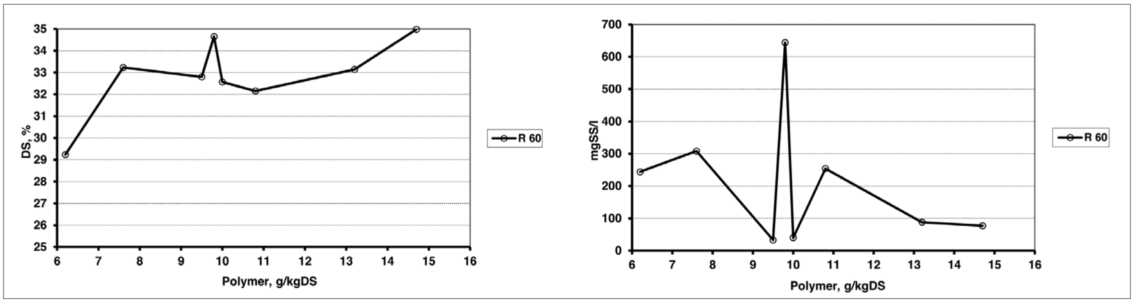

Figure 7. *Results for Klagshamn WWTP with the press. A) The DS concentration as a function of the polymer dose B) The SS concentration in the reject water as a function of the polymer dose.*

charge of the polymer, at least at moderate doses, 7–10 g/kg DS, at both plants.

For the trials with the press, the picture was less clear, since the results were more variable. It seemed that this technique required a certain minimum polymer dose to form a sludge cake at all.

The fact that the dewatered sludge needed more or less manual help to detach from the press is probably an important limitation from a working environment perspective.

The fact that the press proved to be able to deliver a drier sludge than the centrifuge at both locations is interesting, especially since dryness is a key factor for the sludge disposal cost. However, more tests on digested sludge at different plants are required to learn more about the operation (for example how to detach the sludge cake from the press) and the performance stability in different situations.

To determine if the new press technology is advantageous in specific cases, some more aspects, not dealt with in this paper, need to be taken into account, for example:

- Is the capacity of the available machine sizes well suited for the specific case (for example: often at least two machines are desired)?
- In case of expansion, is there enough space in the existing dewatering building?
- Is the sludge transportation system capable of handling a drier sludge?

References

Boehler M., Pinnow D.,Krauss W., Brauchli H. and Siegrist H. 2003. *Neue Presstechnologie zur verbesserten Klärschlammentwässerung*, EA WAG final report, Duebendorf, Schwitzerland, Juni. http://www.eawag.ch/forschung/eng/schwerpunkte/abwasser/presstechnologie/schlussbericht_presstechnologie.pdf (accessed 5 May 2011).

Boehler M., Pinnow D.,Krauss W., Brauchli H. and Siegrist H. 2004. *An Innovative Application For An Established Technology To Improve Sludge Dewatering*. 2004 IWA Publishing. 2nd IWA Leading-Edge Conference on Water and Wastewater Treatment Technologies edited by Mark Van Loosdrecht & Jonathan Clement: ISBN 1 84339 5088.

SIS, 2005. *Determination of the suspended solids SS-EN 872:2005*. ICS 13.060.20;13.060.30.

Svenskt Vatten, 2010. *Disposal cost for sludge*. In Swedish. http://svensktvatten.se/web/Hanteringskostnader_for_slam.aspx (accessed 5 May 2011).

Thunberg, A. 2010. *Optimizing Sludge Dewatering by Using the KemiCond ® Process with the Bucher Hydraulic Filter Press – Full Scale Experiences at Käppala WWTP*. http://www.kappala.se/admin/bildbank/uploads/Dokument/Processutveckling/Kemicond_Thunberg,_A._(2010).pdf (accessed 5 May 201).

VAV. 1984. *Determination of dry solids VAV P54, Aug 1984*. The Swedish Water- and Wastewater Threatment Plants Association. ISSN 0347-1799. VAV P54 1984-08 3000.