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THE BIOGAS PLANT IN KALMAR – POSSIBILITIES AND EXPERIENCES

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Abstract

The use of biological anaerobic treatment for industrial organic waste to close nutrient circulation in society. The organic waste has an clearly potential for reducing use of the earth's resources and will be of essential importance for human living and foodproduktion in an near future.

The paper will give an example of one way to reuse of nutrients back to the farmland, and how earlier Agenda 21 work leads to a better society.

Keywords

Anaerobic treatment, organic waste, nutrient circulation, biogas production, car fuel, upgrading.

History

In the beginning of 1990 Kalmar municipal formed an biogasgroup. The group consisted of representatives from farming, local board of nature, Kalmar university and the local slaughterhouse. Furthermore there were representatives from the municipal, such as Kalmar Energy, solid waste dep. etc. etc.. External help was used from JTI (Agriculture institute) . The group produced, after hard work, an report of all investigations that had been carried out. The summary of the report was that an biogasplant should be located at Moskogen (the main waste disposal), and that the gas should be used as a car fuel. The calculated cost for such a plant wear estimated to 50 mil SEK, and that was to much for anyone of the parties. All these reasons lead to that the plans for the plant was put into hold.
It should be noticed, that from the beginning there was plans for building the new plant in connection with the Kalmar main sewage treatment plant.
During 1996, a large reconstruction started for nitrogen removal at the main sewage plant. At the same time we took a decision to build an facility for external sludge. The facility should also be able to handle other organic wastes for processing in the digester. Before we started building the plant for external sludge and organic wastes, we had a discussion with the local slaughterhouse about there problems with organic waste. At that discussion they told us that they had in total 7000 tons of organic waste. Ofcourse this amount of

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waste made us think of other solutions to treat the waste and the idea of an biogasplant arise again and we decided to make further investigations.

Introduction

The main sewage plant in Kalmar was designed for 130 000 Pe (personal equivalents). The designing was carried out during the happy 70.ies, when everybody calculated with continuos expansion of the society and population. In Kalmar this led to that the main sewage plant were designed for a very high capacity compered with the actual case of incoming load. The only part of the plant that didn't had overcapacity was sludgethickening, but during construction for nitrogen removal, we decided to double the thickening capacity. Due to the doubling of thickening capacity, we were able to double the DS content into the digesters from 2,5 to 5% DS. The larger thickening capacity led to that hydraulic load on the digesters went down from 70 000 m3 to 40 000 m3 per year.
The average intake of sewage is very even spread over the year, due to the fact that most of the industry in Kalmar is food industry. All these facts together made it possible for us to look at the possibilities to increase the intake of organic waste to the digesters. We saw that it was possible to maintain treatment of municipal sludge in only one digester.

In 1996 an projektgroup were formed to investigate the possibilities to increase intake of external organic substances, mainly from the local slaughterhouse (SCAN/KLS), and also from farmers located close to the plant.. Two main facts had to be fulfilled:
1. All residues from the digesters should be able to spread on farmland (closing nutrient circulation in society)
2. All organic substances that comes into the plant, should be approved by the farmers.

The residue from the plant, named "Biomanure" will be certified and have a declaration of content. The declaration will consist of nutrient content, metallcontent and declaration of microbiology (bacteria's). This is done of the reason that the farmers can be able to plan there production on a long term basis. We also guarantees the farmers that there will be no mix between the municipal sludge and the biomanure.

Goals were also set for the municipal sludge. It should be well defined and balanced, with certificate of content. This is carried out by each month's production is isolated in the storage, with its own certificate of content. The certificate tells the farmers metallcontent, metals and nutrients. This has made it possible for us to spread about 80% of the sludge on farmland, the rest is put in the solid waste deposit.

Investigation

The projectgroup, finally consisting of Hans Dahl, Håkan Eriksson, Håkan Andersson and Thomas Ottosson from Kalmar Water company. External persons in the group were Lars Brolin and Anna Lindberg from VBB-Viak in Stockholm. The group started with examination of the amount of organic matters that was possible to treat in the surroundings of Kalmar. The group decided that maximum range should be 20 km from plant to farm or industry. We started a program for analysis in order to find out exact what amounts we had and what the content of different specified parameters were in the organic matters. The parameters we investigated was pH, DS, ash content, Tot P, Tot N, NH4-N, Calcium,

proteins, fat, carbonhydrate and lignocellulosa. All tests was carried out as a double tests. Analyses was also carried out on the sludge that was to be treated in the municipal digester. All analyses was put together sent to Irini Angelidaki at Copenhagen University in order to perform an computersimulation of the digesters. This simulation was carried out in order to find the limitations we had in volumes. The volume in the digesters were the existing 1800 m3 in each digester. Irini found out that, by changing from mesophobic to thermophobic process (37-55 C), we could maintain a very stable process in the municipal digester and also treat more organic matters in the "biodigester".
The simulation that we did for the biogasdigester showed us that we were able to treat about 44 000 tons of organic matters/year, in the proportions of 20 000 ton manure from cows, 17 000 ton manure from pigs and 7 000 ton from the slaughterhouse inkl. blood.

The amount of gas that we can produce is 2 000 000 m3/year incl. Municipal. In order get a healthy economical balance in the plant, we have to process the gas into a carfuel. In that way we can sell the gas equivalent to petrol price. In long terms , the cost of the plant has to be covered by the price of processing the organic residues from the industry and even private households.

With all the above parameters ratified, the group started to look at the construction and building of the plant. We started by getting knowledge from other plants under construction in Sweden. We also travelled around in Denmark, were there is several plants for treatment of organic matters, mainly manure, but even some industry. The groups opinion was that the knowledge about treating organic matters is bigger in Denmark than in Sweden, due to there problems with a highly developed animalproduction. We also noticed that there knowledge in processing biogas was less than in Sweden. The plants we visited in Denmark were builded as simple as possible, and in Sweden they were more technical sophisticated and also more problems. The groups meaning was that we had to find something in the middle of this two ways of constructing plants in order to keep the building costs down.

The main problems in all plants that we looked at, was heat exchanging and solid waste grinding. We understood that we had to put a lot of effort in constructing these parts of the plant.

Construction Procedure

Kalmar Water took the decision to build the biogasplant. In order to not end up in conflicts with the entrepreneur, it was decided that the plant should be built on an open term contract, were the entrepreneur should have the full responsibility for the plants performance. Kalmar Water together with the entrepreneur should be involved in buying all materials and machinery on the open market in order to get the best price possible.
VBB-Viak in Stockholm got the contract to make the basic constructions and drawings
There were also taken into consideration, possibilities to processing organic waste from private households. In the future it will prohibited to deposit organic waste on the solid waste deposit (2005). There had to place for a third digester in the future. All machinery had to be designed for that kind of waste.

The construction had to be highly automatic, and the need for manpower should be as low as possible. The plant should be operated by ordinary staff of the waste water plant. All equipment should be chosen to correspond with waste water plant, both electrically and mechanically, in order to keep the need of spareparts as low as possible. This will also hold down the need for education.
All important equipment had to be redundant and not causing any unnecessarily stops in production. The redundancy should be automatically, to prevent the necessity of manual work at evenings and weekends.

The municipal part of the plant is very conventional and didn't need much reconstruction. There was need of an sludge/sludge heatexchanger and additional flowmeters on both gas and sludge.

In the gasside of the process it was only needs an extra flowmeter and condesatebottle. The gas will be led to the existing gasstorage tank, constructed as a floating clock. From the gasstorage the gas is led to the different users. In Kalmar we use the gas for internal heating, steamproduction at the local hospital and for processing of carfuel.

Process Description

The overall waste handling is divided into five different parts: collection, hygienisation, digestion, waste treatment and finally gas treatment.

The solid waste and solid manure will be collected in a building including a collection pocket, where the supplied waste automatically is measured. The liquid waste is also received in this building and the supply measured. The solid waste will pass a metal detector before being macerated in to pieces of maximum 10 mm particle size. After the macerating, it is transported into a mixing tank were it is mixed with the liquid waste, e.g. blood and liquid manure. The mixing tank is also a buffer tank for the process and is totally mixed. From the mixing tank all the substrate is transported to the hygienisation part.

The hygienisation part consists of three tanks, each 12 m^3, used as a continuous process. The substrate is having a detention time in the hygienisation for approximately 1 hour at a temperature of 70 °C. The plant equipped with several heat exchangers for recovering the energy.

The hygienisated substrate is pumped into the digester, where the detention time is approximately 18 days. The residue from the digester is pumped into a storage tank of 500 m^3, and is a high quality fertiliser, which can be used directly by the local farmers.

At present, the existing digesters are producing some 1.000.000 m^3 biogas per year, which is corresponding to an energy amount of 6,5 Gwh or some 650 m^3 of diesel fuel per year. The total amount of biogas produced at the plant, after changing to thermophilic digestion, will be approximately. 2.000.000 m^3 per year, i.e. an increase of the production of 140 %, compared to the present operation, or in total some 1.65 Gwh per year,.

In order to get an economically sound business in the operation, the value of the gas must be sufficiently high. That will be achieved by the refining of the gas into a substitute for petrol, by a gas cleaning facility. The equipment will clean the gas to 97 % of methane and compress it to 250 bar. The technology for using biogas is nearly the same as for natural gas. The gas can be used by buses or cars.

Present Situation

The biogasplant has been fully operational since June -98, on floating products such as floating manure and blood. In march -99 we started to processing solid organic waste. Most of the solids comes from the local slaughterhouse (KLS), but we also receive materials from a chickenfaktory located at Öland, approximately 35 km from the plant. Today we are receiving app. 10 tons of solids per day, 85 ton manure and 5 tons of blood. The hydraulic load in the digester is 36 000 m3 per year. The product that we deliver to the farmers has a very good quality. After one years growing season the farmers are very satisfied, and says that they have increased the production per acre.

During the start of the plant we had several problems, and we have made quite a lot of changes in the process. One big problem was that we constructed the plant with to low speed inside the pipework. It has to be constructed for a minimum speed of 1 m/s, preferably 1,5 m/s. The materials that we have to transport inside the pipes is very heavy, and when it is heated it is very difficult to keep the material in solution, The heavy stuff wants to sediment inside the pipes as soon as the speed goes down. This has caused a lot of stops, and that means that we have had to increase the labour with one man.

Initially we allso have had problems with gasproduction of carfuel. The carfuel is specified to keep 97% of methane and a dewpoint of -30 C. This problems is now sorted out, we hope. The gascleaning also needs more service than we estimated from the beginning. The service intervals is 1000 hours. When we will build next step on gascleaning we are going to demand for at least 10000 hours between service.
Today we don't have any problems with the gasproduction. There are approximately 20 sevicecars running on biogas in Kalmar, and there are one wastetruck running on gas (soon two).
We have problems to have cars delivered. It is the carcompanies that haven't been able to deliver cars. One part of the problem has been the Swedish authorities that haven't been able to establish regulations for the cars. For the moment there are regulations coming up from EU, that will be the same in all countries. Hopefully that will solve the problems for the carcompanies.

Economical Evaluation

The total investment cost for the plant is 35,0 MSEK. The split up of the investment is as follows:

food industry waste treatment	30	MSEK,
gas treatment	5	MSEK

Conclusion

The positive and long time experience in anaerobic sludge treatment has successfully been transferred into anaerobic treatment of waste waters with high content of organic matter.

For organic waste, the future seem to be similarly bright, though long-time experience still is lacking. The cases shown for waste water and organic waste above stresses the importance of an overall view and long-term perspective. The anaerobic treatment of organic waste will give an economic alternative for re-use instead of disposal, which will be politically impossible in the future.

REFERENCES

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University of Copenhagen 1996.

Appendix

1. Technical Data.
2. Analysis 1999

Appendix 2

Technical Data Kalmar Biogasplant

Solid waste capacity:	8 Tons/hour
Floating products:	8 m3/hour
Processing capacity:	50 000 Tons/year
Gasproduction:	1 200 000 m3/year
Carfuel production:	60 Nm3/hour
Gasstorage:	2200 Nm3, 250 bar
Mixing Tank:	500 m3
Production Tank:	500 m3
Digester:	1800 m3
Gasstorage:	500 m3
Boiler capacity:	1.1 MWh

Kalmar 1999-09-30
Halina Rybczynski

KALMAR BIOGASPLANT.

Reduction of contagius bakterias in the plant.
What rules are there?
Controlled hygienisation during 1 hour at 70 degreesC
The treatment should be well documented, and microbiology tests should show absence of salmonella bacterias, and less then 100(FS)fekala streptokocker/g

Mikrobiology tests - 1999

Produkt	**Salmonella**	**Listeria**	**E-coli**	**FS**	**Klostridia**
Incoming products 1999					
Januari	No trace	No trace	190 000	9 000	81 000
Februari	No trace	No trace	53 000	12 000	11 000
March	No trace	No trace	12 000	11 000	<100
April	No trace	No trace	140 000	70 000	540 000
May	Mixing Tank emptied				
June	No trace	No trace	160 000	11 000	250 000
July	No trace	No trace	110 000	150 000	36 000
Aug	No trace	No trace	37 000	45 000	140 000
Products Out 1999					
Januari	No trace	No trace	<10	<10	4 500
Februari	No trace	No trace	<10	<10	1 100
Mars	No trace	No trace	<10	<10	<100
April	No trace	No trace	<10	<100	10 000
Maj	No trace	No trace	<10	<10	7 400
Juni	No trace	No trace	<100	<100	<100
Juli	No trace	No trace	<10	<100	3 500
Aug	No trace	No trace	<10	<10	1 400

* Fekala streptokocker and klostridier can grow after they have left the animal itestine.
Klostridias are better survivers. They are earthbakterias.

Comments.
The processed producthas a good hygienic standard for spreadding on famland.
Another advantage is that restproducts are "smellfree" related to normal floating menure.
The product is allso very good to spread whith new technics for farmland nutrients.

Nutrients, kg/m3

As a referens "normal" values for manure from pigs and cows are shown in table

Product	**Tot N**	**Ammonia**	**Tot Phosfor**	**Calium**	**DS %**
Cows (schablon)	3,5	2,0	0,6	4,0	
Pigs (schablon)	3,5	2,5	1,6	1,6	
Average	3,5	2,25	1,1	2,8	

Product IN						
1999	**COD/N**					
January	15,7	3,7	2,5	0,79	2,6	6,6
february	16,8	3,5	2,3	0,58		5,8
March	20,6	3,3	2,2	0,55		5,5
April	18,6	3,9	2,4	0,82		6,8
May	18,3	3,4	1,8	0,58	2,8	6,1
June	16,5	3,3	1,8	0,49	2,0	5,3
July	20,2	3,3	2,0	0,58		5,6

Product Out						
1999	**COD/N**					
January	15,1	3,1	2,3	0,65	2,5	3,4
February	16,4	3,3	2,4	0,88		5,2
March	22,7	3,2	2,5	0,65		5,4
April	18,9	3,7	2,3	0,88		5,5
May	16,3	3,6	2,0	0,61	2,9	5,8
June	16,5	3,0	1,9	0,46	2,5	4,1
July	12,6	3,9	2,7	0,41		3,6

Comments

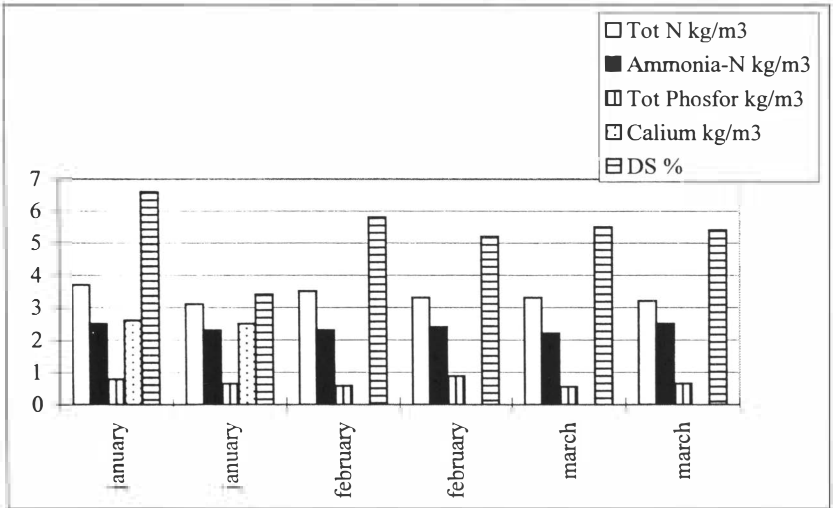
Incomming menure upholds the "normal value" on Calium and Nitrogen
Phosfor content is mutch lower than "normal". Why ?

Metalls, g/m3

	Product IN			Product Out		
Parameter	jan-99	apr-99		jan-99	apr-99	
Zink	19	13,6		18	14,3	
Copper	7,2	5,0		6,5	4,5	
Chrom	0,24	0,27		0,16	0,26	
Nickel	0,16	0,26		0,19	0,21	
Lead	0,07	0,14		0,05	0,09	
Cadmium	0,014	0,012		0,012	0,014	
Mercury	0,002	0,002		0,001	0,002	
Calcium	1,06	1,43		0,88	1,05	
Magnesium	0,44	0,40		0,34	0,36	

Comments
Metallcontent is a little lower out from the plant, than incomming. As average the metallcontent should be considered as low. Compered whith sludge from the waste water plant, is the metallcontent 5-10 times lower, exept copper and zink. These values are about the same.

Substanses		In january	Out january	In february	Out february	In march	Out march
Tot N	kg/m3	3,7	3,1	3,5	3,3	3,3	3,2
Ammonia-N	kg/m3	2,5	2,3	2,3	2,4	2,2	2,5
Tot Phosfor	kg/m3	0,79	0,65	0,58	0,88	0,55	0,65
Calium	kg/m3	2,6	2,5				
DS	%	6,6	3,4	5,8	5,2	5,5	5,4



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