Suspended sediment dynamics in five intensive agricultural river catchments


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Introduction

- Excessive supply of fine sediment (<63 µm) into freshwaters can have negative chemical and ecological impacts. High suspended sediment concentrations (SSC) and deposition of sediments onto river beds impair ecological functioning and can store nutrients and metals.
- Cost-effective management of soil erosion and in-stream sediment can prevent the deterioration of soil and freshwater resources. Quantification of eroded soil, or sediment, from a river catchment assesses the magnitude of the soil erosion and sediment problem.
- It is important to establish an understanding of the relationship between sediment loss and catchment land use such agriculture to inform land management strategies.

Methods

Sediment data were collected in five intensive agricultural river catchments in Ireland (Fig. 2 and Table 1). High-resolution SSC data were collected at each catchment outlet using a turbidimeter housed in a novel out-of-channel water quality laboratory (Fig. 3). Turbidity units were calibrated to SSC at each site using a rating curve (Fig. 4). Discharge data is combined with SSC to estimate suspended sediment yield (SSY).

Results

- High SSCs occur during short time periods (i.e., storm-events) (Fig. 5a) and are responsible for the majority of the total SSY (Fig. 5b).
- Poorly-drained catchments have longer periods of moderate SSC (10-100 mg/l) than those with better drainage.
- Inter-annual variability exists in all catchments; individual years report one-third to nearly two times the average annual SSY.
- Average SSY was higher in catchments with poor soil drainage characteristics; GB, GC and AB, than those with well drained soils; GA and AA (Fig. 6).
- Catchment AB, with a greater proportion of arable land use, had much higher SSY.
- Catchments with predominantly grass-based land use but poor drainage can export large SSY.

Discussion

- High SSC values are critical to the generation of SSY.
- Elevated SSCs occur during short time periods primarily following rainfall events.
- Sediment production (average annual SSY) could be explained predominantly by dominant soil drainage class.
- Catchments with poorly-drained soils and periods of bare cover have the greatest risk of sediment loss.
- Internationally, these average SSY values are low, however, considerable inter-annual variability suggests that spatial and temporal changes in runoff and soil erosion affect sediment dynamics.
- The character, timing and catchment conditions (including land use) during each rainfall event are likely to be important for sediment production and, therefore, sediment management.

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Fig. 1 Post-harvest agricultural landscape.
Fig. 2 Study catchments.

Table 1. Characteristics of five study catchments

<table>
<thead>
<tr>
<th>Study catchment</th>
<th>Size (km²)</th>
<th>Soil drainage class</th>
<th>Land use (% of utilised area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grassland A</td>
<td>7.9</td>
<td>Well</td>
<td>% Grassland % Arable</td>
</tr>
<tr>
<td>Grassland B</td>
<td>11.5</td>
<td>Poor</td>
<td>% Grassland % Arable</td>
</tr>
<tr>
<td>Grassland C</td>
<td>3.3</td>
<td>Moderate</td>
<td>% Grassland % Arable</td>
</tr>
<tr>
<td>Arable A</td>
<td>11.2</td>
<td>Well</td>
<td>% Grassland % Arable</td>
</tr>
<tr>
<td>Arable B</td>
<td>9.4</td>
<td>Poor</td>
<td>% Grassland % Arable</td>
</tr>
</tbody>
</table>

Fig. 3 (left) High resolution water quality laboratory.
Fig. 4 (below) Turbidity-SSC rating curve at Grassland B catchment.

Fig. 5 (left) Exceedance-frequency graphs of a) SSC and time, and b) SSC and total SSY.
Fig. 6 (top right) Annual SSY for study catchments for hydrological years 2009-2012 (Oct-Sep).
Fig. 7 (bottom right) Conceptual model of annual average SSY (contours t km⁻² yr⁻¹) according to land use and soil drainage characteristics.

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