Soil and Water Chemistry in Three Irish Agricultural Catchments and Implications for Nutrient Loss and Catchment Management

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Introduction

Soils and geology play a key role in determining the pathways of water flow and water chemistry in catchments. Both water pathways and chemistry, in turn, play a key role in determining stream water quality exiting a catchment and the impact of management practices on water quality. In this paper, we characterise water chemistry and pathways for three contrasting Irish catchments in the Agricultural Catchments Programme (ACP), relate them to catchment soils and geology, and explore implications for agricultural management practices to minimise nutrient (N, P) loss to surface waters.

Methods

Six catchments were chosen to represent a range of soil types and geologies, and agricultural production systems and intensity at scales from 6-30 km^2 (Fig. 1). It was expected that nutrient loss pathways would differ between catchments as a result of the dominant soils and geology. For this study, three catchments were used. Details of catchment soils, geology, and expected pathways are shown in Table 1. Composite soil samples were taken from a semi-regular grid (*ca.* 30 points per catchment) over 0-10 cm depth for soil chemistry analysis. Water flow and chemistry is monitored at the outlet of each catchment. A representative topographic transect of multi-level wells has been installed in each catchment to monitor groundwater flow and chemistry.

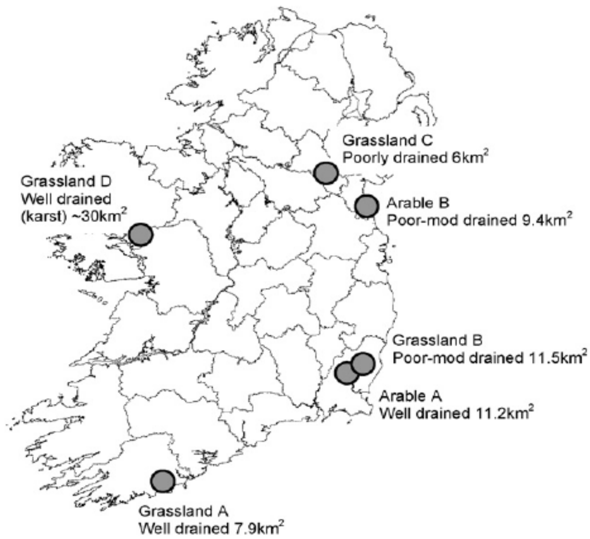

Fig. 1.The six catchments of the ACP in Ireland.

Table 1. Dominant catchment soil, geology and expected nutrient loss pathways.

	Soil Type	Soil Drainage	Topography
Grass A	Brown Podzolic	Well	Rolling
Arable A	Acid Brown Earth	Well	Rolling
Arable B	Grey Brown Podzolic	Poor-moderate	Rolling

	Bedrock	Pathway
Grass A	Sandstone, mudstone	N via subsurface flow
Arable A	Slate, Siltstone	N via subsurface flow
Arable B	Calcareous Greywacke	P via overland flow

Results

A summary of catchment soil chemistry is shown in Table 2. The three catchments could be clearly distinguished in terms of their water chemistry. For example, Fig. 2 shows Ca versus Na concentrations in stream water and groundwater. Both stream and groundwater are tightly clustered in Arable A and Grassland A, indicating that subsurface flow probably dominates in these catchments, reflecting their predominantly well-drained soils. This would be consistent with the relatively high nitrate-N (29 and 26 kg/ha/yr) and low P (0.2 and 0.5 kg/ha/yr) and suspended sediment (5 and 4 t/km^2/yr) exports observed over an initial one-ear period for Arable A and Grassland A, respectively. Arable A had the lowest Ca concentrations in soil and groundwater, reflecting its siliceous geology, and this was reflected in low Ca concentrations in the stream.

Table 2. Soil chemistry (0-10 cm). Fe, Ca, Mg and K are from Mehlich 3 extraction. OM = organic matter.

		(wt. %)		(mg/kg)		
Catchment	pH	OM	Fe	Ca	Mg	K
Grass A	5.9	7.5	484	1673	134	149
Arable A	6.4	7.8	249	1541	234	141
Arable B	5.7	6.5	354	1919	139	137

In contrast, there was a marked division between stream and groundwater chemistry in Arable B. Both stream water and soil in Arable B had the highest Ca concentrations, consistent with the calcareous bedrock. Groundwater in Arable B was highest in Na and high in Ca. However, stream water in Arable B was low in Na and Ca concentrations in the stream were higher than in the groundwater. This would suggest that overland flow dominates in this catchment, enriching stream water in Ca and diluting Na concentrations. This is consistent with the predominantly poor to moderately drained soils of the catchment and higher P (0.8 kg/ha/yr) and suspended sediment exports (15 t/km^2/yr) and lower nitrate-N exports (20 kg/ha/yr) observed.

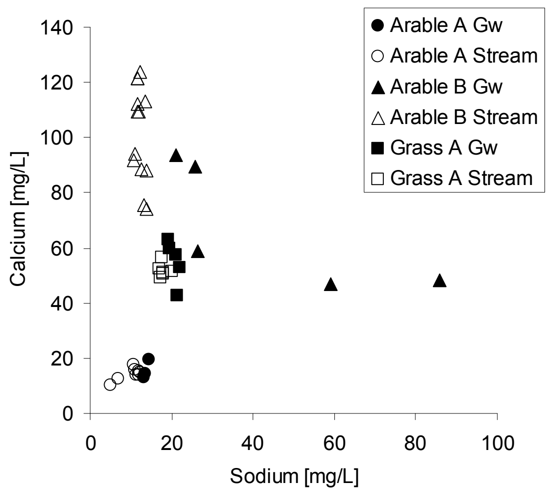

Fig. 2. Ca and Na concentrations in the stream (monthly samples) and near-stream groundwater (means of monthly samples) across a range of depths (2 – 50m) in each catchment.

Discussion and Conclusions

These preliminary results suggest that the expected dominant nutrient loss pathways for the three catchments are likely correct. This study illustrates the importance of soils and geology in determining water flow and nutrient loss pathways at the catchment scale. Pathways of nutrient loss can differ significantly between catchments as a result and this has implications for catchment management; a particular measure to control nutrient loss may be more suited to one catchment than another.

The study also shows that simple water chemistry parameters, in conjunction with information on soils and geology, can be useful for inferring dominant pathways for water flow and nutrient export in a catchment.