The solid liquid separation as part of the management of manure

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Animal wastes
Valorization:
- agronomic
- energetic...
- industrial...

Animal wastes valorization is a key task but it’s important to ensure their correct and sustainable management.

Main management steps

1) PRODUCTION
2) STORAGE
3) AGRONOMIC UTILIZATION
TREATMENT

Regardless the type of treatment, the manure management normally includes all these steps.

What “correct” management means?

SUSTAINABILITY
ECONOMIC
ENVIRONMENTAL

Main criticalities for a correct animal waste management

- Nutrients surplus in high density livestock areas
- Low manure value
- High transport and land application costs

Necessity to increase the manure value

How to overcome the main criticalities

- Reduction of the manure volume
- To increase the manure NPK concentration
- To avoid nutrients losses

Enhanced manure value
- Easier and more efficient agronomic utilization
- Reduced manure transport/distribution costs
How to reduce manure volume
SOLID-LIQUID SEPARATION OF ANIMAL SLURRY
partial removal of suspended particles from the liquid manure

Main Characteristics of Liquid fraction
- Reduced amount of total solids
  - Improved slurry handling properties
  - Land application in crops post emergence is possible
- Lower P and N content
  - Higher volume application rates are possible
- N mostly in mineral form
  - Immediately available for the crops

POSSIBLE UTILIZATIONS OF SLURRY LIQUID FRACTION
- applied with irrigation water (FERTIGATION)
- further refined:
  - membrane filtration
  - evaporation
  - struvite crystallization
  - NH$_3$ stripping
  - …

POSSIBLE USES OF SLURRY SOLID FRACTION
- Export to outside farm areas
- Composting
- Organic-mineral fertilizers production
- Bedding material
- Energy production:
  - feedstock for A.D. plants
  - pelletizing → combustion

Main Characteristics of solid fraction
Higher concentrations of total solids, N, P, and trace elements than raw slurry
- Higher value of the product
- Possible alternative use (compost, feedstock for biogas plants...)
- Can be more conveniently transported to outside farm areas

N in organic form
- Good for soil amendment
POSSIBLE USES OF SLURRY SOLID FRACTION

- Drying and pelletizing

THE SOLID-LIQUID SEPARATION

The device must be chosen according to the required nutrients separation EFFICIENCIES and according to the following treatments that have to be performed:

1. Total solids separation
2. Nitrogen abatement
3. P₂O₅ abatement

Solid liquid separation techniques

- Devices for the separation of coarse particles (d>0.1mm)
- Devices for the separation of both coarse and small (d<0.1mm) particles

- Gravity separators
- Flotation
- Mechanical separators
- Chemical-mechanical separators

Separation of coarse particles (d>0.1mm)

STATIONARY INCLINED SCREEN

The separation occurs by gravity. The treatment intensity depends on mesh size. Problems of mesh occlusion

kg solid / m³ slurry = 30-50

Separation of coarse particles (d>0.1mm)

ROTATING SCREEN

Stainless steel rotating barrel with 0.8-2.0 mm mesh combined with scrapers

The separation is performed by the combined action of the barrel rotation and gravity

Possible cloggings

Low operative costs (0.5€/m³ slurry)

kg solid fraction / m³ slurry = 30-50

Separation of coarse particles (d>0.1mm)

VIBRATING SCREEN

Metallic grid on a vibrating frame. Mesh size 0.4 mm

Lower risks of cloggings (due to the vibrating screen)

High operative costs

Frequent cleanings of the screen are necessary

kg solid fraction / m³ slurry = 30
The process is improved by using chemical additives

**SETTLING BASINS**

Max 0.75 m³/h x m² basin surface

Raw or screened slurry

Liquid fraction (to storage)

The process is improved by using chemical additives

**kg solid fraction/ m³ slurry = 17-20**

**FLOTATION**

FLOTATION UNIT: air is bubbled from the bottom of the basin so that the aggregation of solid particles is promoted. The lighter particles are transported to the surface where they're scraped away.

**kg solid fraction/ m³ slurry = 350-450**

(*)The process is improved by using chemical additives

**SCREW PRESS**

Screw action on the cylindrical screen

Mesh size: 0.4-0.7 mm → 1.5 mm

**kg solid fraction/ m³ slurry: 20-40**

**Pig slurry**

**Cattle slurry**

**ONE STAGE ROTATING**

Separation achieved by the counterpressure of two sets of rollers over a cylindrical screen

Mesh size: 0.8-1.0 mm → 1.5 mm

**kg solid fraction/ m³ slurry: 8-50**

**Pig slurry**

**Cattle slurry**

**DECANTING CENTRIFUGE**

Centrifugal forces separate the liquid and solids onto the inside wall of the cylinder into two layers. An auger, which turns slightly faster than the cylinder, moves the solids to the conic part of the unit where they are discharged.

Mesh size: 0.8-1.0 mm → 1.5 mm

**kg solid fraction/ m³ slurry: 30-100**

**Pig slurry**

**kg solid fraction/ m³ slurry: 120-220**

**Cattle slurry**

**CHEMICAL ADDITIVES** combined with mechanical separation

**CHEMICAL – MECHANICAL SEPARATION**

**Mesh size: 0.2 mm**

**Slurry/flocculant mixing unit**
CHEMICAL – MECHANICAL SEPARATION

Max flow rate: 7.5 m³/h
Water consumption: 60-150 l/m²
Energy requirement: 1.2-1.5 kW/h
Additive application rate: 4 g/l

kg solid fraction/m² slurry: 120-260

PROBLEMS OF MECHANICAL SEPARATION

Mechanical Separators
- Sometimes low working rate
- Separation efficiency linked to slurry characteristics (e.g. TS content)
- High maintenance and management costs
- Difficult choice of the most suitable device
- Difficult choice of the correct additive dose
- Technology still not completely ready
- High maintenance costs (according to the separator typology)
- Still few experimental data available

Chemical-Mechanical Separators
- Often unbalanced P:N ratio in the solid fraction (P content can be 3 to 4 times higher than N)

Research activity carried out by DISAFA – University of Turin

➢ Testing of solid-liquid separation systems for pig and cattle slurries (raw and co-digested)

- Decanting centrifuge
- Screw press
- One stage rotating

1) Separation efficiency (PIG SLURRY)

Best separation efficiencies of all parameters achieved by decanting centrifuge

1) Separation efficiency (CATTLE SLURRY)

On average, best separation efficiencies of all parameters achieved by decanting centrifuge (highest P separation efficiency by screw press)
1) Separation efficiency

Obtained amount of solid fraction

- Higher amount of separated solid fraction from cattle slurry and with the screw press.

### Pig slurry

- Screw press
- One stage rotating
- Decanting centrifuge

### Cattle slurry

- Screw press
- One stage rotating
- Decanting centrifuge

1) Separation efficiency

% of TS content in the solid fraction

- Pig slurry
- Cattle slurry

- Similar TS content of the solid fraction regardless the mechanical separator.
- Highest TS content in the solid fraction (up to 32%) by using decanting centrifuge.

1) Separation efficiency

Screw press: effect of the slurry input flow rate on the separation efficiency

- Pig slurry 3.4% TS
- Cattle slurry 8.5% TS

- Higher separation efficiency of all parameters at lower input flow rates.

1) Separation efficiency

Average separation efficiency achieved with raw and co-digested slurry

- Higher separation efficiency with co-digested slurry.

2) Costs

Screw press

- Decreasing utilization costs with increasing amount of yearly separated slurry.
2) Costs
Operating costs

Screw press and one stage rotating: lower utilization costs due to their higher working rate (up to 40m³/h) compared to decanting centrifuge

3) Energy requirements
Average Energy requirements (kWh/m³)

Pig slurry 0.6-3.5 kWh/m³
Cattle slurry 0.5-5.3 kWh/m³

Up to 10 times higher energy requirements with decanting centrifuge

3) Energy requirements
Average Specific Energy requirements
(kWh/kg separated N)

Pig slurry 4.4-7.5 kWh/kgN
Cattle slurry 0.8-7.8 kWh/kgN

Lower specific energy requirement with cattle slurry and screw press

4) Environmental aspects
Emission of NH₃, CH₄, CO₂, N₂O

Traditional management (no mechanical separation)
Mechanical separation

4) Environmental aspects
Effect of mechanical separation on gaseous emissions during pig slurry storage

Higher environmental impact of slurry management with mechanical separation than traditional management (+25% CO₂eq. emission)

4) Environmental aspects
Effect of mechanical separation on CO₂eq. emissions during pig slurry storage

Higher environmental impact of slurry management with mechanical separation than traditional management (+25% CO₂eq. emission)
4) Environmental aspects

NH3 losses from land application of raw and chemomechanically separated pig slurry

Cumulative ammonia losses of the two fractions and of the raw slurry
(Index values: raw slurry = 100)

SUMMER TRIAL

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<th>liquid + solid fraction</th>
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WINTER TRIAL

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<th>liquid + solid fraction</th>
</tr>
</thead>
<tbody>
<tr>
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<td>alfalfa</td>
<td>98</td>
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</table>

In warm temperature conditions, highest environmental impact of slurry management with mechanical separation than traditional management (up to +40% CO2eq. emission)

Conclusions

Pros of the mechanical separation:
- smaller storage tanks are required for the liquid fraction storage compared to raw slurry storage;
- easier management (storage and application) of the solid fraction compared to raw slurry;
- several possible alternative utilizations of the solid fraction (biogas production, composting, pelletizing...);
- the transport of the solid fraction to outside farm areas is more convenient than raw slurry due to increased NPK concentration;
- possible utilization of the liquid fraction for barns “flushing”, thus water saving and reduced slurry dilution

Cons of the mechanical separation:
- Higher management costs (separator purchase and maintenance)
- No specific spreaders for the application of solid fraction are available
- Unbalanced N:P ratio in the solid fraction with organic-mineral fertilizers production should be encouraged
- Possible more negative impact on the atmosphere (gaseous losses)

Conclusions

Solid liquid separation of animal slurry combined with non-environmentally friendly manure management practices (e.g., uncovered stores, broadcasting application) might negatively impact on \( \text{NH}_3 \) and GHG atmospheric emissions.

Solid and liquid fractions have to be managed using state-of-the-art gaseous emissions mitigation options.

Covered liquid fraction storage tanks, acidification...

Band spreading, injection, acidification...

ANIMAL MANURES AND DIGESTATE MECHANICAL SEPARATION

TECHNIQUE THAT STILL NEEDS FURTHER RESEARCH AND IMPLEMENTATION

THANK YOU FOR YOUR ATTENTION!

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