

The stable oxygen isotope ratio of resin extractable phosphate derived from fresh cattle faeces

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Phosphorus losses from agriculture pose an environmental threat to watercourses. A new approach using the stable oxygen isotope ratio of oxygen in phosphate ($\delta^{18}\text{O}_{\text{PO}_4}$) may help elucidate some phosphorus sources and cycling. Accurately determined and isotopically distinct source values are essential for this process. The $\delta^{18}\text{O}_{\text{PO}_4}$ of animal wastes have, up to now, received little attention.

Phosphate (PO_4) was extracted from cattle faeces using anion resins. The contribution of microbial PO_4 was assessed using extraction in both de-ionised water and 'Ringer's solution' which purports to protect microbial cells from lysis during extraction. Determination of the number of bacteria was undertaken using the standard plate count method for E.coli, a faecal indicator organism. Properties of the extracted faeces can be found in Table 1. Microbiological results indicated that much of extracted PO_4 was not derived directly from the gut fauna lysed during the extraction of PO_4 from the faeces.

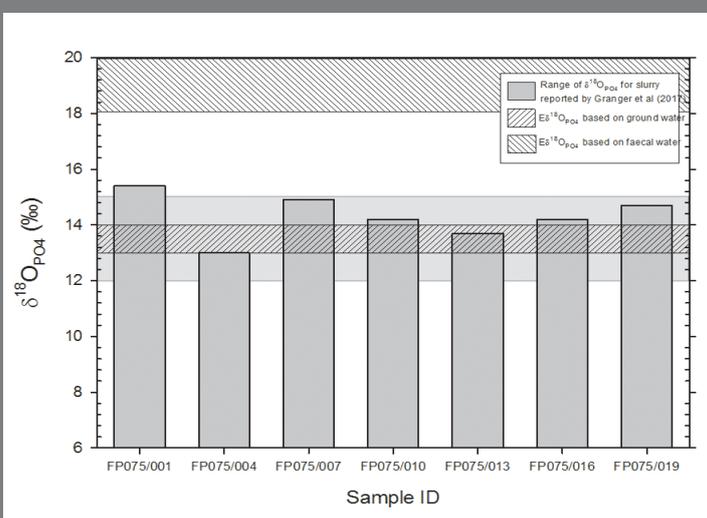
The $\delta^{18}\text{O}_{\text{PO}_4}$ of extracted PO_4 was measured by precipitating silver phosphate and subsequent analysis on a thermal conversion elemental analyser at 1400°C , with the resultant carbon monoxide mixed with a helium carrier gas passed through a GC column into a mass spectrometer. Faecal $\delta^{18}\text{O}_{\text{PO}_4}$ values ranged between $+13.0$ and $+15.4\text{‰}$.

These data were compared to the theoretical value for $\delta^{18}\text{O}_{\text{PO}_4}$ which has achieved equilibrium through cycling of PO_4 via the ubiquitous enzyme pyrophosphatase. This value can be calculated for a given temperature and the $\delta^{18}\text{O}_{\text{H}_2\text{O}}$ of the water in which the PO_4 is dissolved.

Water was extracted from frozen faecal samples using a cryogenic extraction line water oxygen isotope ratios ($\delta^{18}\text{O}_{\text{H}_2\text{O}}$) were determined on a dual-inlet mass spectrometer through a process of headspace carbon dioxide equilibration with water samples.

Assuming faecal $\delta^{18}\text{O}_{\text{H}_2\text{O}}$ values represented cattle body water the predicted pyrophosphatase equilibrium $\delta^{18}\text{O}_{\text{PO}_4}$ ($E\delta^{18}\text{O}_{\text{PO}_4}$) values ranged between $+17.9$ and $+19.9\text{‰}$ (Figure 1.)

Figure 1. The range of $\delta^{18}\text{O}_{\text{PO}_4}$ values for deionised water extracted fresh faeces compared to i) the reported values for agricultural slurry, ii) the $E\delta^{18}\text{O}_{\text{PO}_4}$ for cattle assuming body water $\delta^{18}\text{O}_{\text{H}_2\text{O}}$ is equivalent to ground water and, iii) the $E\delta^{18}\text{O}_{\text{PO}_4}$ for cattle assuming body water $\delta^{18}\text{O}_{\text{H}_2\text{O}}$ is equivalent to faecal water.



While fresh faecal $\delta^{18}\text{O}_{\text{PO}_4}$ values were equivalent to those reported elsewhere, they were different to the $E\delta^{18}\text{O}_{\text{PO}_4}$ value calculated from the faecal $\delta^{18}\text{O}_{\text{H}_2\text{O}}$ value. Our results indicate that slurry PO_4 is, in the main, derived from animal faeces although an explanation for the observed value range could not be determined.

Faeces ID	%DM	Ringers solution			Deionised water		
		Faeces used (g)	$\mu\text{g PO}_4\text{-P}$ recovered	$\mu\text{g PO}_4\text{-P g}^{-1}$ DM	Faeces used (g)	$\mu\text{g PO}_4\text{-P}$ recovered	$\mu\text{g PO}_4\text{-P g}^{-1}$ DM
FP075/001	16.6	23.4	259	67	2.2	3145	8635
FP075/004	10.0	28.8	247	86	1.8	699	3885
FP075/007	9.3	23.5	204	93	1.6	772	5161
FP075/010	12.6	99.1	874	70	1.7	1431	6686
FP075/013	10.0	100.2	805	80	2.0	840	4181
FP075/016	10.6	100.4	786	74	1.7	739	4109
FP075/019	10.8	100.2	814	75	1.5	1192	7331

Table 1. Properties of the different fresh faeces samples collected.