How to reduce environmental impacts from animal manure by more than 50%?

Results of a design and evaluation study on strategies for integrated manure management

Wednesday 17 September 2014, Peter Groot Koerkamp
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Co-authors

Jerke de Vries (PhD student), 17 January 2014

From Animals to Crops – ‘Environmental consequences of current and future strategies for manure management

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Manure management & environment

Mineral fertilizer production

Electricity, heat & fuel production

N₂O, CH₄, odour

Excretion inside housing (N, P and C)

Storage / processing

Transport

Field application, soil tillage & in-field traffic

Crop uptake

18 - 33% N efficiency

52 - 65% P over application

€ or ¥, animal welfare

NO₃⁻, P
Goal & challenge

Goal

- Reduce environmental impact from manure management by at least 50% for various impacts at the same time
- More than double the N use efficiency

Challenge

- Avoid pollution swapping
Approach

1. Analyse & evaluate current strategies: digestion, high-tech manure processing and segregation
2. Design future strategies
3. Analyse & evaluate future strategies

Methods:
2. Engineering Design (ED) for new manure chains
3. Modelling of losses - Life cycle assessment (LCA) for environmental impact
Engineering Design: involved processes

Production & volatilization of:

1. Ammonia (NH$_3$)
2. Methane (CH$_4$)
3. Nitrous oxide (N$_2$O)
4. Nitrate leaching (NO$_3^-$)
5. Use of fossil energy
6. Run-off & leaching of nutrients (N & P)
7. Soil carbon depletion
8. Particulate matter formation (from gaseous losses)
Application of Engineering Design

<table>
<thead>
<tr>
<th>Steps</th>
<th>Example</th>
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</thead>
<tbody>
<tr>
<td>1. Emission process</td>
<td>▪ Conversion urea → NH₃</td>
</tr>
<tr>
<td>2. Process factors involved</td>
<td>▪ Temp., pH, enzyme activity</td>
</tr>
<tr>
<td>3. Functions needed</td>
<td>▪ Lower temperature</td>
</tr>
<tr>
<td>4. Principle option</td>
<td>▪ Move to cold storage</td>
</tr>
<tr>
<td>5. Technical solution</td>
<td>▪ Pumps</td>
</tr>
<tr>
<td>6. Interactions</td>
<td>▪ NO₃⁻ leaching, energy use</td>
</tr>
</tbody>
</table>

Table with 39 lines with processes & involved factors
Selected technical solutions – main effect

- Segregation of pig and dairy cattle urine and feces inside the housing system (CH₄ & NH₃ emission)
- Bio-energy production from feces (fossil electricity/heat)
- Addition of zeolite to solid dairy cattle manure (NH₃)
- Sealed storages (volatilization of N and C)
- Ammonia emission reducing application techniques (NH₃)
- Improved application & tillage management (N₂O, fossil energy, N loss)
Life Cycle Assessment

4 representative crop-manure combinations in NW-Europe:

- Gras – liquid cattle manure
- Gras - solid cattle manure
- Maize – liquid cattle manure
- Wheat – liquid pig manure

- Reference: house with slats & storage, no storage covers, broadcast spreading, plowing, random traffic
- Monte-Carlo uncertainty analysis on loss coefficients
- Effects: Climate Change, Terrestrial Acidification, NUE
Results: environmental evaluation
Manure management & environment

Mineral fertilizer production

Electricity, heat & fuel production

Excretion inside housing

Storage / processing

Transport

Field application, soil tillage & in-field traffic

Crop uptake

In-house

Outside

Outside

Field
Climate change ($\text{CO}_2$, $\text{N}_2\text{O}$ and $\text{CH}_4$)

In-house
Outside
Field
External

kg $\text{CO}_2$-eq

Ref  |  IS
---   |---
Grass | Grass | Maize | Wheat

Table:

<table>
<thead>
<tr>
<th></th>
<th>Ref</th>
<th>IS</th>
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<tbody>
<tr>
<td>Grass</td>
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<td>Grass</td>
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<td>Maize</td>
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<tr>
<td>Wheat</td>
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</table>
Terrestrial acidification ($\text{NH}_3$)

- In-house
- Outside
- Field
- External

<table>
<thead>
<tr>
<th>Plant Type</th>
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<tr>
<td>Grass</td>
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</table>
Nitrogen Use Efficiency (crop-excreted)

Grass
Grass
Maize
Wheat
Discussion & conclusion

- Adapted design methodology proved to be effective

- Successful in doubling N-use efficiency and prevention of polluting swapping: reduction >50% on all impacts

- Validate model results of emissions: lab & field

- Economic consequences
Further reading


Segregation of faeces and urine of pigs by a manure belt under a slatted floor

谢谢

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