Comparison of soil solution sampling techniques in a Norway spruce forest in Finland

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- Tension lysimeters – suction cups
- Zero-tension lysimeters
### Soil Moisture Content

<table>
<thead>
<tr>
<th>Soil moisture content</th>
<th>DRY</th>
<th>MOIST</th>
<th>WET</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 %</td>
<td></td>
<td></td>
<td>Field capacity</td>
</tr>
</tbody>
</table>

**Type of soil water or location**

- **DRY**: Absorbed
  - Water retained or moved by capillary forces
- **MOIST**: Micropores (capillaries)
- **WET**: Free-flowing water
  - Water percolates down to perched or groundwater
  - Groundwater (GW) or perched water (PW)
  - If the GW or PW level rises above the lysimeter
  - (Not applicable)

**Figure 4.** The soil water fractions sampled by zero-tension lysimetry, tension lysimetry and centrifuge drainage (thick black lines). The thin red lines indicate the fractions that cannot be sampled. The actual fractions sampled by tension lysimetry can vary depending on the size of the vacuum applied and the moisture content of the soil during sampling (dotted lines). Similarly the amount of adsorbed water sampled by centrifuge drainage depends on the magnitude of the centrifugal force applied.
Soil solution – an indicator of

- Nutrient availability / heavy metal toxicity
- Nutrient / heavy metal leaching
- Soil acidification
- Soil forming processes
Comparison between tension (T) and zero-tension (Z) soil solution (Derome et al. 2000)

Figure 6. Mean SO$_2$-S, NH$_4$-N and NO$_3$-N concentrations in soil solution collected at depths of 20 and 40 cm using tension (T) and zero-tension lysimeters (Z-T) in Norway spruce and Scots pine stands during the snowfree season in 1998 and 1999. The numbers refer to the monitoring plots, which are arranged in order from south to north.
Soil solution – an indicator of

• Nutrient availability / heavy metal toxicity
• Nutrient / heavy metal leaching
• Soil acidification
• Soil forming processes

Soil solution – sampled by

• Tension lysimeters
  ➢ nutrient uptake by vegetation
  ➢ soil buffering and neutralizing processes

• Zero-tension lysimeters
  ➢ movement of ions and compounds between the soil horizons
Juupajoki Level II site 11

February 2014
February 2012
## Characteristics of the stands (measured 2009-2010)

<table>
<thead>
<tr>
<th></th>
<th>Juupajoki 'damaged'</th>
<th>Tammela 'reference'</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main tree species</strong></td>
<td>Norway spruce</td>
<td>Norway spruce</td>
</tr>
<tr>
<td><strong>Stems ha(^{-1})</strong></td>
<td>852</td>
<td>663</td>
</tr>
<tr>
<td><strong>Stem volume m(^3) ha(^{-1})</strong></td>
<td>419</td>
<td>360</td>
</tr>
<tr>
<td><strong>Basal area m(^2) ha(^{-1})</strong></td>
<td>38</td>
<td>33</td>
</tr>
<tr>
<td><strong>Arithmetic mean height, m</strong></td>
<td>21</td>
<td>22</td>
</tr>
<tr>
<td><strong>Mean diameter, cm</strong></td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td><strong>Stand age</strong></td>
<td>90</td>
<td>70</td>
</tr>
<tr>
<td><strong>C/N ratio</strong></td>
<td>28</td>
<td>31</td>
</tr>
<tr>
<td><strong>N concentration in needles</strong></td>
<td>1.26 %*</td>
<td>1.21 %*</td>
</tr>
</tbody>
</table>

*Average conc. In all ICP forest needle conc. 1.18% (Norway spruce)
Bulk deposition (open area): NO$_3$N and NH$_4$N concentrations

**Juupajoki**

- NO$_3$N $R^2$ = -0.10
- NH$_4$N $R^2$ = -0.09

**Tammela**

- NO$_3$N $R^2$ = -0.28*
- NH$_4$N $R^2$ = -0.01
Zero-tension NH$_4$N and NO$_3$N soil solution concentrations in Juupajoki and Tammela Norway spruce plots at depth of -5 cm ja -40 cm

Juupajoki

Tammela

Thinning (2006)

NO$_3$N -05 cm $R^2= 0.39^{***}$, slope 0.01 mg/l/year
-40 cm $R^2=0.27^*$, slope =0.03 mg/l/year
NH$_4$N -05 cm $R^2=0.26^*$, slope = 0.009 ml/l/year
-40 cm $R^2=0.27$

NO$_3$N -05 cm $R^2= 0.02$
-40 cm $R^2=0.24^*$, slope=0.001 mg/l/year
NH$_4$N -05 cm $R^2=0.10$
-40 cm $R^2=0.09$
NO$_3$-N 1997-2015
Zero-tension 40cm

NO$_3$-N 1997-2015
Tension 40cm
7th ICP Forests Scientific Conference  22–23 May 2018 – Riga

DOC 1997-2015
Zero-tension 20cm

DOC 1997-2015
Tension 20cm
Seasonal variation of NO$_3$-N at 40cm depth
mean values 1997-2015

Tension
Zero-tension

mg NO$_3$-N / L

Period number

StdDev

period_number

7th ICP Forests Scientific Conference  22–23 May 2018 – Riga
Seasonal NO$_3$-N variation at 20cm depth, mean values 1997-2015
Seasonal variation of NH$_4$-N at 40cm depth
Seasonal NH4-N at 20cm depth

Mean NH4-N, mg/L

period_number

Zero-tension

Tension
Seasonal variation of total-N at 40cm depth
Seasonal total-N at 20cm depth

Mean n_total-N mg / L

period_number

Zero-tension

Tension
Seasonal variation of DOC at 40cm depth

DOC, mg / L

StdDev
Mean DOC, mg / L

Seasonal DOC at -0.20 depth

Zero-tension

Tension

period_number
Seasonal variation SO4-S at 40cm depth
Conclusions

- The two different sampling techniques represent distinct “soil water worlds”
- However, factors causing the differences largely unclear
- Thorough investigations needed
Thank you