Applied Effectiveness of Vegetative Barriers in the Trapping of Phosphate-Bound Runoff Sediment in the Macatawa Watershed

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GES 401 - Hope College

BACKGROUND
Lake Macatawa

- one of the most nutrient rich lakes in Michigan (EPA 1999)
- high phosphorous concentrations in Lake Macatawa are believed to be the leading cause for the hypereutrophicity (Ide 2000)
- consequences (EPA 1999):
  - high turbidity
  - low visibility
  - algal blooms
  - high sediment deposition
  - low dissolved oxygen
  - eventual ecosystem collapse

![Diagram of eutrophication cycle](image-url)
Sixty-five percent of the phosphate entering the Macatawa watershed is bound electrostatically to sediment, more specifically silt and clay sized particles (Anderson, 2011).

- results from topsoil erosion from agricultural fields (due to fertilizer application)
- sediment ends up in Lake Macatawa
- eventually becomes bioavailable

PURPOSE
Our ultimate goal was to test the effectiveness of vegetative barriers in decreasing the flow of sediment-bound Phosphorus, hoping to ultimately reduce the transport of Phosphorus to the watershed.

Questions to be Addressed

1. Knowing that phosphorous will be bound much more commonly to small sediment particles, what size of sediment can a vegetative barrier trap and how much?
2. How efficiently does a vegetative barrier slow the rate of water flow?
METHODS

Site Description

- Brouwer Farm, Zeeland
- Soybean field adjacent to a Lake Macatawa tributary
- ~80m long gully interrupted by three vegetative barriers, each ~15m apart
- Gully flows directly into river
Vegetative Barriers

- mesh sock containment system
- Switchgrass (*Panicum virgatum*)

![Diagram of mesh sock containment system]

Experimental Methodology

- Six sediment collectors were installed in the gully at sites A1-C2
- Heavy rainfall event was anticipated

![Diagram of sediment collectors and gully]

![Field photo of sediment collectors in gully]
Rain Event

- Only one rain event was strong enough to produce samples in collectors (Sunday, Nov. 23-Monday, Nov. 24)
- involved snow melt and precipitation
- saturated the soil which led to significant amounts of surface runoff that collected in the gully
ANALYSIS AND RESULTS

Sediment Size and Quantity

Sediment Analysis- Size (hand samples)

- samples were shaken in a water column and allowed to settle into layers of like grain sizes
- volumetric proportions of grain sizes were calculated
- grain sizes measured using microscopy
### Results - Sediment Size

**Volumetric Proportions of Sediment Layers in Hand Samples**

<table>
<thead>
<tr>
<th>Sediment Layer</th>
<th>Range (microns)</th>
<th>Mean (microns)</th>
<th>Wentworth Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-20</td>
<td>4</td>
<td>clay/very fine silt</td>
</tr>
<tr>
<td>2</td>
<td>1.25-25</td>
<td>7</td>
<td>very fine silt</td>
</tr>
<tr>
<td>3</td>
<td>1.25-250</td>
<td>62</td>
<td>coarse silt</td>
</tr>
<tr>
<td>4</td>
<td>1.25-667</td>
<td>167</td>
<td>fine sand</td>
</tr>
</tbody>
</table>

### Results - Flow Rate

**Gulley Flow Rate**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Clicks/30 sec</th>
<th>m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>upstream</td>
<td>382</td>
<td>0.38</td>
</tr>
<tr>
<td>A1</td>
<td>173</td>
<td>0.20</td>
</tr>
<tr>
<td>A2</td>
<td>178</td>
<td>0.20</td>
</tr>
<tr>
<td>B1</td>
<td>127</td>
<td>0.16</td>
</tr>
<tr>
<td>B2</td>
<td>135</td>
<td>0.17</td>
</tr>
<tr>
<td>C1</td>
<td>139</td>
<td>0.17</td>
</tr>
<tr>
<td>C2</td>
<td>121</td>
<td>0.15</td>
</tr>
<tr>
<td>Downstream</td>
<td>151</td>
<td>0.18</td>
</tr>
<tr>
<td>River</td>
<td>470</td>
<td>0.45</td>
</tr>
</tbody>
</table>
Results - Sediment Quantity

the amount of sediment collected in this gully during this rain event shows no clear indication that the amount of sediment being transported decreased due to the barriers

<table>
<thead>
<tr>
<th>Sediment collected in rain event</th>
</tr>
</thead>
<tbody>
<tr>
<td>mass sample (g)</td>
</tr>
<tr>
<td>A1</td>
</tr>
<tr>
<td>A2</td>
</tr>
<tr>
<td>B1</td>
</tr>
<tr>
<td>B2</td>
</tr>
<tr>
<td>C1</td>
</tr>
<tr>
<td>C2</td>
</tr>
</tbody>
</table>

CONCLUSION
Conclusion

★ Conclusions are based on our results from one particular rain-on-snow event within this specific gully

- Here, we found that the barrier selectively trapped coarser sediment (less important for Phosphate transport)
- did not appear to have large effect on the amount of overall sediment trapped

Discussion

- more research needs to be done in order for us to draw specific conclusions about the effectiveness of vegetative barriers!
  - applications outside of the gully
    - involving overland flow
    - during smaller rain events
Acknowledgements

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- Jim Baaker, Walters Gardens - Concept, experimental design, site location
- Lynn Brouwer - site owner

References


Sas, H. 1989. Lake restoration by reduction of nutrient loading: expectations, experiences and extrapolation. Academia-Verlag, Richarz, St. Augustine, Germany.
