Environmental Sustainability of Vegetable Production above a Shallow Aquifer

Vesna Zupanc
University of Ljubljana, Slovenia

FAO/IAEA International Symposium on Managing Soils for Food Security and Climate Change Adaptation and Mitigation
23 – 27 July 2012
Vienna, Austria
City of Ljubljana

- Capitol of Slovenia
  - 300,000 inhabitants

- Fresh water supply from groundwater

- Market for fresh vegetables
Intensive vegetable production on water protection areas

Intersection of interests:

- Urban area
- Agricultural land
- Environment – water supply for the city
Land use and water protection areas on Ljubljana Field

Land use

Water protection areas
(Ministry of Environment, 2005)

Decree on the water protection zone for the aquifer of Ljubljansko polje

Ministry of Environment, 2005
Fertile arable land above shallow aquifer

Tectonic depression

Very intensive agricultural land use – vegetable production

Photos: http://www.life-income.si/landscape
Lithology of Ljubljana aquifer

Bračič Železničnik et al, 2005
Constant recharge due to snow melt from NW Alpine part

Major water fluxes of Ljubljana aquifer

Nature of the cover above shallow aquifer

Gravelly layers with low retention capacity
High threat of nitrate leaching
Shallow groundwater level

Dynamic capacity of Ljubljana aquifer is between 3 to 3.5 m$^3$/s.

Photos: http://www.life-income.si/landscape
Challenges of vegetable production on shallow aquifer

- Stable yield
- Environmentally friendly
- Interchangeable climatic conditions:
  - High temperatures in summer, drought on shallow, stony soils
  - High precipitation events
Challenges of vegetable production on shallow aquifer

• Under such conditions – shallow aquifers are vulnerable to nitrate pollution
  – high nitrogen fertilizer applications in the intensive vegetable production areas
  – urban and industrial pollution
Experiment - comparison of farmer’s practice

Treatments:

- **Control** no fertilisation, farmer’s irrigation practice
- **Farmers** broadcast fertilisation, irrigation once after planting
- **100% irrigation** (fertigation)
Intensive vegetable production on water protection areas

Legend: 
- **urbanized area**
- **protection zone area**

\(^{15}\text{N} \text{labelled fertiliser}

**NUCLEAR TECHNIQUES**
Fertigation: labelled KNO$_3$ + unlabelled water soluble Ca(NO$_3$)$_2$ in tap water solution with final relative $^{15}$N concentration of 3.52±0.04 at.%.

Farmer’s practice unlabelled Ca(NO$_3$)$_2$ (0.365 at.% $^{15}$N) was broadcast, application of the labelled fertiliser as a solution.
Field experiment on Ljubljana Field - measurement tools

1 Environscan (FDR)
2 Trase (TDR)
3 soil water sampling
4 groundwater sampling
5 rain gauge (precipitation/farmer’s irrigation control)
## Results – water balance

<table>
<thead>
<tr>
<th>(mm)</th>
<th>Endive 2006</th>
<th>Cabbage 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fertigation</td>
<td>Farmer's practice</td>
</tr>
<tr>
<td>Rainfall</td>
<td>355</td>
<td>184</td>
</tr>
<tr>
<td>Irrigation</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>$ET_{crop}$</td>
<td>220</td>
<td>214</td>
</tr>
</tbody>
</table>
# Results – nutrient balance

<table>
<thead>
<tr>
<th></th>
<th>Endive 2006</th>
<th>Cabbage 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fertigation</td>
<td>Farmer’s practice</td>
</tr>
<tr>
<td>Estimated nitrate-N losses (kg ha(^{-1}))</td>
<td>43</td>
<td>117</td>
</tr>
<tr>
<td>N input</td>
<td>79</td>
<td>80</td>
</tr>
<tr>
<td>Crop N uptake</td>
<td>63(^a)</td>
<td>69(^a)</td>
</tr>
<tr>
<td>N balance</td>
<td>–28</td>
<td>–6</td>
</tr>
</tbody>
</table>
Nitrate in groundwater

Nitrate Concentration (mg/l)

V-1  V-2  V-3  V-4  V-5

23.5.06  31.8.06  9.12.06  19.3.07  27.6.07  5.10.07  13.1.08  22.4.08
Groundwater level

Ground level
273 m asl
fertigation and control treatment had the lowest 15N atom % excess

→ lowest N leaching deriving directly from added fertiliser (autumn and winter)
Yield

Best results with farmer’s practice


Conclusions

• With the help of nuclear techniques we were able to identify environmentally friendly techniques, that potentially require more time and money – to successfully implement them in practice – possible through legislation, financial endorsement and education
Conclusions

• Direct results represent guidelines for fertigation in the production of vegetables with a shorter growing period (i.e. lettuce and Brassicaceae), grown on areas where potentially high groundwater pollution is possible due to the soil structure.

• Fertigation, as an environmentally friendly practice, should therefore be considered for vegetable production.
Cooperation with:

Slovenian Research Agency (ARRS)  L1-7097 (C)
Nitrate migration in a plant-soil-groundwater system
Applied Research Project

Jože Janež, Sneberje, farmer

IAEA  Protecting Groundwater and Soil against Pollutants Using Nuclear Techniques  TC project
SLO/5/002
Working team on the research project

Martina Šturm, Sonja Lojen, Institute Jožef Stefan, Department of Environmental Sciences

Janko Urbanc, Geological survey of Slovenia

Branka Železnik Bračič, Drinking water and Sewerage System Public Utility

Joseph Adu-Gyamfi, Soil Science Unit, IAEA, Vienna, Austria

Marina Pintar, Peter Korpar, Vesna Zupanc, Biotechnical Faculty Ljubljana, Agronomy Department
Thank you for your attention!