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Analysis of a five-year high resolution phosphorus dataset for signals of diffuse and point source pollution change in rural catchments

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Monitoring the efficacy of phosphorus (P) mitigation measures for both diffuse and point sources is difficult due to sample resolution and processes related to seasonality and hydrology. High-resolution monitoring by bankside analysers has increased in catchment studies, capturing the variation of P signals in flowing water from multiple sources and hydrological dependencies. However, while these high-resolution data can offer new insights into P patterns related to process, there is no theory on how these data should be used to investigate catchment change influences on stream P chemistry over time.

Here we demonstrate the analysis of a five-year sub-hourly dataset of total P spanning a period of voluntary and mandatory mitigation measures to reduce soil P in high status fields and also replacement of defective septic systems. These two mitigation measures were deemed to have influences on both diffuse, storm dependent P transfers during high flows, and point, storm-independent P transfers during low flows. The data were gathered by Hach-Lange Phosphax systems linked to hydrometric stations in two 5km^2 rural catchments (in the Irish border region) so that P concentration and discharge were measured synchronously.

A series of ranked percentile high flow and low flow discharge ranges (e.g. Q_5-Q_{10} and Q_{90}-Q_{95}, respectively) were determined for the five year period and, in each year, the P concentration data were extracted, which corresponded to these ranges. Each discharge percentile range was associated with several hundred mean hourly total P concentrations in each year and were compared using ANOVA to determine the magnitude and significance of change on a year-by-year basis.

Over the five year period, the high flow analysis indicated that diffuse stream P concentrations had increased in both catchments (0.152 to 0.280 mg l^{-1}, and 0.228 to 0.391 mg l^{-1}), despite efforts to reduce soil P status. Subsequently, it was shown that the potency of high flow P transfers increased if the catchments had been exposed to low-level but persistent wetting (not related to the magnitude of annual rainfall).

The low flow analysis also indicated that, despite septic system mitigation, P concentrations either increased (0.120 to 0.148 mg l^{-1}), or showed no change (0.136 mg l^{-1}) over the five years. These storm-independent signals were linked to an increased septic system density (through single house building) in the catchments despite mitigation of some existing defective systems.

The results have utility for catchment managers expecting to see changes from large investments in mitigation policies. For example, successes or failures due to poor planning, low uptake or, possibly more importantly, the influences of hydrological change between years. The study also demonstrates the utility of high resolution data capture of nutrient hydrochemistry – as a tool to detect changes in complex catchments – in addition to furthering process understanding.