CREW CENTRE OF EXPERTISE FOR WATERS

# Factoring Ecological Significance of Sources into Phosphorus Source Apportionment Phase 2

Full report available at:
crew.ac.uk/publication/Eco_significance


Photo: Miriam Glendell


Photo: Miriam Glendell


Photo: Steve Addy

# Executive Summary

## Factoring Ecological Significance of Sources into Phosphorus Source Apportionment: Phase 2 Understanding the link between phosphorus and ecological impact in Scottish streams

### BACKGROUND

Phosphorus (P) source apportionment is an important tool for prioritising mitigation strategies and assessing compliance as part of River Basin Management Planning[1] process within the EU Water Framework Directive. However, the methodology for P source apportionment in rivers is subject to significant errors and uncertainty as annual total P loads are assumed to correlate with ecological impact, despite a wealth of evidence to demonstrate other factors such as seasonality and P bioavailability that affect the processes and mechanisms responsible for the transport of P from source to river systems (Stutter *et al.*, 2014).

In 2014 CREW delivered a descriptive methodology[2] of how modelled Total Phosphorus (TP) loads could be modified to take account of their impact on ecology (Phase 1). In the absence of measured bioavailable P concentrations (by the Scottish Environment Protection Agency), the study examined indirect evidence that Soluble Reactive Phosphorus (SRP) loads from different sources had a different impact on the ecological response due to differences in bioavailability of P fractions and timing of inputs. These relationships were examined and tested (Appendix 1) within the context of other pollutants and in catchments with different characteristics.

This project (Phase 2), therefore aims to: (i) evaluate the relevance of the method developed in Phase 1 for the SAGIS tool to derive 'ecologically significant source apportionment' and (ii) examine potential factors affecting ecological status based on the regulatory data.

### RESEARCH QUESTIONS (PHASE 2)

- What is the relative importance of different phosphorus (P) fractions and sources on diatom response?
- How important is P in affecting diatom status in the context of multiple stressors (nutrients, land cover and catchment hydrological characteristics) in running waters?
- How do factors influencing the phosphorus-diatom relationship vary between different catchments?

*In this study, we use the term 'stressor' to mean an environmental factor that has an adverse impact on the ecological community.*

### MAIN FINDINGS

Data from 45 Scottish streams were examined to identify a relationship between diatom response (a key ecological indicator for water body status) and other factors including: nutrients, SRP loads from different sources, land cover proportions and hydrological catchment characteristics.

- The Trophic Diatom Index (TDI) was used to represent the ecological response. TDI allows a comparison of the observed state of a water body against that expected in the absence of anthropogenic disturbance by deriving the Ecological Quality Ratio (EQR TDI) between the observed and expected diatom status. Higher values indicate higher ecological status.
- In agreement with previous work, diatom response was negatively associated with P species (SRP and TP), nitrate ($NO_3$-N) and urban land cover and positively associated with seminatural land cover type. The relationship varied with season, with higher ecological status associated with spring.

1) What is the relative importance of different P fractions and sources on the diatom response?

- Total phosphorus concentration was more strongly associated with the diatom response EQR TDI than SRP, although the differences between them were small.
- A negative association was observed between P concentrations (mg $L^{-1}$) and diatoms, but this study did not find evidence of a relationship between P loads and diatoms in running waters

2) How important is P in affecting diatom status in the context of multiple stressors (nutrients, land cover and catchment hydrological characteristics) in running waters?

- Semi-natural land cover had the strongest positive association with EQR TDI, while urban land cover had a significant negative association with the ecological response.
- After excluding the overarching impact of land cover, the ratio of $NH_3$-N to $NO_3$-N as well as $NO_3^-$ N concentrations also had a negative effect on the EQR TDI.

3) How do factors influencing the phosphorus-diatom relationship vary between different catchments?

- The analysis highlighted catchment-specific responses, whereby catchments could be grouped according to most strongly associated stressors.
- The relationship between TP, SRP and EQR TDI was not spatially consistent and varied more between catchments for TP than for SRP.

1 *https://www.sepa.org.uk/environment/water/river-basin-management-planning/*
2 *https://www.crew.ac.uk/publication/ecological-significance-phosphorus*

## RECOMMENDATIONS

- The complex relationship between multiple stressors (P and N species, land cover proportions) and ecological response between catchments, supports the need for further research into factors that may affect the spatial variability in the stressor-response relationship. This could be informed by further collection of data with high temporal resolution in representative catchment types.
- Effective mitigation measures should target all stressors in concert, taking into account catchment-specific responses in different catchment types.
- In future research, the bio-available P (BAP) fraction should be measured and monitored alongside SRP and TP at a number of representative locations across Scotland to provide data for model development and validation.
- Reflecting the overriding importance of land cover highlighted in this study, it has been suggested that current mitigation policies may not be sufficient to achieve good ecological status and that targeted land cover change may need to be considered.

**Published by CREW** – Scotland's Centre of Expertise for Waters. CREW connects research and policy, delivering objective and robust research and expert opinion to support the development and implementation of water policy in Scotland. CREW is a partnership between the James Hutton Institute and all Scottish Higher Education Institutes supported by MASTS. The Centre is funded by the Scottish Government.

**Please reference this report as follows:** M. Glendell, M. Stutter, I. Pohle, J. Palarea-Albaladejo, J. Potts, L. May (2020) Factoring Ecological Significance of Sources into Phosphorus Source Apportionment - Phase 2. CRW2017_09.
ISBN number: 978-0-902701-71-7 Available online at: crew.ac.uk/publications

CREW CENTRE OF EXPERTISE FOR WATERS

The James Hutton Institute

Scottish Government
Riaghaltas na h-Alba
gov.scot