Controls on the phosphorus content of fine stream bed sediments in agricultural headwater catchments at the landscape-scale

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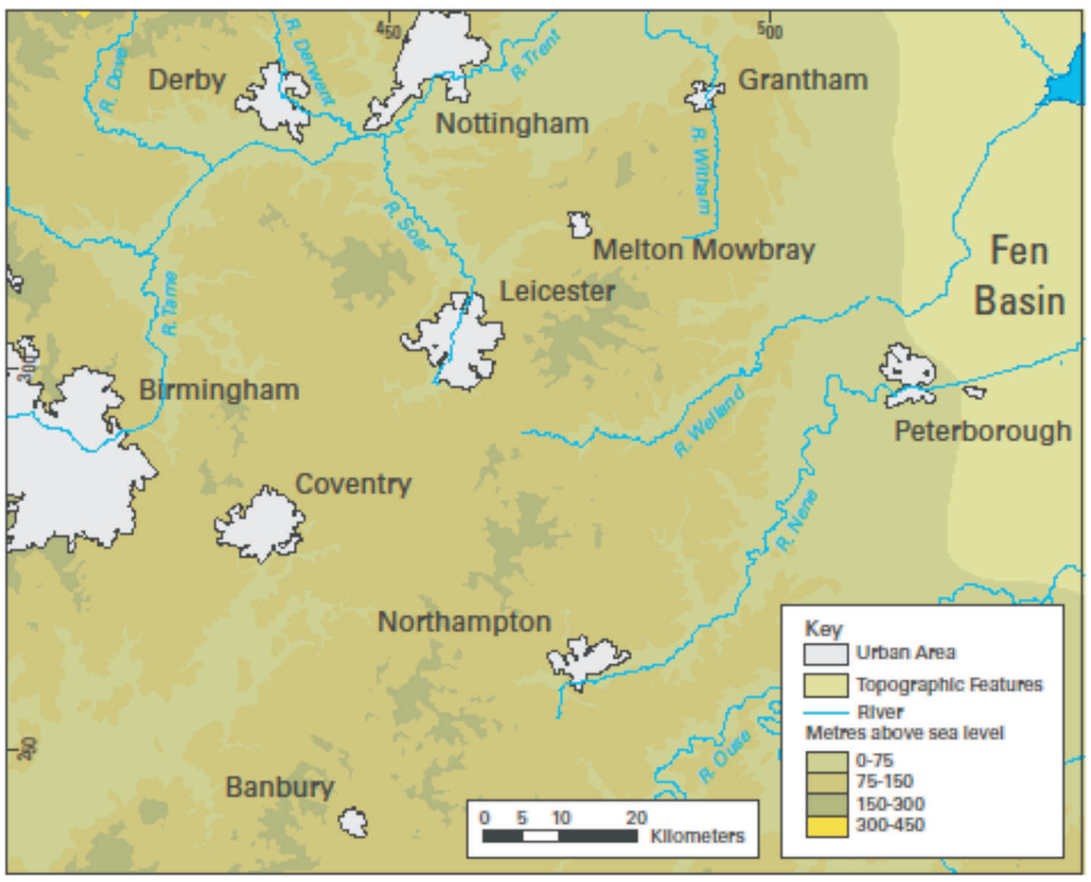
Summary

Analyses of snapshot, fine bed sediments (BS; n= 1052) from agricultural headwater catchments showed that a series of their inorganic and organic components account for 62% of the variance in their P content. The concentration of the rare earth element cerium (Ce) provided a signature for combined inputs of applied fertiliser P and native P (apatite). The proportions of arable and grassland by area in each catchment -- and soil parent material type – were statistically significant predictors of BSP. A significant correlation between total topsoil iron concentrations and BSP suggests that high-resolution spatial data on topsoil Fe -- using survey data and parent material maps -- should be included in models for P transfer to bed sediments. The specific surface area of BS -- based on BET nitrogen adsorption -- accounted for only a small proportion of BSP.



The study regionin central England from which stream bed sediment samples and topsoils were collected

Survey and Methods

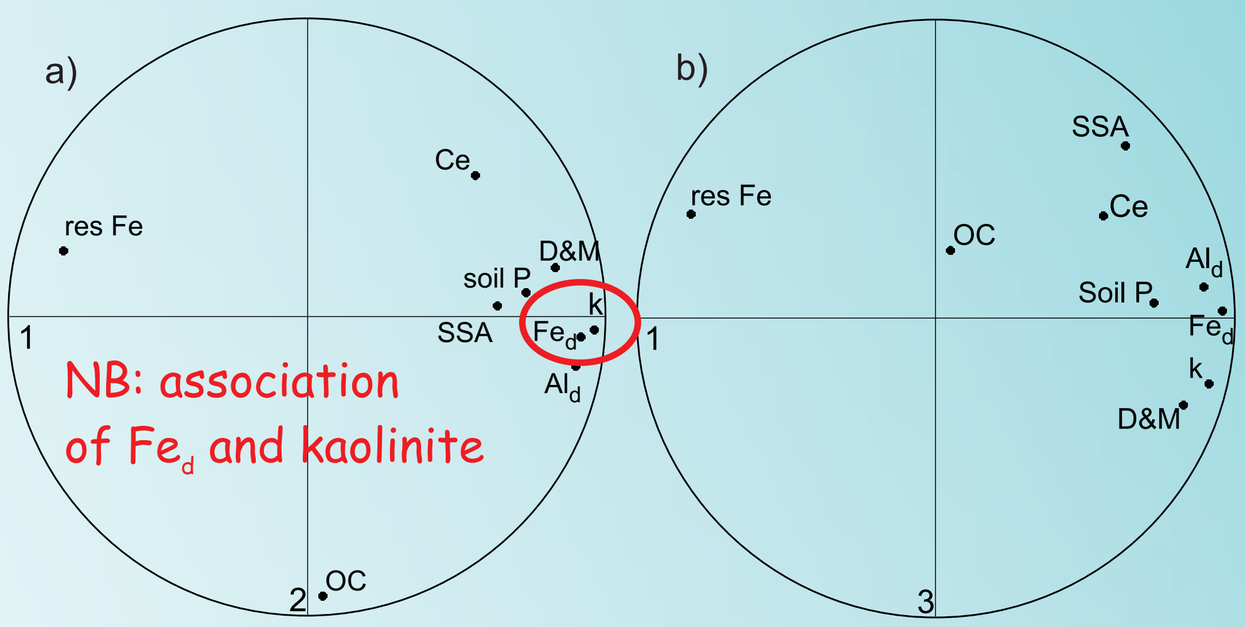
Active stream bed sediments sampled: the < 150 micron size range material was collected. Measurements: 55 elements (major and trace including total P and total Fe), total organic carbon, dithionite extractable Fe_d and Al_d (based on spectrsoscopy), BET specific surface area, total. Residual Fe was the difference between total Fe and Fe_d. Catchment area was determined based on a DEM, and the types of bedrock were classified from geological maps. The proportions of arable and grassland in each catchment were calculated from land cover data. The relative abundance of kaolinite and dioctahedral clay and mica (D&M) were estimated from MIR diffuse reflectance spectroscopy. Topsoil samples (n=7,500) were collected in every other square kilometre of the study area (15,400 km2): analysed for total P and Fe which was used to calculate mean catchment topsoil concentrations for these two properties. The data were analysed statistically sing linear regression and principal component analyses.

Results

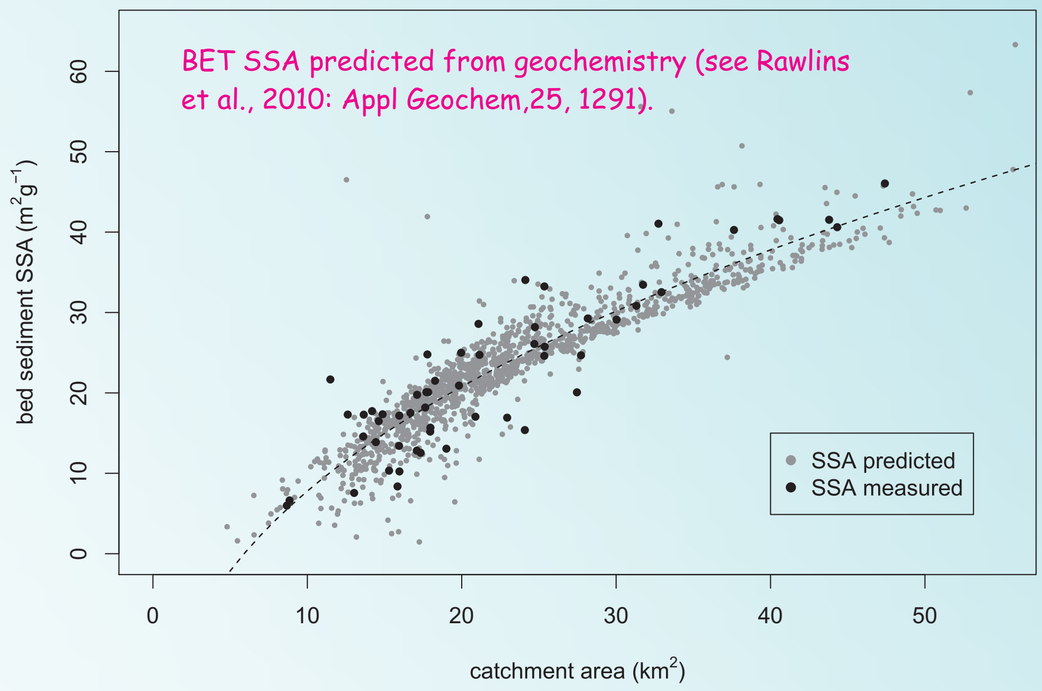
Summary statistics from simple linear regression for log bed sediment P (n=1052) for a range of explanatory variables (P<0.05).

Predictor	Estimate	Std. Error	adjusted R^2 (%)
log Al_d	0.583	0.024	35.6
log Fe_d	0.44	0.021	28.4
log Fe	0.62	0.035	23.0
[a]residual Fe	-0.59	0.04	16.4
kaolinite	241	16.1	17.4
[b]topsoil P	0.53	0.035	18.2
Organic carbon	0.135	0.01	11.6
Ce	0.008	69.4 $\times 10^{-5}$	10.4
[c] D&M	-1.07	0.146	4.7
SSA	0.006	0.001	1.4

[a]residual Fe is total Fe_d minus total Fe determined by XRFS (see text)
[b] average catchment topsoil P
[c] dioctahedral clay and mica minerals



Projections of the correlations between variables and the principal component scores in unit circles: **a)** component 2 against component 1; **b)** component 3 against component 1. SSA=specific surface area, OC=organic carbon, k=kaolinite, D&M=dioctahedral clay and mica, Fe_d=dithionite extractable iron , Al_d=dithionite extractable aluminium, soil P= mean catchment topsoil phosphorus, res Fe=residual iron.



Fine bed sediment mineral specific surface area versus catchment area (km^2) at 1052 sites.
The dashed line is a power function fitted to the data