Phosphorus losses from soil to water – an isotopic assessment

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Introduction

Phosphorus (P) is an essential micro-nutrient for plants and as such, it is essential to modern agricultural systems. However, in many parts of the world, a P surplus now exists such that more P is contained within the soil than is required by plants, leading to increased P in the soil and ultimately, a proportion of this is lost to watercourses. Even small increases in P in watercourses can have serious detrimental effects and, for this reason, it is essential we understand better the P losses and key sources in the landscape.

Stable isotope ratios have been used to track elements during transfers between different pools. However, P has only one stable isotope. Despite this, a new stable isotope approach has been developed because most P is bound to oxygen (O), forming phosphate (PO4) and this new approach uses the ratio between the heaviest and lightest O isotopes in PO4 (δ18OPO4).

In this study, we aimed to look at the δ18OPO4 of different P pools in the soil profile, see if they varied, to look at the δ18OPO4 of animal wastes which are deposited on the soil and to see if the δ18OPO4 in the water draining the soil retained any of these source values.

Soil samples were collected at 5 locations, to a depth of 30cm, across sub-catchment 2 of the NWFP. Soils were then immediately sieved to 2mm. A sub-sample were collected for water content and δ18OH2O analysis. The remaining moist soil was sequentially extracted for 'Resin-P', 'Microbial-P', 'Organic-P' (NaOH/EDTA), and '1M HCl-P'. Fresh animal faeces were also sampled and extracted.

Depth	Water	$\delta^{18}O_{H2O}$	Resin	Micro	NaOH EDTA	1M HCl
(cm)	(%)	(‰)	($\mu g\ P\ g^{-1}$)			
0-5	23	-3.63	15	55	492	30
5-10	23	-5.19	12	66	537	22
10-15	23	-6.21	10	35	457	24
15-20	21	-10.88	6	24	354	14
20-30	18	-6.41	0.2	0.5	210	1

Properties of the soil sampled in sub-catchment 2

Results

- Isotopic data from both the Resin and microbial P were very similar with mean δ18OPO4 of 17.64 and 17.17‰ respectively with the depth profile data indicating that perhaps the δ18OPO4 was getting slightly light with depth. This is similar to the theoretical microbial equilibrium value which also gets lighter with depth due to δ18OH2O also getting lighter.

- Resin extractable δ18OPO4 from fresh cattle and sheep faeces were found to range between 10.7 and 14.2‰ which is lower than many other sources of PO4 and is worthy of further investigation.

- Normally PO4 sampling in water is undertaken by collecting sufficient volume as to contain >20µmoles P. However, PO4 concentrations were found to be so low, especially as base flow, that this option was not practical. Instead novel passive sampling approaches were undertaken using anion resins AND DGT's (diffusive gradients in thin films). However, even after a 13-day deployment insufficient PO4 was collected for isotopic analysis.

Conclusions

1. Further work is needed to develop a methodology which will enable PO4 sampling in low PO4 concentration waters to determine its δ18OPO4.

2. Animal wastes, as a PO4 source, need far greater attention if the δ18OPO4 tool is to be successfully used to characterize PO4 sources to drainage