Retention of sediments and nutrients in buffer zones with different riparian vegetation
D.Krzeminska, A-G. B. Blankenberg, A. Nemes, F. Bøe, E. Skarbøvik

The aim: to show how buffer zones with different vegetation cover may influence the water, sediment and nutrient transport within the catchment.

We present field based research focusing at the effectiveness of buffer zones for:

- the retention of nutrients and particles
- the protection against bank erosion

Buffer zones with: (a) grass, (b) trees; (c) berry bushes

Location of:
- field observation
- experimental plots along Hobøl River
(source: Google Maps)
• **Eutrophication** is a major problem for freshwater quality, due to excess phosphorus inputs from agriculture area.

Eutrophication in rivers and lakes due to phosphorus

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• **3 % of Norway’s total area is arable land**, and 30 % of this can be used for cereal production and vegetables.

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**Water quality**
- Very poor
- Poor
- Moderate
- Good
- Very good

Climate and pollution agency, 2008
www.environment.no

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**Land use**
- Crop and pasture
- Forest
- Hardwood coppice
- Glacier, snow, bare rock

Nations Master, 2012
• There is a system of **subsidies** for environmental measures in agriculture to encourage farmers to take steps **to reduce erosion and runoff**, among others **to establish buffer grassed zones along rivers and streams**.

• The acreage and cultural landscape scheme (direct payments from the government) is the most important program for crops including fodder and grassland.
Runoff simulation experiments:

- Mimicking surface runoff from the agricultural land that enters and flow through the buffer zone to the stream.

**Experimental setup:**

Runoff simulation setup: (a) water from the stream was pumped to a tank and mixed with slurry to a known suspended sediment concentration; (b) the mix was distributed upslope of the experimental plots by line irrigation; (c) surface runoff was collected downslope and laboratory analyzed for: **suspended sediment, total phosphorus, total nitrogen, organic matter and clay content**.

For more details see: Krzemska et al. 2020, NIBIO Report 6(30)
Stream bank hydrogeological monitoring and slope stability estimation

- **Long-term hydrogeological monitoring** of stream banks. The monitoring involves:
  - spatial and temporal monitoring of soil moisture conditions - $\theta$ (FDR)
  - ground WL (DIVER) and WL in the stream (ULTRASONIC)
  - soil shear strength - $\tau$ (FIELD INSPECTION VANE TESTER)

- **Stream bank stability modeling** (BSTEM)

**Monitoring setup:**

For more details see: Krzeminska et al. 2020, NIBIO Report 6(30)
Krzeminska et al. 2019, CATENA 172: 97-96
Infiltration capacity/reduction of surface runoff:

### RESULTS

**Methods:**
- double/single ring for infiltration capacity
- constant head method for $K_{sat}$
- mini-disk infiltrometer for $K_{near sat}$

### GRASS and SHRUBS

<table>
<thead>
<tr>
<th></th>
<th>Depth</th>
<th>Crop field</th>
<th>Upper part of the buffer zone</th>
<th>Lower part of the buffer zone</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Infiltration capacity [cm/min]</strong></td>
<td>surface</td>
<td>0,15-0,22</td>
<td>&lt;0,01</td>
<td>&lt;0,01</td>
</tr>
<tr>
<td><strong>Saturated hydraulic conductivity - $K_{sat}$ [cm/min]</strong></td>
<td>0-10 cm</td>
<td>0,24-0,46</td>
<td>0,01-0,01</td>
<td>0,01-0,25</td>
</tr>
<tr>
<td></td>
<td>20-30 cm</td>
<td>&lt;0,01</td>
<td>&lt;0,01</td>
<td>&lt;0,01</td>
</tr>
<tr>
<td><strong>Unsaturated hydraulic conductivity – $K_{near sat}$ [cm/min]</strong></td>
<td>0-10 cm</td>
<td>0,02-0,03</td>
<td>0,02-0,05</td>
<td>0,02-0,05</td>
</tr>
<tr>
<td></td>
<td>20-30 cm</td>
<td>0,02</td>
<td>&lt;0,01</td>
<td>&lt;0,01</td>
</tr>
</tbody>
</table>

### TREES

<table>
<thead>
<tr>
<th></th>
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<th>Lower part of the buffer zone</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Infiltration capacity [cm/min]</strong></td>
<td>surface</td>
<td>0,15-0,22</td>
<td>1,56-1,65</td>
<td>0,55-1,38</td>
</tr>
<tr>
<td><strong>Saturated hydraulic conductivity - $K_{sat}$ [cm/min]</strong></td>
<td>0-10 cm</td>
<td>0,24-0,46</td>
<td>0,42-1,33</td>
<td>0,88-3,61</td>
</tr>
<tr>
<td></td>
<td>20-30 cm</td>
<td>&lt;0,01</td>
<td>0,15-2,18</td>
<td>0,47-2,15</td>
</tr>
<tr>
<td><strong>Unsaturated hydraulic conductivity – $K_{near sat}$ [cm/min]</strong></td>
<td>0-10 cm</td>
<td>0,02-0,03</td>
<td>0,26-0,76</td>
<td>1,63 – 1,87</td>
</tr>
<tr>
<td></td>
<td>20-30 cm</td>
<td>0,02</td>
<td>1,01 – 1,46</td>
<td>1,26 – 3,16</td>
</tr>
</tbody>
</table>
Retention effect ($R_{sim}$):

$$R_{sim} = \frac{m_{in} - m_{out}}{m} \cdot 100\%$$

$m_{in}$ and $m_{out}$ - masses entering and leaving the test plots.

<table>
<thead>
<tr>
<th>Effectiveness of buffer zone with GRASS</th>
<th>GRASS</th>
<th>TREES</th>
<th>SHRUBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infiltration/runoff reduction</td>
<td>%</td>
<td>60–82</td>
<td>100</td>
</tr>
<tr>
<td>Suspended sediment</td>
<td>%</td>
<td>86–94</td>
<td>-</td>
</tr>
<tr>
<td>Total phosphorus</td>
<td>%</td>
<td>76–89</td>
<td>-</td>
</tr>
<tr>
<td>Total nitrogen</td>
<td>%</td>
<td>78–89</td>
<td>-</td>
</tr>
<tr>
<td>Total organic carbon</td>
<td>%</td>
<td>72–80</td>
<td>-</td>
</tr>
</tbody>
</table>

For more details see: Krzemska et al. 2020, NIBIO Report 6(30)
Stream bank stability:

modeling scenarios:
- *(existing)* – slope angle as observed in the field
- slope 24.7° - assuming the minimal slope angle (observed in the field)
- slope 54.0° - assuming the maximal slope angle (observed in the field)

RESULTS

Histograms of calculated safety factors for all simulated scenarios. Shadowed areas indicate stability classes according to the BSTEM model: red – unstable slope; yellow – conditional stability; green – stable slope.

For more details see: Krzemsinska et al. 2020, NIBIO Report 6(30)  
Krzemsinska et al. 2019, CATENA 172: 97-96
## CONCLUSIONS

For more details see: Krzemska et al. 2020, NIBIO Report 6(30)

<table>
<thead>
<tr>
<th>Buffer zones with</th>
<th>Runoff infiltration</th>
<th>Influence on transport of</th>
<th>Reduction of slope erosion (=material loads to the streams)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sediment</td>
<td>Hydrological effect</td>
</tr>
<tr>
<td>Grass</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shrubs</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trees</td>
<td>100%</td>
<td>No surface runoff observed</td>
<td></td>
</tr>
</tbody>
</table>

*Based on saturated and unsaturated infiltration tests no there is no significant difference in infiltration capacity between buffer zone and crop field.*

**Colour scale**

- Strong positive effect
- Moderate positive effect
- Small or none positive effect
Thank you for your attention

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