Developing Multi-Pollutant Phytoremediation Strategies To Sustainably Improve Water Quality: Lessons From Harvesting Wild Macrophyte Communities

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1. Introduction (project background and fieldwork survey)

A major challenge to the provision of a safe and sustainable water supply is **the impact of diffuse pollutants such as phosphorus, nitrogen and heavy metals**. Macrophytes (aquatic plants) have a demonstrable ability to sequester & remediate waterborne pollutants. However, **most studies focus on single plant species ignoring the untapped potential of employing plant communities.** A field survey of macrophytes and water quality in central Scotland was carried out to determine the potential for **harvesting wild macrophyte communities** from pollutant impacted freshwaters as an effective phytoremediation strategy. The primary research questions for this survey was:

1. Is there a difference between the water quality between areas of macrophyte stands and vegetated areas (i.e. can evidence of active plant sequestration be seen in the field)?
2. Which macrophyte communities have the greatest potential for simultaneously sequestering meaningful concentrations of multiple pollutants?
3. What is the element storage potential of wild macrophyte stands?

2. Methods

- Survey comprised a **stratified random sampling approach targeting freshwaters with known** stands of macrophytes in quantities sufficient for harvesting.
- **Water samples were taken within macrophyte** stands & unvegetated areas **for nutrients** (N-species & Phosphorus), **metals** (e.g. Iron, Copper & Zinc) and **faecal indicator organisms** (*Escherichia coli*) (Fig.1).
- A random sample of macrophytes was **identified for community information**, and then harvested to **quantify biomass and element tissue content**.
- Vegetation **stand area was measured** *in-situ* or using areal photography **to quantify total biomass and element harvesting potential**.

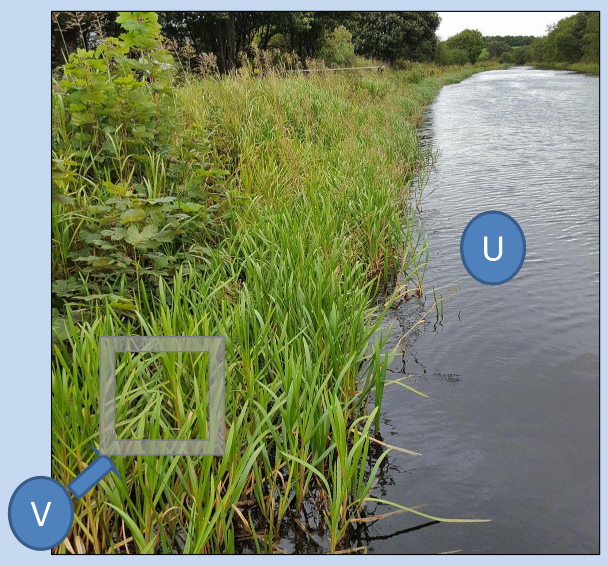

Fig.1 Example target plant community of *Glyceria maxima*, Forth & Clyde Canal, showing vegetated stand sample point (V) with 0.25m^2 quadrat, and unvegeted sample (U) point for comparison

2. Preliminary results

Q.1. Water quality in vegetated and unvegetated locations

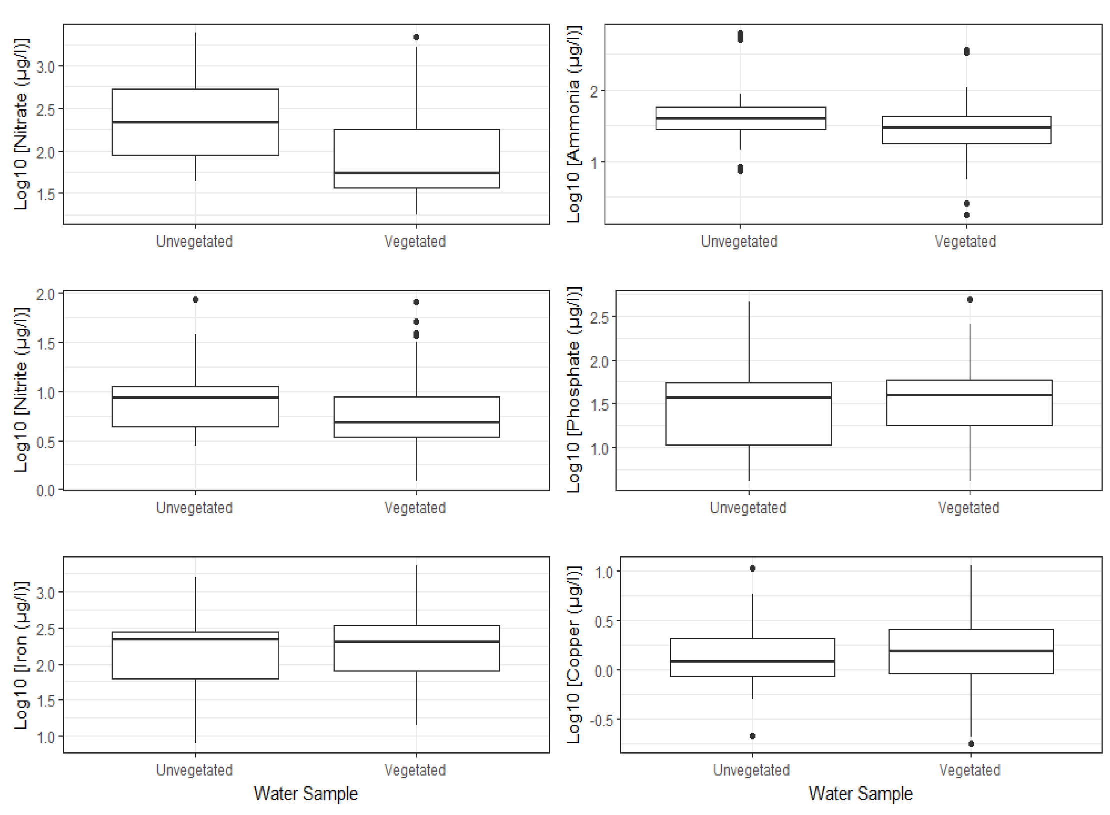

Fig.2. Selected element concentrations in water of areas where macrophytes are absent (unvegetated) and areas where macrophytes are present (vegetated).

- Nitrate and nitrate water concentrations are significantly lower in proximity to macrophytes suggesting that the presence of aquatic plants may actively buffer nitrate and nitrate levels in freshwater systems.

Q.2. Element sequestering by macrophytes

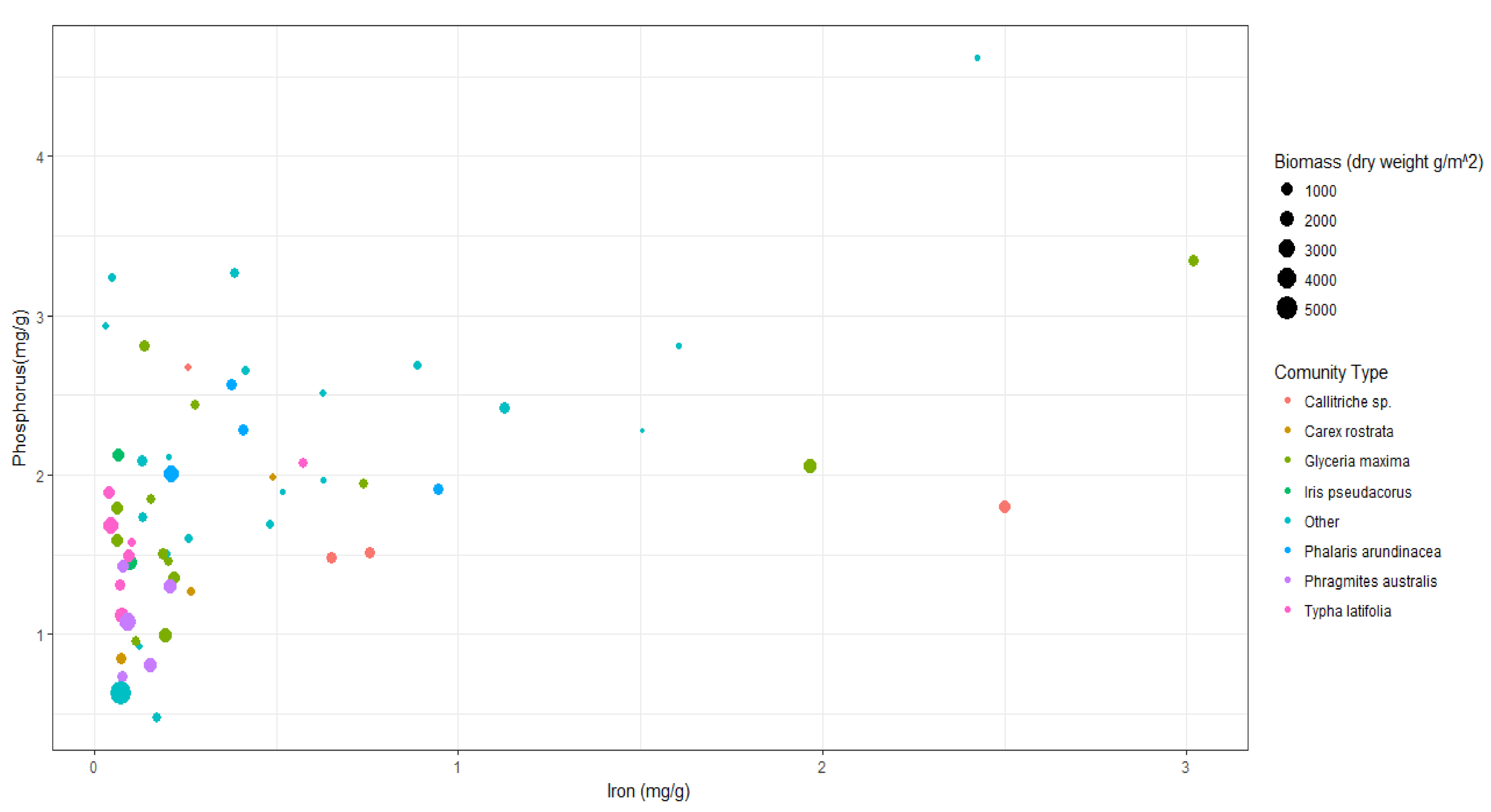

Fig.3. Phosphorus (mg/g) and Iron (mg/g) macrophyte tissue concentration where sample biomass (dry weight g/m^2) and plant community type (dominant species component) can be discriminated.

- Vegetation communities with *Glyceria maxima* as the dominant species show the greatest multi-pollutant potential for both phosphorus and iron (Fig.1.).

Q.3. Element storage potential of wild macrophyte communities

	Harvestable element content per macrophyte stand (g)			
	Phosphorus	Iron	Copper	Zinc
Max	2051.19	403.43	8.56	33.93
Min	0.06	0.04	0.01	0.002
Mean	158.02	28.94	0.39	2.11

Table 1. Mean harvestable element content per macrophyte stand (g) for selected elements

- There is potential for harvesting meaningful quantities of elements from vegetation stands, especially from high biomass stands (Fig.4.). Water quality may be improved by annual harvesting of these stands.

3. Future work

3.1 Field Survey data analysis

- Further identify macrophyte communities with multi-pollutant potential and associated ecosystem services;
- Quantify land use around sites through a GIS-based approach to investigate targeting phytoremediation strategies linked to land-use around freshwaters;
- Use element storage potential in macrophyte communities to scale up phytoremediation potential in Scotland.

3.2 Project

- Conduct further fieldwork trials of different vegetation communities and their phytoremediation potential;
- Develope ecological engineering solutions for optimal deployment of macrophytes in the field (e.g. floating treatment wetlands) (Fig.5).

Fig.4 *Typha latifolia* dominated community with multi-pollutant remediation potential

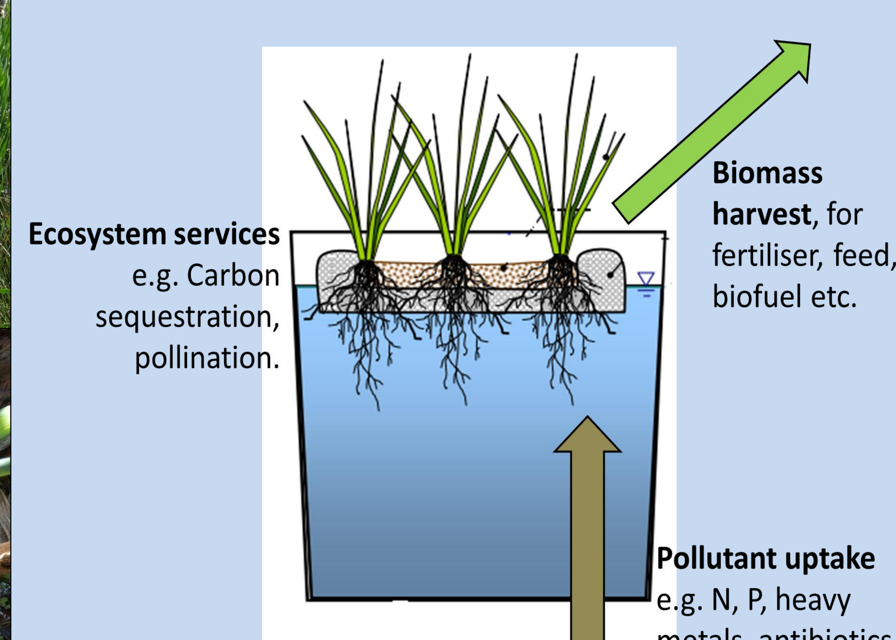

Fig.5 Floating treatment wetland experiment concept, experiments to commence Spring 2018

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