Natural systems for phosphorous removal from wastewater

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The challenge

The application of the European Union's **Water Framework Directive** will lead to stricter consents for wastewater effluents discharge and in particular for the release of phosphorus (P) such that **very low phosphorus concentrations,** down to 0.1 mg P/L, will need to be achieved. Phosphorus removal from wastewater in conventional treatment is achieved by modified activated sludge for biological nutrient removal (BNR), by coagulation or a combination of both processes. Both are successful at meeting current consents but become less attractive when meeting lower target levels due to **concerns over the robustness of performance delivery and excessive use of chemicals and energy**. It is also important to note that these technologies are **not suitable for small sewage treatment works**.

Biological Nutrient Removal (BNR)

Advantages:

- **Remove both P and N** from wastewater.
- Generate biosolids during the process, therefore offering potential for **resource recovery**.
- Produce biogas (**energy**) by anaerobic digestion of the waste sludge.
- **Nutrients** can be recovered as fertiliser by direct land application of the nutrient-rich biosolids or by struvite crystallisation in the sludge liquor.

Disadvantages:

- **Require specific operational conditions** that can't be met for all wastewaters.
- **Very low consents** are difficult to achieve.

Coagulation with metal salts (ferric or alum)

Advantages:

- A **proven technology** for P removal.
- Can be directly implemented in the biological treatment step of conventional systems or as a polishing step often in combination with sand filtration.
- Simple and efficient, this technology **can reach very low P levels**.

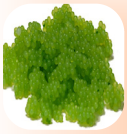
Disadvantages:

- Requires **large volumes of chemicals** to meet low P consents, hence generating **high volumes of sludge** that require treatment and disposal. In which case, this technology becomes **uneconomical**.
- Not suitable for **small works**

Novel technologies

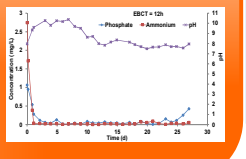
There is then a need for alternative technologies to meet this new stricter consent in particular for application in small sewage treatment works (STW). The aim of this task (WP3 – Task 3.4) is to investigate at demonstration scale two novel natural systems, an **immobilised algae bioreactor** and a **reactive media for reed bed** as tertiary treatment technologies for removal of phosphorus to low levels. As part of this, we will not only evaluate the potential of these technologies for **phosphorus removal** but also investigate any additional benefits such as **resource recovery** and **hazardous chemicals removal**.

Immobilised algae bioreactor (IABR)



Implementation of algae for nutrients removal from wastewater in either open ponds or closed photo bioreactors has been limited due to the costly downstream harvesting system and extended retention times (days) required. **Immobilised algae** in alginate beads offer a more viable approach as **harvesting is facilitated** and **high rate reactors** with shorter contact times can be implemented.

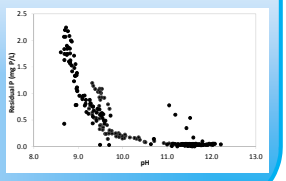
Trials of the immobilised algae photo-bioreactor at bench scale demonstrated the full potential of the system with **near complete removal of phosphate, ammonium and nitrate**. Similarly to BNRs, algae have the added benefit of **resource recovery** with **production of biogas** from anaerobic digestion of the harvested beads and **recovery of the nutrients** as fertiliser.



Reactive media reed bed (RMRB)

In this reed bed based technology, conventional reed bed media is replaced by a reactive media (i.e. **steel slag** a waste by-product from the steel industry) for P removal. The phosphates present in the wastewater to be treated reacts and precipitates with the calcium on the surface of the media and dissolved in the water.

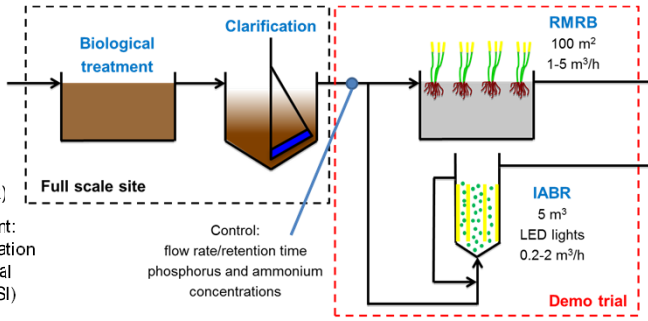
Reed beds are **passive systems** and are known to be **easy to implement and cheap to operate**. As a technology to be specifically applied at **very small works less stringent consents** will be expected (<1 mg P/L). Initial trials have demonstrated the potential of steel slag to achieve the **low P effluent concentrations** for discharge but this was associated with an **elevated pH** (>10).



Packington STW

32,000 PE
Oxidation ditch (BNR)

River Mease catchment:
Special Area of Conservation (SAC) & Site of Special Scientific Interest (SSSI)



Attributes:
Relatively low cost and passive solution
Reuse of a waste material

Areas of development:
Understand contact time requirements
pH and precipitate management

Attributes:
Relatively passive process
Removal of P & N
Energy production from AD of algal biomass

Areas of development:
Understand contact time and mixing requirements
Assess beads life and integrity
Assess energy production potential

Hazardous chemicals removal

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WatStech Water Science & Technology Group

SEVERN TRENT WATER