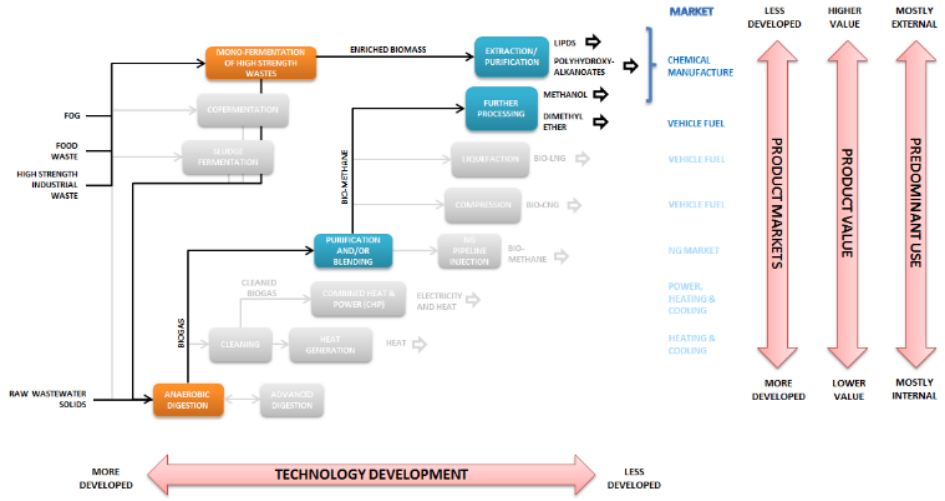
Executive Summary

THE Water Research FOUNDATION

Who moved my carbon?

A Multi-Platform Approach for Recovering High Value Carbon Products at Water Resource Recovery Facilities (NTRY4R14/4821)



Roadmap to the Recovery of High-Value Carbon Products from WRRF Wastestreams.

The Central Issue

Effective organic carbon management is critical for water resource recovery facilities (WRRFs) seeking to achieve electrically neutral or positive operating status, while also reducing nutrient removal costs. The emerging paradigm regarding carbon management at WRRFs practicing anaerobic digestion involves redirecting carbon from the liquid to solids phase of the process to maximize biomethane production, which can then be beneficially recovered. While energy recovery from biomethane can provide immediate benefits to many utilities, there are other valuable carbon products, such as volatile fatty acids (VFAs) and polyhydroxyalkanoates (PHAs), which have higher revenue potential than that associated with biomethane energy recovery.

Context and Background

This work provides insight that can help advance the use of carbon recovery technologies at WRRFs, and demonstrates the use of a multi-platform approach to facilitating high value carbon recovery from wastestreams. This platform uses VFAs as a building block, since VFAs are a remarkably flexible feedstock that can be used towards the production of high-value commodities and chemicals like lipids, biomethanol, or polyhydroxyalkanoates (PHAs). An Excel-based tool was created which utilities can use to consider the economic benefits and/or drawbacks of implementing carbon recovery. The project's goal was to increase knowledge regarding carbon recovery technologies to facilitate a more rapid shift by utilities to embrace resource recovery as a method for generating high value carbon products.

Findings and Conclusions

The market assessment confirmed that high value carbon products like VFA, alcohols, PHA, and lipids are promising end-products that should be considered by utilities that are interested in maximizing the value of carbon. The researchers' experimental fermentation work demonstrated that increasing organic loading rates can increase total carboxylic acid concentrations, but not increase particulate chemical oxygen demand (pCOD) hydrolysis in fermenters. Additionally, it was demonstrated that increasing pH and solids retention time (SRT) can help boost acidogenesis in co-fermentation systems, which can increase VFA production. A look at experimental PHA production work demonstrated that coupling fermentation with PHA production was feasible. Additionally, findings indicated that multi-pulse feed can increase PHA yield versus single pulse feed regimes with fermentate and that PHA yield in combined fermentation/PHA production systems is limited by the mass and purity of VFA available in the fermentate.

Management and Policy Implications

The results of this research provide utility managers, utility research and development managers, and sustainability managers with a market analyses for four categories of high value carbon products (VFAs, alcohols, PHAs, and lipids) and includes product conversion rates for

fermentation and PHA production from systems utilizing primary solids and high strength organic wastes. It identifies operational and process changes that utilities can use in their existing fermentation systems to maximize VFA production. The TERRY-Carbon tool developed in this study can assist utility personnel who want to consider implementing carbon recovery at their facility.

Related WRF Research

Project Title	Research Focus
Beyond Nutrients: Recovering Carbon and Other Commodity Products from Wastewater (NTRY3R13)	Demonstrates that the recovery of high value carbon products and non-nutrient commodity products is the next step in resource recovery and that the recovery of these products is contingent not only on the availability of mature, reliable, and cost competitive technologies, but also on whether the implementation of these technologies is synergistic with the goal of producing a high-quality effluent that can be discharged to the environment or reused without being detrimental to human and environmental health.
Producing Value-Added Biopolymer from Methane Gas Generated by Water Resource Recovery Facilities (NTRY5R14)	Explores optimal integration of biopolymer production and WRRF processes and demonstrates that untreated biogas produced at WRRFs can be used as a viable feedstock to produce PHA. The project team found that converting biogas into biopolymers was more than three times more economical than converting it to electricity and more than two times more economical than converting it to vehicle fuels.
Extraction of Lipids from Wastewater to Produce Biofuels (U3R13)	Demonstrates that extraction of lipids from wastewater greases to produce biodiesel has environmental benefits, despite challenges with the economic and practical implementation of producing biodiesel from wastewater grease. While there are also challenges to purify the biodiesel product to reliably meet on-road fuel specifications, producing biofuels from wastewater greases helps to recover useful resources from wastewater.
Carbon Capture and Management Strategies for Energy Harvest from Wastewater (U3R14)	Facilitates the design and optimization of high-rate processes to improve the conditions associated with carbon sorption (energy efficient) and carbon oxidation (energy inefficient). Identifies process control strategies for optimized HRP processes, a cost-effective means of removing carbon while reducing the aeration demand and volume requirements from WRRFs.
Fermenters for Biological Phosphorus Removal Carbon Augmentation (NUTR1R06g Compendium)	Presents key questions related to the use of fermenters for Bio-P removal in a frequently asked question and answer format, providing an overview of the process.

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