Sediment Delivery and Nutrient Export as Indicators of Soil Sustainability in an Iowa Agricultural Watershed

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Introduction

- Eroded sediment from tilled cropland has a major adverse effect on productivity of soils and greatly affects surface water quality.
- Particulate N and P may constitute approximately 20% and 70% of total N and P in streams.
- Quantifying and tracking soil erosion and sediment N and P export from agricultural watersheds is a key component for evaluating long-term soil sustainability.
- The Revised Universal Soil Loss Equation (RUSLE) estimates gross erosion from agricultural watersheds is a key component for evaluating long-term soil sustainability.

Methods

- The 780 ha subbasin is located in the northern portion of the 88 km² HUC 12 Rapid Creek watershed in Johnson County, Iowa. The subbasin is situated on the southern edge of the Iowan Surface landform region in eastern Iowa (Figure 1).

Results

- Sediment delivery ratios (SDRs) are used to correct the estimate of total gross erosion for the fraction that is exported from a watershed.
- Specifically, our study objectives were to (i) evaluate and quantify watershed-scale storage of SOC, N, and P in the top 20 cm (plow layer) of the study area; (ii) estimate watershed-scale sediment erosion and delivery; and (iii) quantify export of SOC, N, and P to Ripit Creek and assess the long-term soil sustainability of agricultural practices in the watershed.

<table>
<thead>
<tr>
<th>SOC</th>
<th>N</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>51</td>
<td>51</td>
</tr>
<tr>
<td>Std. dev.</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>Min.</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Max.</td>
<td>8.6</td>
<td></td>
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</tbody>
</table>

- We compiled high-frequency stream data as daily average stage and converted it to daily discharge.
- Turbidity was measured at a bridge sensor and converted to TSS based on a relationship created at a nearby site.
- Sediment delivery from the subbasin to Rapid Creek was calculated by comparing the exported mass of sediment and nutrients to their watershed-scale erosion rates estimated using the RUSLE model.

Discussion

- Varying reduced tillage and rotation management strategies appeared to have no effect on overall SOC concentrations in surficial soils.
- N concentrations exhibited a normal distribution and did not show any systematic field by field variations that would suggest potential source areas for NO3-N loss.
- Approximately 31200 Mg (45 Mg ha⁻¹) of P are present in the plow layer of our study area.
- We estimate that approximately 1940 Mg of N (2.79 Mg ha⁻¹) are present in the plow layer of our study site.
- We estimated total P storage to be approximately 1390 Mg (1.79 Mg ha⁻¹).
- Soil texture was uniform across the subbasin (Table 1).
- Bulk density did not vary significantly and averaged 1.26 g cm⁻³.
- Total SOC and N concentrations varied across the subbasin (Fig. 3).
- SOC and N concentrations were positively correlated in subbasin soils (P<0.0001) (Fig. 5).
- We estimated the total mass of SOC and N to be 3.12 x 10⁴ and 1.94 x 10³ Mg, respectively (Table 2).
- We estimated that only 1.4% of N export to Rapid Creek is in the form of particulate N delivered by erosion processes. This is significantly lower than previous studies which suggest that up to 20% of N export may be due to soil erosion.
- P export was lower than other study estimates (40% compared to 70%).

Implications

- In many areas, soil development has stagnated and improvements to soil health are not likely to occur under present conditions.
- In Rapid Creek, existing BMPs are reducing nutrient export to stream water but more effort is needed to establish BMPs in the study area which will reduce both non-particulate and particulate nutrient export.
- Implementation of a cover crop further reduces soil erosion and increases nutrient holding capacity as well as water holding capacity in the soil which reduces dissolved nutrient concentrations.
- Ultimately, agroecosystems that make better use of short- and long-term C and P pools will be more productive and environmentally sustainable.

References