Ricard Matzen, Kopenhagen

Separation of Liquid Pig Manure

Experiments using Flocculation and Ion Exchange

This paper reports the function and working results from a pilot plant in which liquid pig manure was flocculated with Geko-bentonite. The supernatant was irrigated on agricultural land throughout the year, in wintertime, only after ion exchange of ammonium with Agrolith. Earlier laboratory research showed that it is possible to purify the liquid to the concentration wanted, although higher purity costs more. The thicker slurry fraction was stored and treated as ordinary liquid manure. In order to maintain ability for pumping, the treatment was stopped at approximately 12% dry matter content and it represents a concentration of the liquid manure to approximately one-quarter or one-third of the original volume.

Prof. Dr. Ricard Matzen is scientific staff member at Department of Agricultural Sciences/Agricultural Engineering at The Royal Veterinary and Agricultural University Kopenhagen, Agrovej 10, DK 2630 Taastrup, e-mail:Ricard.Matzen@agsci.kvl.dk.
The Danish Agricultural and Veterinary Research Council and other founds financed this project.

Keywords

Liquid manure, volume reduction, flocculation, ion exchange

Danish farmers have to face large investments in slurry tanks after revision of environmental laws in 1992, which increased the requirements for storage capacity to nine months' production. The necessary tank capacity can be reduced considerably, if the liquid manure is separated into a thin fraction (nearly water), which may be irrigated directly onto the field, and a concentrated slurry fraction with less volume, which may be stored until spreading on the field, is appropriate.

Laboratory experiments [1] showed that it is possible to flocculate liquid pig manure with bentonite and that an almost clear liquid is obtained. This liquid is suitable for irrigating in summer, even onto sensitive crops. However in wintertime, due to increased pollution risks, it is necessary to clean the liquid additionally before irrigation and laboratory experiments showed that ion exchange is appropriate.

A pilot plant [2] was built and the liquid manure was flocculated with Geko-bentonite and ion exchange of ammonium was carried out with Agrolith.

Experimental arrangement and method

The separation starts in the liquid manure storage tank (1) in *Figure 1*, where the slurry is separated naturally into three fractions by gravity and time: a floating layer (2), liquid fraction (3) and sediment (4). The liquid fraction is taken out by means of a pump on a „suction float" (5) in order to ensure that the liquid is taken below the floating layer. This liquid passes a simple filter (6), where clods of faeces, remnants of fodder, etc. are removed. After passing the filter the liquid manure is treated at the plant in two steps (7 and 8). First the flocculent (9) is added by a mixer (10). In the laboratory experiments, the clay mineral Geko-bentonite was found to be appropriate. During this process, the organic matter is captured in the clay flocks and settles on the bottom. The treatment in vessel (7) separates the major part of the volatile solids, and the liquid phase is transferred to vessel (8), where the flocculating process is repeated. In that way, the two bentonite

treatments result in an almost total removal of organic matter. The slurry from the bottom of both vessels is led back to the storage tank.

After the two flocculation steps there is no more organic matter in the water fraction, which explains why the ammonium production resulting from the breakdown of the organic matter stops. But the ammonium and other dissolved inorganic salts remain nearly unreduced in the liquid. At the final stage, the ammonium is removed from the water fraction by cation exchange (11). For this purpose, the mineral Agrolith (a refined glauconite) was found to be appropriate.

Agrolith is too expensive to spread on the soil and therefore it is regenerated by calcium chloride (12). The product from the regeneration, ammonium chloride, can be used as fertiliser, e.g., for sugar beets.

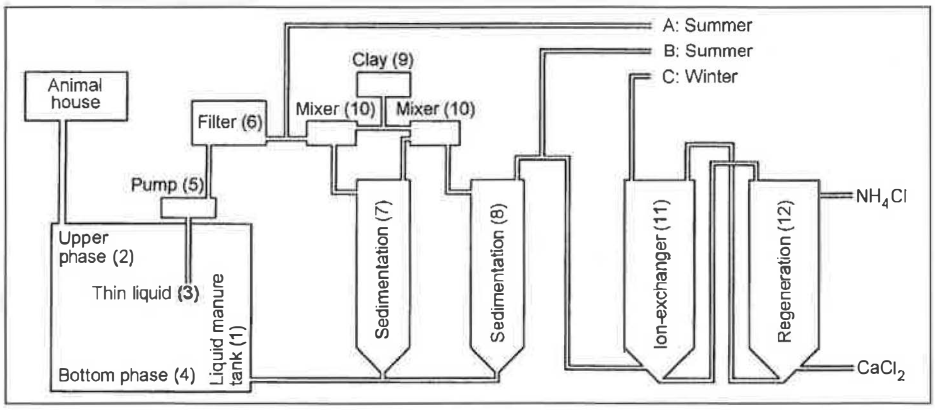


Fig. 1: Flow diagram for the pilot plant. Numbers refer to the text

Fraction	Dry matter %	Total N kg/m³	NH_4-N kg/m³
Manure from animal house	3.7 (3.5)	4.40 (4.5)	3.20 (2.8)
Liquid after filter (6)	1.43 (1.5)	3.20 (3.5)	2.70 (2.5)
Liquid after flocculation 1 (7)	1.03 (1,12)	2.94 (3.2)	2.60 (2.3)
Liquid after sedimentation 2 (8)	0.84 (0.94)	2.74 (3.0)	2.56 (2.3)
After cation exchange (11)	0.85 (0.96)	0.25 (0.05)	0.08 (0.03)

Table 1: Values measured in the pilot plant from treatment of liquid pig manure with 0.3% (= 2 x 0.15%) bentonite and Agrolith ion exchanger. The numbers after the fractions refer to Fig. 1. (Note: Numbers in parentheses are the corresponding values from laboratory experiment.)

The pilot plant

The plant was built for 200 sows and 5000 fattening pigs per year resulting in a liquid manure production of about 5500 m^3/a. A storage tank for liquid manure of 1060 m^3 was available at the farm.

For flocculation, two concrete tanks were built, 4.0 m high and 1.25 m in diameter, each with a volume of 4.9 m^3. Two other bins with the same dimensions were built as buffer tanks. In the plant a dose of 0.2% was used, and the flocks settle slowly with a velocity of about 1 cm/min.

For ion exchange, five plastic storage tanks, each holding 540 litres was installed in parallel. The ion exchanger remained in one tank (marked 11 in Fig. 1), while another tank was regenerated with calcium chloride (marked 12 in Fig. 1).

Experimental details

The pilot plant was in continuous operation one year and samples were taken two to three times per week. Samples were taken from untreated liquid manure, after the filter, after flocculation 1, flocculation 2 and after the ion exchanger. Samples were analysed for dry mater content, nitrogen (N-Kjeldahl) and ammonia.

Results from pilot plant

Table 1 shows the content of dry matter, total nitrogen and ammonium nitrogen in the liquid after the different processes. The experiments showed that it is possible to reach a dry matter content in the sediment of 12% or higher.

Strategy for application

Reliability is important, and even if the laboratory experiments showed that one treatment of 0.2% bentonite was sufficient in most cases, we have chosen, to be sure the flocculation is safe, the use of a two step flocculation process of 0.15% each.

In the summer growing season (May – July), the liquid manure may, without further treatment than the filtering, be irrigated directly on the field by means of an ordinary irrigation system. For sensitive crops the liquid has to be diluted with water. This procedure was tested on oscillating spray lines as well as mobile irrigation systems with sprinkler nozzle. No difficulties were observed.

In autumn (August – October) and the early growing season April, only the bentonite process is needed.

In the winter period (December – March) the slurry can be stored in the tank, or if capacity is limited, the full process of the two-stage bentonite, followed by the ion exchange is to be used.

The use of calcium as regenerating component is not optimal in connection with ion exchange, but, if seen from an environmental point of view, more correct than use of sodium or potassium. Control of the potassium part of the nutritive salts from the liquid manure is not unimportant when irrigating small areas during the winter season.

The slurry fraction, which is sediment and parts of the lower fraction, is returned to the main store tank for liquid manure. The slurry will settle on the bottom of the tank and form stable sediment. Before spreading, the tank is stirred in the usual way.

Conclusions

- Flocculation in 4.0 m high cylindrical tanks worked satisfactorily and even better than in the laboratory cylinders of 0.35 m height.
- The diameter must be designed to give a liquid manure velocity in the tank less than the flocculation sinking velocity.
- Using the two-stage flocculation system almost all organic matter will settle. Some problems of flocculation functional safety still exist.
- It is possible to reach a dry matter content of 12% or higher, but then the pumpability becomes difficult.
- The economics of building a flocculating plant will be influenced by several factors such as investment in storage tanks, handling equipment, transport distances, etc. The method is likely to be of interest to medium and large farms.

References

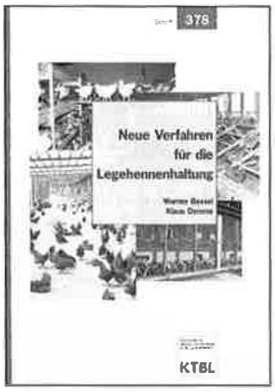
[1] *Henriksen, K.; L. Berthelsen* and *R. Matzen*: Separation of Liquid Pig Manure by Flocculation and Ion Exchange. Part 1: Laboratory Experiments. J. Agric. Engng. Res. (1998), Vol. 69, p. 127 – 131

[2] *Henriksen, K.; L. Berthelsen* and *R. Matzen*: Separation of Liquid Pig Manure by Flocculation and Ion Exchange. Part 2: Pilot-Scale System. J. Agric. Engng. Res. (1998), Vol. 69, p. 115 – 125

NEUE BÜCHER

Neue Verfahren für die Legehennenhaltung
KTBL-Schrift 378. Von W. Bessei und K. Damme. KTBL-Schriften-Vertrieb; 1998, 75 S., DIN A 4 broschiert, 26 DM, ISBN 3-7843-1983-1

Die konventionellen Verfahren der Käfighaltung von Legehennen in Batterien stehen seit geraumer Zeit in der öffentlichen Diskussion. Bei den Neu- und Weiterentwicklungen verschiedener alternativer Haltungsverfahren steht häufig eine spezielle Vermarktungsstrategie im Hintergrund. Weitere Verbreitung finden einige Volieren- und Bodenhaltungssysteme, die unter Namen wie „Natura-System", „Boleg 2", „Voletage" oder „Harmony 3" von verschiedenen Firmen angeboten werden.



Nach der Beschreibung der rechtlichen Rahmenbedingungen gibt die Veröffentlichung einen Überblick darüber, welche Haltungssysteme in welchem Umfang in Deutschland eine Rolle spielen. Daneben wird die Situation in einigen Mitgliedstaaten der EU und in den Nachbarländern geschildert.

Einen weiten Umfang nimmt die Beschreibung verschiedener Haltungssysteme ein unter Berücksichtigung der wichtigsten Komponenten wie Legenester, Nestböden, Eiabnahme, Fütterung, Tränken, Sitzstangen und Entmistung. Anschließend werden die unterschiedlichen Haltungssysteme hinsichtlich folgender Kriterien bewertet:

- Umweltaspekte unter besonderer Berücksichtigung von Geruchs- und Staubemissionen,
- Tierverhalten und -gesundheit,
- Produktqualität,
- Management, besonders im Hinblick auf Herdensteuerung,
- Arbeitsqualität.

Am Ende erfolgt eine Betrachtung der Wirtschaftlichkeit, wobei insbesondere der Investitionsbedarf für Gebäude und Stalleinrichtungen, Arbeitszeitbedarf und die variablen Kosten untersucht werden.