Integrated assessment of manure transport induced by European environmental regulations: a life cycle approach for liquid pig manure in Germany

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Motivation

• Manure is transported out of regions with high livestock density
• Transport is caused by the Fertilizer Directive (FD) that is currently revised
• Literature compares different manure transport and processing scenarios (e.g. Lopez-Ridaura et al. 2009)

• Missing:
  • Comparison of “no transport“ vs. “transport“
  • Influence of legislation causing transport

⇒ Highly relevant because transports are likely to increase due to revised regulation

Figure 1: Livestock units per ha in Germany (TI 2014)
Material & methods

- Life cycle approach; functional unit of 1 m$^3$ liquid pig manure transported
- Lorry transport over 100 km from pig to arable farm, both growing wheat

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Exporting farm</th>
<th>Importing farm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulation causing export</td>
<td>P surplus limit of 20 kg/ha</td>
<td>P surplus limit of 0 kg/ha</td>
</tr>
<tr>
<td>Manure ex-/imported</td>
<td>10.5 m$^3$/ha</td>
<td>(10.5+) 5.4 m$^3$/ha</td>
</tr>
<tr>
<td>Change of mineral fertilizer use</td>
<td>No change</td>
<td>+21.2 kg N/ha</td>
</tr>
</tbody>
</table>
System boundaries & emission sources

No Transport

Manure

Storage → Application → Plant production

NH$_3$  N$_2$O  NO  NO$_3$  CH$_4$  CO$_2$  PO$_4$

Transport

Storage → Application → Plant production

Exporting farm

Mineral fertilizer

Importing farm

Mineral fertilizer
System boundaries & emission sources

- Manure
  - Storage → Application → Plant production
  - Exporting farm
  - Mineral fertilizer

- Transport

- Importing farm
  - Storage → Application → Plant production
  - Mineral fertilizer

Emissions:
- NH₃
- N₂O
- NO
- NO₃
- CH₄
- CO₂
- PO₄
## Results

<table>
<thead>
<tr>
<th></th>
<th>Climate Change</th>
<th>Terrestrial acidification</th>
<th>Freshwater eutroph.</th>
<th>Marine eutroph.</th>
<th>Particulate matter form.</th>
<th>Fossil fuel depletion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg CO₂ eq</td>
<td>kg SO₂ eq</td>
<td>kg P eq</td>
<td>kg N eq</td>
<td>kg PM₁₀ eq</td>
<td>kg oil eq</td>
</tr>
<tr>
<td>FD 2007</td>
<td>-21.00</td>
<td>-0.26</td>
<td>-0.03</td>
<td>-0.12</td>
<td>-0.05</td>
<td>-1.69</td>
</tr>
<tr>
<td></td>
<td>-0.43%</td>
<td>-0.11%</td>
<td>-1.10%</td>
<td>-0.44%</td>
<td>-0.16%</td>
<td>-0.92%</td>
</tr>
<tr>
<td>FD 2017</td>
<td>20.44</td>
<td>0.10</td>
<td>-0.02</td>
<td>-0.13</td>
<td>0.01</td>
<td>2.85</td>
</tr>
<tr>
<td></td>
<td>0.56%</td>
<td>0.06%</td>
<td>-1.24%</td>
<td>-0.53%</td>
<td>0.03%</td>
<td>2.16%</td>
</tr>
</tbody>
</table>

Table 1: Change of environmental impact per m³ manure exported
Figure 2: Change of TA and ME per m³ manure exported in FD 2007
Conclusion

• Manure transport can reduce environmental pressure caused by livestock concentration
• Environmental impact depending on regulation triggering manure export
• Danger of pollution swapping (regional and between emissions)
  ➔ Regulatory gap in environmental law
Conclusion

- Manure transport can reduce environmental pressure caused by livestock concentration.
- Environmental impact depending on regulation triggering manure export.
- Danger of pollution swapping (regional and between emissions).

Regulatory gap in environmental law.

Petra Busch (SRU)
Till Kuhn
Jörg Rieger

Thank you!

Questions or comments?
Conclusion

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• Environmental impact depending on regulation triggering manure export
• Danger of pollution swapping (regional and between emissions)
  ➔ Regulatory gap in environmental law