Farm Scale Nitrogen Budgets

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Environmental impact assessments

- Obligatory when farms wish to expand or intensify
- Only medium & large farms
  - > about 8500 kg N/ha/yr excretion
- Includes N losses
  - Ammonia (Habitats Directive + national limits)
  - Nitrate leaching (Nitrates and Water Framework Directives)
- Wanted a tool for regulators
  - Internet-based
  - Farm N balance
Philosophy

- Farm N balance is more reliable than animal, manure management or soil N balances
- Farm N balance acts as a constraint rather than an indicator
- Calculate N losses using independent models
- Adjust to be consistent with farm N balance
Calculations

- **Estimate farm N surplus**
  - Now
  - After farm expansion/intensification

- **Partition farm N surplus between**
  - N losses
  - Change in soil N storage

- Does not assume soil N storage is in equilibrium with management
Components of farm N surplus

- Animal feed
- Bedding
- Fertiliser
- Manure
- Fixation
- Deposition
- Seed

Farm

- Animal products
- Crop products
- Manure
Modelling of N losses

N feed → Livestock → Housing → Storage

N products → NH₃ → NH₃, N₂, N₂O

EF

Fields

Change in soil N

EF

Simple model

N in products

NH₃ → N₂ → N₂O

EF

Simple model

NO₃

Simple model

Note: NO and DON not included

EF = Emission factor
Data sources

- Linkage to national databases, e.g.
  - Soil type
  - Current numbers of animals
- Many inputs standard, e.g.
  - Standard N excretion rates
  - Standard crop yields at maximum N application
  - Limited choice of crop mixtures
- Regulation is more farm type specific than farm specific
Example: dairy farm

- 118 mature dairy cows
- 130 heifers
- 26 bull calves
- Area = 100 ha, clayey sand
Table 2  Crop mixtures in dairy scenarios

<table>
<thead>
<tr>
<th>Crop</th>
<th>Conventional dairy Dairy FYM</th>
<th>Dairy maize Dairy maize high</th>
<th>Dairy grass Dairy grass low</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ha</td>
<td>ha</td>
<td>ha</td>
</tr>
<tr>
<td>Spring barley</td>
<td>7</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>Spring barley + grass catch-crop</td>
<td>7</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Grass/clover</td>
<td>30</td>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>Whole-crop spring barley + grass catch-crop</td>
<td>26</td>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>Maize</td>
<td>30</td>
<td>35</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
Standard animal N use efficiencies

Inputs/Outputs

- Animal tissue exported
- Milk exported
- Crop prod exported
- Bedding
- Animal feed
- Atmos
- Seed
- Fixation
- Fert N

kg N/ha/yr
Standard animal N use efficiencies

Partitioning N surplus

-60 to +140 kg N/ha.

- Soil
- NO3
- DeN
- NH3
Change assumed efficiencies

- Milk 25%, growth 12.5%
- Maize – increase animal N efficiency by 10%
  - Better N:energy balance in feed
- Grass – decrease animal N efficiency by 10%
  - Poorer N:energy balance in feed
Variable animal N use efficiencies

Inputs/Outputs

- Animal tissue exported
- Milk exported
- Crop prods exported
- Bedding
- Animal feed
- Atmos
- Seed
- Fixation
- Fert N

kg N/ha

maize high

grass low
Variable animal N use efficiencies

Partitioning N surplus

- Soil
- NO3
- DeN
- NH3

kg N/ha

-60
-40
-20
0
20
40
60
80
100
120
140

maize high

grass low
Conclusions

- Method can be applied to a farm or a sector
- Use of farm N balances imposes discipline
  - Identifies inconsistencies
- Estimated losses very sensitive to N efficiencies used
Danish N regulation

- Farm-scale plant-available N quotas
  - Depends on soil type and cropping
  - Maximum application rate for each crop

- Plant-availability of N
  - Mineral N = 100% available
  - Cattle slurry = 70% available
  - Cattle solid = 45% available
  - Pig slurry = 75% available

- N quota = 90% of economic optimum
Nitrogen standards for the crops e.g. 160 kg N/ha
(10 % below economic optimum)

Max. use of inorganic fertilizers
(55 kg N/ha)

Standards for utilisation
e.g. 75 % for pig slurry

kg N/ha - average on farm level

Animal manure-N

Nitrogen quota

N from animal manure  Fertilizer N  Economical under fertilization