Evaluating nutrient management regulations at different scales in agricultural catchments in Ireland

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The Irish Agriculture and Food Development Authority
Evaluating nutrient management regulations at different scales in agricultural catchments in Ireland

• Legislative constraints on nutrient use for agriculture in Ireland
• Approaches to evaluating mitigation measures for nutrient loss
  ➢ Experimental scale
  ➢ Spatial scale
  ➢ Temporal scale
• Conclusions
• Implications for policy and expectations

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EU Nitrates Directive National Action Programme (NAP)

- Implemented in Ireland on a whole-territory basis
- Constrains N & P applications of inorganic & org. fertilisers
- Caps livestock intensity at 170 kg Organic N ha\(^{-1}\)
- Supports a derogation up to 250 kg Org. N ha\(^{-1}\)
- Mandatory on-farm organic manure storage requirements
- Separation of clean and dirty water
- Ploughing restrictions and green cover establishment
- Farm herd and nutrient management records
The NAP measures are about managing the nutrient SOURCE and MOBILISATION.

The Surface and Groundwater/Drinking Water Regulations for monitoring the DELIVERY and IMPACT.

Wall et al. ES&P 2011
National Fertilizer Use Trends for N, P, K

% change in fertilizer N P and K usage between 2003 and 2008

Source: Lalor et al. 2010

Source: Teagasc
Field-by-field (2ha) soil test

- Soil testing for P only required on derogation holdings
- Assume P index 3 (replacement) on non-derogation holdings
**Catchment soil P distribution**

- Time-taken (lag) to return soil test P-index 4 soils to P-index 3?

![Bar chart showing soil P distribution across different catchments.]

- **Mean STP:**
  - Arable A: 6.2 mg L⁻¹
  - Arable B: 6.6 mg L⁻¹
  - Grassland A: 6.8 mg L⁻¹
  - Grassland B: 4.6 mg L⁻¹
  - Grassland C: 5.2 mg L⁻¹
  - Grassland D: 6.6 mg L⁻¹
**Soil P saturation and storage**

- Higher propensity for P loss with higher levels of soil P saturation
- Variability in soil P storage exists between soil types
Soil P mobilisation and loss risk

- Higher risk of P loss at higher levels of P saturation
- Variability in P loss (WSP) with different soil types?
Lag-time in Soil P Decline for Restricted P Input Scenarios

Grassland A (well drained)

26% P-Index 4 soils in 2009

S1: (-30 kg/ha)
S2: (-15 kg/ha)
S3: (-7 kg/ha)

Wall et al., In review
Farm Gate N & P Balances

- Evaluating nutrient use efficiency on farms

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Arable A</th>
<th>Arable B</th>
<th>Grassland A</th>
<th>Grassland B</th>
<th>Grassland C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm</td>
<td>Farm 1</td>
<td>Farm 2</td>
<td>Farm 3</td>
<td>Farm 4</td>
<td>Farm 5</td>
</tr>
<tr>
<td>Farm Production</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tillage &amp; Lamb</td>
<td>60.6 ha</td>
<td>Beef &amp; Tillage</td>
<td>49.64 ha</td>
<td>Dairy</td>
<td>59.58 ha</td>
</tr>
<tr>
<td>Stocking Rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STP ≤ Index 3</td>
<td>41 kg O.N. ha⁻¹</td>
<td>67 kg O.N. ha⁻¹</td>
<td>212 kg O.N. ha⁻¹</td>
<td>142 kg O.N. ha⁻¹</td>
<td>132 kg O.N. ha⁻¹</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Imports</th>
<th>N</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilisers</td>
<td>8200</td>
<td>1600</td>
</tr>
<tr>
<td>Bulky Feeds</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Concentrate Feeds</td>
<td>184</td>
<td>51</td>
</tr>
<tr>
<td>Cattle Purchases</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sheep Purchases</td>
<td>33</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>8417</td>
<td>1662</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exports</th>
<th>N</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle Sales</td>
<td>120</td>
<td>41</td>
</tr>
<tr>
<td>Sheep Sales + Wool</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Dead Animals</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Milk Sales</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Crop Sales</td>
<td>8350</td>
<td>1513</td>
</tr>
<tr>
<td>Total</td>
<td>8479</td>
<td>1557</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Whole Farm Balance</th>
<th>-62</th>
<th>105</th>
<th>2599</th>
<th>-625</th>
<th>10561</th>
<th>113</th>
<th>6974</th>
<th>984</th>
<th>4898</th>
<th>-37</th>
</tr>
</thead>
<tbody>
<tr>
<td>N Surplus (kg/ha)</td>
<td>+1.0</td>
<td>+52.3</td>
<td>+177</td>
<td>+117</td>
<td>+87</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>P Surplus (kg/ha)</td>
<td>+1.7</td>
<td>-12.6</td>
<td>+1.9</td>
<td>+16.5</td>
<td>-0.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Soil P Required (STP ≤ Index 3) | 60% | 799 | 14% | 291 | 4% | 383 | 90% | 1730 | 66% | 1215 |

The Irish Agriculture and Food Development Authority
Nitrogen Fertiliser Input to Catchment Fields

<table>
<thead>
<tr>
<th>Crop</th>
<th>Arable A</th>
<th>Arable B</th>
<th>Grassland A</th>
<th>Grassland B</th>
<th>Grassland C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean kg Org. N ha$^{-1}$</td>
<td>64</td>
<td>96</td>
<td>155</td>
<td>102</td>
<td>110</td>
</tr>
<tr>
<td>$n$ Fields</td>
<td>30</td>
<td>215</td>
<td>215</td>
<td>124</td>
<td>359</td>
</tr>
<tr>
<td>Grassland Mean</td>
<td>67</td>
<td>114</td>
<td>226</td>
<td>128</td>
<td>46</td>
</tr>
<tr>
<td>Crop requirement$^\Delta$</td>
<td>40-75</td>
<td>75-110</td>
<td>150-185</td>
<td>75-110</td>
<td>75-110</td>
</tr>
<tr>
<td>Main Max</td>
<td>190</td>
<td>226</td>
<td>236</td>
<td>160</td>
<td>-</td>
</tr>
<tr>
<td>Crop Mean</td>
<td>129$^\dagger$</td>
<td>158$^\ddagger$</td>
<td>163$#$</td>
<td>135$^\dagger$</td>
<td>-</td>
</tr>
<tr>
<td>Crop requirement$^\Phi$</td>
<td>135</td>
<td>210</td>
<td>180</td>
<td>135</td>
<td>-</td>
</tr>
</tbody>
</table>

$^\dagger$ Spring Barley, $^\ddagger$ Winter Wheat, $\#$ Maize for Silage

$^\Delta$, Grass N requirement is N needed for grass production for the mean stocking rate for the catchment

$^\Phi$, Crop N requirement is N needed for crop production based on the type of crop production on N index 1 soils
# Phosphorus Fertiliser Input to Catchment Fields

<table>
<thead>
<tr>
<th>Crop</th>
<th>Arable A</th>
<th>Arable B</th>
<th>Grassland A</th>
<th>Grassland B</th>
<th>Grassland C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean kg Org. P ha(^{-1})*</td>
<td>8</td>
<td>14</td>
<td>23</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>n Fields</td>
<td>30</td>
<td>215</td>
<td>215</td>
<td>124</td>
<td>359</td>
</tr>
<tr>
<td>Grassland</td>
<td>Mean</td>
<td>9</td>
<td>5</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Grass requirement(^\Delta)</td>
<td>4</td>
<td>5</td>
<td>9</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Main</td>
<td>Max</td>
<td>68</td>
<td>37</td>
<td>41</td>
<td>37</td>
</tr>
<tr>
<td>Crop</td>
<td>Mean</td>
<td>25(^\dagger)</td>
<td>7(^\dagger)</td>
<td>7(#)</td>
<td>23(^\dagger)</td>
</tr>
<tr>
<td>Crop requirement(^\Phi)</td>
<td>29</td>
<td>42</td>
<td>40</td>
<td>29</td>
<td></td>
</tr>
</tbody>
</table>

\(^\dagger\) Spring Barley, \(^\dagger\) Winter Wheat, \(#\) Maize for Silage

\(^\Delta\) Grass P requirement is P offtake based on the type of animal production and mean stocking rate for catchment

\(^\Phi\) Crop P requirement is crop P offtake based on the type of crop production, assuming average yields
Irish Lake Water Quality up to 2009

The Irish Agriculture and Food Development Authority
Irish River Water Quality up to 2009

The Irish Agriculture and Food Development Authority
Outlet sub-hourly measurements

Discharge
TP
TRP
TON
Temperature
Conductivity
Turbidity
High resolution water quality monitoring vs. 12 monthly samples

The Irish Agriculture and Food Development Authority
Catchment runoff flashiness & P export during “closed period”

2010-2011

In brackets:
% soil P index 4
Mean organic P kg ha\(^{-1}\) yr\(^{-1}\)

Q5 : Q95 ratio of closed period

Grass B (6%, 15)
Arable B (19%, 14)
Grass A (26%, 23)
Arable A (18%, 10)

TP
TRP

The Irish Agriculture and Food Development Authority
Conclusions

• There is a policy expectation that BMP at farm scale will cascade down and be neutral or beneficial to water quality at catchment scale.

• Policy (mitigation measures) and Expectations (water Q targets) may not always be linked.

• Many DISCONNECTIONS may exist which are masked by monitoring scales.

• Legacy effects exist - change may not be fast!

• Source complexity & lag times increase with catchment scale.

• Effective scientific evaluation must be adaptive, inclusive and work at multiple scales when and where appropriate.
Implications for the evaluation of environmental policy

- Implementation of mitigation measures must be complemented with monitoring at appropriate scales to evaluate their efficacy
- Long term monitoring may be required at multiple scales to disentangle CAUSE and EFFECT
- Time scales from implementation to targets must be realistic
- Goals must be realistic and achievable
  - spatial and temporal variability
  - biophysical and socio-economical variability
- Integrated catchment studies provide a realistic scale for evaluation
  - N and P transfer impacts may be buffered
  - Facilitates science-farmer partnerships
  - Mimic large scale dynamics but also allows process level studies

www.teagasc.ie/agcatchments

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• Colleagues in the ACP team

  • Catchment farmers for their participation in the programme

  • DAFM for funding the programme