Project Deliverable 4.2

OVERVIEW OF ENERGY EFFICIENT SLUDGE DEWATERING TECHNOLOGIES

Case study report

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INTRODUCTION

In the STEP project deliverable 4.2 we describe the development of sludge dewatering technologies, with focus on energy efficiency and based on the experiences of the three partners running WWTPs and handling sludge: Bornholm (Denmark), Goleniow (Poland), and Mittskåne Vatten (Sweden).

Different countries in EU have different traditions and issues about sludge dewatering. The partners in STEP are currently using much the same sludge dewatering technologies, although the sludge is treated in different ways afterwards: composting, direct use in agriculture, mineralization and combustion.

I. SLUDGE FROM SMALL AND MEDIUM WWTPS

The production of sludge is primarily a result of introducing biological WWTPs in the treatment of urban waste water, to meet the demands for adequate water quality in the recipients.

Taking Bornholm as an example, the biological WWTPs was constructed in the beginning of the 1990'ies, with a few minor exceptions, with capacity ranging between 1.000 – 60.000 PE. The original sludge dewatering equipment was sieve presses, centrifuges, and a single sludge mineralization plant (earth basins for evaporation and mineralization, planted with reeds). Most of the original dewatering equipment has been replaced with screw presses in the recent years, which is the technology that seems to be best suited for small and medium WWTPs for now, as will be discussed in the next chapter.

SCREW PRESSES

The following is based on a note from our consultant engineer EnviDan (Appendix 1), in the planning process of renewing the sludge dewatering equipment on Rønne WWTP (main WWTP on Bornholm, 60.000 PE).

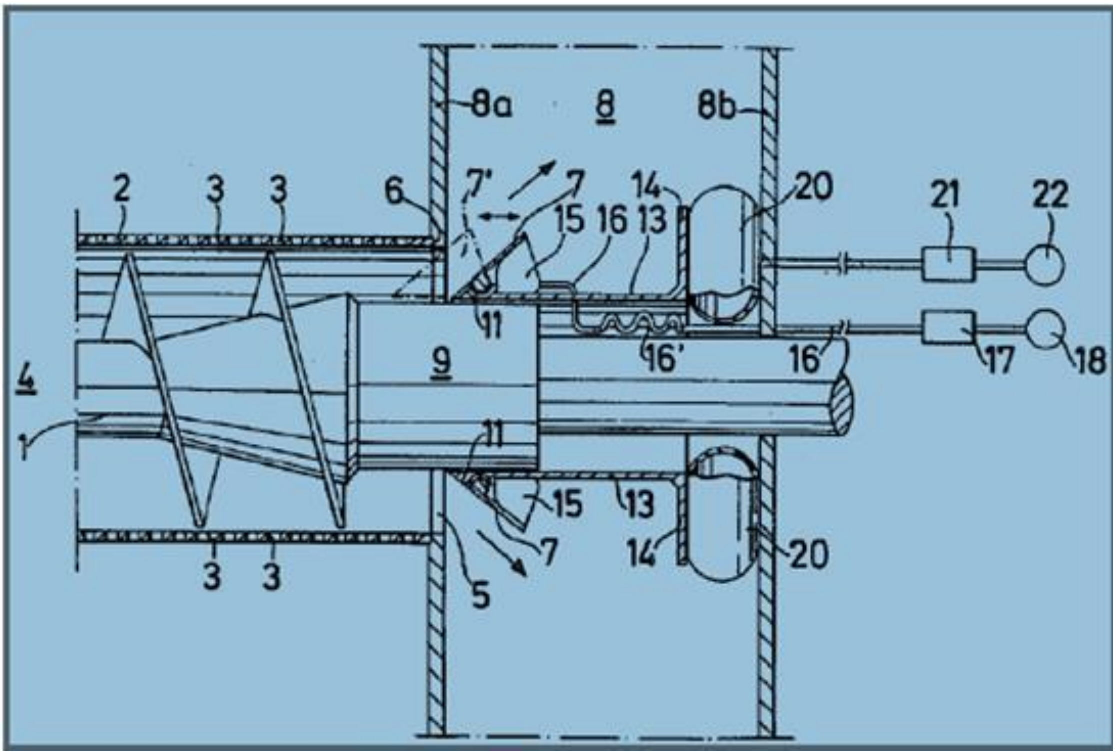


Fig. 1 Screw presses principle scheme

Principles of screw press action (as in Figure 1):

Summary from patent application for screw press dated 1987-12-01pat. No. US4709628A. The patent is free. “A screw press for dewatering sludge and fiber suspensions, having a feed screw, a perforated drum surrounding the feed screw, an inlet or infeed aperture at one end of the drum, and an end wall section at the other end forming an annular outlet or outfeed aperture. The end-wall section includes a plurality of flaps located as an extension of the feed screw, the flaps being yieldable arranged to adjust the size of the outlet aperture. The end of each flap nearest the axis (9) of the feed screw (1) is pivotally mounted on an attachment connection (11), and the attachment connection (11) is arranged for movement along the axis of the feed screw (1). The flaps (7) are arranged to be pressed outwards under the influence of a first force generating arrangement (15, 17 and 18) to form a larger angle with the screw axis (9), thereby causing the outlet aperture to decrease in size. The attachment connection (11) is arranged so that it and the flaps connected thereto can be moved axially towards the outlet aperture (5) under the influence of a second force generating arrangement (20, 21, 22), to also decrease the size of the outlet aperture, the two force generating arrangements being adjustable independently of one another.” In a screw press incoming suspension is captured by the helix of the screw and advanced towards the annular outlet while being compressed. Compression of the material during its travel along the screw takes place due to the fact that the outlet aperture is relatively small; the water or other liquid pressed from the sludge departs through the perforations in the drum casing. The residual water content of the dewatered pulp discharged through the outlet depends to a very large extent on the size of the outlet.

The total solid content in the dewatered sludge will for biological sludge normally be in the range of 18-22%. The construction of the screw press I hermetically enclosed structure in order to ensure a safe a healthy environment. The structure is mechanically ventilated.

Number of manpower days for daily service and maintenance is at a minimum. The screw press is designed for continuously operation 24/7 and no service personal is required during the operation.

Table 1 shows the estimated consumption of water, polymer and energy compared to the amount of dewatered sludge. The values shown are all based on previously investigation of dewatering equipment installed.

Table 1. Consumption of water, polymer and energy compared to the amount of dewatered sludge.

Sludge dewatering methods	**Energy consumption***	**Compressed air consumption**	**Polymer consumption (active polymer)**	**Water consumption**
	kWh/ton TS		**kg/ton TS**	**m^3/ton TS**
Screw press	5-8	Compressed air for control and pressure in screw press	10-12	Water consumption only for wash of press during operation 2-5
Centrifuge	11-17	No consumption	9-11	Only water consumption for wash of press shut down

* *Energy consumption only refers to the direct power uptake from the screw press.*

Based on the above comparison choosing of sludge dewatering systems a sludge dewatering solution based on a screw press will in general result in the lowest operation cost, mainly caused by low energy consumption for the screw press. Suspended Solid (SS) in the reject water from the sludge dewatering process often very based on the efficiency of the dewatering equipment. Reject water from screw presses will in general be in the range of 800-1.200 mg SS/l which is slightly higher than reject water from centrifuges. However it is often seen that the SS in the reject water from screw presses is well below the range of 800-1.200 mg SS/l when the collide particles in the sludge are low.

Economy – estimate for implementing screw press dewatering on Rønne WWTP. A total estimated budget for changing the existing dewatering plant is as follows in the table 2 below.

Table 2. Estimated budget for changing the existing dewatering plant.

	DKK	**€ approx.**
Item 1. Design-and tendering of contractor:		
Construction cost	700.000	93.000
Mechanical equipment and installation	3.100.000	413.000
Electrical equipment, installation and SCADA system	500.000	67.000
Unforeseen cost	400.000	53.000

	DKK	€ approx.
Design and tendering documents	600.000	80.000
Item 2. Evaluation of offers and contracting:		
Evaluation, contracting and follow up on installation	200.000	27.000
Total estimated investment:	**5.500.000**	**733.000**

The above mentioned investment cost will result in following savings (in Danish crones DKK) per year:

- Estimated yearly saving of cost for polymer will be approx. DKK 175.000, - based on a yearly consumption of approx. 5 ton active polymer.
- Estimated yearly savings for stopping use of burned lime powder, approx. DKK 500.000-700.000, -
- Energy savings approx. DKK 50.000- 100.000, -
- Total estimated yearly savings, approx. DKK 725.000-975.000,-

The above investment costs must be seen in the context of stopping the addition of burned lime to the dewatered sludge, an operating savings of DKK 500-700.000, - per year, and that a reduced polymer consumption can be expected, since polymer is only dosed at one point in the process. It is estimated that the annually savings approx. 5 ton of active polymer, of approx. 35 kr. / kg corresponding to approx. DKK 175.000 per year.

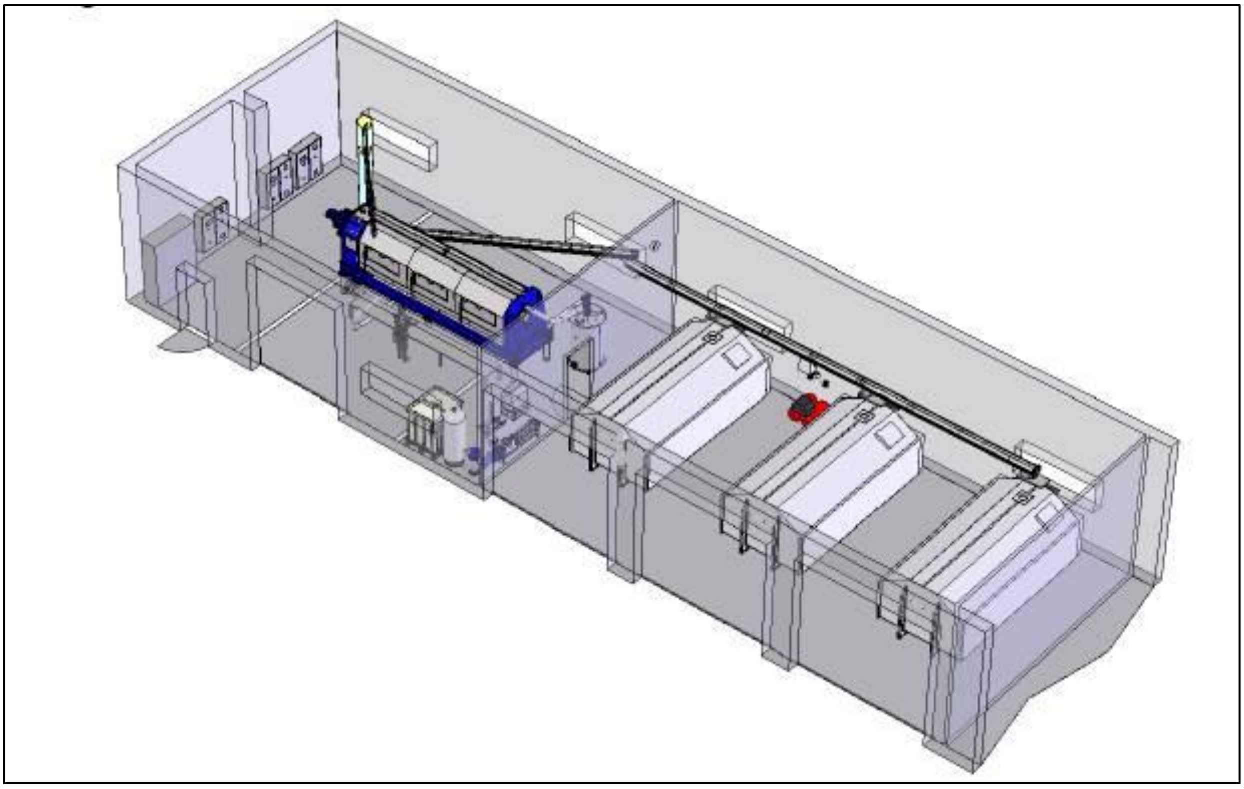


Fig. 2. Screw press dewatering system in Rønne WWTP

Tendering for implementing of screw press dewatering system on Rønne WWTP (see sketch Figure 2 above), was done in the autumn of 2019. The best offer was given from a Danish supplier dealing with an Austrian build screw presses, to a price of a little less than 4.000.000 DKK, or approx. 530.000 €. The new dewatering system will be installed in the summer 2020.

Today we use 48.000 kWh per year for sludge dewatering on Rønne WWTP, this is equivalent to 48 kWh per ton Dry Matter, because the sludge production from is approx. 1.000 ton Dry Matter per year. The expected power consumption for the new system is 6 kWh per ton Dry Matter, and thus the power consumption for dewatering is expected to be reduced with more than 85 %.

From a similar installation on Nexø WWTP (10.000 PE), made a few years ago, we have experienced a reduction in power consumption in this range (more than 85%). Screw press for sludge dewatering at Nexø WWTP, Bornholm (Figure 3). The dewatered sludge falls directly down a container that is transported to an external storage when full.

Fig. 3 Screw press for sludge dewatering at Nexø WWTP, Bornholm

SLUDGE MINERALIZATION PLANTS

A sludge mineralization plant is beds/basins planted with reeds for drainage and further sludge stabilization. In addition, the aerobic conditions in the plant enable the sludge to reduce the content of environmentally harmful substances.

Sludge mineralization plants are suitable for the treatment of biological sludge, and the thin sludge (with, for example, 0.5-1% TS) is pumped directly to the plant.

The plant is constructed as a concrete or soil pool with a waterproof membrane at the bottom and an effective drainage system in a porous filter layer. On top of the filter, a growth layer is established and planted with reeds, to increase the evaporation of water from the sludge. The drainage system collects the filtered water and returns it to the inlet of the treatment plant. The drainage system and the plant roots help to ensure aerobic conditions in the plant.

Sludge mineralization plants are typically sized to accommodate 10 years of sludge production. However, the experience from several existing plants is that in practice the capacity is not as great as previously assumed. The dry matter content of the sludge is increased to a final solids content of approx. 20-30% TS, and by mineralization the content of organic matter is reduced by up to 25%. The experience from a number of plants has shown that it is difficult to obtain the dry matter content as required for the sizing and establishment of the plants.

The sludge residue is usually used for agricultural purposes, but if the quality requirements cannot be met, it may be necessary to dispose of it in another way, e.g. by incineration or landfill.

Advantages:

- Highly energy efficient – and cost efficient. Requires very little maintenance. Reducing quantity and volume of sludge.

Disadvantages:

- Large area requirements (up to 0,5 m^2/PE) – and large initial investments. Nutrients are lost in the mineralization process, especially N.

The mineralization plant at Boderne WWTP, Bornholm

The WWTP (4.000 PE) and mineralization plant was established in the late 1980’ties, to accommodate the sludge from the WWTP for a least 10 years (Figure 4). However the evaporation and mineralization has been very effective, so the plant has been running for more than 30 years now, without been emptied. In 2019 the ground around and between the basins was raised ½ meter to create more volume.

Fig.4 Sludge mineralization plant at Boderne WWTP, Bornholm

CONCLUSIONS

In general the sludge dewatering system of the individual WWTP must be designed according to the local circumstances, needs and possibilities. However we see a clear trend among the partners in STEP project to replace dewatering systems with new systems based on screw presses, and this improves energy efficiency of the sludge dewatering systems with up to app. 85%.

A very different, but also highly energy efficient combined dewatering/storage method, is implementation of sludge mineralization - usually designed from the start of the WWTP, and having the disadvantage of large area requirements, which is not always available, and large initial construction costs.

II. SLUDGE FROM SEPTIC TANKS

This part of the report consists of different approaches in Denmark - Bornholm, and Sweden - Höör and Hörby.

Denmark – Bornholm:

- Collecting and dewatering sludge.
- Composting and use in agriculture.
- Energy efficiency and economy, nutrients and carbon.

Sweden - Höör and Hörby:

- Collecting and dewatering sludge
- Use in agriculture.
- Energy efficiency and economy; nutrients and carbon.

GENERAL BACKGROUND

Many wastewater companies handle the collection, transport, treatment and disposal of sludge from the septic tanks in the local areas without sewers. There are different approaches to solve the challenges in this work. The Swedish partner in STEP project has focused much of their work to solve their challenges in relation to sludge from septic tanks. In this case study the partners explain their approach in relation to sludge from septic tanks, and we compare the different approaches in relation to energy-efficiency, but also reuse of nutrients and carbon and overall economy.

DENMARK - BORNHOLM APPROACH

In Bornholm the systematic collection and handling of sludge from septic tanks started in 1992, in Nexø municipality. When the five municipalities were merged in 2003, all the app. 5.000 septic tanks on Bornholm were included in the systematic collection and handling of sludge.

The most common way to handle sludge from septic tanks in Denmark is to treat the sludge in the larger Wastewater Treatment Plants (WWTP's).

On Bornholm we have from the start chosen to treat sludge from septic tanks separately, based on concern about capacity and energy consumption of WWTP's. The sludge from septic tanks is used in agriculture after separate treatment, according to the Danish rules (see more in the STEP-study on rules/legislation in the partners countries).

<u>Collecting and dewatering sludge</u>

Bornholm's Wastewater A/S has put the work with sludge form septic tanks out to EU-tender several times, and we have over the years simplified the description of the work to the contractors (see description for tender in appendix 2).

The sludge from emptying septic tanks are collected and dewatered in a special vehicle called KSA (see appendix 3) that manage to empty app. 30-40 septic tanks before it must be emptied of dewatered sludge. Dewatering is mechanical with use of polymer.

The septic sludge is effectively dewatered to app. 30% Dry Matter (DM).

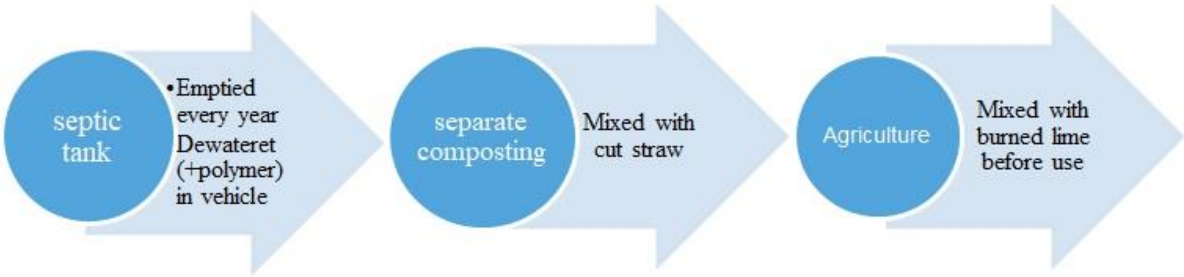


Fig. 5.

Composting and use in agriculture

The dewatered sludge is composted in a barn by the same farmer that uses the sludge as fertilizer in agriculture. The sludge is mixed with cut straw, and the piles turned regularly. Once a year, usually in august, the composted sludge is mixed with app. 8% burned lime and used as fertilizer in agriculture. Before the composted sludge is used in agriculture, the Wastewater Company makes an analysis of the content of heavy metals and some organic substances, which are specified in the Danish rules (see table 3).

Denmark has the strictest limit value for Cd in EU – 0,8 mg/kg DM – but there is also a limit value in relation to phosphorus – 100 mg/kg P – and it is enough that the content is below one of the limit values. The limit value for Cd in the EU-directive is 20-40 mg/kg DM.

Table 3. Comparison of heavy metals and organics in sludge from septic tanks and WWTP (Rønne)

	Analysis of composted sludge from septic tanks (mean)	**Analysis of sludge from WWTP (Rønne - mean)**	**Limit values**
	mg/kg DM	mg/kg DM	mg/kg DM
Pb	26	12	120
Cd	**1,4**	0,8	**0,8**
Cu	258	168	1.000
Cr	13	10	100
Hg	**0,7**	0,3	**0,8**
Ni	17	10	30
Zn	1.070	495	4.000
Cd/P (mg/kg P)	**76**	35	**100**
Hg/P (mg/kg P)	38	14	200
Tot N (g/kg DM)	29,5	48,3	

	Analysis of composted sludge from septic tanks (mean)	**Analysis of sludge from WWTP (Rønne - mean)**	**Limit values**
	mg/kg DM	mg/kg DM	mg/kg DM
Tot P (g/kg DM)	18,5	22,8	
LAS	423	< 108	1.300
Sum PAH	1,7	0,6	3
Sum NPE	3,4	1,5	10
DEPH	2,5	5,5	50

(*More information about the organic compounds is available in the STEP deliverable about National Legislation comparison*).

Table 3 show that the content of heavy metals and organics is generally lowest in the sludge from WWTP. In Denmark the metal content must either be below the usual limit value in mg/kg DM or below a special Danish phosphorus related limit value in mg/kg P in the sludge (only for the metals: Pb, Cd, Hg, Ni). The initial content of organics in the sludge from septic tanks is very high, and often exceeds the limit values, but composting is effectively reducing these compounds.

In Denmark the rules about use of sludge in agriculture specifies that the producer of sludge must make a declaration of the sludge to be used in agriculture, and send it to the municipality and the farmer(S) using the sludge ad fertilizer. The declaration tells from where the sludge origins, restrictions in use and storage on the property, and the content of heavy metals and organics. An example of such a declaration (see appendix 3).

Energy efficiency, nutrients, carbon and economy in this approach

Energy efficiency – qualitatively assessed

- Transport: because the sludge is dewatered in the transport vehicle, and reject water is put into the next emptied septic tank, the energy use for transportation is reduced app. 50%.
- Dewatering: dewatering is mechanical in the transportation vehicle, with addition of polymer, and hence the energy consumption is minimal.
- Composting: involves turning the piles and mixing with straw and lime - low energy consumption.
- Spreading the compost: mostly energy for transport, like other organic fertilizers - low energy consumption.

Nutrient recycling – qualitatively assessed

- The composting process involves a small loss of nitrogen – evaporation off ammonium.
- Agricultural use ensures an effective recycling of the nutrients in the composted sludge.

Carbon storage – qualitatively assessed

- The composting process involves a small loss of easily degradable organic carbon (as CO_2 emission).
- Agricultural use ensures recycling/storage of most of the carbon in the composted sludge, including the added straw.

Economy

In 2020 the owners of septic tanks on Bornholm pay:

- **523 kr. or app. 70 Euro** (25% VAT included) for the yearly emptying of a septic tank – all expenses included.

Bornholm's Wastewater A/S pays our current contractor:

- **400 kr. or app. 54 Euro** (25% VAT included) per emptied septic tank, all included.

Administration of costumer payment, handling of complains etc., analysis of sludge; dialog with authorities etc. is done by the Wastewater Company. These administrative tasks accounts for the difference between costumer payment and contractor payment.

SWEDEN - HÖÖR AND HÖRBY APPROACH

Collecting and dewatering sludge - Existing handling

In Sweden, external sludge from septic tanks is collected from individual properties once a year, usually through trucks operated by the municipality. In Höör and Hörby, trucks with the capacity to dewater the sludge on-site are being used. The dewatering on site is achieved by letting the larger particles settle in the tank carried by the truck. The water is then returned to the septic tank on the property. The use of this method means that more septic tanks can be emptied on the same route since the actual volume being emptied is roughly 1 m^3 compared to 2-3 m^3 if the whole tank would have to be emptied. The truck then transports the sludge to the wastewater treatment plant (WWTP) where it is released into the incoming wastewater stream.

The cost for a truck to empty the content from septic tanks at the wastewater treatment plant is roughly 25 €. The cost for Mittskåne Water to ensure a safe collection of the treated sludge is about 28 €/ton.

Fig. 6

Advantages

Nutrients are recovered and spread on arable land.

Disadvantages

The external sludge usually has a relatively high content of heavy metals in relation to nutrients, and hence deteriorates the sludge quality. Further, the external sludge has relatively low levels of oxygen and therefore needs to be aerated, which in turn consumes larger quantities of energy.

External treatment of sludge – Pilot plant

Höör and Hörby wastewater treatment plants have relatively high levels of metals in the processed sludge; this has been a problem for many years. According to internal analyses, the reason for these levels is most likely due to the sludge from the septic tanks (Table 4).

Since the sludge from the septic tanks is responsible for a considerable part of the metal load, there are reasons to investigate this issue further. Mittskåne Water therefore took the decision to evaluate a new setup where the external sludge from septic tanks is treated separately. If the sludge is dewatered and the water phase, the supernatant, is the only fraction released into the incoming wastewater stream, possibly a reduction in metal load could be obtained. Mittskåne Water has therefore rented and purchased equipment to put this solution into practice.

Table 4. Comparison of the mean values for dewatered external sludge to the processed sludge at the wastewater treatment plant (WWTP) in Hörby (mg/kg dry matter).

	Dewatered external sludge	**Processed sludge at the WWTP**	**Threshold limits**
Pb	10,97	8	100
Cd	0,70	0,71	2
Cu	624	389	600
Cr	9,94	19,75	100
Hg	0,32	0,22	2,5
Ni	9,75	10,56	50
Zn	873	469	800
Cd/P	103	36	

A dewatering system for external sludge is already being used by the Municipality of Östersund (Figure 7).

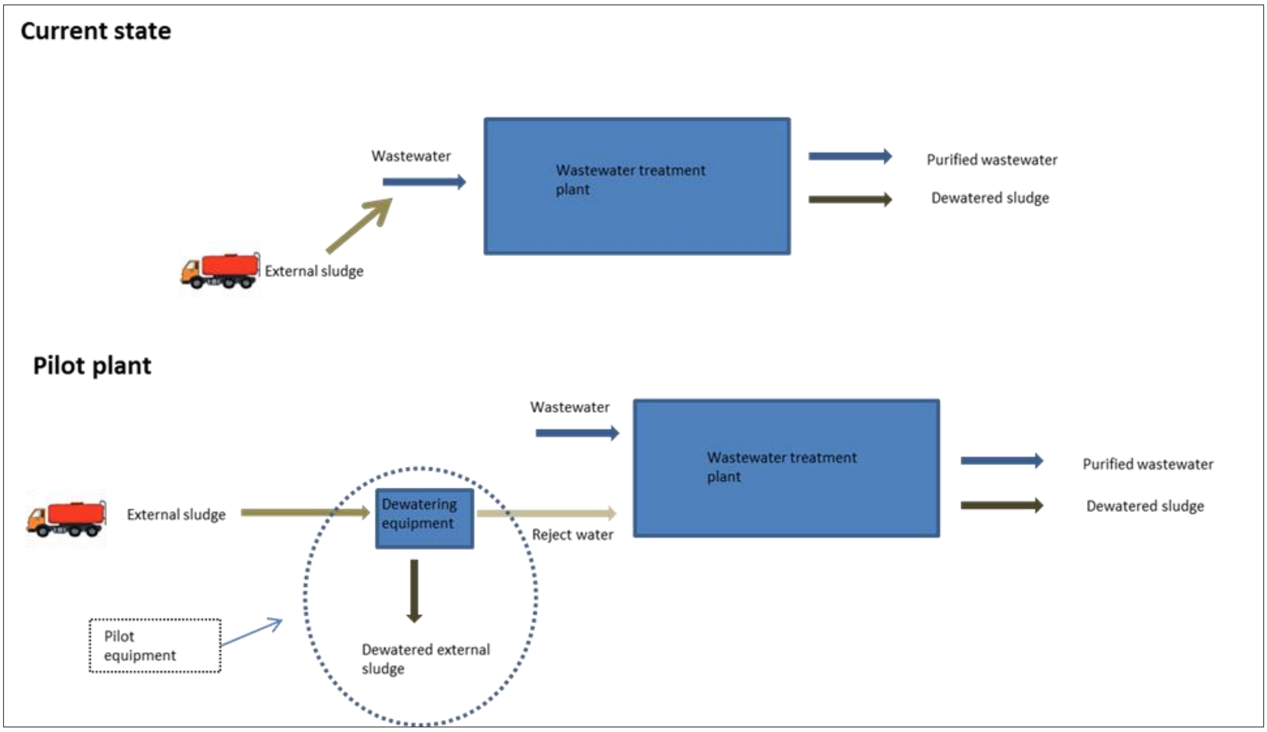


Fig. 7. The external sludge handling system in the Municipality of Östersund.

The facility in Östersund has been operational for several years and it is therefore possible to evaluate the investment.

The facility receives about 6 500 – 7 000 m^3/year and is operational for about 7-8 months per year (not during winter). Roughly, it can be considered as two parts: the receiving part and the dewatering part.

The part that receives the sludge is comprised of a tile drainage layer and integrated screenings press and washing system. The total energy demand can be estimated to 556 kWh/season. Electricity, water and maintenance are not included in the price.

Table 5. Energy demand of the receiver part.

Filtration 2,2kW x 121h	265 kWh
Two sand ”traps” (1,1kW x 51h) + (0,55 x 66h)	91 kWh
Screw wash press 3kW x 66h	200 kWh
Total	**556 kWh/ season**

The dewatering part is comprised of two pumps, one for the sludge and one for the polymers, the dewatering device and transport equipment for the sludge to the silo.

Table 6. Energy demand of the dewatering part.

Pump for polymers 1,1kW x 867h	950 kWh
Dewatering device, 1,5 kW x 867h	1 300 kWh
Sludge pump, 4kW X 867h	3 468 kWh
Sludge screw transporter (3kW x 867h) x 3st	7 800 kWh
Total	**13 500 kWh/season**

The need for chemicals and associated costs

External sludge is easily dewatered and a polymer flow of 250 liters/hour, with a dry matter ratio of 0,15 – 0,20%, and a corresponding sludge flow of 6-7 m^3/h have been found to enhance operations. Only one polymer is being used for the dewatering. The concentration 0,20% returns (in solid form) 0,5 kg powder/ 250 liters complete solution. 867 x 0,5 kg returns a consumption of polymers of roughly 400 kg/season. Total cost (if the kg price of polymers is about 2,5-3 €) = 1 200 €/season.

In total for the year 2013, a volume of 6 600 m3 external sludge was treated. Dry matter level before dewatering was observed to 1% and after 27%. Electricity for the dewatering of 1 m3 sludge amounted to 2,12 kWh/m3. The cost for chemicals (polymers) was estimated to 0,2 €/m^3.

Use in agriculture

Table 7 shows the level of metals and nutrients in the external sludge compared to the threshold values in the current legislation. The elevated metal levels mean that the sludge cannot be dispersed on arable land. The advantage is, however, that the metal content from the WWTP is reduced since the external sludge has been treated in a different process. The chances that the outgoing sludge from the WWTP will be better suited for dispersal on arable land will be increased.

Table 7. Comparison of legislation thresholds for metal content with the content at Hörby WWTP after the pilot plant evaluation (mg/kg dry matter)

	Threshold current legislation	Threshold proposed legislation (2030)	Metal content dewatered external sludge (pilot plant)
Pb	100	25	11
Cd	2	0,8	0,70
Cu	600	475	624
Cr	100	35	9,94

	Threshold current legislation	Threshold proposed legislation (2030)	Metal content dewatered external sludge (pilot plant)
Hg	2,5	0,6	0,32
Ni	50	30	9,75
Zn	800	700	873
NH_4-N	-	-	4,7
N-tot	-	-	32,7
P-tot	-	-	6,7
TS	-	-	33
Cd/P-kvot			103

Energy, nutrients, carbon and economy in this approach

It is difficult to compare the current handling with an external handling of sludge since there exist very little data and the result will be heavily influenced by site characteristics (Table 8).

Table 8. Summary of the alternatives.

	Current handling	External handling of sludge
Energy	Amount of energy per cubic meter external sludge that is treated at the WWTP (12,5 kWh/m^3 – Danish EPA 1991)	Energy consumption is estimated to 2,12 kWh/m^3 external sludge to increase the level of dry matter from 1 to 27% (Municipality of Östersund facility). To this it must be added the energy consumption for treatment of the supernatant.
Conclusion	Separate handling of external sludge is much more energy efficient than current handling (treatment in WWTP).	
Nutrients	The nutrients are recovered and recirculated by dispersal on arable land.	Since the dewatered external sludge contains high levels of metals it cannot be dispersed on arable land. However the outgoing sludge from the WWTP will be better suited for dispersal on arable land.

	Current handling	External handling of sludge
Conclusion	Both manners of handling can increase or decrease the use of sludge on arable land.	
Carbon	All carbon in sludge is applied on arable land. The easy degradable carbon is mineralized to CO_2	The external sludge will most likely be combusted and then the carbon will be transformed to carbon dioxide instead of stored in the soil.
Conclusion	Both manners can increase or decrease the carbon storage in the soil of arable land.	
Transport	By returning the liquid to the septic tanks the energy costs for transports is reduced. There is also another type of dewatering where polymer is used to generates a higher dry matter level and therefore increased return of liquid, which in turn generates a lower demand for transports.	
Economy	Very hard to estimate the cost for treating 1 m^3 of external sludge.	
User economy	The cost for emptying a septic tank at the treatment plant is roughly 25 € per septic tank. The owner of the septic tank pays about 90 € to have the tank emptied.	

III. SUMMARY AND CONCLUSIONS

The experiences described in this study from Bornholm and Höör – Hörby can hopefully be of interest for other Wastewater companies there in the future have to implement a systematic collection and handling of sludge from septic tanks in their local area.

A few quantitative conclusions can be drawn:

Energy for transport:

- It is important that the vehicle used for emptying and transport of sludge from septic tanks is able to perform a good dewatering of the sludge, so as much reject water as possible can be returned to the septic tanks, this reduces both the transported load and the number of times the vehicle must return to unload sludge.

Energy for treatment of the sludge in WWTP or separate sludge handling:

- It is very energy demanding to treat sludge from septic tanks in WWTPs – specially for supplying air to the aerobic processes in the WWTPs – the Danish EPA has estimated an energy consumption of app. 12,5 kWh/m^3. Whereas the separate dewatering described by the Swedish partner is only 2,12 kWh/m^3 (treatment of reject water not included)

In general the systematic collection and handling of sludge from septic tanks must be organized according to the local circumstances, needs and possibilities. However it is clear, that separate handling of sludge from septic tanks is much more energy efficient than treatment in WWTPs.

Treatment in WWTPs is of course an easy way to “get rid of” sludge from septic tanks, if you have a WWTP with sufficient capacity, and you only have one sludge fraction in the end. But other factors than convenience is worth to consider, as this study shows.

APPENDIXES

Appendix 1. EnviDan, 2018.

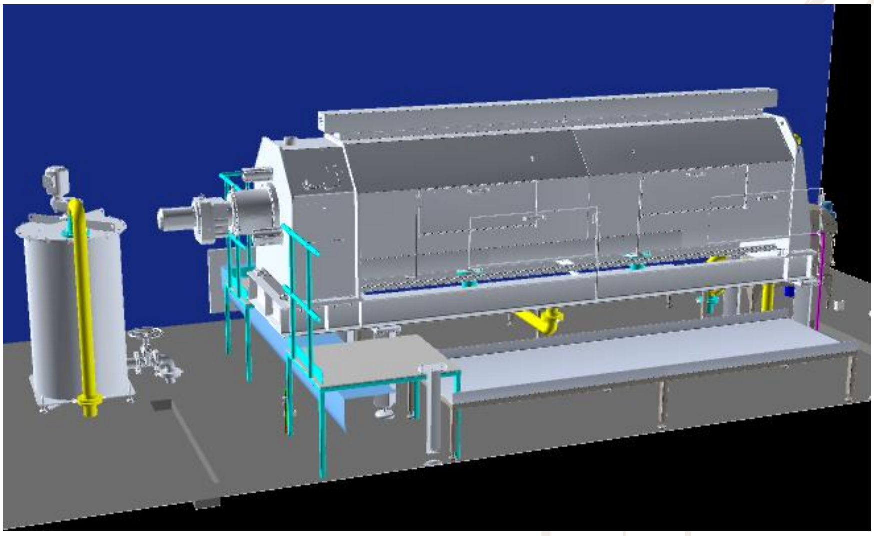
Appendix 2. Tender description.

Appendix 3. KSA.

NOTAT

Dato:	06 marts 2018
Projektnavn:	Slutafvander Rønne RA
Projektnr.:	117 0340-3
Udarbejdet af:	Kim Bruun Petersen
Kvalitetssikring:	Stine Lundbøl Vestergaard
Modtager:	Bornholm Spildevand
Side:	1 af 11

Vedr.: Rønne Renseanlæg, Slutafvander



Indhold

1. Indledning

Nærværende notat omhandler de indledende overvejelser omkring udskiftning af slutafvandingsudstyret på Rønne Renseanlæg.

Nuværende slutafvandingsinstallation består af en forafvander fabrikat Alfa-Laval og en dekanter/centrifuge ligeledes fabrikat Alfa-Laval som slutafvander.

Der udover indgår der et kalkdosering- og iblandingsanlæg til brug for iblanding af kalk i det afvandede slam.

Den fremtidige slamafvandingsinstallation ønskes simplificeret således at der kun indgår ét trin i afvandingen, og således at der fremover ikke anvendes kalkiblanding. Kalkiblandingen er ikke længere et krav og medfører i dag en driftsomkostning på kr. 500-700.000, - pr. år.

Der er ønske om at den fremtidige slamafvanding udføres med skruepresse således at afvandingsprincip og type svarer til det slamafvandingsudstyr der anvende på anlæggene i Tejn og Svaneke.

2. Slammængder

I det følgende redegøres der for den teoretiske slammængde der produceres på Rønne Renseanlæg. De teoretiske slammængder estimeres ud fra oplysninger omkring anlæggets drift samt anlæggets opbygning. De teoretiske slammængder sammenholdes med de slammængder der er registreret som slutafvandet (inden kalktilsætning) på Rønne Renseanlæg, hertil anvendes de grønne regnskaber.

Ved opstilling af massebalance for den gennemsnitlige forureningsmæssige belastning for 2016-2017 baseret på de akkrediterede indløbsanalyser på indløbet, ligger den teoretiske slamproduktion for Rønne Renseanlæg imellem 2.800-3.200 kg SS/dag_7.

Af de grønne regnskaber fremgår det at der i perioden 2013-2016 i gennemsnit er slutafvandet 2.975 kg TS/d_7, med variationer fra 2.600 kg TS/d_7 til 3.350 kg TS/d_7 årene imellem, hvilket også stemmer overens med registreringerne i EnviTronic, hvorfra de grønne regnskaber genereres.

Den teoretiske slamproduktion estimeret fra en fuld massebalance for Rønne Renseanlæg stemmer derfor overens med de, i det grønne regnskab og EnviTronic, registrerede slutafvandede slammængder, inden kalktilsætning.

Det vurderes derfor, at slammængderne fra Rønne Renseanlæg i snit udgør 3.000 kg TS/d_7 eller 1.095 ton TS/år med variationer i den daglige slamproduktionen i intervallet 2.600-3.400 kg TS/d_7 og på årsbasis 950-1.250 ton TS/år.

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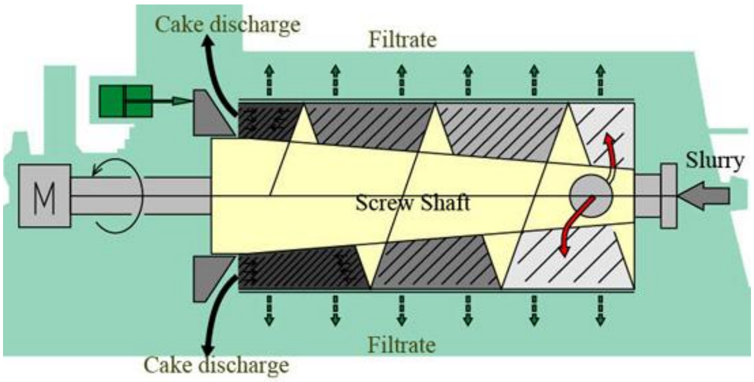
3. Skruepresse kontra dekanter/centrifuge

3.1 Skruepresse



Figur 1: Principskitse af skruepresse

Skruepressen kan anvendes til både forafvanding og slutafvanding, og har et bredt funktionsområde sammenlignet med flere af de andre teknologier til afvanding.
Skruepressen benytter sig alene af tryk til afvanding af spildevandsslammet. Overordnet består skruepressen af en konisk formet skrue og en cylindrisk si, inddelt i 3 zoner. Vandet fjernes gradvist fra zone til zone, først det frie vand, senere i processen fjernes vandet under stadig højere tryk og pres. Det tørstofindhold skruepressen leverer, afhænger alene af opholdstiden i skruepressen og justeres ved regulering af skruens omdrejningshastighed. Der kan almindeligvis opnås et TS-indhold i det afvandede slam på 18-22 %.

Skruepressen leverer slamafvanding i et hermetisk lukket system, hvilket tilgodeser både det sikkerheds- og sundhedsmæssige arbejdsmiljø. Antallet af mandtimeforbrug til renholdelse og vedligehold er således minimeret. Der skal påregnes anvendt eksterne ressourcer til vedligeholdelse og reparation.
Afvanding ved skruepresse kan forløbe kontinuerligt 24 timer i døgnet og det er således ikke nødvendigt at der er driftspersonale tilstede under drift. Skruepressen er den afvander der har det bredeste tørstofområde og som lettest kan omstilles i driften.

English abstract

One such press is described, inter alia, in Swedish patent specification No. 7605402-2 and incorporates a feed screw, a perforated drum which surrounds the feed screw and which has an inlet or infeed aperture at one end thereof and an annular outlet or outfeed aperture at the other end thereof. The outlet aperture is formed between an opening in the end-wall part of the drum and a flow regulator mounted in the extension of the screw.

In a screw press incoming suspension is captured by the helix of the screw and advanced towards the annular outlet while being compressed. Compression of the material during its travel along the screw takes place due to the fact that the outlet aperture is relatively small; the water or other liquid pressed from the sludge departs through the perforations in the drum casing.

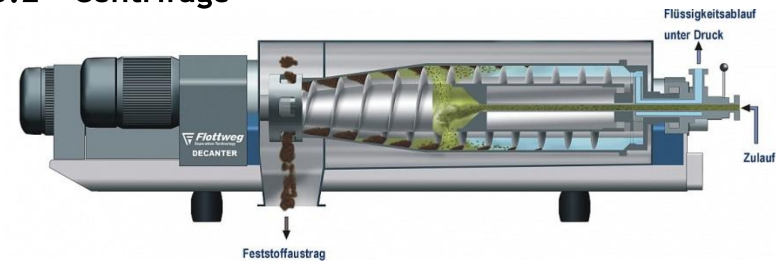
The residual water content of the dewatered pulp discharged through the outlet depends to a very large extent on the size of the outlet.

The total solid content in the dewatered sludge will for biological sludge normally be in the range of 18-22%

The construction of the screw press I hermetically enclosed structure in order to ensure a safe a healthy environment. The structure is mechanically ventilated.

Number og manpower days for daily service and maintenance is at a minimum.The screw press is designed for continuously operation 24/7 and no service personal is required during the operation.

3.2 Centrifuge



Figur 2: Principskitse af slamcentrifuge / dekanter

En centrifuge eller en dekantercentrifuge adskiller det flokkulerede slam fra væskefasen ved hjælp af centrifugalkræfter. Det afvandede slam fjernes kontinuerligt ved hjælp af den indvendige skrue, der "pløjer" det afvandede slam af centrifugens sider og videre ud. Centrifugalkraften komprimerer det faste stof og dræner den overskydende væskefase (rejektvandet). Centrifuger anvendes oftest når der skal opnås et højere tørstofindhold på 18-25 %. Afvandingsegenskaberne er kun i mindre grad afhængig af det tørstof der tilledes.

Centrifugen arbejder i lighed med skruepressen i et lukket system, og har de samme fordele i relation til sikkerhed, sundhed og mandtimeforbrug som skruepressen. Som følge af den høje rotationshastighed er centrifugen væsentlig mere støjende end de langsomtgående afvandingsmaskiner. Tilsyn og reparation af centrifuger udliciteres almindeligvis. Da centrifugen kan betegnes som en højhastigheds teknologi til afvanding, anbefales det ofte at centrifugen kun kører når der er mandskab tilstede på anlægget.

3.3 Forventet TS indhold efter afvanding

Det forventelige TS indhold i afvandet slam fra de 2 forskellige afvandingstyper er oplistet i nedenstående tabel.

Metode til slutafvanding	Forventet tørstofindhold (% TS)
Skruepresse	18-22
Centrifuge	18-22- (25)

Tabel 1: Tørstof ved forskellige afvandingsmetoder

Som det fremgår af tabel 1, så er de 2 slamafvandingstyper sammenlignelige og valg af slamafvadingstype bør ikke bero på det forventede opnålige TS indhold

3.4 Effekt-polymer og vandforbrug

I nedenstående tabel er angivet estimater for forbrugsstoffer omregnet pr. ton TS afvandet. De nævnte estimater er baseret på tidligere undersøgelser af slamafvandingsudstyr, og der må forventes en vis variation i værdierne afhængig af det aktuelle slam der afvandes.

Metode til slutafvanding	*Effektforbrug for afvandingsenhed kWh/ton TS	Trykluftforbrug	Aktivt polymerforbrug Kg/ton TS	Vandforbrug m^3/ton TS
Skruepresse	5-8	Behov for luft til styring af tryk i pressen	10-12	Diskontinuerligt vandforbrug til skylleprocedure under drift 2-5
Centrifuge	11-17	Ingen forbrug	9-11	Kun vandforbrug til skylning ved stop af centrifuge

Tabel 2 Forbrugsdata

* I effektforbruget er kun indregnet selve slamafvandingsenheden, da perifert udstyr (pumper og transportør m.m.) forventes at være af samme størrelse for alle slamafvandingstyper)

Med baggrund i ovenstående sammenligning vurderes det, at valg af en skruepresseløsning generelt vil medføre laveste samlede direkte driftsomkostninger, efter som at effektforbruget er lavest, polymerforbrug er af samme størrelsesorden som centrifugen og vandforbruget og luftforbruget for begge er begrænset.

English abstract

Tabel 2 shows the estimated consumption og water, polymer and energy compared to the amount of dewatered sludge. The values shown are all based on previously investigation of dewatering equipment installed.

Sludge dewatering methods	**Energy consumption kWh/ton TS*	*Compressed air consumption*	*Polymer consumption (active polymer) Kg/ton TS*	*Water consumption m^3/ton TS*
Screw prese	*5-8*	*Compressed air for control of pressure in screw press*	*10-12*	*Water consumption only for wash of press during operation* *2-5*
Centrifuge	*11-17*	*No consumption*	*9-11*	*Only water consumption for wash of press shut down*

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Tabel 2 Forbrugsdata

**Energy consumption only refers to the direct power uptake from the screw press.*

Based on the above comparison choosing of sludge dewatering systems a sludge dewatering solution based on a screw press will in general result in the lowest operation cost, mainly caused by a low energy consumption for the screw press.

3.5 Krav til resurser / mandetimer

I nedenstående tabel 3 er angivet skønnet mandetimeforbrug for drift af selve slamafvandingsenheden. Det skønnede antal timer er baseret på at alle systemer styres i forhold til slamflow/TS ind og doseret polymermængde.

Metode til slutafvanding	Opstart af slamafvandingsudstyr Timer/dag	Løbende tilsyn til under drift Timer/dag	Nedlukning af slamafvandingsudstyr Timer/dag	Samletantal skønnet antal mandetimer pr. år ved 200 arbejdsdage Timer
Skruepresse	0,5	0	0	100
Centrifuge	0,5	0	0	100

Tabel 3 Mandetimeforbrug estimeret

Som det fremgår at tabel 3 vurderes det, at krav til ressourcer/mandetimer for såvel skruepresse som centrifuge er sammenlignelige.

3.6 Valg af afvandingstype

Med baggrund i ovenstående samt det faktum, at der, som nævnt i pkt. 1, i dag på såvel Nexø Renseanlæg som Tejn Renseanlæg anvendes skruepresse som slutafvander, anbefales det at der også i fremtiden på Rønne Renseanlæg anvendes skruepresse til slutafvanding. De er derfor i det efterfølgende arbejdet videre med en skruepresseløsning for Rønne Renseanlæg.

4. Valg af presse og pladsforhold

4.1 Driftstid og kapacitet af presse

En skruepresse er normalt designet for at kunne driftes uden tilsyn, og at pressen dimensioneres for driftstider på 12 timer pr. dag. Dette gøres for ikke at vælge en for stor presse med dertil hørende ekstra investeringsomkostninger.

Regnes der med at pressen kører 5 dage pr. uge og i samlet 40 uger om året medfører dette at pressen skal have en kapacitet på ca. 460 kg TS/time.

Når der kun er valgt at køre 40 uger pr. år skyldes det, at der skal være tid til planlagte servicearbejder, og at der tillige skal være kapacitet til at udtage ekstra overskudsslam, når der omlægges fra vinterdrift til sommerdrift.

4.2 Pladsforhold og placering af presse

Pladsforholdene i slamafvandingsbygningen på Rønne Renseanlæg er gode, og da den fremtidige slamafvanding bliver reduceret til ét trin vil der være god plads rundt om en fremtidig skrupresseinstallation, også selv om pressen vælges placeret på langs af rummet.

En presse med en kapacitet på ca. 460 kg TS/time har en længde på ca. 4,5 m, så der vil ikke være behov for at ændre bygningen for at give plads til en skruepresse af denne størrelse.

For at kunne løfte det afvandede slam op til containerne foreslås det, at pressen løftes et stykke op fra gulvet, og derfra via skruetransportører føres til slamcontainerne.

Nedenstående er vis den eksisterende slamafvandingsinstallation og et forslag til placering af pressen og tilhørende udstyr. Forslaget er kun et ideoplæg, og med de gode pladsforhold der er i slamafvandingsbygningen vil der være mulighed for at ændre placeringen om dette ønskes.

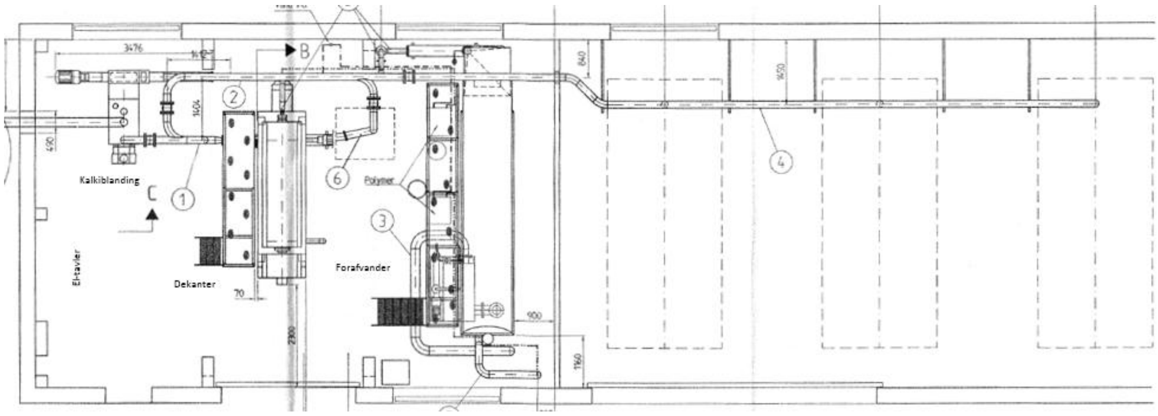

Fig. 4 Eksisterende slamafvandingsinstallation

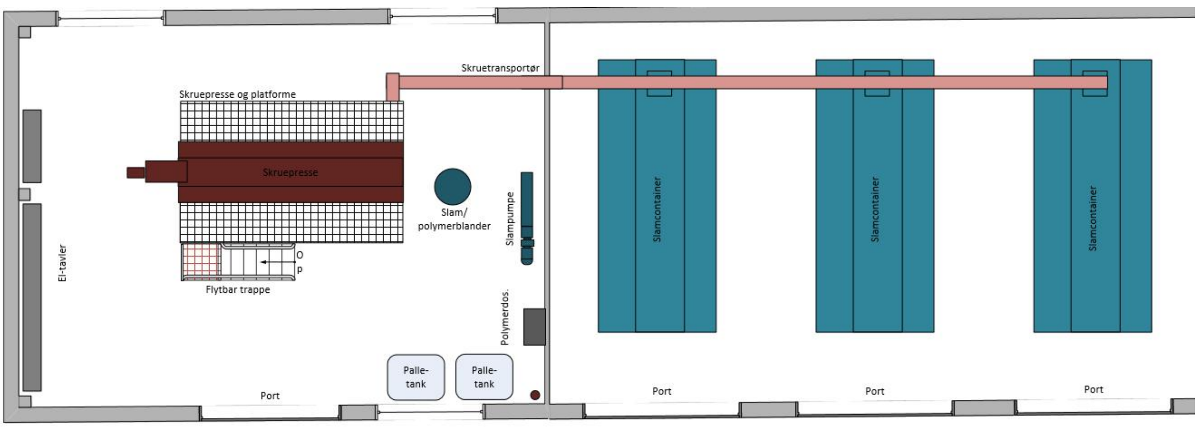

Fig. 5 Mulig fremtidig placering af slamafvandingsudstyr

5. Vurdering af SS i rejektvand fra skruepresser

5.1 Generel vurdering af indflydelse fra SS i rejektvand

SS i rejektvandet fra slutafvanding kan variere meget afhængig af slamafvandingsudstyrets effektivitet. For skruepresseinstallationer ses det almindeligvis, at de garanterede koncentrationer af SS fra leverandørens side ligger mellem 800-1.200 mg SS/l, hvilket er lidt højere end det der normalt forventes fra dekanter afvanding. Det skal dog tilføjes at SS-koncentrationen ofte ligger væsentligt under dette niveau på anlæg hvor den kolloide del af SS i det tilførte slam er lav.

English abstract

Suspended Solid (SS) in the reject water from the sludge dewatering process often very based on the efficiency of the dewatering equipment. Reject water from screw presses will in general be in the range of 800-1.200 mg SS/l which is slightly higher than reject water from centrifuges. However it is often seen that the SS in the reject water from screw presses is well below the range og 800-1.200 mgSS/l when the collide particles in the sludge are low.

Gennem årene har der været diskussioner i spildevandsteknisk sammenhæng, om SS i rejektvand fra slamafvanding generelt har indvirkning på processen i renseanlæggene. Der har specielt været fokus på, om der kunne konstateres højere SS koncentrationer i afløbet fra efterklaringstanke, når SS koncentrationen i rejektvandet steg. Dette har ikke kunne registreres i de informationer som EnviDan har kendskab til.
Den almindelig antagelse er, at de fine fraktioner af SS, (den kolloide fraktion af SS) som rejektvandet indeholder, bliver indbygget i slamflokkene i processtankene, og at dette er årsag til, at der ikke kan konstateres højere SS i udløb fra efterklaringstanke, når SS i det tilbageførte rejektvand stiger.

5.2 Tilbageføring af SS til processen

Med en overskudsslammængde på 3.000 kg TS/dag$_7$ og med en koncentration på ca. 1,2-1,5 % vil der være behov for at indpumpe ca. 200-250 m^3/d$_7$, eller 280-294 m^3/d$_5$.

Forudsættes det, at der i rejektvandet er en koncentration af SS på ca. 800 mg/l vil det svare til at der dagligt er tilbageført ca. 225-235 kg SS/dag$_5$, svarende til en tilbageføring på ca.7,5 %.

Denne øgede tilbageførsel vil følges af en tilsvarende forøgelse i eksempelvis energi og polymerforbrug til slutafvanderen.

5.3 Tilbageføring af SS fra rejektvand til slamafvanding

Ønskes det trods ovenstående at reducere SS i rejektvandet til et minimum, da er det muligt at filtrere rejektvandet inden det ledes tilbage til processen, og returnere det tilbageholdte SS til slamafvandingen direkte til slam/polymerblandetanken før slamafvandingsanlægget. En løsning som dog vil fordyre den samlede slamafvandingsinstallation og kræve ekstra driftsomkostninger.

6. Økonomi

Et budget for en ombygning/udskiftning af den nuværende forafvander- og dekanteranlæg, er estimeret nedenstående:

Post 1: design-udbud og anlæg	
Bygge- og anlægsomkostninger	700.000
Maskinudstyr, levering og montering	3.100.000
El-tavle og SRO og installation	500.000
Uforudsigelige omkostninger	400.000

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Projektering og udarbejdelse af funktionsudbud	600.000
Post 2: Evaluering af tilbud, kontrahering og tilsyn	
Evaluering, kontrahering og tilsyn med M-entreprise	200.000
Samlet anlægskalkule	**5.500.000**

English abstract:

Economy:

A total estimated budget for changing the existing dewatering plant is as follows:

Item 1: design-and tendering of contractor	
Construction cost	*700.000*
Mechanical equipment ad installation	*3.100.000*
Electrical equipment, installation and SCADA system	*500.000*
Unforeseen cost	*400.000*
Design and tendering documents	*600.000*
Item 2: Evaluation of offers and contracting	
Evaluation, contracting and follow up on installation	*200.000*
Total estimated investment	*5.500.000*

The above-mentioned investment cost will result in following savings per year:

Estimated yearly saving of cost for polymer will be approx.. DKK 175.000,- based on a yearly consumption of approx. 5 ton active polymer.

Estimated yearly savings for no use og lime powder approx. DKK 500.000-700.000,-

Energy savings approx. DKK 50.000- 100.000,-

Total estimated yearly savings approx. DKK 725.000-975.000,-

Der er i kalkulen regnet med, at den nuværende belastning varetages på 40 uger og 5 dage pr. uge i 12 timer.

Budgetkalkulen er baseret på priser indhentet til tilsvarende anlægsstørrelse med. Der er ikke udført detailvurdering af den samlede fremtidige installation.

Der er kalkulen ikke indregnet evt. indtægter ved salg af det gamle slamafvandingsudstyr, da det formodes at denne indtægt vil balancere med slutafskrivningen af udstyret.

De ovennævnte investeringsomkostninger skal ses i sammenhæng med, at der ved at undlade kalkstabilisering opnås en driftsbesparelse på kr. 500-700.000,- pr. år, samt at der kan forventes et reduceret polymerforbrug da der kun skal doseres polymer én gang. Det skønnes at der årligt kan spares ca. m^3 / 5 ton aktiv polymer, á ca. 35 kr/kg svarende til ca. kr. 175.000 pr. år.

En overslagsberegning af mulig besparelse i energiforbrug baseret på erfaringstal fra tilsvarende anlæg på Nexø Renseanlæg indikerer, at der kan forventes en besparelse på rundt regnet kr. 50.000-100.000,-. Besparelse skyldes primært at skruepressen anvender ca. 50% mindre effektforbrug pr. kg/TS afvandet og at der i det nye slamafvandingsanlæg ikke er behov for forafvanding og klaktilførelse.

Alt i alt en forventet besparelse på ca. kr.725.000-975.000 pr. år, hvilket giver en tilbagebetalingstid på ca. 6-8 år i forhold til de estimerede samlede anlægsomkostninger.

7. Post script:

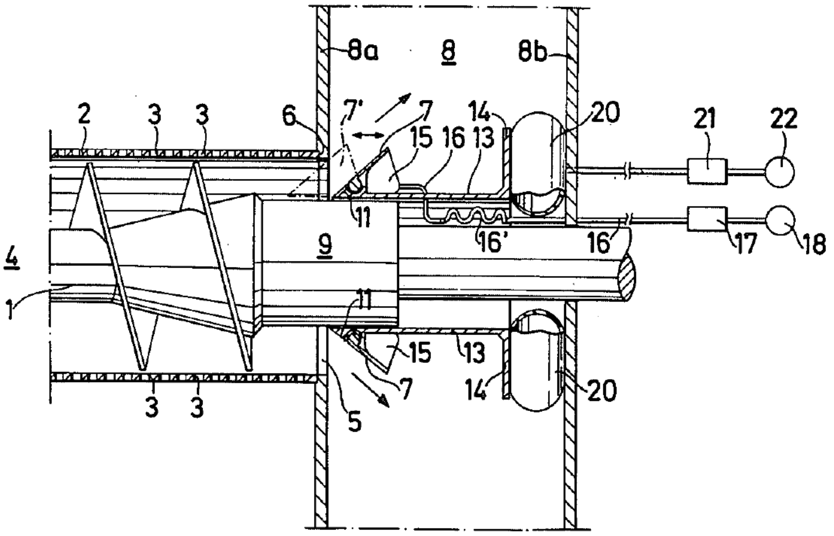
Summary from patent application for screw press dated 1987-12-01pat. No. US4709628A

The patent is free.

7.1 Screw press for dewatering sludge and fiber suspensions

7.1.1 Abstract

A screw press for dewatering sludge and fiber suspensions, having a feed screw, a perforated drum surrounding the feed screw, an inlet or infeed aperture at one end of the drum, and an end wall section at the other end forming an annular outlet or outfeed aperture. The end-wall section includes a plurality of flaps located as an extension of the feed screw, the flaps being yieldably arranged to adjust the size of the outlet aperture. The end of each flap nearest the axis (9) of the feed screw (1) is pivotally mounted on an attachment connection (11), and the attachment connection (11) is arranged for movement along the axis of the feed screw (1). The flaps (7) are arranged to be pressed outwards under the influence of a first force generating arrangement (15,17,18) to form a larger angle with the screw axis (9), thereby causing the outlet aperture to decrease in size. The attachment connection (11) is arranged so that it and the flaps connected thereto can be moved axially towards the outlet aperture (5) under the influence of a second force generating arrangement (20,21,22), to also decrease the size of the outlet aperture, the two force generating arrangements being adjustable independently of one another.



Description and terms

The task must be carried out in accordance with the descriptions and conditions below which apply to the entire contractual relationship. The party wishing to invoke force majeure must notify the other in writing without undue delay.

1. The extent and terms of the contract

1.1

The handling system for septic tanks comprises a total of approx. 5,300 properties on the whole of Bornholm (Bornholm Region Municipality).

The task includes emptying septic tanks as well as transportation, disposal and handling of sludge - cf. point 3. The contractor must carry out the administration, planning and control of the work itself, thus emptying is performed correctly and on time.

The contractor's ongoing reporting on the operation must be via the EnviTrix database. Registered information about the tank is checked at each emptying (tank type, tank volume, cover type and any deficiencies). With new tanks, as a minimum, the tank's location and type are also registered.

The contract period is 5 years, with an option for one years extension of the contract. Unit prices in the price list is fixed for the first two years of the contract period. Then the unit prices are adjusted annually with the increase in Statistics Denmark's net price index

1.2

The usual number of septic tanks that must be emptied per year is calculated in relation to the emptying frequency, which is usually:

- Residential houses: one emptying every year
- Summer houses: one emptying every two years.

This emptying frequency is decided by the authority - Bornholm Region Municipality.

There is a total of approximately. 5.300 properties with septic tanks - of which approx. 1.500 are summer houses. The contract amounts to approx. 4.400 emptyings per year.

At summer houses, septic tanks usually have to be emptied outside the tourist season, during the period March-June.

At residential houses septic tanks usually have to be emptied during the period April - December incl.

The contractor must respect the authority decision of which users the contract covers.

2. Emptying septic tanks etc.

2.1

The contractor must acquire, clean and maintain the material needed for the job, as well as necessary garage or parking space for vehicles. The contractor must ensure that all off the involved material is in working order and legal condition. Vehicles must appear in generally maintained and cleaned condition. Replacement equipment must, if applicable, be deployed without extra payment.

The contractor is obliged to use vehicles that are suitable and equipped in the individual emptying task, and which to the least extent inflict damage to the access roads. emptying method requires the use of emptying equipment that can carry out drainage and refilling of septic tanks with reject water (such as KSA equipment). The vehicle must be equipped with high pressure washers and min. 50 m suction hose.

In cases where the access conditions require a smaller vehicle, a smaller vehicle must be used.

2.2

The septic tank must be emptied of floating sludge and settled sludge, according to a plan prepared by the contractor and approved by the authority. The contractor must respect the fact that the authority, in specific cases, determines a specific emptying frequency, according to the regulation.

2.3

The contractor must advise users 14 days prior to the start of emptying. Advice / notification must be made by SMS via the add-on module in EnviTrix, and by advertising in an island-wide newspaper as well as on the contractor's own website. A week before the advertised time, the contractor must be able to tell the specific day when the emptying will take place.

2.4.

The contractor should be able to solve minor tasks for the individual user on general emptying visits. This should be agreed in advance and set in all cases directly between the user and the contractor.

2.5

Emptying a normal septic tank includes driving to the tank, removing the cover, removing floating sludge and settled sludge, replenishment with reject water, cleaning of edge for sludge residues, removing stones and the like, flushing the inlet and outlet in the septic tank, and applying the cover.

Rejectwater must be filled in the septic tank, so that the tank is delivered as far as possible in water-filled condition (about 10 cm under outlet).

2.6

The contractor must understand that the users' septic tanks are of varying size, design, capacity and location and has been subject to varying loads. Septic tanks with a capacity of 1-3 m3 are considered normal size. Tanks with 2 and 3 chamber tanks are considered as one tank. the tank can have up to 3 lids / chambers: For these tanks (of which only a few) the first chamber is always emptied while the second chamber is visually inspected and emptied if sludge is accumulated. The contractor must make these emtyings to the regular unit price in the price list. Where there are several tanks in series or in direct connection with each other, these tanks are considered as one tank and relevant chambers must be emptied.

For septic tanks with a volume greater than 3 m3, a fixed price of DKK 50, excl. VAT, per emptied m3 that exceeds 3 m3 is payed.

The price is fixed for the first two years of the term of the contract. Then the price is adjusted annually with the increase in Denmark's Statistics net price index.

2.7

In cases where access conditions require a smaller vehicle, a normal small sludge veehicle can be used - so far there has been used a small vehicle for approx. 250 of the annual emptying. The contractor will be paid the normal unit price in the price list.

The contractor can, in agreement with the authorities, deliver untreated sludge from such emptyings at the Waste Water Treatment Plant in Rønne, Nexø, Tejn, the contractor must not pay for the delivery of the sludge. The contractor must continuously state how many emptied tanks is delivered to WWTP.

2.8

When visiting new tanks, the contractor must register where the septic tank is located, and enter the location in the database, and register the tank type, volume and other information relevant for emptying the septic tank.

2.9

The contractor must print an emptying report at each emptying visit. The emptying report is generated in EnviTrix database. If the property owner lives on the address, the emptying report is delivered on the address (in mailbox or directly to the owner, if present at the emptying visit).

If the owner does not live the property, the contractor must send the emptying report by ordinary mail to owner's addres.

2.10

Unsuccesfull visit for emptying

If, for various reasons, a tank cannot be emptied, the reason for the unsuccessful visit must be documented by images that are added to the tank's "Pictures" tab in the EnviTrix database.

In cases where the contractor cannot immediately find the tank, the contractor must carry out a thorough study about the property and investigate whether the owner or others are at home, and get the owners information about the location of the tank. The contractor must expect to spent time on this (10 minutes)

that must be included in the price offer. Unsuccesfull emptyings is settled with 50% of the price of a normal emptying according to the list price.
In case of a unsuccesfull visit the contractor is obliged - at the request of the users - to carry out a follow up visit - the contractor can, for example, organize follow up rounds, each follow up emptying is payed with 60% of the price for a normal emptying.
The contractor must inform the user in advance, that the user has to pay extra for the follow up emptying.
2.11
If there is a need for extra emptying, including acute, the landowner himself can request these from the contractor. These empyings are settled directly between the landowner and the contractor. The contractor must make sure that the customer agrees with this before the emptying is carried out.
2.12
When emptying properties with SPF stables, the contractor must drive a special route with cleaned equipment, where only the SPF stables are visited - the route has so far included approx. 135 locations. The contractor must carry out these emptyings to the regular unit price in the price list

3. transport, treatment and disposal of sludge

3.1
The contractor must transport the sludge to the storage facility, and compost the sludge by mixing cut straw, and aerate by turning the piles. Storage, and the use of the composted sludge for agricultural purposes must comply with the requirements in the legislation. For the lime stabilization of the sludge, an amount of approx. 8% burnt lime must be mixed in the composted sludge.
The contractor must have sufficient capacity for storing the sludge, and through agreements with farmers, have sufficient agricultural area according to the regulation.
NB: Sludge must not be spread within the special groundwater protection sites, which are mapped as an annex. There may be minor adjustments to the areas gradually as the groundwater mapping progresses.
3.2
As an alternative to fulfilling the requirements in 3.1, the contractor may choose to enter into an agreement to deliver the sludge to a biogas plant. Documentation for this must be sent to the authority.
3.3
The Waste Water company orders sampling and analysis of the composted sludge. Normally, only one analysis is performed per year at mid-August before spreading the sludge. If the analysis shows that a batch of sludge does not meet the requirements for use for agricultural purposes, the Waster Water company take over responsibility and the cost of the further processing / disposal of the batch in question.

Simon Moos
Maskinfabrik a|s

MOOS KSA

Mobile sludge dewatering incorporating 30 years of experience and development

The history of our company...

Simon Moos Manufacturing A/S was established in 1977 by the current directors Simon Moos and Hanne Aamand. The company is based near the town of Sonderborg on the Island of Als which lies just off the southeast coast of mainland Denmark. The knowledge gained over the years from the contracting division of Simon Moos has allowed our company to design, develop and produce equipment for the wet waste industry in particular their own series of jet-vacs and not to mention the well known mobile and stationary units for the effective dewatering and treatment of sludge's. We are an international company with over 60 employees and have an export share of 75% spread over three continents.

The Moos group, Sønderborg.

...and the story of the KSA...

KSA translated means combined sludge tanker and on-site dewatering and as the name implies it does exactly what it says.

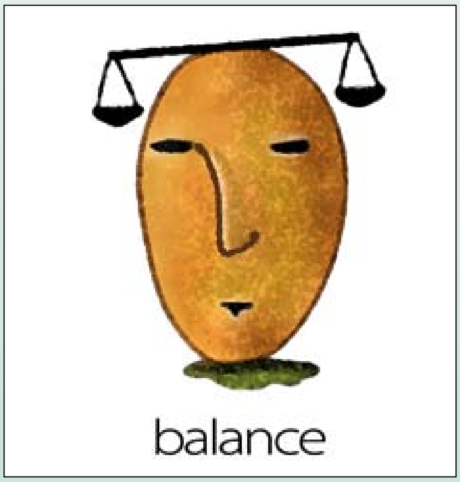
The principle behind the MOOS KSA system is "volume reduction". Realising that the average tanker load of sludge contained a high percentage of water, which was needlessly being transported for disposal at the local waste water treatment works, Simon Moos decided to develop a system that would take the treatment works to the sludge and the KSA was born.
The advantages of this system are:

- Lower transport and running costs
- Lower disposal costs
- Lower environmental impact
- Requires one man to operate the system with a radio remote control
- Reduces the pressure on the Waste Water Treatment plants

MOOS KSA, year 2006

...a company with strong values...

Simon Moos Manufacturing A/S is firmly rooted in the South of Denmark where there is a strong tradition in manufacturing and engineering. Here the major part of our product programme is being designed and produced. We attach great importance as an employer in the fact that our employees, whether he or she works on the shop floor, on the design and production team or with the sales department all share the same values, commitment and enthusiasm in producing top quality products for the industry. We attach great importance and take pride in our openness and our ability in understanding the market place. Our company's keyword is, "balance", balance between meeting the customers requirements and producing the right type of equipment to service their needs. A good indication that we are living up to our reputation and achieving our goals in being a leading force in the manufacturing industry is that we are able to boast re-sales to our customers of 95%. This fact makes our company very proud.



The keyword in the company is balance

...a guaranteed investment for the future...

"The increasing environmental impact must be disconnected from the economic growth." A European environmental protection agency quotation.
Eventually this sentence will become a standard remark in any global or national environmental strategy.

The current situation with global warming, the rising amounts of waste being produced and the growing need to reduce it along with other sources of pollution has resulted globally in various political initiatives, the purpose of which is to change the attitude of waste companies and industry in obtaining a greater environmental awareness. In financial terms companies will notice increasing costs for the disposal of waste water. The permitted limits for contaminants in waste water will become lower and lower. Fuel, road tax and disposal along with clean water supplies etc. will eventually become subjected to higher environmental duties. If companies are unwilling to adapt to changes in environmental legislation they will probable notice a marked reduction in profits. Using the KSA system in certain circumstances could reduce or even waiver the current landfill duty within the United Kingdom. The Simon Moos KSA system fits the global environmental strategy because it reduces waste volumes by up to 90% and the dry filter cake produced can be safely desposed of at a licensed landfill site or recycled and used as fertilizer after a controlled sanitation process to name but a couple of routes.

Dewatering of the sludge to a dry mass with various recycling possibilities!

The emptied tanks are refilled with the cleansed water via the KSA.

...a global presence!

The KSA has been sold to more than 20 countries spanning 3 continents. It has been a great challenge to our production department to design a totally reliable unit that is able to function both in extremely cold climates experienced by countries like Scandinavia, Canada, Iceland and North America, to very hot climates as found in places like Tahiti! We believe that the successful expansion of the Simon Moos brand is attributed to a highly motivated work force who constantly strive for perfection. We did not capture a new geographic market from a concept but from a first class product. We as a company have an open approach to our customers and the market place; this is a part of the Danish culture. This fruitful approach to our way of doing business has resulted in continuous product development where we have combined the best ideas from our engineers and designers with input from our customers worldwide.

The KSA is successfully operating on 3 continents!

A carefully manufactured unit...

The KSA, combined sludge tanker and dewatering unit starts with the basic model and can of course be tailored to the individual customer requirements. This means that a unit can be equipped with a pressure tank, suction boom, industrial jetting pump and many other options, it all depends on the individual customer's needs. The unit can be mounted on 2, 3 or 4 axle chassis, either as a fixed construction or on a hook or wire lift system. The strength in our production concept is and always will be customer driven! All our units are built to the individual customer's specifications.

Basis specification for a standard KSA

Length inclusive of hose reel	6865 mm	**Power take- off from lorry**	90 kw
Width	2460 mm	**Hydraulic equipment**	190 ltr/230 bar
Height	2165 mm	**Vakuum pumpe SAMSON**	15000 ltr. Min. free flow or larger
Weight	7100 kg	**Suction hose reel**	60 m 3", divided into 30 m and 2X15 m.
Vacuum tank	4,500 ltr or 5,000 ltr	**Sludge pump ALLWEILER**	Max. 30 m3 per hour
Polymer tank	1700 ltr.	**Polymer pump ALLWEILER**	Max 2,4 m3 per hour
Dewatering tank	8400 ltr.	**Jetting pump PRATIS-SOLI**	120 ltr/100 bar
Reject water tank	3600 ltr	**Jetting hose reel**	40 m ¾" + 20 m ½"
Oil tank for hydraulic system	250 ltr	**Oil burner STROCO. Fresh water tank (hand washing)**	35 kw 44 ltr.

...the advantages of the KSA system!

With the KSA-system you obtain the following:

- An approximate volume reduction of between 60% - 90 %!
- Transport time and running costs are greatly reduced!
- A radically reduction in disposal costs!
- Able to be self-sufficient with jetting water!
- A reduced wage bill!
- Remain a reliable and tested quality product!
- Easily operated – by on person !
- Deliver a rapid and effective dewatering of $5m^3$ in 8 minutes or $30m^3$ per hour direct feed!
- 30 years development experience!
- Complete remote control of all necessary functions!
- A very stable unit!

...an effective operation...

The KSA operation's effectiveness is based upon our experience over the last 30 years of development, where the objectives have always been to increase stability, efficiency and increase the functions of the KSA system. This has been achieved in co-operation with our engineers and customers. A basic description of how the KSA system works is briefly described below. However, to have the complete picture you have to see it in action! In order to show the unit's efficiency a KSA operator in Denmark can empty between 25 and 35 septic tanks in an ordinary working day without having to discharge, as all the permeate has been used to re-prime the septic tank with the correct PH and bacteria culture. The phrase you're looking for is "efficient".

A KSA can be operated either from the control panel in the machine room or by way of the radio remote control.

The sludge is taken up into the vacuum tank exactly the same way as you would by a traditional jet-vac or tanker.

When the vacuum tank has been filled, the sludge is then pumped into the dewatering chamber via the machine room. During this process a polymer is added to cause flocculation. During and after the pumping process the dewatering takes place through the filter screens. The flocculated dry matter is effectively held back by special designed filter screens, allowing the permeate to drain into a collection chamber below.

All the manual controls, pumps and indicators etc. are located in the machine room to the front of the unit where an integrated sample point is situated. The purpose of the sample point is to allow the operator to monitor the flocculated sludge during the pumping process.

While the sludge is being pumped to the dewatering chamber the operator can return the cleansed water back to its source, this keeps the process time to a bare minimum, just one of the many practical functions which makes the KSA easy and efficient to operate.

Once full the KSA is discharged by means of a hydraulically operated door on the dewatering chamber. The unit is then raised to allow the dewatered cake to slide out.

...with extensive possibilities...

At sites where sludge's with a relatively high water content and where there is a need to refill or re-prime the emptied tanks with water e.g. septic tanks and garage forecourt interceptors, the KSA unit has a superior advantage compared with traditional systems. The fact that the sludge volume has been reduced by a factor 10, has resulted in the fact that we have customers from the French Alps to large European cities who are using the KSA to service their daily contracts, we even have KSA units mounted on barges in Venice! Originally the KSA was developed for the emptying of septic tanks. However after 30 years it has proven to be the best machine to service many contracts. Some examples are shown below.

Septic tanks

A KSA operator can empty between 25-35 septic tanks in an ordinary Danish working day without having to travel to a disposal point.

Service stations

The KSA is able to carry out a full garage forecourt service and is ideal for cleaning interceptors where there is a need to re-prime the interceptor chambers. It has no problems cleaning jet washes, chassis washes and safety curbs.

Grease traps

The KSA eats grease traps! However if you're worried about the smell being emitted by the vacuum exhaust we can kill that by fitting a UV filter.

Car washes and equipment wash downs

The KSA has been dewatering the contents of car washes and equipment wash downs with great effect since 1993!

WWTP

Over the years the KSA has played an important part in relieving the pressures on small waste water treatment plants and satellite works where traditionally the effluent was removed by tankers. The KSA also works very well on larger treatment plants when used in conjunction with the Simon Moos AVC system.

Canal cleaning

The KSA is a great tool in removing algae, silkweed and duckweed from choked canals, ponds and other waterways.

Gully emptying

The traditional way of emptying gullies is with a gully sucker. Once full the gully sucker decants its dirty water down the last gully to be cleaned allowing the contaminated water to eventually find its way into a water course, and depositing solids in the drainage system which will need additional cleaning at a later date. "Kind of defeats the object"!

The KSA, with or without a suction boom, is ideal for emptying gullies as it doesn't need to continually refill with clean water and it is able to discharge its surplus cleansed water safely.

...recycling of the dewatered sludge!

There are several routes for recycling and disposing of the dewatered cake from the KSA system.
Depending on the specific nature of the dewatered cake it can either be lime stabilized and used as fertilizer on agricultural land, composted or used in biogas plants. Difficult cakes can be used to accelerate the burning process at incineration plants or as a last resort be deposited at a landfill site.

In addition to the fact that we construct effective sludge dewatering systems, it is also one of our strengths at Simon Moos Manufacturing that we are able, through the contracting division of the company, to offer advice and technical support in the handling of sludge's from the knowledge and experience we've gained over many years.

WWTP/waste disposal site
The dewatered sludge can be delivered to the wastewater treatment plant or other reception points.

Biogas
Dewatered sludge's, especially from grease traps are very suitable for biogas units.

Combined power and heating stations
The energy contents in dewatered sludge can be used in public combined power and heating stations together with the incineration of other waste products.

Composting / lime stabilization
With a Moos lime / sludge mixing plant dewatered sludge is mixed with lime. The pH level is raised to 14 and you obtain the optimum temperature of approximately 80° C this gives an effective sanitation and delivers a log 6 reduction in pathogens.

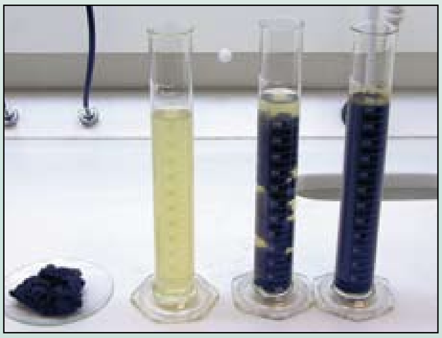
Agriculture
Dewatered sludge with/without composting is an attractive organic fertilizer, which lessens the need to use expensive chemical alternatives.

Forestry
If sludge is treated in a drying plant you are able to produce pellets that are suitable for spreading as fertilizer in forestry etc.

...a quality cleansed water

During the dewatering process the flocculated sludge captures any harmful particles and holds them within the dewatered cake. This means that the cleansed water is of a high quality and can be used for jetting and to re-prime septic tanks, interceptors and car washes etc. The KSA is unique in its performance as shown in the reduction table opposite.

Parameter	Reduction KSA
Suspended solids (SS)	95 %
COD	85 %
Total-phosphate (P)	60 %
Total-Nitrogen (Tot-N)	67 %



A complete solution...

When designing and developing the KSA system we have attached importance in the fact that the KSA unit should be easy to operate, to service and to maintain. Training and instruction, which is part of the delivery package, can take place at the customer's location which allows continuity in familiar surroundings servicing the customers own contracts.

It is easy learning to operate a KSA. We give you practical instruction in your own surroundings!

...with effective support!

If you need support we have an excellent backup service:

- Help yourself concept
  – Complete technical documentation and instruction books are produced with each build. Copies of which are delivered with
  the unit.

- Telephone support
  – We are always ready with telephone assistance and guidance.

- Spare parts
  – Our stores are fully stocked and able to deliver spares by the next working day.

- On-site service
  – Our engineers and technicians will come to your assistance if the situation requires. Alternatively you could call in at one of our local service departments.

Naturally we keep all common spare parts in stock and forward by express from day to day -worldwide.

You can always call us for support, questions etc.

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