Equipment for applying organic fertilizers (PART I)

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Main problems in applying organic fertilizers

- Generally unknown and low content of nutrients
- Not efficient quality of distribution
- Environmental contamination
1) Generally unknown and low content of nutrients

**Chemical fertilizers**
- well known N, P, K.. content
- More than 50% of N in volume
- Low transport and distribution costs

**Organic fertilizers**
- N, P, K.. content ??
- Chemical analysis necessary
- N content < 10% (in volume)
- High transport and distribution costs

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**Determination of the manures NPK content**

- **Slurry**
  - Densimeters
  - NIR
  - Conductivity meter method

- **Solid manure**
  - ..??
1) Generally unknown and low content of nutrients

In line systems for measurement of manure nutrient content (N, P, K)

a) Conductivity meter method

It provides the user with stable and correct values, according to the calibration curves for:

- TKN
- N-NH$_4$
- K$_2$O

No correlation for:

- P$_2$O$_5$
- TS
1) Generally unknown and low content of nutrients

In line systems for measurement of manure nutrient content (N, P, K)

b) Near-Infrared Spectroscopy (NIR)

It provides the user with stable and correct values for:

- TKN
- N-NH$_4$
- TS

Nevertheless:

- High investment costs
- Still few experiences of NIR utilization in real operative conditions (lens cleaning problems)

2) Not efficient quality of distribution

transverse uniformity

CV=56.6%

>10 times more product!

amount of manure (kg) vs distance from the center of the spreader
2) Not efficient quality of distribution

- longitudinal uniformity

<table>
<thead>
<tr>
<th>Application rate (kgN/ha)</th>
<th>&lt;100% difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>&gt;100% difference</td>
</tr>
<tr>
<td>100</td>
<td>&gt;100% difference</td>
</tr>
<tr>
<td>150</td>
<td>&gt;100% difference</td>
</tr>
<tr>
<td>200</td>
<td>&gt;100% difference</td>
</tr>
<tr>
<td>250</td>
<td>&gt;100% difference</td>
</tr>
</tbody>
</table>

3) Main environmental problems related to manure spreading

- Air pollution \((\text{NH}_3, \text{N}_2\text{O}, \text{odors})\)

- Soil and water pollution \((\text{N, P, heavy metals})\) related to an inefficient dose control system and soil compaction
**NH₃** losses from land application

**MAIN FACTORS**

- Site & environmental conditions
- Application systems

**NH₃** losses from land application: effect of Temperature

Cattle slurry
St= 1.9%
Namm.=0.29%
Dose = 21 t/ha

<table>
<thead>
<tr>
<th>Temperature</th>
<th>NH₃ losses (% on TKN applied)</th>
</tr>
</thead>
<tbody>
<tr>
<td>26°C</td>
<td>26%</td>
</tr>
<tr>
<td>6.4°C</td>
<td>7%</td>
</tr>
</tbody>
</table>

(Balsari et al., 1994)
**NH₃** losses from land application:

(Pain, 1988)

**NH₃** losses from land application:

(Trial A (T= 16.0° C) vs Trial B (T= 8.7° C))

(Balsari et al., 1994)
**NH₃ losses from land application:**

**Pig slurry**
- TS = 1%
- TN = 0.37%

More losses with lower application rates

<table>
<thead>
<tr>
<th>Application rate (t/ha)</th>
<th>N-NH₃ losses (% on TKN applied)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 40</td>
<td>15.5%</td>
</tr>
<tr>
<td>40 - 90</td>
<td>9%</td>
</tr>
<tr>
<td>&gt; 90</td>
<td>3.5%</td>
</tr>
</tbody>
</table>

(Balsari et al., 1994)

**NH₃ losses from land application:**

Pig slurry (TS= 1.0%  TN = 0.30%  Rate = 20 t/ha)

Crops residues reduce NH₃ losses

<table>
<thead>
<tr>
<th>Soil type</th>
<th>N-NH₃ losses (% on TKN applied)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare soil</td>
<td>40%</td>
</tr>
<tr>
<td>Maize stalks</td>
<td>21%</td>
</tr>
<tr>
<td>Grassland</td>
<td>7%</td>
</tr>
</tbody>
</table>

(Balsari et al., 1994)
**NH₃** losses from land application:

Pig slurry

TS = 1.7%

Application rate = 20 t/ha

N-NH₃ losses (% on TKN applied)

<table>
<thead>
<tr>
<th>pH 8.2</th>
<th>40%</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH 5.7</td>
<td>11%</td>
</tr>
</tbody>
</table>

Lower losses from acid soils

(Balsari et al., 1994)

**NH₃** losses during land application

~ 2% of N-NH₃ in slurry

(Balsari et al., 1994)
**NH₃ losses after land application: emission pattern**

- Pig slurry
- TS = 2.6%
- Application rate = 44 t/ha

*In the first 78hrs >70% of N-NH₃ is lost*

(Balsari et al., 1994)

**NH₃ losses after land application: effect of spreading technique**

- **Gun sprayer**
  - >30% of NH₃-N applied

(Balsari et al., 1994)
**NH₃ losses after land application: effect of spreading technique**

**Splash plate**

At least 25-30% of NH₃-N applied

(Balsari et al., 1994)

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**NH₃ losses after land application: effect of spreading technique**

**trailing hoses**

up to 15-20% of NH₃-N applied

(Balsari et al., 1999)
NH₃ losses after land application: effect of spreading technique

2 - 3% of NH₃-N applied

(Balsari et al., 1999)

How to further reduce ammonia losses

Acidification of slurry at application
(Up to 80% reduction of ammonia losses)
Main environmental problems related to manure spreading: soil compaction

Excessive soil compaction:

- increases runoff
- reduces plant root growth
- decreases plant’s ability to take up nutrients and water infiltration into the soil
- increases risk of crop diseases

yield losses

Factors affecting soil compaction

**Effect of soil moisture and axle load on depth of compaction**

Better multi axles spreaders – use of low pressure and large section tyres

(Soehne, 1958)
INNOVATIVE SOLUTIONS FOR THE APPLICATION OF ORGANIC FERTILIZERS

Research activity carried out by DISAFA - University of Turin

A) Development of new slurry spreaders
B) Development of new solid manure spreaders
C) Development of manure spreaders for orchards
D) Proposal of a standard methodology for the environmental evaluation/classification of a slurry spreader (ENTAM certification)
A) Development of new slurry spreaders

THE PRESENT SITUATION
i. Short available periods for slurry application
ii. Lack in knowledge on the NPK content of slurry
iii. Difficult control of the slurry application rate
iv. High ammonia emission at application
v. Lack of systems enabling the traceability of slurry application

OBJECTIVES
i. To reduce soil compaction
ii. Enable the slurry application also in post emergence
iii. To adjust the slurry application rate according to the machine’s forward speed, crop requirements and slurry NPK content
iv. To abate ammonia emission at application
v. To trace nutrients application

TWO-MODULES SLURRY SPREADER
A) Development of new slurry spreaders

**TWO-MODULES SLURRY SPREADER**

| Front module (5m³) | Rear module (5m³) | Three points linkage |

Connection system

- DGPS
- Proximity
- Three points linkage
- Refolding device
- Steering axle
- Frame locking device
- Slurry characteristics sensor (FERTIMETER)
- Control of lobe-type pump rotation speed

Type: Atmospheric pressure tank
Capacity: 5 + 5 m³
Slurry injection device for post emergence
B) Development of new solid manure spreader

PRESENT SITUATION

DOSE ADJUSTMENT AND CONTROL SYSTEM
Inside view of the hopper

- hopper side wall
- conveyor endgate
- conveyor

Weighting system

- 3 load cells
control system

control unit

hydraulic motor of the conveyor

LONGITUDINAL UNIFORMITY

conventional spreader

developed spreader
C) Development of manure spreaders for orchards

<table>
<thead>
<tr>
<th>PROBLEMS</th>
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<tbody>
<tr>
<td>Orchards soils are lacking in organic matter and are mostly managed with chemical fertilizers</td>
</tr>
<tr>
<td>Exceeding manure-related nutrients in high-density livestock areas</td>
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<tr>
<td>No specific machineries available on the market for manure application in orchards</td>
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<td>To export exceeding nutrients (and organic matter) to orchards</td>
</tr>
<tr>
<td>To limit the use of chemical fertilizers</td>
</tr>
<tr>
<td>To apply the correct NPK rate according to orchards requirements and NPK content of the slurry</td>
</tr>
<tr>
<td>To localize manure in an even way and on the soil areas where the roots are more active</td>
</tr>
</tbody>
</table>

C) Development of manure spreaders for orchards

- **Slurry spreader**
- **Solid fraction spreader**