ACREC FINAL REPORT
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RENDERING CO-PRODUCTS AS ELECTRON DONORS FOR SUBSURFACE REMEDIATION: A new market for rendered co-products

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Project Start Date: May 10, 2017
Project Completion Date: August 30, 2018
Project Duration: 15 months

Lay Summary of Work

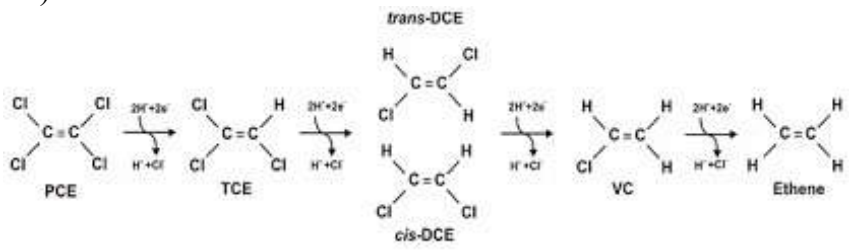
All data demonstrated that substantial number of animal co-products served as electron donors for TCE reduction to ethene. In the final report below we report that all co-products tested to data facilitate the reactions of interest. Several of the co-products promote biodegradation at a rate faster than commercially available electron donors.

Overview of Project and Goals

The broad of objective of the proposed research is to demonstrate that mid and low value animal co-products will serve as electron donors for three major environmental contaminants. The specific objectives of the proposed work are to: 1) identify the types of co-products that will work as electron donors, which are effective enough to supplant "designer electron donors" currently marketed, 2) quantify the rate and extent of trichloroethylene (TCE), hexavalent chromium, and mixed energetics with the best co-products, and 3) conduct a market analysis on use of these products based on five vendors within the industry.

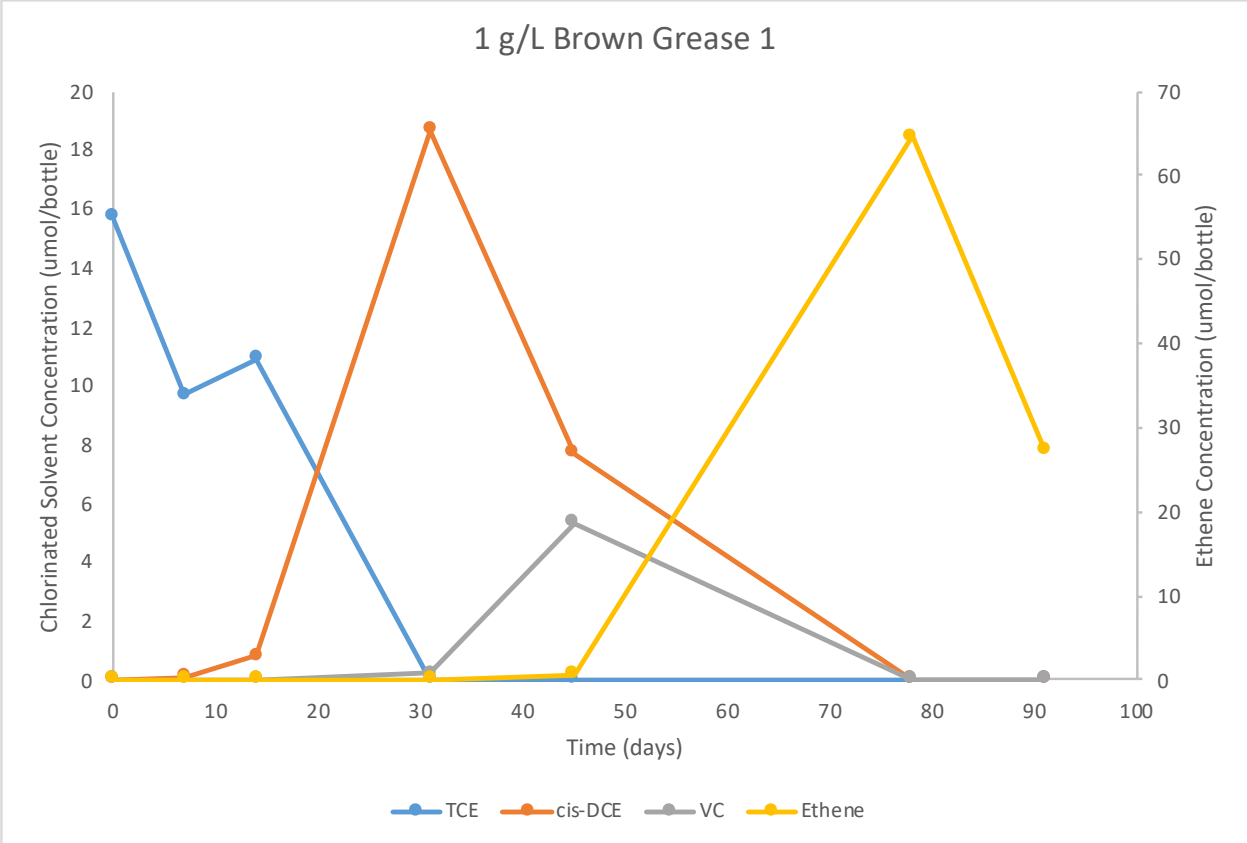
Project Overview

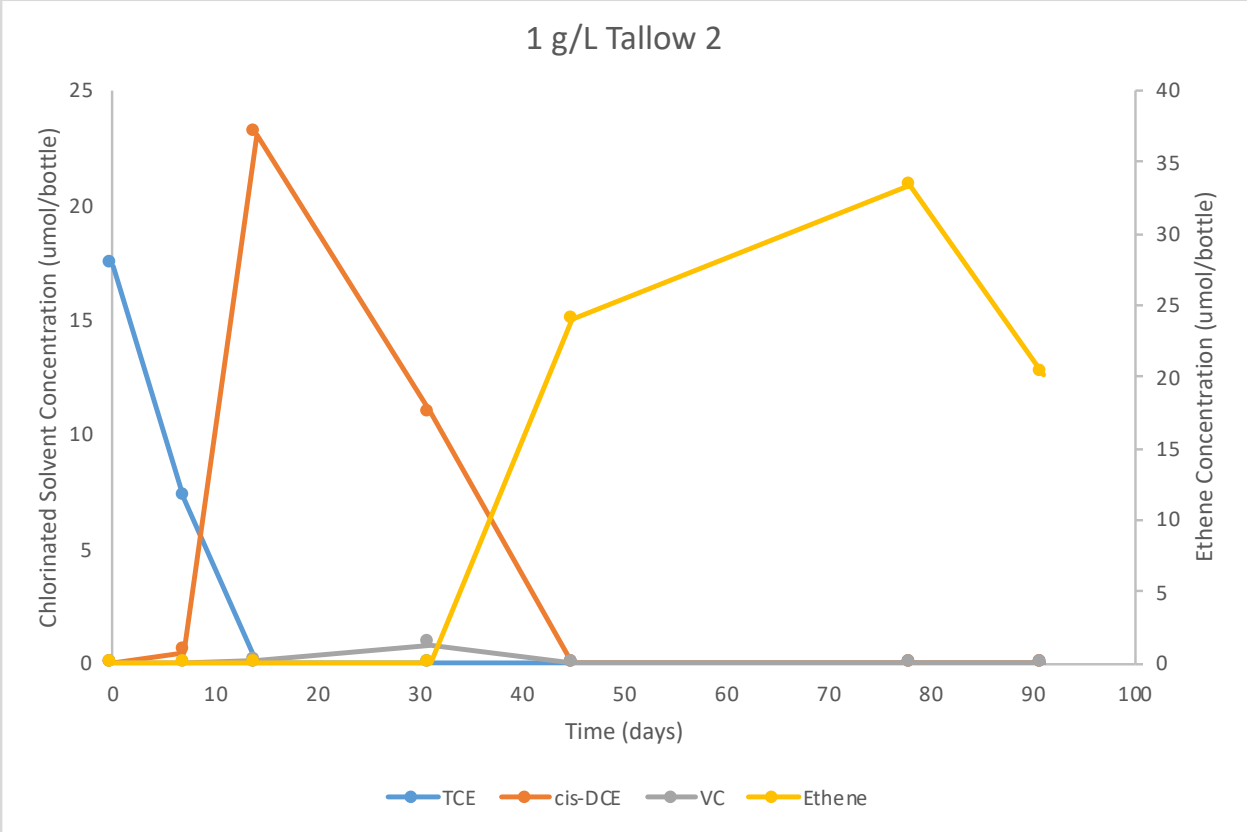
Trichloroethylene (TCE) contaminated aquifer material was used in all year 1 experiments. It was from a site at which I am the lead remediation consultant (representing my company Finneran Environmental, LLC). The site has contributed material to my research in the past. The figure below demonstrates the strategy we are using, which is to add the co-products as electron donors, to stimulate complete TCE reduction to the innocuous end product ethylene gas (also called ethene).

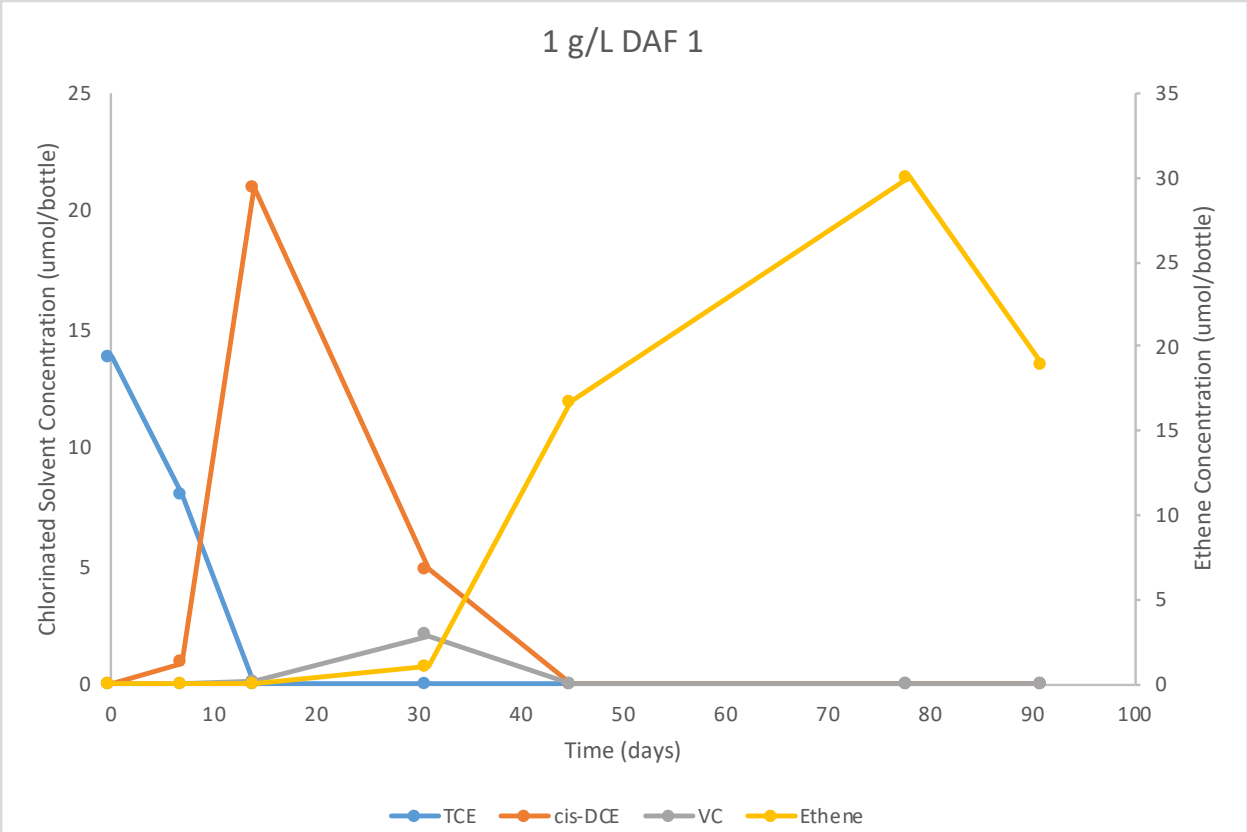


The goal was simple: add "raw" co-products at 1g/L without any pre-treatment and stimulate native microorganisms to reduce TCE to ethene. One mol of TCE becomes 1 mol of ethene, so success was operationally defined as ethene production at or near 1:1 stoichiometry between TCE reduced and ethene generated. We tested the co-products versus several control electron donors, which have been reported in the literature and that are currently vended in the remediation marketplace.

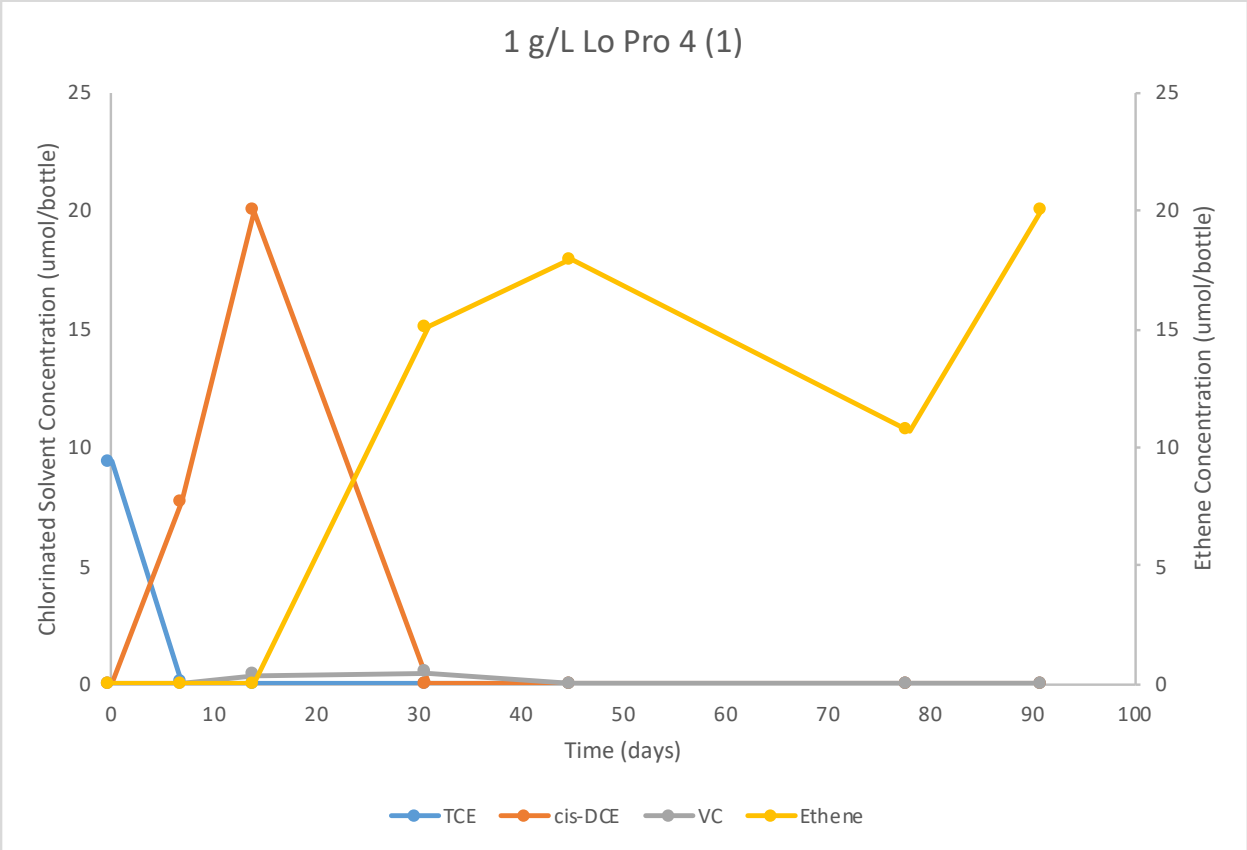
The plot below is TCE reduction with brown grease, tallow, and DAF as the sole electron donors. These are typical plots generated for most co-products tested, but brown grease has been reported as one of the lowest value materials being tested. TCE was completely reduced to ethene in 40-80 days with co-products. This was as fast as any of the current commercial vendor material tested (80-85 days to complete reduction). As I said when we met last year – I don't need to be better than the current materials, just as good as them since this material is much less expensive.




1 g/L Tallow 2
Chlorinated Solvent Concentration (umol/bottle)
Ethene Concentration (umol/bottle)
Time (days)
TCE
cis-DCE
VC
Ethene


1 g/L DAF 1
Chlorinated Solvent Concentration (umol/bottle)
Ethene Concentration (umol/bottle)
Time (days)
TCE
cis-DCE
VC
Ethene

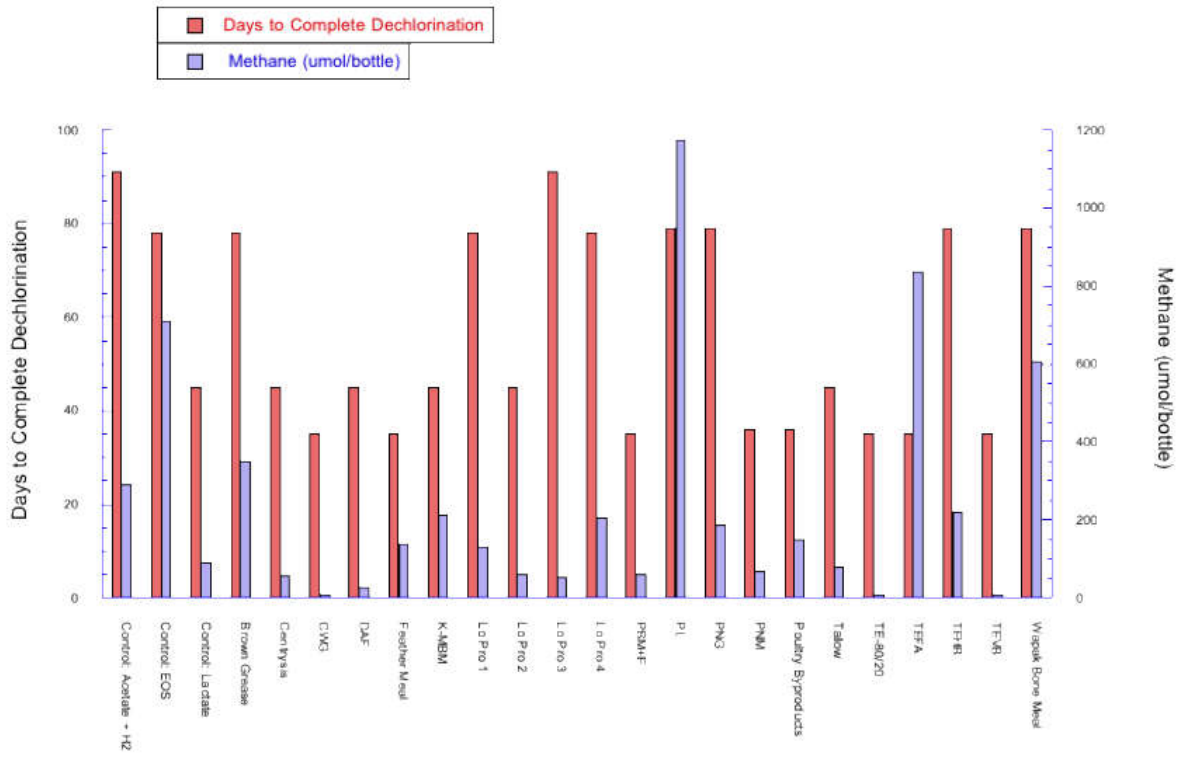
The plot below is for a higher value product, LoPro 4, but it is clear to see that it worked very well. Ethene was nearly stoichiometric at day 30, which is extremely fast. Our phase 2 work will focus on combining small masses of high value product into large masses of lower value products, to simultaneously optimize performance and cost.



To date this project has gone better than could have been imagined. Our initial year was meant screening year, with single co-product use (as raw materials). We are already optimizing the single co-products, and our phase 2 work is focusing on co-product combinations.

Many of the materials are in fact better than those currently available. The figure below demonstrates the TCE:ethene stoichiometry for all co-products tested, so the ACREC members can see how its material fared.

However, many of the materials are in fact better than those currently available. I have included a figure demonstrating the TCE:ethene stoichiometry for all co-products tested, so the ACREC members can see how its material fared.



Impacts and Significance to the rendering industry

The goal of this work was to develop novel electron donors (also called remediation substrates) for the soil and groundwater remediation industry, derived from animal co-products. The theme of the underlying science was this: there is a wide array of contaminants for which electron donors are amended into the subsurface as the primary remediation strategy. Recent shifts in the industry have coalesced around using higher molecular mass lipid and protein-based electron donors, and the rendering industry has a number of co-products that are similar to very expensive designer molecules being used. The science is not disputable; adding rendering co-products as electron donors for remediation works very well. This project unequivocally demonstrated that raw material co-products are excellent electron donors for environmental remediation. The work has progressed to a provisional patent, and we are working with two companies to develop this into a full patent by the end of the phase 2 project period. This project has identified a new, realistic market for rendering co-products.

Intellectual Property Development

Provisionally patented: Patent # 62/690,573
http://curf.technologypublisher.com/technology/28452

Currently discussing licensing with two companies: Tersus Environmental (NDA in place), and Provectus Environmental Products. Tersus has discussed options that include opening a SC branch to vend the product in SC and throughout the Southeast.

Publications
Due to patenting we have not submitted a manuscript. This was disclosed in a presentation at the Society for Industrial Microbiology (SIMB) meeting in August of 2018 (Chicago IL). We currently have two upcoming talks: NRA National Meeting (October 2018), and NGWA Groundwater Summit (December 2018).

Outside Funding
We have begun SBIR proposals with the prospect of Tersus Environmental serving as the outside small business. We have obtained Clemson student funding (John Houston) to offset the cost of the project (fully funded MS student for 2 years). We are submitting a proposal in the upcoming NSF Environmental Engineering solicitation.

Future Work
Phase 2 of this project: **RENDERING CO-PRODUCTS AS ELECTRON DONORS FOR SUBSURFACE REMEDIATION: Optimization with co-product mixtures**, was funded and began in August of 2018.

Acknowledgements
This work was completed by Alexander Rogier (MS 2018), Thomas Dick (BS 2018), Kameryn McGee (MS 2018), and with limited support by several Finneran Research Group undergraduate RAs. John Houston (MS 2020), has taken over and is leading phase 2.