Phosphate fertilisers improve agricultural production but can become pollutants, producing algal blooms, when transferred to streams and lakes. **Barry Rawlins'** team investigate controls on organic and mineral storage of phosphorus in stream-bed sediments on a landscape scale.

In bloom

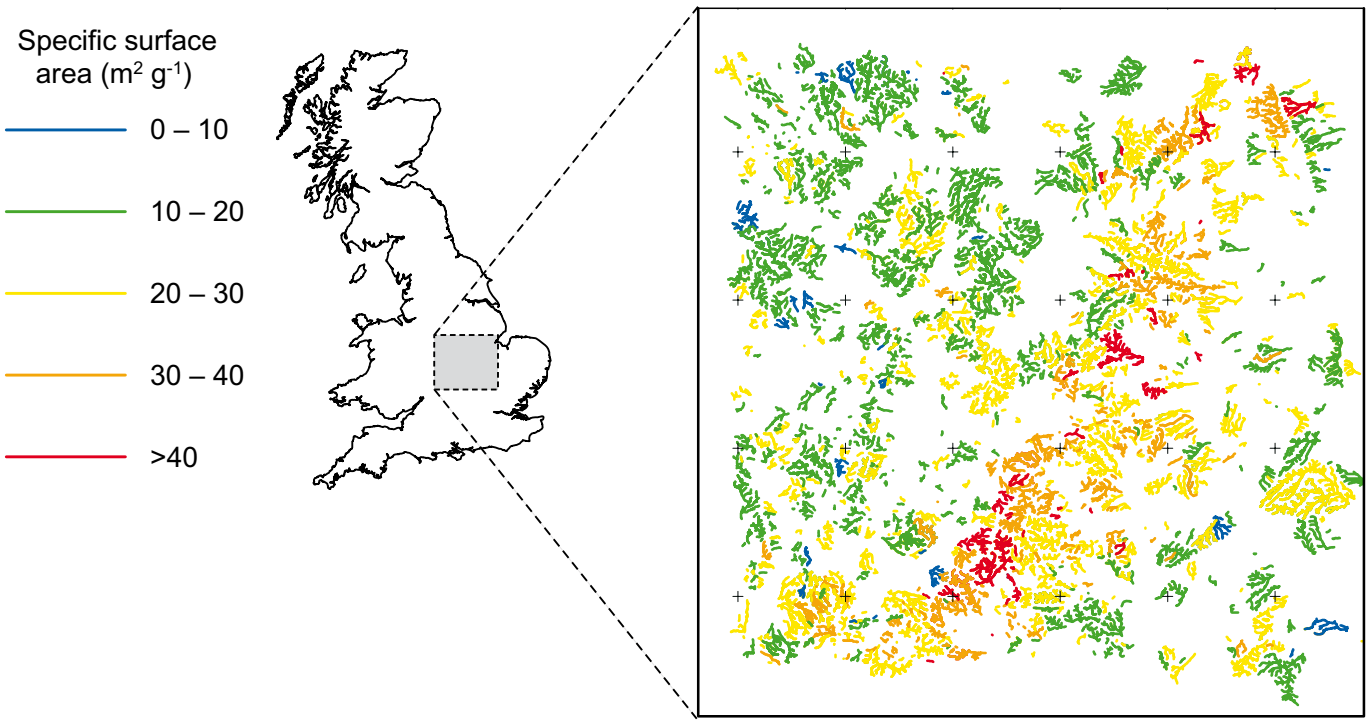
Much of the phosphorus which ends up in stream sediment, either through soil erosion or via field drains, is transported attached to particles. The quantity and chemical form of phosphorus in the stream sediment largely controls its concentration in stream water. The phosphorus in the sediments is associated with particular components such as organic matter, iron-bearing minerals and clay minerals.

Previous studies have suggested that sediment phosphorus may be correlated with the mineral surface area of the sediment. Until recently, researchers could only assess these relationships in individual catchments, not across entire landscape regions where the significance of these relationships may be clearer. We have used measurements of the components of the organic and mineral composition of around 1800 fine-grained sediments across a large agricultural region of England to establish how they affect the quantity of phosphorus stored in headwater stream-bed sediments at the landscape scale. The stream-sediment samples were collected as part of the BGS Geochemical Baseline Survey of the Environment (G-BASE) project.

We measured the mineral surface area of 60 stream sediments using a sophisticated technique based on nitrogen gas. We found that we could accurately predict the surface area for all the other sediments using the concentrations of four elements (vanadium, aluminium, calcium and rubidium) in the sediment. These elements are associated with particular minerals which have different surface area properties. The bedrock geology is the dominant factor controlling 40 per cent of the variation in mineral surface area; the different rock types contain a range of mineral types and quantities.

One of the most effective ways to determine the amounts of these components in the sediment is using infra-red spectroscopy. The reflected spectra of each sediment sample is captured using a spectrometer and statistical models are used to accurately estimate the concentrations of each of four components (iron-oxide, organic carbon, 2:1 and 1:1 clay minerals[1]) based on both their spectral signatures and laboratory-based measurements of their concentrations in a subset of samples. By subtracting the estimated concentration of iron-oxide minerals in each sediment sample from our measurements of the

Phosphorus is a valuable resource for agricultural production that increases early plant growth and nutrient uptake.



Specific surface area of fine stream sediments in the study region; covering 15 400 square kilometres of the East Midlands. Units are square metres per gramme (m^2 g^{-1}).

total concentration of iron we also estimated the quantities of non-oxide iron minerals in the sediment.

In addition to measurements of total concentrations of phosphorus in the soil across our study region, we used our accurate estimates of the different organic and mineral phases in the stream sediment to assess how important they are in explaining the concentrations of phosphorus in the bed sediments. We performed a statistical analysis to show how the different components related to one another. The first component of the variation is strongly related to the iron-oxide and clay content, whilst the second component is largely dominated by organic matter (organic carbon). The third component is related to mineral surface area.

When we use all these data in a simple statistical model, these seven components explain a large part (52 per cent) of the variation in the total concentration of phosphorus in the sediment. The dominant factors, in order of decreasing importance, are the concentrations in the sediment of iron-oxide > organic carbon > mineral surface area and the concentration of phosphorus in the soil. Strong relationships between these components have not been observed previously at the landscape scale and they help us to understand those factors controlling the quantity of phosphorus in bed sediment.

When phosphorus is transferred into streams it can become a pollutant leading to problems such as algal blooms. This dense growth of plant life is a result of large quantities of phosporus in the water and sediment.

Our study shows the relative importance of seven factors which influence phosphorus storage in stream sediments at the landscape scale and that the bedrock geology is one of the dominant factors controlling the physical properties, such as surface area, of stream-bed sediments. We also found indirect evidence of the chemical forms in which phosphorus is stored in bed sediments. These findings have implications for our understanding of how this phosphorus may be released into stream water. This could help us to find ways of reducing stream water phosphorus concentrations in the future.

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[1] Clay minerals are built of tetrahedral and octahedral sheets. A 1:1 clay consists of one tetrahedral sheet and one octahedral sheet. A 2:1 clay consists of an octahedral sheet sandwiched between two tetrahedral sheets.