General overview on the purpose and advantages of nutrient bookkeeping for modern farming and environment protection

Bernhard Osterburg, Johann Heinrich von Thünen-Institut, Braunschweig

HELCOM Workshop on status of nutrient bookkeeping in the Baltic Sea countries
28-29 April 2015, Oldenburg, Germany
Structure

1. Purpose of nutrient accounting in agriculture
2. Concepts, uncertainties, methodological variations
3. Nutrient balances versus fertilisation plans
4. Discussion
Nutrient balances in agriculture: background

- N and P surplus important agri-environmental indicator
- ‘Pressure indicator‘ for potential losses into the environment = potential pollution
- Surface & groundwater, marine environment (NO$_3$, P)
- Gaseous emissions (NH$_3$, N$_2$O)
- Habitats sensitive to nutrient inputs (N, P)
- Impacts: water pollution, eutrophication, acidification, PM (particulate matter), climate (greenhouse gases)
- Resource efficiency: high energy input (mineral N), non-renewable, scarce resource (P)
- N and P are major nutrients, a key for crop productivity
Nutrient balances in agriculture:
Legal basis and international agreements

EU directives related to N (and P) emission
- Water Framework Directive (WFD, 2000/60/EC)
- Marine strategie Framework Dir. (MFD, 2008/56/EG)
- Nitrates Directive (ND, 91/676/EEC)
- Groundwater Directive (GWD, 2006/118/EC)
- National Emission Ceilings Dir. (NEC, 2001/81/EC)
- Fauna Flora Habitats Directive (FFH, 92/43/EEC)

International agreements
- International Marine Protection (PARCOM / HELCOM)
- Convention on Long-range Transboundary Air Pollution
- Kyoto protocol
Nutrient balances and “accounting” in agriculture: Purpose

National and regional level: Nutrient balances
- Environmental observation
- International environmental reporting (national or regional level, e.g. OECD national N surface balance)
- Basis for modeling of water pollution
- Input for ranking of water bodies according to WFD

Farm and field level: Nutrient accounting
- Nutrient management at farm level (*balances vs. plans*)
- Basis for technical advice, benchmarking
- Legal thresholds, mandatory rules
Example 1: National balances
EUROSTAT Gross N balance (2001-2010)

Purpose and advantages of nutrient bookkeeping
### Example 2: Analysis of national time series
#### Germany - national N farm gate balance 1990 - 2010

<table>
<thead>
<tr>
<th>in kg N/ha UAA</th>
<th>Diff. 2010-1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilizer</td>
<td>-26.34</td>
</tr>
<tr>
<td>N deposition</td>
<td>-1.4</td>
</tr>
<tr>
<td>N fixation</td>
<td>-1.33</td>
</tr>
<tr>
<td>Seeds</td>
<td>-0.31</td>
</tr>
<tr>
<td>Feed (inland)</td>
<td>6.06</td>
</tr>
<tr>
<td>Feed (import)</td>
<td>3.66</td>
</tr>
<tr>
<td><strong>Sum of inputs</strong></td>
<td><strong>-26.98</strong></td>
</tr>
<tr>
<td>plant products</td>
<td>17.47</td>
</tr>
<tr>
<td>livestock products</td>
<td>7.04</td>
</tr>
<tr>
<td><strong>Sum of outputs</strong></td>
<td><strong>24.51</strong></td>
</tr>
<tr>
<td>Reduction of N balance</td>
<td>-51.49</td>
</tr>
</tbody>
</table>
Example 3: Regional balances
Germany, gross N surface balance (2003)

N surface balance
in kg N/ha UAA

- < 50
- 50 - < 80
- 80 - < 100
- 100 - < 120
- 120 - < 150
- > 150
- no data

Purpose and advantages of nutrient bookkeeping
Example 4: Farm balances
Germany, gross N surface balance (1999/00-2000/01)
Concepts 1: 
Farm Gate Balance

**Purpose and advantages of nutrient bookkeeping**

**Farm gate balance**
(+ / - stock changes)

**Input**
- Secondary fertilisers (compost)
- Leguminous N-fixation
- Mineral fertiliser
- Atmosph. deposition (net)
- Seeds, plants
- Feed concentrates, forage
- Purchased animals

**Surplus**
Accumulation in soil, leaching into ground and surface water, volatilisation, denitrification etc.

**Output**
- Crops for market
- Animal products

Source: Bach und Frede, 2005
Concepts 2: Surface (Field) and Stable (Livestock) Balance

**Surface balance**
- Crop production

**Stable balance**
- Feed from own production
- Manure / slurry
  - NH$_3^+$ volatilisation
  - Feed concentrates, forage

**Input**
- Secondary fertilisers (compost)
- Leguminous N-fixation
- Mineral fertiliser
- Atmosph. deposition (net)
- Seeds, plants
- Feed concentrates, forage
- Purchased animals

**Output (leaving the farm)**
- Crops for market
- Animal products

Surplus
- Accumulation in soil, leaching into ground and surface water, volatilisation, denitrification etc.
Concepts 3: Fertilisation planning

Fertiliser plan

Crop nutrient requirements

Input

Secondary fertilisers (compost)
Leguminous N-fixation
Mineral fertiliser
Atmosph. deposition (net)
Seeds, plants
Feed concentrates, forage
Purchased animals

Manure / slurry

NH$_3$-volatilisation

Feed from own production

Output (leaving the farm)

Crops for market
Animal products

Stable balance

Livestock production (stable)

Surplus

Accumulation in soil, leaching into ground and surface water, volatilisation, denitrification etc.

Soil N mineralised

Output (leaving the farm)
Uncertainties and methodological variations

General uncertainties:
• Data on amounts of fertiliser and harvested products
• Coefficients for nutrient content (default values)
• Yearly variations

Methodological variations:
• Which nutrient flows are considered?
• Gross versus net nutrient accounting (nitrogen): Deductions from total nutrient flow in order to account for gaseous nutrient losses or low nutrient availability
• Gross (farm gate) balances: appropriate AE indicator
• Net (surface) balances: appropriate for farm benchmarking
• Fertiliser plans: appropriate for farm management
Nutrient balances versus fertiliser plans

In both concepts:
- Inputs of fertilisers, accounting for losses etc. is similar
- Fixing the yield levels, realised or expected, is crucial

Fertiliser plans: fixing crop nutrient requirements is crucial
P: balances useful only for several years avg., observation of soil P
### Data for calculation and verification of nutrient balances and fertiliser plans

<table>
<thead>
<tr>
<th>nutrient balance</th>
<th>fertiliser plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral N input</td>
<td>real input</td>
</tr>
<tr>
<td>Manure N input</td>
<td>heads x excretion – loss</td>
</tr>
<tr>
<td></td>
<td>livestock numbers</td>
</tr>
<tr>
<td></td>
<td>excretion rates, losses</td>
</tr>
<tr>
<td>legume N fixation</td>
<td>area x standard rate</td>
</tr>
<tr>
<td>other N input</td>
<td>receipts/accounts</td>
</tr>
<tr>
<td>Cultivated area</td>
<td>area register / IACS</td>
</tr>
<tr>
<td>N removal with harvest</td>
<td>real yields</td>
</tr>
<tr>
<td>Marketed crops</td>
<td>receipts/accounts</td>
</tr>
<tr>
<td>Cereals etc. for feeding</td>
<td>plausibility checks</td>
</tr>
<tr>
<td>Higher N content (wheat)</td>
<td>receipts/accounts</td>
</tr>
<tr>
<td>Forage crops</td>
<td>consistent with excretion</td>
</tr>
</tbody>
</table>

- Main difference is the calculation of **yields**
- Verification of real yields versus usefulness of standard yields
Is assumption of standards yields useful?
Yields of winter wheat throughout Germany (2010)

Approximately 60 kg N/ha
Discussion

• Integrated abatement strategy needed, curbing N surplus while increasing N use efficiency and avoiding negative impacts on productivity

• Using the N balance or fertiliser plans as indicator for good practice? Policies addressing P surplus and pollution?

• Maximum N balance surplus versus maximum nutrient inputs

• Mandatory versus voluntary, advice-oriented approaches

• Crucial points: verification of yield levels, control of mineral fertilisers purchase, manure im-/exports

• Impacts: N – concentration versus total loads
  P – control of runoff