RIVER SEDIMENTS AS A SOURCE OF SOLUBLE REACTIVE PHOSPHORUS IN A MIXED LAND USE RIVER SYSTEM

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AIMS - To investigate bed sediment-water interactions during summer (a critical period for P effects on ecosystems) and compare P sorption properties of sediments and soils.

SAMPLING - Agricultural soils, river water and bed sediments were sampled from tributaries and main stem sites of the River Dee (NE Scotland) during: (i) May-04 (storm flow), (ii) Aug-04 (extended baseflow period), and (iii) May-05 (flow event recession).

MODELLING P SORPTION:

(i) Equilibrium P concentration, EPC_0 (solution concentration at which no net sorption occurs) derived from batch isotherms (0-20 µM PO_4(P) in 0.01M $CaCl_2$, at 5°C) according to $n_a = K_d c - n_i$, where K_d is the distribution coefficient, n_a and n_i the adsorbed and original (FeO paper desorbable P) sediment/soil P content, c is the equilibrium concentration of SRP, then $EPC_0 = c$ when $\Delta n_a = 0$.

(ii) The molar ratio, $Z = P_{ox} / 0.5(Fe_{ox} + Al_{ox})$ acid ammonium oxalate extractable Fe, Al, P.

(iii) P = sediment EPC_0 - river [SRP] (+ve values = P release).

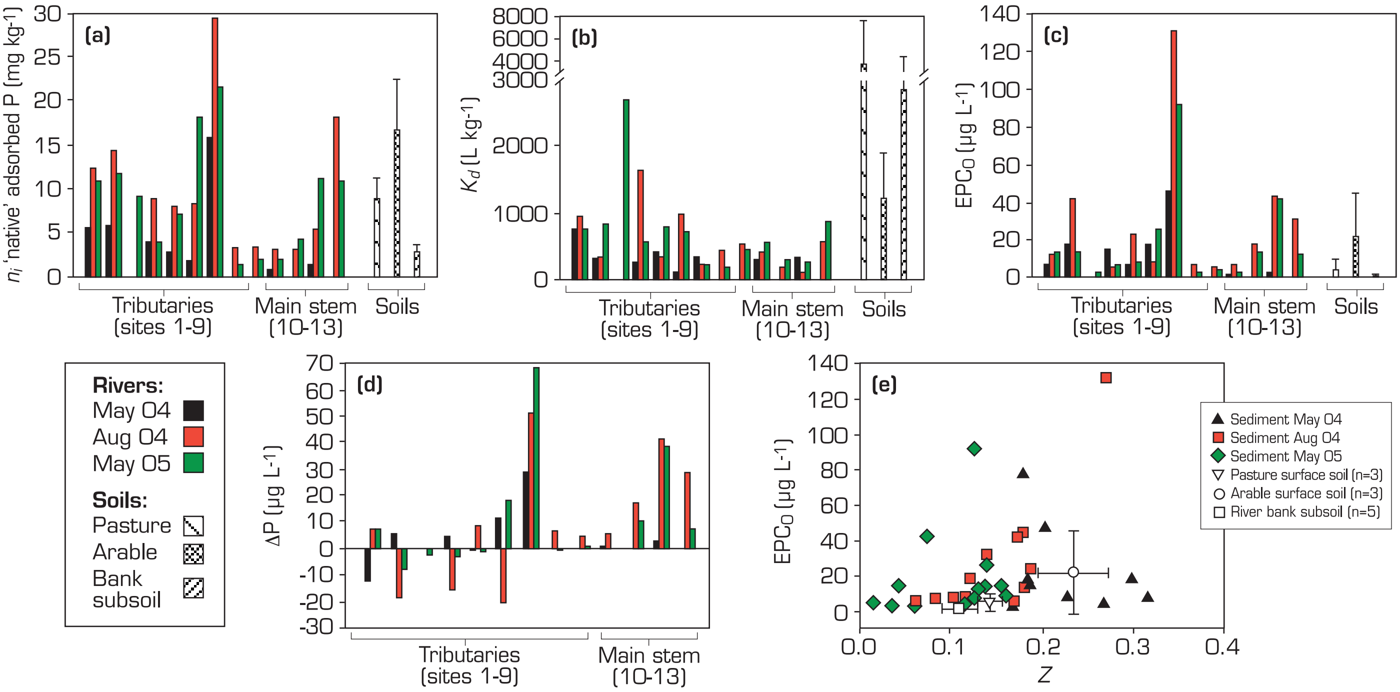
HOW DO LAND USE PRESSURES AFFECT SEDIMENT P STATUS?

Native sediment P (n_i), desorption potential (EPC_0) and P saturation (Z) increased from: low intensity land use sites (tributaries 8, 9, main stem 10, 11) < downstream main stem sites (12, 13) < agricultural tributaries (1-6) and << than in the presence of a point source (tributary 7, STW population 1200).

Table 1. Catchment, temporal mean river data and spatial mean soil properties

	Catchment		River water		Sediment / soil		
Site	Area (km^2)	Pasture + arable % area	pH	SRP (µg l^{-1})	pH_{water}	Total Ca (g kg^{-1})	Org C (g kg^{-1})
1	4	46	7.49	10	6.48	16	15
2	31	67	7.51	32	6.40	20	20
3	35	32	7.16	5	6.21	11	28
4	37	63	7.53	14	6.42	22	13
5	51	60	7.49	11	6.54	31	5
6	58	63	7.46	15	6.57	27	5
7	71	56	7.48	41	6.35	11	13
8	94	2	6.50	2	5.93	11	7
9	212	10	6.70	4	5.63	6	5
10	1005	3	6.84	2	6.03	13	8
11	1348	9	6.97	2	6.23	9	6
12	1775	13	7.05	3	5.97	18	6
13	2005	19	7.13	3	6.04	11	42
Pasture surface soil					5.03	26	41
Arable surface soil					5.88	26	34
Stream bank subsoil					5.76	28	20

Fig. 1. Sorption properties (a) n_i, (b) K_d, (c) EPC_0 for river bed sediments and soils, (d) P values for sediments, and (e) EPC_0 against Z *(site numbers as in Table 1)*.



ARE SEDIMENTS SOURCES OR SINKS OF P TO WATERS?

Sediments were mostly potential P sources to waters (Fig. 1d). In 5, 10 and 18 cases ΔP values (µg P l^{-1}) were respectively categorized as <-5 (sink), -5 to 5 (in equilibrium) and >5 (source). Lower reaches of the main stem had accumulated sediment P likely to desorb (EPC_0 values >> river water SRP concentrations). However, during baseflow (Aug-04) bed sediments became potentially strong sinks for P at the most intensively agricultural sites (sites 2, 4, 6).

HOW DO RIVER SEDIMENT P SORPTION PROPERTIES COMPARE TO THOSE OF SOURCE SOILS?

Smaller K_d values for sediments suggested weaker SRP sorption to sediments than soils. Smaller sediment EPC_0 and larger Z values in May-04 showed that sediments became more similar to arable topsoil at high flow. Conversely, increased sediment EPC_0 and n_i baseflow suggested in-stream accumulation of P. Fig. 1e shows how the sediment P release potential varies with surface P saturation. In Aug-04 a sharp increase in EPC_0 for Z>0.12 is similar to the 'change point concept' applied to soils (three outlying data points relate to larger Ca contents and potentially stronger P sorption related to clay content).

HOW CAN MODELLING APPROACHES BE IMPROVED?

Simplistic modelling methods highlight spatio-temporal variability in P interactions between sediments and waters related to diffuse and point source pollution pressures and in-stream processing. However, simulations may be refined by incorporation of the effects of biotic processes, redox and changing water chemistry in P modelling approaches.