Solid liquid separation of livestock slurry

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ABSTRACT

Large quantities of pig and cattle slurry are produced in western European countries, furthermore, livestock farming is becoming increasingly specialized, leading to a reduction in the number of farms. At the same time, specialization into livestock production has led to a concentration of animal production on large farms in restricted areas, a pattern found throughout Europe. In livestock production areas, a surplus of nutrients may be produced in relation to crop requirements, increasing the risk of nutrient losses to the environment.

Slurry is produced in large amounts and has a low concentration of nutrients, and thus the cost of transporting the nutrients from livestock farms with a nutrient surplus to arable farms with a nutrient deficit is high. However, the cost of transporting nutrients can be reduced by separating slurry into a high dry-matter (DM) and nutrient-rich solid fraction and a liquid fraction, so that a much smaller volume of manure will need to be transported from one farm to another.

There are different systems for separating slurry into a nutrient and dry-matter rich fraction and a liquid fraction; for instance, mechanical screen separators, sedimentation, centrifugation, biological treatments and reverse osmosis.

The total cost of the separation process is crucial for optimizing the efficiency of utilization of nutrients in the manure. The costs vary widely, often reflecting the sophistication and efficiency of the technique. Sedimentation, mechanical screen separators and centrifugation are simple techniques that are cost effective, while biological treatments, evaporation, ultrafiltration and reverse osmosis are complex and expensive techniques.

The most informative index of separation is the reduced separation efficiency index; where an index value of 0 indicates that the nutrients are distributed equally between the solid fraction and the liquid fraction, and a value of 1 indicates that the nutrients are concentrated in the solid fraction. The reduced separation efficiency values obtained when using simple mechanical screen separators were 0.07-0.5 for dry matter (DM), 0.01-0.1 for total N (TN) and 0-0.2 for total phosphorus (TP). In comparison, decanting centrifuges are very efficient in removing DM (index: 0.36-0.74) and TP (index: 0.4-0.82), but not in separating TN (index: 0.11-0.19).
The costs of treating 4,000 tonnes of slurry with a mechanical screen separator and with a
decanting centrifuge are £0.44/tonne p.a. and £2.21/tonne p.a., respectively. Often the cost of
separating slurry on a farm can be reduced if a group of farmers together are contracting a
contractor to separate their slurry using a mobile separator.
Slurry Separation
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Objectives

- Produce a nutrient poor liquid fraction and a dry-matter (DM) and nutrient-rich solid fraction, so that a high amount of nutrients cheaply is transported from one farm to another in the small volume of solid manure.

- Optimise the composition of nutrients in relation to the demand of crops, i.e. in slurry the concentration of phosphorous is high compared to nitrogen.
Disharmony
Manure production in livestock units, average production 1.31 LU/ha.
Faeces

Liquid fraction

Simpel separation:

Simpel separation:

Solid fraction

Screen separators (>1mm)
Screw press (0.5-1 mm)
Centrifuge (0.001-0.025 mm)
Flotation (0.001 mm)

Application

Source separation:

Faeces

urine

30% of N
90% of P

70% of N
10% of P

Slurry

Liquid fraction

Sophisticated separation

UF: ultra filtering (0.00002 mm)
RO: reverse osmosis (2*10^{-7} mm)
Distillation
NH_3-stripping

Water

Manure concentrate

Source separation:

30% of N
90% of P

70% of N
10% of P
Sophisticated separation

<table>
<thead>
<tr>
<th>Fraction</th>
<th>% of slurry volume</th>
</tr>
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<tbody>
<tr>
<td>Solid</td>
<td>4-15</td>
</tr>
<tr>
<td>Ammonium</td>
<td>3-5</td>
</tr>
<tr>
<td>P/K</td>
<td>16</td>
</tr>
<tr>
<td>Water</td>
<td>66-75</td>
</tr>
</tbody>
</table>

1000 kg Slurry

199 kg Solid fraction

801 kg liquid fraction

150 kg NPK-fraction

633 kg Water

18 kg Ammonium
Simple separation

Decanter centrifuge

Screw press
Screen separators, > 1mm

Separation efficiency, % DM or P

Fraction > 1 mm, g l\(^{-1}\)

Dry matter

Phosphorous
Separation pig slurry: decanter centrifuge

- Zink
- Cupper
- Ammonium
- Organic N
- Total-P
- DM
- Amount

Fraction transferred to DM-rich fraction, Pct.
Transfer of plant nutrients and heavy metals to the dry matter rich fraction
N and P balance for untreated and separated slurry

**Untreated slurry**

Livestock units ha\(^{-1}\)

<table>
<thead>
<tr>
<th>Nitrogen (kg Ha(^{-1}))</th>
<th>Phosphorous (kg Ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>-140</td>
<td>0</td>
</tr>
<tr>
<td>-120</td>
<td>20</td>
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<td>-100</td>
<td>40</td>
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**Separated slurry**

Livestock units ha\(^{-1}\)

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Nitrogen fertilizer efficiency
(From: Torkild Birkmose, Danish Agricultural Advisory Service)

Nitrogen efficiency, % of Nitrogen applied

- Digested slurry
- Cattle slurry
- Pig slurry

Spring crop
Winter crop
Cost related to treated volume

Amount of manure treated annually (1000 tonnes)

Treatment costs (EURO/tonne)

- Screw press
- Decanter centrifuge
Can small and medium size farmers afford separation?

Solutions:
- Mobile decanter centrifuge: Dutch example, 8.5 EURO/ton solids removed from the farm = 1-1.5 EURO/ton slurry treated.
- Centralised biogas plants
Conclusion

- Harmoni.
  - Separation may improve harmony between animal- and plant production
- Simple separation will allow an harmonic livestock of up to 2-2.5 LU/ha

- Fertilizer value is improved by separation because nutrient composition reflects crops demand
- Digestion will improve N availability