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Mobile Liquid Manure Treatment Systems

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Introduction

In the last years liquid manure became responsible for pollution of soil and ground water by nitrate and phosphate. Therefore four states of the Federal Republic of Germany passed liquid manure regulations in order to control manure spread on the soil. In many cases family farms are affected. The four states support the subjected farmers.

In the state of Schleswig-Holstein the Minister of the Environment supported the development and the construction of two mobile systems for liquid manure treatment. The Institute of Agricultural Engineering was responsible for scientific support.

Process descriptions

The technical process of the "Kieler Verfahren"

The Kieler Verfahren was developed by the UTW Ostenfeld, the AMT Hamburg and the Institute of Agricultural Engineering.

The process is demonstrated in figure 1 and its specification is demonstrated in figure 2. It is a physical - chemical - physical slurry purification system. Following the thick arrows first liquid manure is pumped into a sedimentation facility. It is a decanter centrifuge, that separates the liquid manure into a solid and into a liquid phase, the so called centrate. In the solid phase there are all particulate matter with a higher or smaller density than water or with a size greater then 0.05 mm.

The smaller particles remain in the liquid phase. This is pumped into the flocculation/precipitation facility. The process consists of one dynamic and one static mixer. First the centrate is mixed in the dynamic mixer with a flocculant generally

Table 3 the conection between purification degree and pollutant output in the treated liquid manure

	Input	purification degree	output	total purification degree
1. step	100 %	90 %	10 %	90.0 %
2.step	10 %	90 %	1 %	99.0 %
3.step	1 %	90 %	0.1 %	99.9 %

Table 4 quality standards and obtained results of the slury treatment plant from Sulzer Wasser u. Abwassertechnik

Parameter	Input (mg/l)	Output (mg/l)	Quality standard (mg/l)
COD	60,000	400	100
BOD	24,000	15	30
NH - N	5,800	20	10
Total - P	1,800	1	2

WEILAND and HARMSSEN (1992)

Table 5 investments and estimated specific costs per treated cubic meter slurry

Producer (system)	Investment (DM)	Specific costs (DM/m³)
Jugendheim Johannisburg	9,928,000	165.00
Schwarting GmbH	13,159,000	33.00
SKET Schwermaschinenbau GmbH	10,230,000	51.00
Schwarting GmbH	8,151,800	35.00
Fleischfabrik Brögbern	9,740,000	122.00

BMFT (1993)

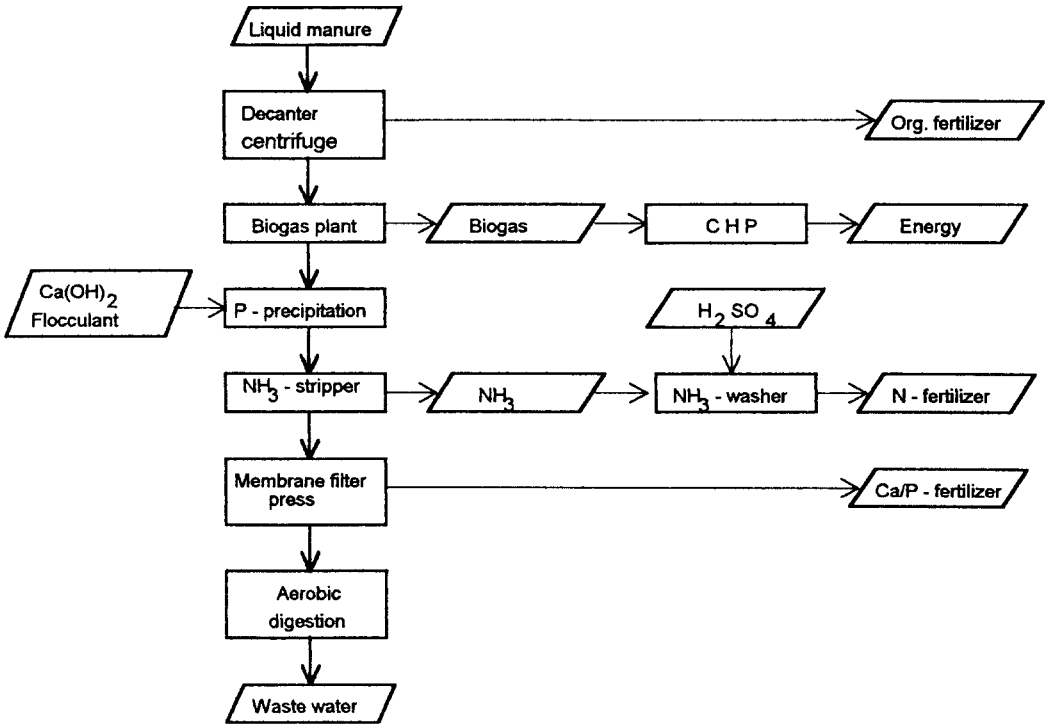

Fig. 1 complete purification system (Sulzer Wasser- und Abwassertechnik)

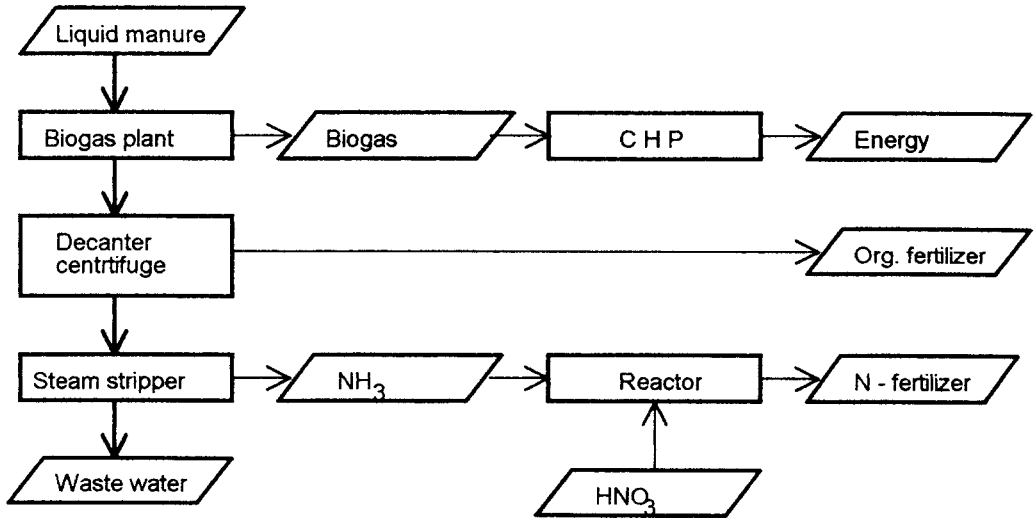

Fig. 2 part purification system (Schwarting GmbH)

Table 1 a review of the producers, the supporting institutions and the degree of purification of the liquid manure treatment systems

	Producer (system)	supporting institution	degree of purification
A	Jugendheim Johannisburg	BMFT	complete
B	Schwarting GmbH	BMFT	part (80% P, 80% N)
C	SKET Schwermaschinenbau GmbH	BMFT	complete
D	Schwarting GmbH	BMFT	part (80% P, 80% N)
E	Fleischfabrik Brögbern	BMFT	part (90% P, 90% N)
F	Sulzer Wasser- u. Abwassertechnik	MELF - LS	complete
G	Preussag/Noell Wassertechnik	MELF - LS	complete

Table 2 a review of the process steps

	Systems						
Process steps	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Separation (solid/liquid)	2	2	2	2	1	1	2
Filtration	3		8			4	
Evaporation					3		4
NH_3 - desorption		3	4	3		5	
Reversible osmosis	4						
Acidification (chem.)			1				3
Neutralization (chem.)							5
P - precipitation			6			3	
Anaerobic digestion	1	1	3	1	2	2	1
Aerobic digestion			7			6	6
Nitrification/denitrification			5				
Slurry throughput/a (1000 m^3)	15	100	50	58	20	10	10

with a three valent iron salt. Normally ironchloridsulfate ($FeClSO_4$) is used. Reactions occur between the iron salt and the colloidal matter in the liquid phase leading to the so called coagulation where micro flocks are built up.

The micro flocks in the centrate reach the static mixer where flocculation aid is dosed. The flocculation aid is an anionic polyelectrolyte supporting the building of macro flocks. They reach within the liquid the flotationreactor. It is built as a plug flow reactor. There they are separated from the liquid.

To support this separation a part of the treated slurry is air saturated by about 6000 hPa corresponding 6 bar. Released in the flotation reactor the air bubbles are formed on which the macro flocks are adsorbed. The buoyancy from the blow hole/solid particle complex is greater than the total sum of flow resistance and particle weight (figure 3). So the complex is floating to the surface. A suction device is cleaning the surface from the macro flocks. The liquid is now poor in dry matter content. The solid (macro flocks) is a mud with a dry matter content from 6 to more then 10 %. This is called flotat. It is recycled to the decanter centrifuge where it is further dewatered.

The solid matter is composted, dried, packed in sacks and sold as a natural fertilizer. The liquid looks like yellow waste water. It is spread on the soil like liquid manure.

The "ETH slurry treatment system"

The second system for liquids manure treatment supported by the minister of the Environment of the state of Schleswig-Holstein is a plant of the ETH company in Hamburg. ETH stands for disposal, transport and trade. The figure 4 demonstrates the technical procedure.

Liquid manure is mixed with industrial residues as for example perlite, flueashes from coal power stations and so on. Sometimes there is a need of additional calcium oxide (CaO) or plaster for better bounding. The mixture is pressed into pellets by a matrix press.

By the use of CaO or other industrial residues with a high CaO content the pH-value is increased, and as a consequence of this ammonia evaporates. Sulphuric acid in the NH_3 - washer absorbs the evaporated ammonia.

The products of this liquid manure treatment plant are pellets and an ammoniasulfate solution. If there are no unwanted components in the pellets you can spread the pellets into the fields. The pellets are poor in nutrients. The ammoniumsulfate is a liquid fertilizer.

Some investigations have demonstrated that a dry matter content of 50 to 70 % is necessary to yield durable pellets. If you have to achieve a dry matter content of the mixture of 50 %, the slurry and the industrial residues must be mixed in a 1:1

ratio. If they are mixed in a 1:2 ratio a 70 % dry matter content in the mixture is achieved.

If the moisture content is higher than 50 % the mixture begins to liquify and flows into the peletting device. The collers lubricate over the matrix and no more mixture is pressed into the matrix holes. Reactions occur between the CaO, the industrial residues and the water of the slurry. The mixture in the matrix holes is hardening off and obstructs the holes.

A dry matter content of 50 % was aimed. But often the mixture of the industrial residues and the other mineral additives separates in its components during the transport with the auger from the silo into the plant. So often the minimum moisture content of at least 50 % could not be kept stable. The system mainly failed because of this technical problem.

The effect of liquid manure treatment with the "Kieler Verfahren"

Many investigations have demonstrated that about 30 % (9 - 70 %) of the nitrogen in pig slurry and about 45 % (19 - 65 %) of the nitrogen in cattle slurry is part of the organic compounds "Vetter and Steffens 1986". These organic compounds are mainly in the solid substances. 90 % of the phosphate is adsorbed at the solid substance. So if liquid manure is separated into a liquid and into a solid phase, the organic nitrogen compounds and nearly all phosphate will be found in the solid phase. The figures 5 and 6 demonstrate the effect of liquid manure treatment with the Kieler Verfahren.

The solid phase of the cattle slurry (figure 5) has a dry matter content of about 20 %, that of the pig slurry has a dry matter content of about 25 %. 80 to 75 % is water with solved nutrients That is the reason why more than 50 % of the nitrogen of the pig slurry and more than 65 % of the nitrogen of the cattle slurry is separated with the solids. Due to the added flocculant the solids contain more than 80 % of the phosphate of the pig respectively cattle slurry.

The Economy of the "Kieler Verfahren"

The slurry throughput is up to 10 m^3/h. Flocculant is added in a dose of 0.1 to 1.0 kg Fe^{3+} and flocculant aid is added in a dose of 0.01 to 0.1 kg per m^3 slurry. The economical dates are summarised in table 1 and in table 2.

It demonstrates that liquid manure treatment with the Kieler Verfahren costs 10 to 20 DM/m³ dependent on the slurry throughput per year.

The sale of the composted and sacked solid phase as a natural fertilizer should pay for the process. Economical calculations had as a result that you need about 0.60 DM per kg Compost to make no deficit. This price is too high so that the system will fail without any support of the government.

Conclusion

Two mobile liquid manure treatment systems are presented. The ETH system is mixing slurry with industrial and with other solid and mineral residues. This system failed because of technical problems.

The second system called Kieler Verfahren demonstrates successfully that more than 50 % of the nitrogen and more than 80 % of the phosphate can be separated within the solid phase. But the costs are too high so that this system will fail without any financial support of the government.

References

Vetter, H. and Steffens, G. 1986. Wirtschaftseigene Düngung: umweltschonend - bodenpflegend - wirtschaftlich. Frankfurt (Main)

Table. 1 Economy of the "Kieler Verfahren"

Investment	**1,000000 DM**
Depreciation (10 a)	**100,000 DM**
Rate of interest (5 %)	**50,000 DM**
Personal (8 h/d)	**50,000 DM**
Personal (16 h/d)	**100,000 DM**
Fixed costs p. a.	**200,000 - 250,000 DM**
Cost of repair	**20,000 DM**
Spec. fuel consumption (1 l/m³ slurry)	**1.00 DM**
Transport of the products	**1.50 DM**
Other working - stocks (flocculant, flocculant aid etc.)	**1.50 DM**
Var. costs/m³ slurry (without costs of repair)	**4.00 DM**

Table 2 Specific costs of liquid manure treatment at different throughputs per year

Throughput (m³/a)	**20,000**	**30,000**	**40.000**
Costs (DM/m³)	**15.00**	**12.16**	**10.75**
Costs (DM/DE)*	**600.00**	**486.66**	**430.00**

* 20 m³ = 1 DE, degree of preparation = 50 %

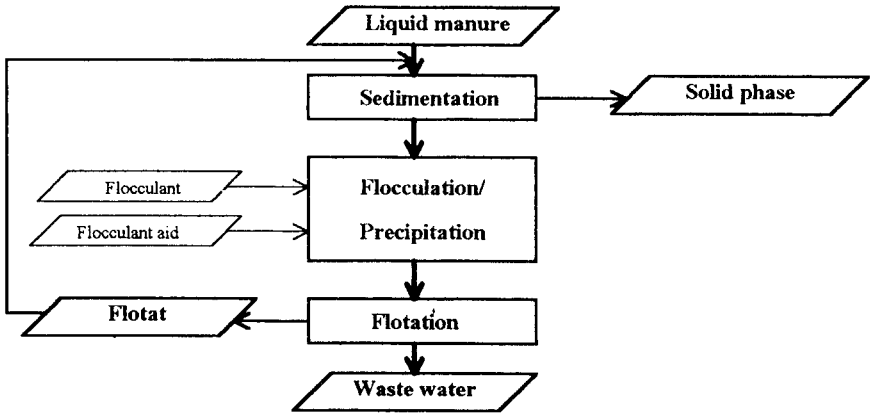

Fig. 1 The "Kieler Verfahren" (technical procedure)

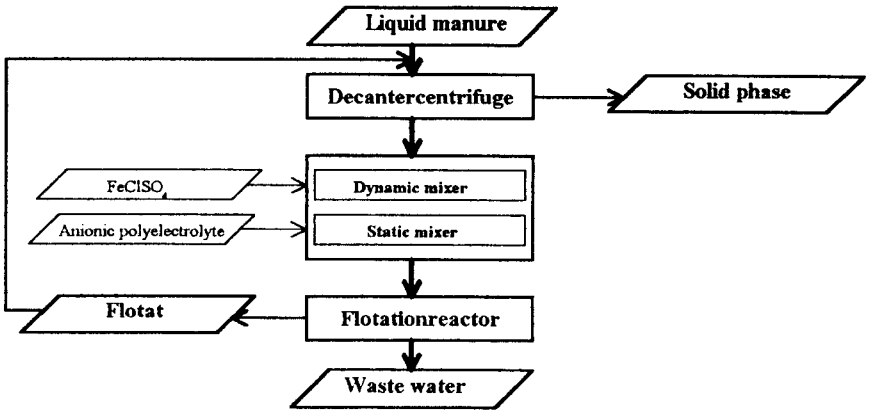

Fig. 2 The "Kieler Verfahren" (specification)

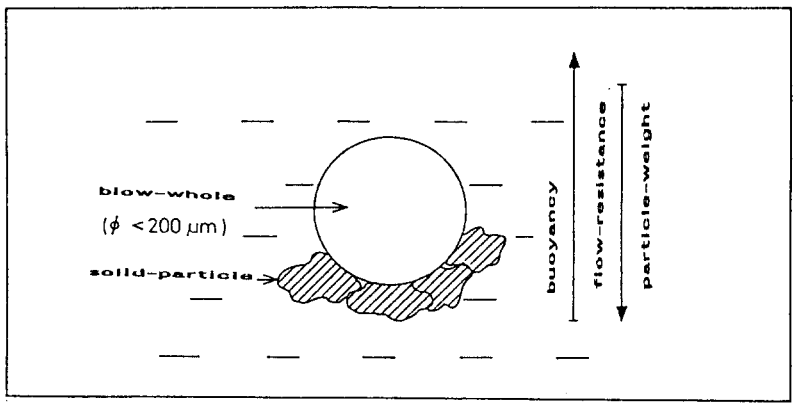

Fig. 3 Flotation of unsolved substance (with flocculants)

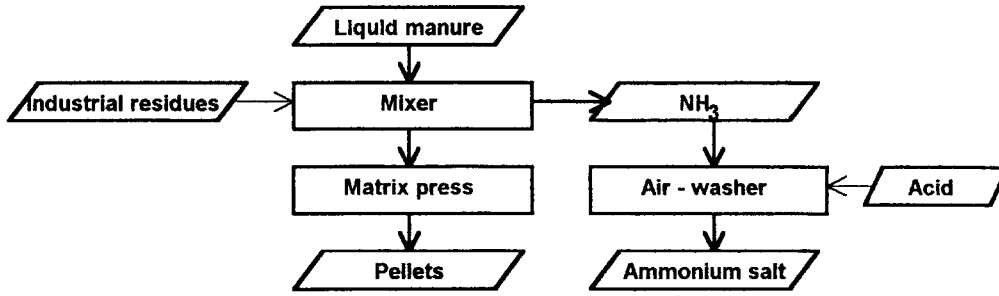

Fig. 4 The "ETH slurry treatment system"

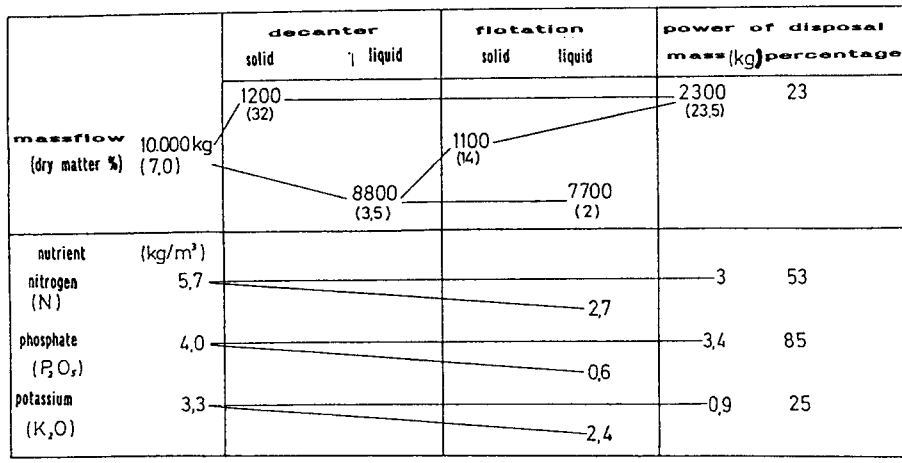

Fig. 5 Power of disposal (cattle slurry)

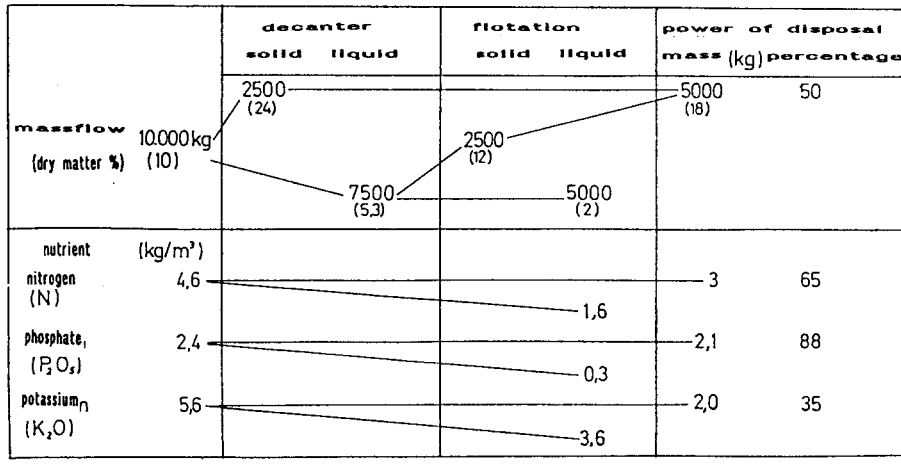

Fig. 6 Power of disposal (pig slurry)