Processes Controlling Release of Phosphorus (P) from Catchment Soils and the Relationship between Total Phosphorus (TP) and Humic Substances (HS) in Scottish Loch Waters

Authors : Xiaoyun Hui, Fiona Gentle, Clemens Engelke, Margaret C. Graham

Abstract : Although past work has shown that phosphorus (P), an important nutrient, may form complexes with aqueous humic substances (HS), the principal component of natural organic matter, the nature of such interactions is poorly understood. Humic complexation may not only enhance P concentrations but it may change its bioavailability within such waters and, in addition, influence its transport within catchment settings. This project is examining the relationships and associations of P, HS, and iron (Fe) in Loch Meadie, Sutherland, North Scotland, a mesohumic freshwater loch which has been assessed as reference condition with respect to P. The aim is to identify characteristic spectroscopic parameters which can enhance the performance of the model currently used to predict reference condition TP levels for highly-coloured Scottish lochs under the Water Framework Directive. In addition to Loch Meadie, samples from other reference condition lochs in north Scotland and Shetland were analysed. By including different types of reference condition lochs (clear water, mesohumic and polyhumic water) this allowed the relationship between total phosphorus (TP) and HS to be more fully explored. The pH, [TP], [Fe], UV/Vis absorbance/spectra, [TOC] and [DOC] for loch water samples have been obtained using accredited methods. Loch waters were neutral to slightly acidic/alkaline (pH 6-8). [TP] in loch waters were lower than 50 µg L-1, and in Loch Meadie waters were typically <10 µg L-1. [Fe] in loch waters were mainly <0.6 mg L-1, but for some loch water samples, [Fe] were in the range 1.0-1.8 mg L-1and there was a positive correlation with [TOC] (r2=0.61). Lochs were classified as clear water, mesohumic or polyhumic based on water colour. The range of colour values of sampled lochs in each category were 0.2–0.3, 0.2–0.5 and 0.5–0.8 a.u. (10 mm pathlength), respectively. There was also a strong positive correlation between [DOC] and water colour (R2=0.84). The UV/Vis spectra (200-700 nm) for water samples were featureless with only a slight "shoulder" observed in the 270–290 nm region. Ultrafiltration was then used to separate colloidal and truly dissolved components from the loch waters and, since it contained the majority of aqueous P and Fe, the colloidal component was fractionated by gel filtration chromatography method. Gel filtration chromatographic fractionation of the colloids revealed two brown-coloured bands which had distinctive UV/Vis spectral features. The first eluting band had larger and more aromatic HS molecules than the second band, and in addition both P and Fe were primarily associated with the larger, more aromatic HS. This result demonstrated that P was able to form complexes with Fe-rich components of HS, and thus provided a scientific basis for the significant correlation between [Fe] and [TP] that the previous monitoring data of reference condition lochs from Scottish Environment Protection Agency (SEPA) showed. The distinctive features of the HS will be used as the basis for an improved spectroscopic tool.

Keywords : total phosphorus, humic substances, Scottish loch water, WFD model
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