Making Biofuel Renewable: Sustainable Phosphorus Recovery from Microbial Biomass

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Introduction

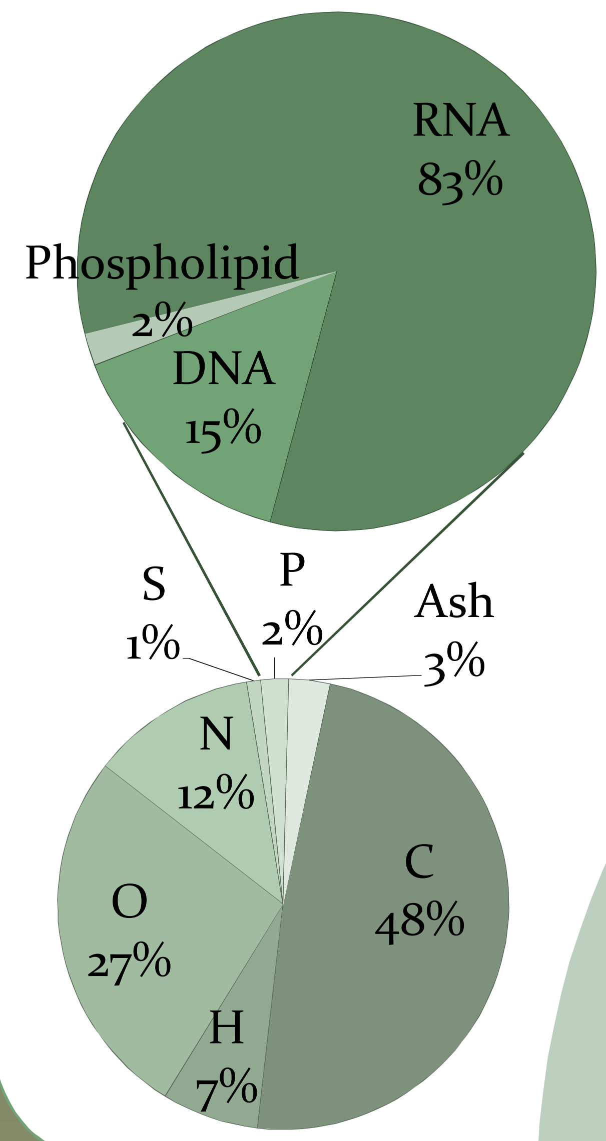
Global climate change and fossil fuel depletion indicate that future energy must come from biofuel. Biodiesel from photosynthetic microorganisms such as cyanobacteria and microalgae does not compete with terrestrial crops for food or arable land, but does require nutrient input. Unfortunately phosphorus (P) is also a limited resource that is critical to food security (Childers 2011). Therefore, P recycling is an important step in improving the overall sustainability of photosynthetic microbe biofuel production.

This poster presents preliminary results of a proof of concept P recycling process integrated with biofuel production. P in biomass is located and tracked though the biofuel production process. It is converted to a biologically useful form, then isolated from the resulting complex solution into a pure concentrate and captured for reuse.

Methods

Elemental analysis is conducted by persulfate digestion per Standard Method 4500-P.B.5 followed by ICP-OES. Sorbent testing is completed using sodium phosphate water at pH=5 with effluent concentrations measured by IC.

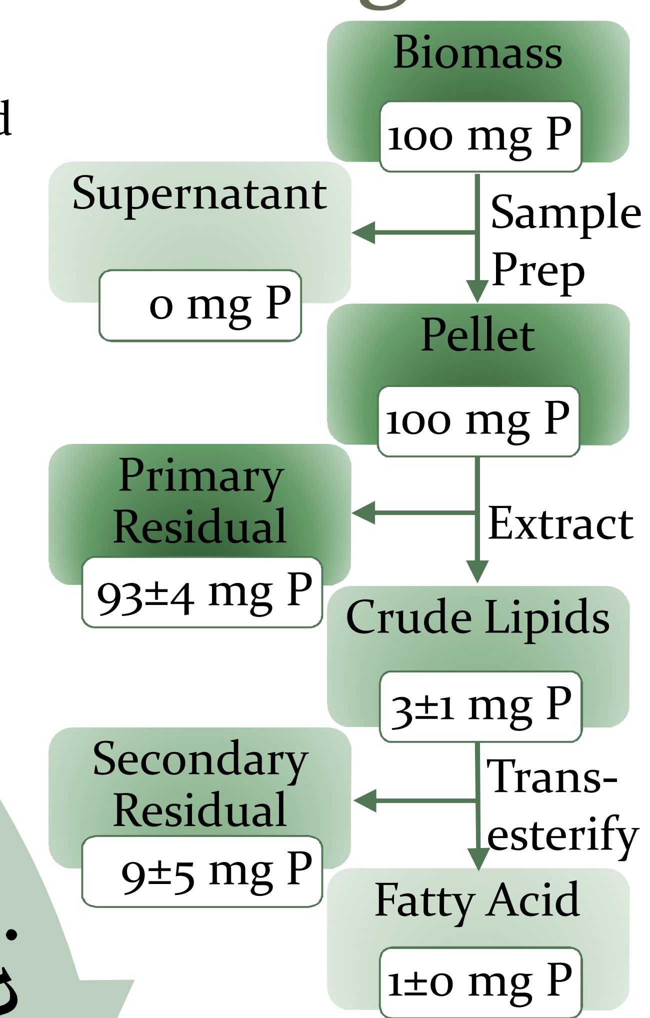
Biomass Composition

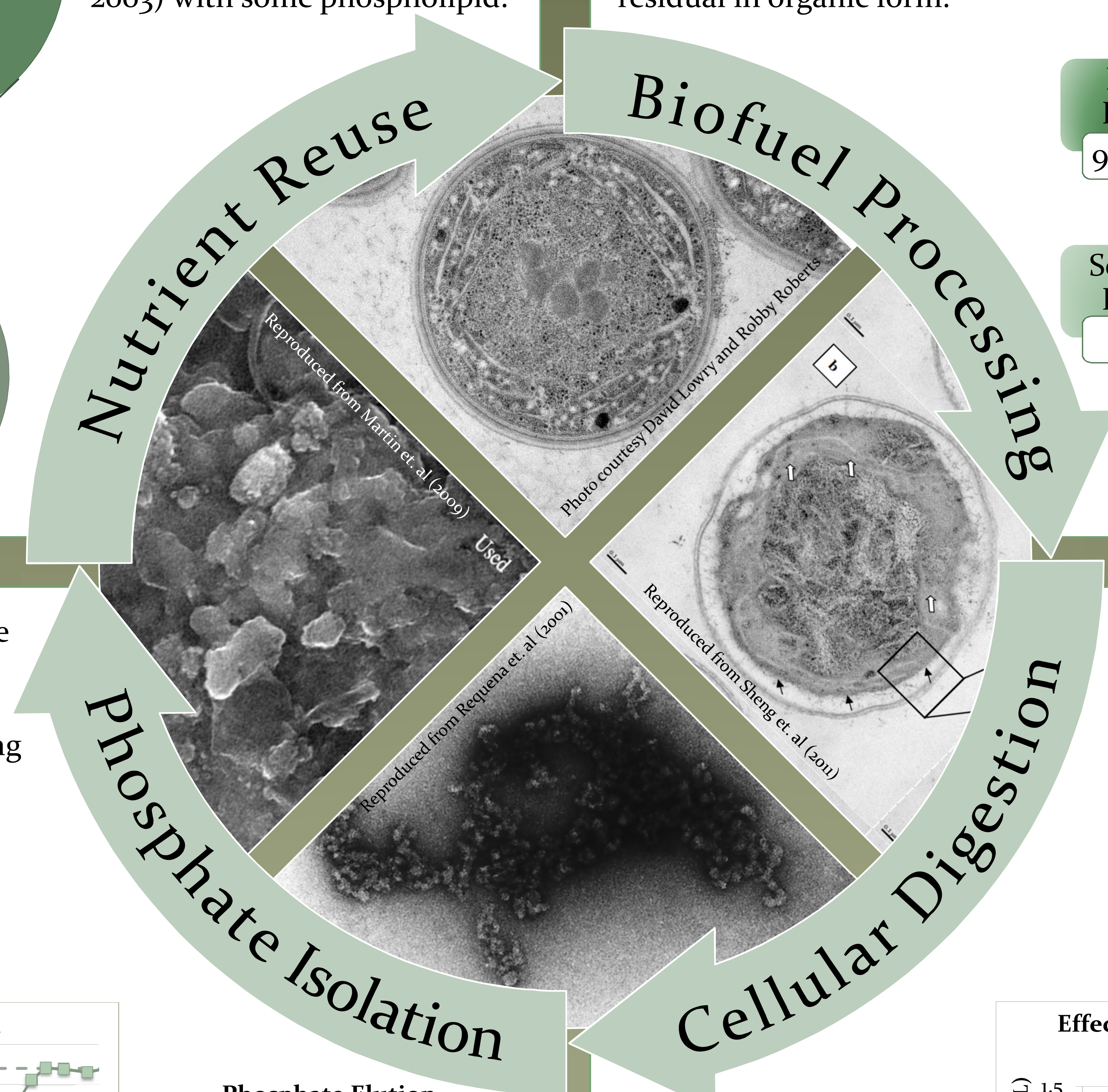


Synechocystis is 1.9±0.1% P by elemental analysis. Literature indicates 1.5% P by weight (Kim 2010), a majority of which is located in nucleic acid (Elser 2003) with some phospholipid.

Biofuel Processing

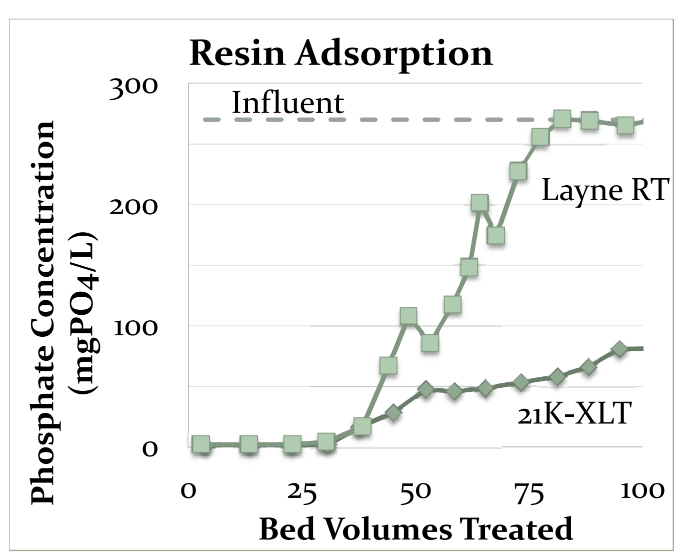
Microbes are converted to biofuel by extracting lipids and refining by transesterification (Sheng 2011). A vast majority of P remains in the primary residual in organic form.

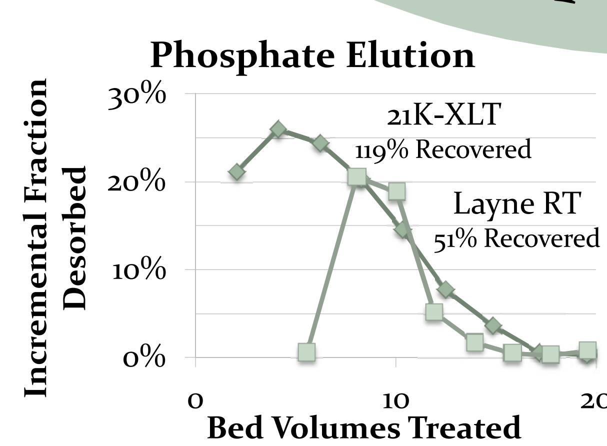




Anion Exchange

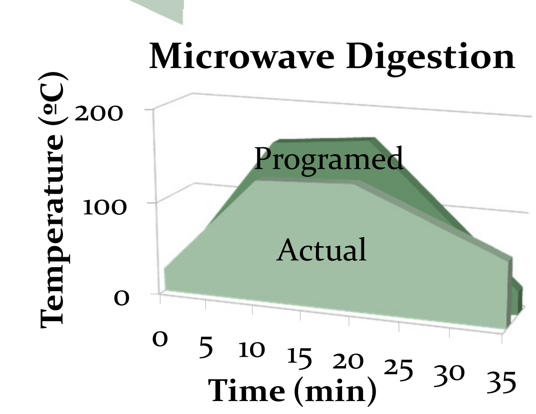
Layne RT, an iron-oxide impregnated ion exchange resin, and Dowex 21K-XLT, a strong base anion exchange resin, have high phosphate sorption capacity with ability to elute a concentrated solution of phosphate.

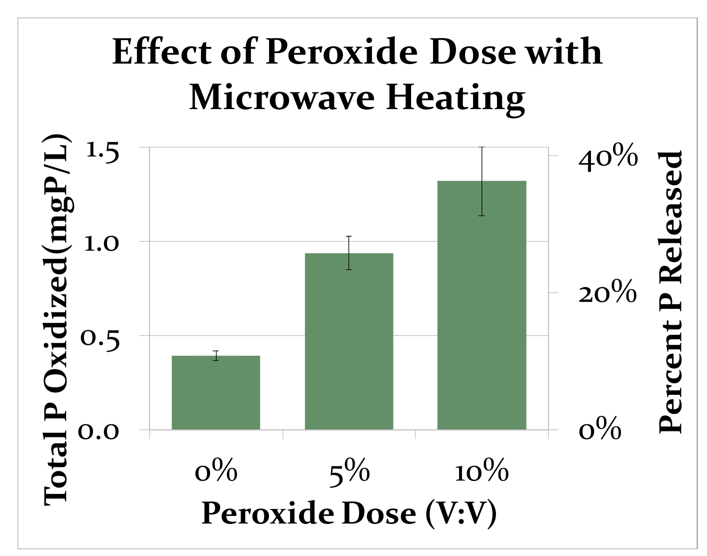




Microwave Oxidation

Microwave treatment with or without hydrogen peroxide effectively converts organic P to phosphate but is energy intensive. Other techniques are anaerobic digestion, application of acid and/or heat, and ozonation.





Impacts

P recycling for biofuel production is an interdisciplinary effort requiring collaboration with microbiologists, biofuel production specialists, sustainability scientists, and process engineers. The research aims to provide green energy by developing a renewable and carbon neutral technology. It conserves natural resources by reducing demand for fossil fuel and P ore. Preservation of nutrient sources provides food security and stability of social systems.

Broader applications include wastewater treatment and eutrophication mitigation. Wastewater sludge may be a renewable source of nutrients for fertilizer if they can be adequately captured, increasing food security. Improved recovery may also be applied to reduce nutrient load in agricultural runoff, maintaining natural water resource quality of downstream water bodies.

References

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