The EU-15 phosphorus balance based on advanced MFA

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Overview

1. The EU-15 P-balance: conclusions drawn
2. Suggestions for next steps
The EU-15 phosphorus balance

Selected model for the EU-15 P-balance

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Main conclusions form the EU-15 balance

Import: 5.2
Export: 0.9
Net Import: 4.3
Domestic Prod.: 0.33
Input Agricult.: 6.2
Output Agric. Prod.: 3.1
Consumption PHH: 1.2
Waste: 0.45
Sewer: 0.58
P – Rec. today: 0.76
P – Rec. opt: 1.6
Subst.: ca. 33% and more
Increase Landfill: 1.4
Increase Soil: 2.9
Losses to Env.: 0.54
General conclusions

Phosphorus management is a regional task (catchments, political regions)
We need a common MFA approach
We need a generic model (COST)
**1st layer: main processes**

Agriculture

Industry

Consumption (PHH)

... ...

8 to 12 processes
Generic P model

1\textsuperscript{st} layer: main processes

- Agriculture
- Industry
- Consumption (PHH)

2\textsuperscript{nd} layer: sub-processes

- Soil
- Animal husbandry
- Plant production

8 to 12 processes

2 to 6 processes

Diagram showing flows and processes in the phosphorus balance model, including
- Deposition
- Fertilizer used
- Compost
- Sewage sludge
- Cesspit
- Fodder
- Agricultural soil
- Livestock manure
- Plant products
- Meat
- Agricultural waste
- Milk & eggs
### Generic P model

<table>
<thead>
<tr>
<th>1st layer: main processes</th>
<th>2nd layer: sub-processes</th>
<th>3rd layer: sub-processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>Soil</td>
<td></td>
</tr>
<tr>
<td>Industry</td>
<td>Animal husbandry</td>
<td>Cattle breeding</td>
</tr>
<tr>
<td>Consumption (PHH)</td>
<td>Plant production</td>
<td>Pig breeding</td>
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<tr>
<td></td>
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<td>Chicken breeding</td>
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</tbody>
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A system of high complexity can be realized with STAN.
A common MFA platform: www.stan2web.net

Centerpiece: the model database
The GUI of STAN
Considering data uncertainty: error propagation

WWTP

Influent

Effluent

Sludge

Mathematical basics

\[ C = f(A, B, \ldots) \]

\[ S_C^2 = \left( \frac{\partial C}{\partial A} \right)_{\bar{A}, \bar{B}}^2 \cdot S_A^2 + \left( \frac{\partial C}{\partial B} \right)_{\bar{A}, \bar{B}}^2 \cdot S_B^2 + \ldots \]

Considering uncertainty of data:

\[ M_{\text{effluent}} = 10\,000 \pm 1000 \text{ kg/h} \]

\[ c_{P,\text{effluent}} = 2 \pm 0.3 \text{ mg/kg} \]

\[ X_{\text{effluent}} = M \times c = 20 \text{ g/h} \]

\[ S_X = (10\,000^2 \times 0.0003^2 + 0.002^2 \times 1000^2)^{1/2} = 4.7 \text{ g/h} \]

\[ X_{\text{effluent}} = 20 \pm 4.7 \text{ g/h} \]
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Considering data uncertainty: data reconciliation

WWTP

Influent 100

Effluent 15

Sludge 90

Input ≠ Output
Considering data uncertainty: data reconciliation

Reconciled process
Input = Output

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Dynamic balancing as a basis for …..

Senthilkumar, K., T. Nesme, A. Mollier, and S. Pellerin (2012), Conceptual design and quantification of phosphorus flows and balances at the country scale: The case of France, Global Biogeochem. Cycles, 26
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