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DECENTRALISED, MOBILE SEPARATION

Technology that can improve biogas production and reduce the environmental impact of pig farming

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Front-page	The power consumption is being checked at the display of the separator. Photo: Henning Lyngsø Foged.				
Back page	The biogas plant on Bornholm, Biokraft, to which the separation solids are delivered. Photo: Henning Lyngsø Foged.				
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Challenges regarding sustainable production of pig meat and biogas

>> Production of pig meat is inextricably linked with the production of manure, often slurry, which should be used in an environmentally safe manner for fertilisation of crops. However, this is complicated by an uneven content of nitrogen and phosphorus in proportion to the needs of the plants, and the content of organically bound nitrogen with a low bio-availability. The value as fertiliser is increased through anaerobic digestion, but the slurry consists of approximately 95 % water, wherefore it is expensive to transport to a regional biogas plant, and it also needs to be mixed with other organic substrates with a higher percentage of dry matter to form the basis of a cost-effective biogas production. This pamphlet informs about decentralised, mobile slurry separation, a technology that meets the abovementioned challenges.

According to the EU directive on industrial emissions, a pig holding in an EU country with e.g. more than 750 sows must acquire an environmental approval. The amount of slurry from 750 sows corresponds to an annual production of around 7,000 tons, containing approximately 25,000 kg of nitrogen and 6,600 kg of phosphorus – thus, there are around 3.8 times as much nitrogen as phosphorus in the slurry. According EU's nitrates directive, the slurry must at maximum be spread with 170 kg N per ha, corresponding to at least 147 ha for a farm with 750 sows, but in Denmark the rules have been tightened further meaning that the slurry in this example should be spread on at least 179 ha with a maximum of 140 kg N per ha.



THERE ARE NO OFFICIAL STATISTICS, BUT IT IS ESTIMATED THAT AROUND 80 % OF THE DANISH MANURE PRODUCTION IS SLURRY.

If the farmer spreads non-separated slurry on 147 or 179 ha, the fields get an average of 45 kg or 37 kg of phosphorus per ha respectively, and that is much

more than the needed 20-25 kg per ha, which is what typical crop rotations with cereal and rapeseed on a pig farm needs.

However, if the farmer separates the slurry, approximately 80 % of the phosphorus and 20 % of the nitrogen is to be found in the separation solids (however, with great variation depending on the separation technology used). If this is sent to a biogas plant and thereafter to specialised crop farms, it can be avoided to over fertilise with phosphorus, which otherwise would end up in the nature causing eutrophication in the water environment.

Another advantage for the pig producer is that the separation liquids, the reject water, is significantly better to fertilise the crops with; almost all of the nitrogen is in on ammonium form, i.e. easy for the plants to absorb, and the thin texture means that it seeps into the soil faster, which again means a limited evaporation of ammonia plus limited odour in connection to the spreading.

The biogas plant cannot make any use of the water – often the challenge is to increase the percentage of dry matter to 10-12 % in the biomass fed to the digestion tank and it is the volatile solids, which provide nourishment to the methane producing bacteria.

Screw pressing and other technologies for mobile separation

>> The purpose of slurry separation is to divide particles of dry litter and undigested feed from the liquid. There are various types of technologies for this, and in principle they could all become mobile and moved from farm to farm. Screw pressing is one of the most widespread technologies for slurry separation.

Slurry separation in general

Slurry is by separation divided in separation solids and separation liquids.

Most often the separation solids will make up 5-10 % of the weight of the raw slurry, depending on the separation technology and type of slurry. The higher percentage of dry matter is in the slurry, the higher is the share of separation solids. The share of separation solids from digestate is relatively low.

When the separation solids are to be used for biogas production, one would

want as large an amount of dry matter as possible since the majority of the dry matter in the slurry is organic and thus nourishes the methane

producing bacteria. In that regard, centrifuge separation is the most effective method. As a rule of thumb, it can be



most effective MANURE IS DIVIDED BY SEPARATING BIOSOLIDS AND REJECT method. As a rule WATER OP. FROM MAIBRITT HJORTH, ASS. PROFESSOR, of thumb, it can be UNIVERSITY OF AARHUS.

expected that 80 % of the phosphorus and 20 % of the nitrogen follows the solid part, with great variation however. By comparing seven different manure separation technologies, the University of Vechta discovered a variation in the amount of nitrogen from around 7 to around 34% in the separation solids fraction, and a corresponding variation in the share of phosphorus from around 46% to around 74%.

The part of the nitrogen that follows the separation solids is mainly organically bound nitrogen, i.e. the part that requires further conversion before it becomes available for the crops.



SEPARATION SOLIDS FROM CENTRIFUGE SEPARATION OF DIGESTATE.

Various separation technologies can be combined in order to increase the efficiency. For example, it is possible to separate a larger share of the particles by flotation of the reject water. Furthermore, the separation efficiency depends on the separation speed.

In the countries surrounding the Baltic Sea, separation is almost only used in I Finland, Germany and Denmark.

A short presentation of separation technologies is made in the following.

Screw press

The screw press separator is constructed like a tube with a snail inside, which mechanically forces the manure upwards through a cylindrical strainer where most of the liquids are pressed through while the largest particles are held back.

Screw press separation is one of the most common technologies for slurry separation, since it is relatively simple and cheap to acquire and use. On the other hand, the separation efficiency is relatively low compared to centrifuge separation.

Centrifuge separation

Centrifuge separation of slurry is based on the different density of the separation solids (suspended particles) and the liquid phase. The separation device is constructed with a vertical or horizontal cylinder where the slurry continuously is twirled around at high speed.



CENTRIFUGE SEPARATOR

Centrifugal separation is considered one of the most efficient methods to separate the nutrients in the manure.



PRINCIPLE SKETCH OF A SCREW PRESS. AFTER MAIBRITT HJORTH, ASS. PROFESSOR, UNIVERSITY OF AARHUS.

Separation by grid

It is possible to use a grid to discard larger particles when separating manure.

This method can also be built into the design of the stables in order to transport the manure out of the stables in a liquid and a solid part. The method is also



GRID IN A COWSHED, WHERE THE SCRAPER PASSES TO SEPARATE THE LIQUID PART FROM THE SOLID. PHOTO FROM <u>HTTP://LIM.DK/</u>.

referred to as source separation.

Separation by filter press

The separation takes place at a porous belt running between two barrels, where the barrels force the liquids through the belt while the solids are scraped off the belt.



FILTER PRESS.

Separation by sieves

When separating by sieves, the slurry is led over a sieve that retains the particles in the manure and lets the liquid pass. Often curved sieve screens, like the one in the picture, are used, where the manure is poured into the top and where the solids slide downwards due to gravity and is led away with a snail or a conveyer belt. Sieves can also vibrate, or be shaped like a conveyer belt.



SEPARATION BY CURVED SIEVE SCREENS. FROM WWW.BDISCREENS.COM.

Separation by drum filters

Drum filters are special types of sieves shaped like a rotating, vertical cylinder with a minor incline. The manure is poured into the highest situated part of the cylinder formed drum sieve, the reject water is gathered in the bottom part, and the separation solids at the lower part of the rotating cylinder.

Separation by natural sedimentation

In natural sedimentation, the fact that the particles and the liquid in the manure have different densities is being used, and it requires large containers with no or low circulation. The containers with low circulation are shaped in a cylindrical form and with a conic bottom where the most solids dense fraction is gathered.

Coagulation - Flocculation

This separation method consists of addition of a chemical agent (coagulant or flocculant), and is not an independent method as such, but a method to increase the efficiency of the succeeding separation by mechanical separation methods, since the chemical agents make the particles in the manure gather in larger particles.

Electrocoagulation

Electrocoagulation consists of an electrolytic cell with an anode and a cathode. During the electrocoagulation the positive ions (Fe3+, Al3+), which are necessary for the coagulation, are released. Like the coagulation – flocculation method, this method is useful in order to increase the separation efficiency of succeeding mechanical separation methods.

Flotation

Flotation happens by injecting compressed air into the bottom of a flotation tank/reservoir with low flow of separation liquids. The released air forms small bubbles causing the particles to float to the surface from where the flotation sludge is removed by skimming the surface. This method is used to decrease the share of particles in the separation liquids from mechanical separation.

Mobile separation plants

Apart from natural sedimentation and flotation, which requires voluminous tanks, separation could in principle be mobile in order to make most use of the investment.

Pilot project on Bornholm

>> Six pig producers on Bornholm are facing more or less the same challenge; to maintain the balance between the nutrients in the manure from their pig production, and the nutrients their crops need. At the same time, the islands biogas plant, Biokraft, face the challenge that they would like to pass more biomass through the plant, which so far has is operating below its capacity. Biokraft would especially like to get more biomass, which could contribute to increase the percentage of dry matter in the substrate, and preferably types that are cheaper than alternatives like e.g. maize silage.

Skruepresserforeningen

In accordance with Danish tradition, six pig producers from Bornholm have formed a cooperative society in order to make use of the advantages of cooperation, in this case regarding slurry separation. Together, the six members of Skruepresserforeningen (In English: The screw press coop) produce a total of around 50,000 tons of slurry per year, and common for them is that they need to export nutrients out of their farms since not all the nutrients can be used as fertiliser in the fields.



VESTREGAARD - ONE OF THE FARMS THAT ARE MEMBERS OF SKRUEPRESSERFORENINGEN.

The cooperation entails the significant advantage that the expenses from operating the separation unit are shared by more, and that the plant probably can run more efficiently since the same person operates the plant on behalf of all the members.

Börger Bioselect screw press

After having gathered experience concerning other separation methods on Bornholm, it has been decided to invest in a Börger Bioselect plant, which is most suitable in the given situation. In principle, the plant is a screw press, but is innovative regarding a number of aspects regarding the construction of the separator and its control system:

- The plant can suck up fresh slurry directly from the manure canals in the stables – this avoids investments in a tank as well as a stirrer for homogenizing of the manure, which is normally a prerequisite for slurry separation. The Börger is capable of regulating the intake according to the texture of the manure, e.g. a lump of manure with a lot of straw makes the plant decrease the speed of the intake. This feature is important in situations like here, where the separation solids are meant for biogas production, since the biogas potential is reduced concurrently with the age of the manure at separation.
- The plant has a rather high capacity, i.e. up to 63 m3 an hour, where the capacity of many other screw presses is 10-15 m3 an hour.
- The separator can be controlled in order to keep the percentage of dry matter between 10 and 25 %.
- The plant is self-priming via a lobe pump, and is suitable for mobile use with "plug-and-play" connection of hoses and power.

THE BÖRGER BIOSELECT BC50 PLANT IS INSTALLED ON A TRIPLE AXEL TRAILER WITH AN INSULATED TARPAULIN.

THE SEPARATION SOLIDS ARE DELIVERED BY A CONVEYER BELT INTO ONE OF THE TWO CONTAINERS, AND IS SUBSEQUENTLY TRANSPORTED TO BIOKRAFT.

The plant rotates between the six members of Skruepresserforeningen every fortnight.

The investment

The investment has included

- A Börger Bioselect BC50 plant installed on a triple axel trailer with an insulated tarpaulin, including a package of spare parts for the most necessary wearing parts.
- 2 containers with a volume of 35 m3, and a tarpaulin, which is rolled over the container during transport.

Total investment: 107,000 €.

The participating members of Skruepresserforeningen have invested in power supply and other improvements of the site where the plant is placed during the separation process.

LOCATION OF THE SEVEN FARMS BELONGING TO THE SIX MEMEBERS OF SKRUEPRESSERFORENINGEN.

Monitoring, registration and analyses

>> In brief, the mobile Börger Bioselect BS50 lives up to the expectations. The plant was relatively cheap to acquire, and it is cheap to run, and besides from one case where the control system was down, it has been running satisfactorily. The largest expense and challenge is concerning the transport between farms. The separation liquids is of a quality, which in most cases is suitable for complete fertilisation, i.e. where both N and P in the fertiliser is in line with the needs of the crop, since the Börger plant does not separate as much phosphorus into the separation solids as a number of various other separation technologies.

Gathered information concerning the economy of the plant

- Power consumption: App. 0.3 kWh per m3 raw slurry incl. stirring.
- Labour: Work hours include:
 - App. one hour per separation is spent on mounting, start-up, wash down, and packing up.
 - Supervision per separation is $\frac{1}{2}$ 2 hours depending on the differences in the percentage of dry matter in the manure.
 - Moving takes around ½ 3 hours depending on the distance and mode of converyance (car or tractor).
- Repair work / stoppage: During the five months the plant has been running, following has occurred:
 - Barrel motor on the separation solids belt (covered by the warranty of the plant)
 - Problems with the frequency control twice, which has meant an extra time consumption of 20 hours for the members of Skruepresserforeningen.
 - So far no spare parts have been changed and there are no signs as such that it should be necessary in the near future.
- Significant challenges
 - Operating the separator at its highest capacity requires low differences in the content of dry matter in the raw slurry.
 - Logistics is a challenge, and especially in connection to the two incidents with the frequency control that gave delays.

- Settlement price on the separation solids: Due to the high gas output of the separation solids it is free to deliver the separation solids as long as the raw manure is not older than 14 days when separated, and the separation solids consists of a minimum of 18 % dry matter. If the manure is 15-30 days by the time of the separation it costs DKK 45 per tons for delivery to Biokraft, and at 31-45 days it costs DKK 60 per tons.
- The delivery costs of separation solids vary a lot from farm to farm some cannot fill a container if the delivery is every 14 days – likewise, the distance influences the price – transport price / tons of separation solids is DKK 40-70.

Qualities and quantities

In the period from putting the plant into operation in mid June till the end of October 2012, i.e. in 4½ months, the plant has separated 19,070 m3 of slurry.

In the following are presented some analysis results for raw manure, separation solids, and separation liquids from two of the farms:

FARM 1, SLAUGHTER PIGS.

	Raw manure	Separation liquids	Separation solids
Total N, kg N/t	5.48	4.88	5,82
NH4 + N, kg N/t	3.60	3.34	3,13
Phosphorus, kg P/t	1.3	1.0	2,1
Potassium, Kg K/t	3.1	2.7	2.5
Dry matter, pct	6.68	4.31	23.46

For farm 1, just over 9 tons of separation solids have been produced for every 100 tons of raw slurry, and around 11 % of the nitrogen and 24 % of the phosphorus is removed with the separation solids.

FARM 2, SOW AND PIGLETS.

	Raw manure	Separation liquids	Separation solids
Total N, kg N/t	4.27	4.13	6.11
NH4 + N, kg N/t	3.00	3.05	2.56
Phosphorus, kg P/t	1.1	1.00	3.3
Potassium, Kg K/t	2.0	2.00	1.9
Dry matter, pct	4.65	3.24	20.76

For farm 2, slightly less than 10 tons of separation solids have been produced for every 100 tons of raw slurry, and around 13 % of the nitrogen and 28 % of the phosphorus is removed with the separation solids.

Thus, the separator removes enough nitrogen in order to meet the Danish requirement on 120 kg N/DE.

Optimal separation method to enable full fertilisation?

When viewing the results of the separation with the Börger Bioselect plant, the immediate impression is that the separation efficiency is low.

However, this is considered a great advantage by the members of Skruepresserforeningen, compared to other separation technologies they have tested. The low separation efficiency makes it possible to use the separation liquids for full fertilisation of their fields, i.e. to base fertilisation of their crops alone on separation liquids. Other technologies separate much more phosphorus into the separation solids fraction, and therefore place the farmers in a situation where they would have to purchase phosphorus in mineral fertilisers.

The following table shows the supply of nutrients to fields fertilised with 25 tons of separation liquids per ha from the two farms:

SUPPLY OF NUTRIENTS TO FIELDS FERTILISED WITH 25 TONS OF SEPARATION LIQUIDS PER HA FROM THE TWO FARMS, ALL NUMBERS IN KG PER HA.

	Total N	NH4+ N	Р
Farm 1	122	84	25
Farm 2	103	76	25

As a rule 25 tons of separation liquids would provide full fertilisation in many situations, and provide N and P in balance with the needs of the crops.

Further information

>> Literature, homepages etc., where further information on mobile manure separation is to be found.

- AgroTechnologyATLAS <u>http://agro-technology-atlas.eu/</u>.
- Baltic Compass http://www.balticcompass.org.
- Entschärfung der Nährstoffüberschüsse durch Kaskadennutzung von Gülle und Gärresten? "Workshop Gülleseparation" der Bioenergie-Region Südoldenburg mit internationaler Beteiligung. <u>http://www.bioenergie-suedoldenburg.de/projekte-in-der-region/guelleseparation/workshop.html</u>.
- Sector Study concerning prioritised innovative agro-environmental technologies for sustainable food production in the Baltic Sea Region <u>http://agro-technology-atlas.eu/docs/repo20905 Baltic Compass Sector Study.pdf</u>.
- "Win-win technologies for nutrient management" en mobile partial virtual exhibition with video clips and PowerPoints <u>http://agro-technology-atlas.eu/win_win_technologies_for_nutrient_management.aspx</u>.

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