Agricultural impact on groundwater vulnerability to nitrate in northern Croatia

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• nitrate leaching to groundwater is major concern throughout intensive agricultural area

• when it comes to measures for nitrate leaching reduction, then climate characteristics or natural soil properties can not be controlled ↔ land use and land management can be adapted to the given natural conditions
• to implement regulations from the Nitrate Directive in Croatian rural sector detailed research was set in Varaždin County:
  (a) 59% of County agricultural land
  (b) average parcel size: 0,23 ha
  (c) 85% of agricultural production is crop production
  (d) intensive vegetable production
  (e) chicken and cattle farms: 1,5 LU/ha
Objectives

- to put available scientific information on nitrate leaching from agriculture in the study area in relation to land use, land management, climate and soil, by setting up the field lysimetric trial

- to identify practical breeding methods responsible for high nitrate leaching in the study area
• land use databases
  - ARKOD and CLC 2006 analysis and comparison
• groundwater nitrate concentrations
  soil residual nitrogen
  lysimeter installation
Lysimeter installation
Table 1. Data on agricultural land use according to ARKOD and CLC 2006

<table>
<thead>
<tr>
<th>Land use</th>
<th>ARKOD</th>
<th>CLC 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>percentage of VZ area</td>
<td>percentage of PVZ area</td>
</tr>
<tr>
<td>arable land</td>
<td>32,51</td>
<td>32,08</td>
</tr>
<tr>
<td>greenhouse</td>
<td>0,05</td>
<td>0,03</td>
</tr>
<tr>
<td>meadow</td>
<td>4,14</td>
<td>2,99</td>
</tr>
<tr>
<td>pasture</td>
<td>0,13</td>
<td>0,07</td>
</tr>
<tr>
<td>vineyard</td>
<td>0,49</td>
<td>0,63</td>
</tr>
<tr>
<td>fruit species</td>
<td>0,46</td>
<td>0,43</td>
</tr>
<tr>
<td>nut species</td>
<td>0,18</td>
<td>0,11</td>
</tr>
<tr>
<td>mixed permanent species</td>
<td>0,01</td>
<td>0,02</td>
</tr>
<tr>
<td>different land use</td>
<td>0,22</td>
<td>0,12</td>
</tr>
<tr>
<td>total</td>
<td>38,19%</td>
<td>36,48%</td>
</tr>
</tbody>
</table>

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groundwater nitrate concentrations
### Soil Sampling Results

<table>
<thead>
<tr>
<th>Parcel no.</th>
<th>Depth (cm)</th>
<th>NO$_3$-N (kg/ha)</th>
<th>total NO$_3$-N (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0-30</td>
<td>378</td>
<td>675</td>
</tr>
<tr>
<td></td>
<td>30-60</td>
<td>201</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60-90</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0-30</td>
<td>88</td>
<td>130</td>
</tr>
<tr>
<td></td>
<td>30-60</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60-90</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0-30</td>
<td>172</td>
<td>256</td>
</tr>
<tr>
<td></td>
<td>30-60</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60-90</td>
<td>21</td>
<td></td>
</tr>
</tbody>
</table>
leachate amount
● land use database analysis confirmed groundwater nitrate vulnerability in research area
● the same analysis showed no difference between land use within PVZ and VZ
● the same conclusion is conducted from groundwater monitoring results
● total N content in 1 m soil profile within research area was up to 700 kg/ha in 2012
● leached N amount varied from 3% to 32%
- there is evident high agricultural impact on groundwater vulnerability to nitrates
- higher nitrate leaching causes mineral fertilization
- quantities of residual N in soil and high percolate concentrations of NO₃-N indicate on necessity for precision in fertilizers application and soil and water management strategies