DOE Bioenergy Technologies Office (BETO)

2023 Project Peer Review

1.2.1.7 MSW Decontamination and Preprocessing

April 4, 2023

Feedstock Technologies

Vicki Thompson
Idaho National Laboratory

Battelle Energy Alliance manages INL for the
U.S. Department of Energy's Office of Nuclear Energy

Idaho National Laboratory

Project Overview

- *Project History*
  - *Seed project in FY20 to examine MSW as a potential feedstock*
  - *Decontamination strategies assessed, conversion improvements determined for enzymatic hydrolysis and microwave pyrolysis*
  - *TEA conducted to determine the cost of decontamination*
  - *Met the project goal to increase conversion rates of MSW by at least 15% at a cost no more than $25/ton*
  - *Successful merit reviewed proposal in FY21 for a full AOP project*
- *Project Goals*
  - *Understand types of contamination present and their impact on conversion yields*
  - *Develop decontamination strategies*
  - *Understand the TEA/LCA tradeoffs for these strategies*
  - *Sustainable Aviation Fuel Grand Challenge calls out MSW*
  - *Can MSW be utilized by itself or in blends as a SAF feedstock?*

1 – Approach

- *Previous research*
  - *Decontamination strategies assessed, conversion improvements determined for enzymatic hydrolysis and microwave pyrolysis*
  - *Met the project goal to increase conversion rates of MSW by at least 15% at a cost no more than $25/ton*
  - *Demonstrated proof of principle that MSW decontamination works and is cost-effective*
- *Approach*
  - *Identify most impactful MSW fractions focusing on rural and underserved communities*
  - *Identify contaminants and their impact on yields for fast pyrolysis and fermentation pathways*
  - *Identify decontamination strategies and conduct TEA/LCA*
  - *Determine role of blending MSW with other feedstocks*

1 – Approach

- *Challenges*
  - *Decontamination may be too expensive*
  - *Rapid shifts in MSW markets*
  - *Heterogeneity*
- *Go/No-Go*
  - *Demonstrate two blends of MSW with corn stover and pine residues*
  - *Cost less than $85.51/ton (FY16 $) with at least 10% MSW and comparable yields to stover and pine alone*
- *Risks and Mitigation*
  - *Rapidly shifting markets (paper shortage during pandemic)*
  - *Too expensive to decontaminate materials*
  - *MSW fractions may not be suitable for conversion pathways*

1 – Approach

- *Collaboration and Relevant Stakeholders*
  - *This project procured MSW for FCIC and helped source MSW for other FT projects*
  - *Collaborations*
    - *1.2.1.4 Co-Products from MSW*
    - *1.2.2.1051 and 1.2.2.2051 competitive BETO-FOAs with Amp Robotics*
  - *Work with Resource Recycling to understand stakeholder needs*
- *Diversity, Equity and Inclusion Approach*
  - *Target a rural community without access to recycling and an underserved community*
  - *Work with RRS to sample their waste streams*
  - *Characterize, decontaminate and assess yields as well as costs*
  - *Report results back to communities to inform their waste strategies*
  - *Use data to develop educational models (BRIDGE)*

2– Progress and Outcomes -

- *Project Management – 6 Tasks*
  - *Identifying and sourcing MSW from rural and underserved communities*
  - *MSW characterization and mapping*
  - *MSW storage*
  - *Mechanical Preprocessing and Decontamination*
  - *Screening MSW decontamination effectiveness and MSW blends*
  - *TEA/LCA*
- *Progress and Milestones*
  - *All tasks on track except storage*
  - *Concerns over potentially enriching for hazardous organisms had to be mitigated*
  - *The Q2 milestone to conduct two-week storage trials of MSW* ***is on track***
  - Go/No-Go milestone ***is on track to be met***

2– Progress and Outcomes – Rural Waste

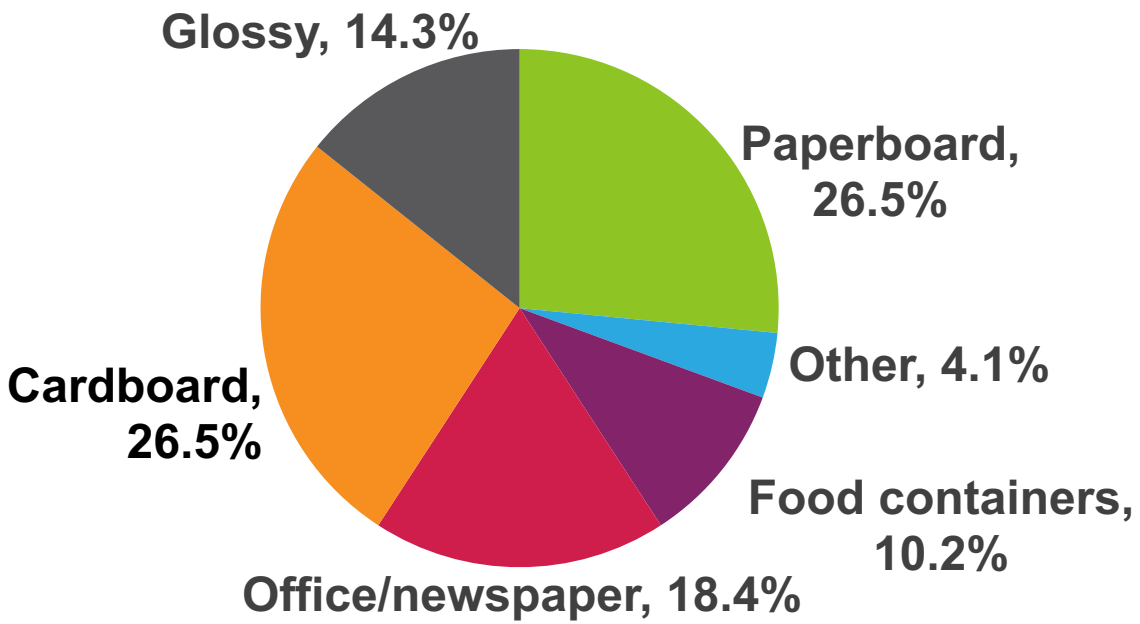
FY22 Q1 and Q2

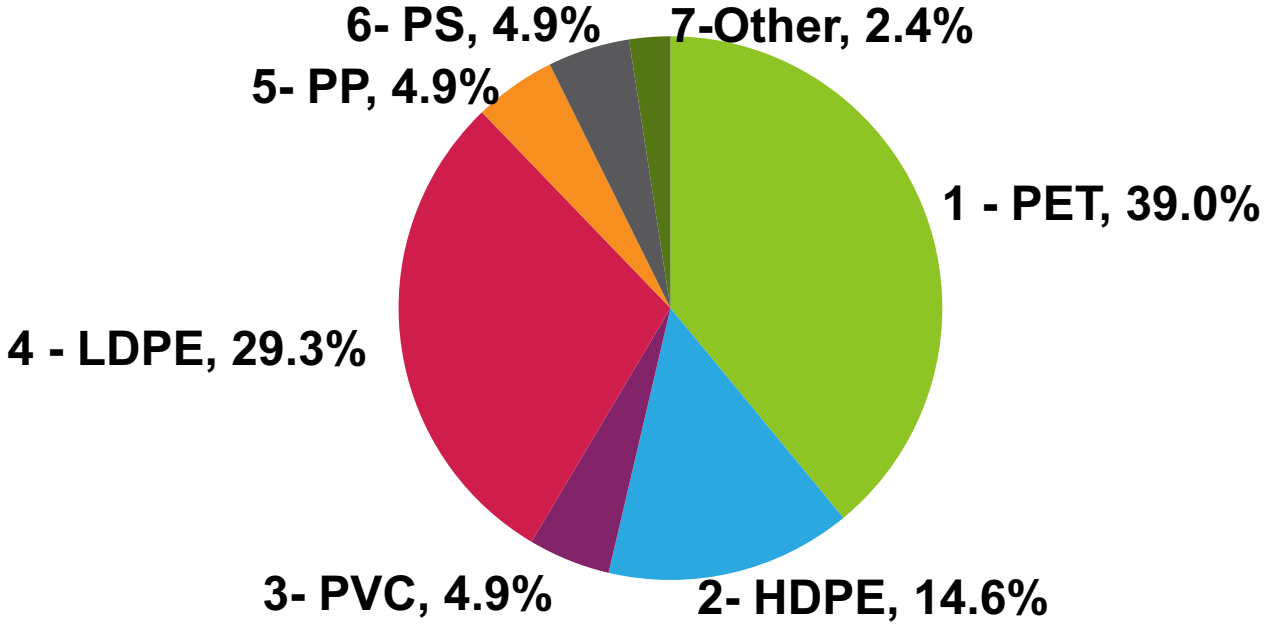
Q1 – source waste from at least one rural or underserved community

Q2 – characterize the waste streams

Salyersville, KY pop. 1536 in Magoffin County, pop. 11,500

Progress – received and characterized 50 kg of mixed paper and plastic





2– Progress and Outcomes – Decontamination

FY 22 Q3

Objective – Screen decontamination methods for contaminants identified in FY22 Q2

Progress – Identified contaminants in paper/cardboard and developed decontamination methods

Decontamination method	Paper fraction	Targeted contaminants
Blending	Newspaper	Acidic coatings
	Copy paper	Alkaline fillers
Acid wash (H_2SO_4)	Copy paper	Alkaline fillers
	Paperboard	Pigments and adhesives
	Cardboard	Adhesives
Alkaline wash (NaOH)	Newspaper	Acidic coatings
	Paperboard	Pigments/adhesives
	Cardboard	Adhesives
Dimethyl ether (DME)	Copy paper	Alkaline fillers
	Newspaper	Acidic coatings
	Glossy paper	Polyethylene, silicone, wax

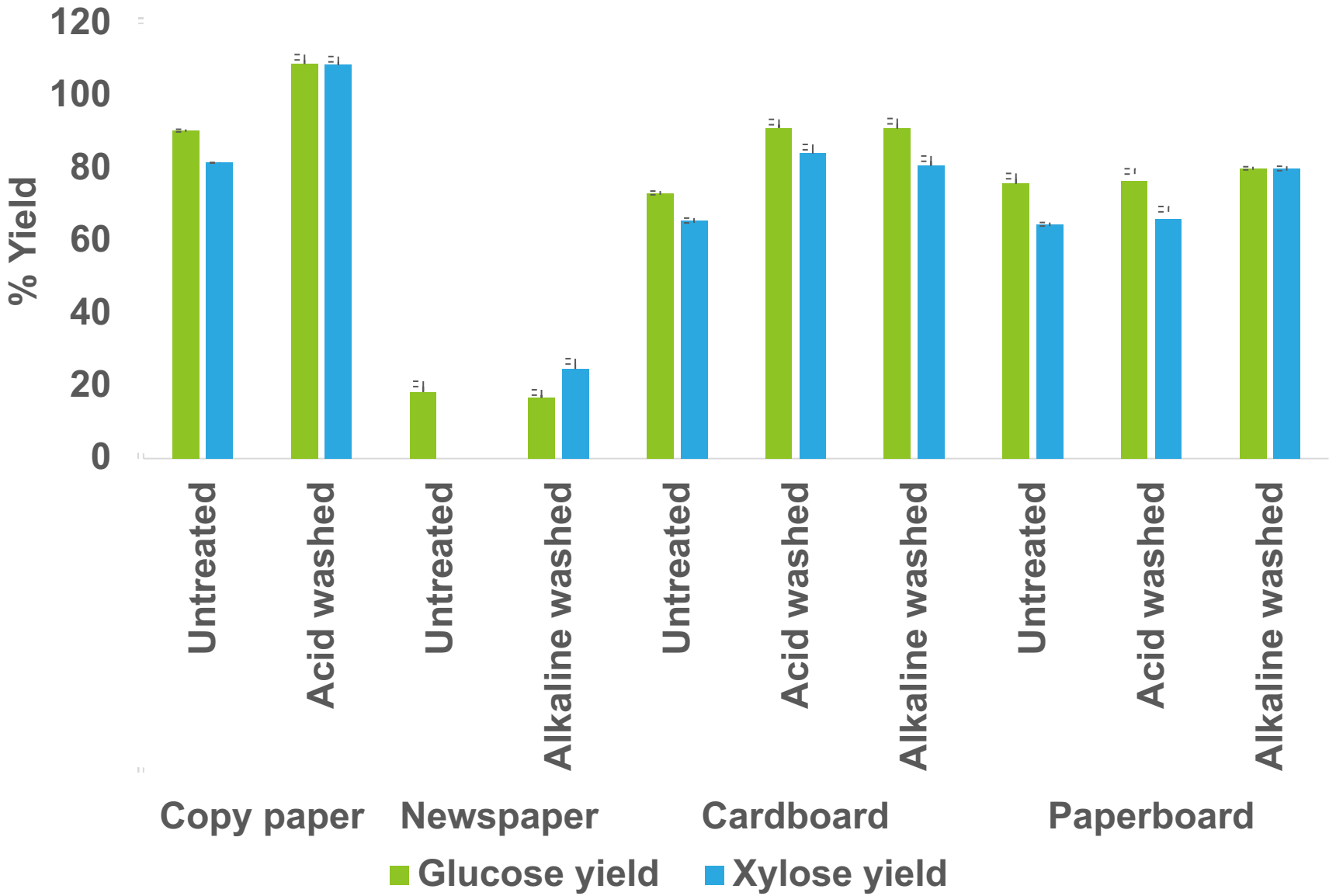
2– Progress and Outcomes – Decontamination

FY22 Q3 and Q4

Objective – Assess decontamination efficiency and conduct TEA/LCA

Progress – Enzymatic hydrolysis yields for treated materials and TEA

Treatment	Acid CP	Acid CB	Alkaline CB
Contaminant removal (%)	100	76-78	64-76
Cost $/ton	25	18	17
Milestone?	Yes	No	No



CP – Copy paper

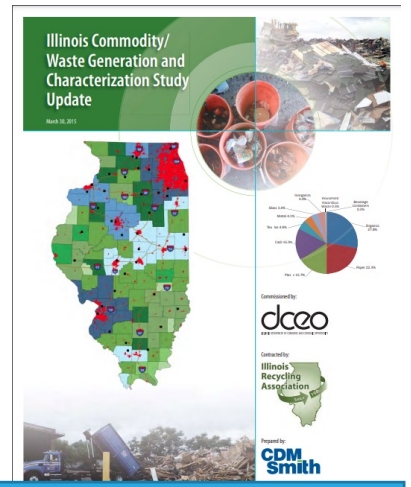
CB - Cardboard

2 – Progress and Outcomes – MSW Quality Mapping

FY23 Q1

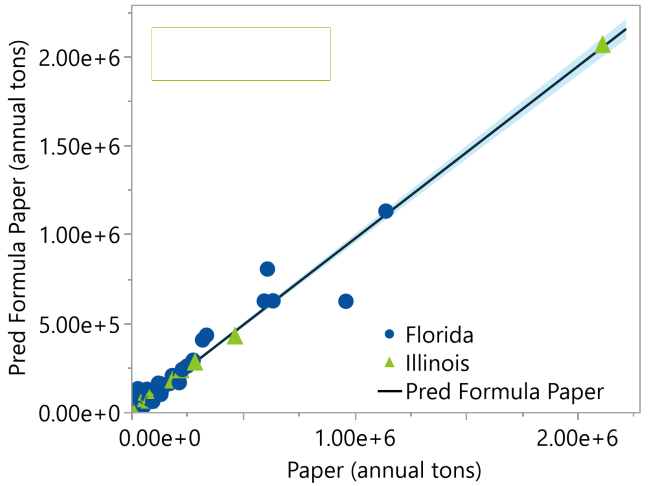
Task Objective: Develop quality variability models for MSW resources using spatial and temporal socioeconomic factors.

Progress: Proof-of-concept model demonstrating prediction of MSW fractions using socioeconomic spatial factors (counties in two states for one year).



State-Level Waste Generation Reports

Publicly Available County Level Socioeconomic Data



Multivariate Linear Regression Models

2– Progress and Outcomes – MSW Storage

FY23 Q2

Objective – Store MSW materials for a minimum of two weeks

Progress – Finally assembly of system underway. Textiles, grass clippings and food-soiled paper will be incubated at two moisture contents. Dry matter loss, compositional changes, temperature and gas production will be monitored.

2– Progress and Outcomes – MSW blending

FY23 Q2 Go/No-Go

Objective – Demonstrate two blends of MSW with corn stover and pine residues and determine cost, blend percentage, and conversion yield. Cost no higher than $85.51/ton, with at least 10% MSW and comparable yields to stover and pine residues alone.

Progress – Developed stover and paper/cardboard blends and plastic blended with either paper/cardboard or pine residues. Conversion screening and TEA in progress

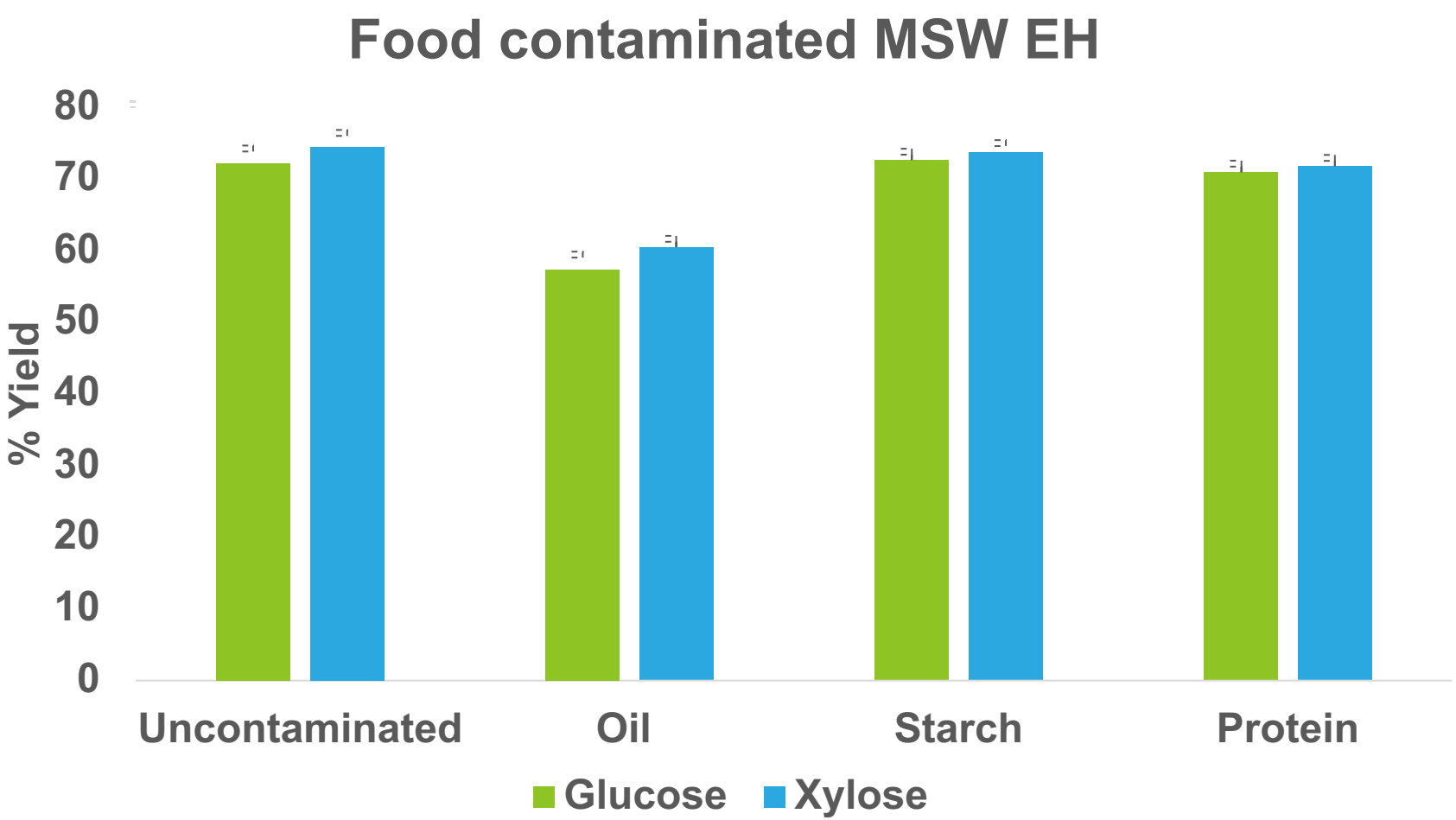
Enzymatic Hydrolysis Screening

95% corn stover + 5% copy paper
90% corn stover + 10% copy paper
80% corn stover + 20% copy paper
95% corn stover + 5% cardboard
90% corn stover + 10% cardboard
80% corn stover + 20% cardboard

Microwave Pyrolysis Screening

90% Corn stover + 10% multilayer paper
90% pine residues + 10% multilayer paper
90% Corn stover + 10% MRE multilayer
90% Pine residues + 10% MRE multilayer

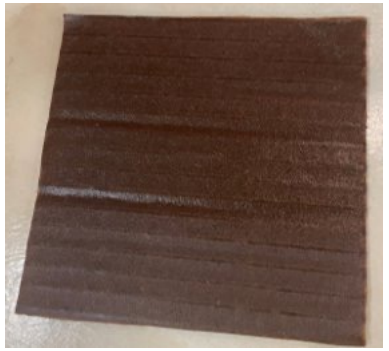
2– Progress and Outcomes – Contaminant Quantification



4.6 mg/cm^2

9.3 mg/cm^2

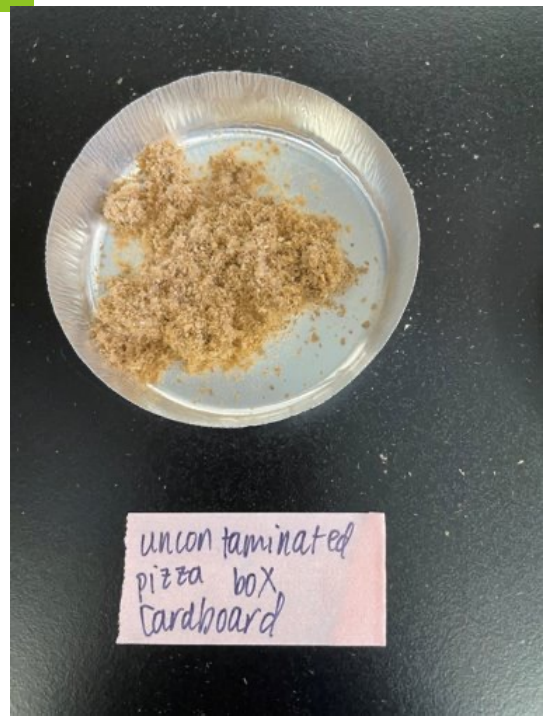
16.6 mg/cm^2

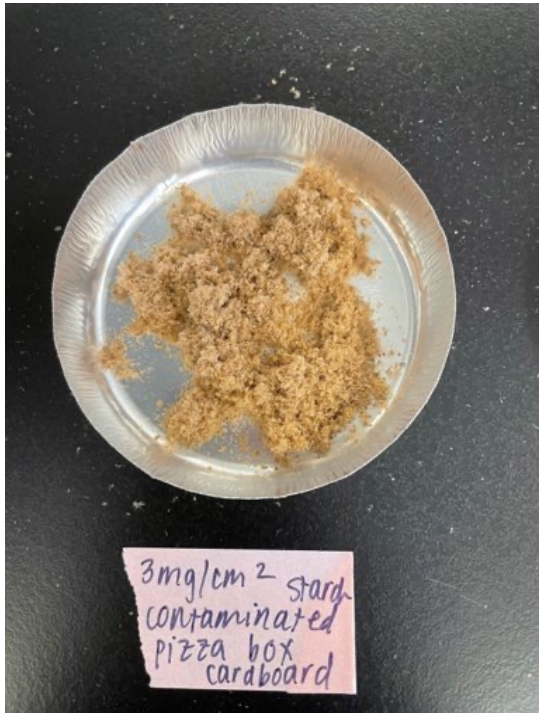


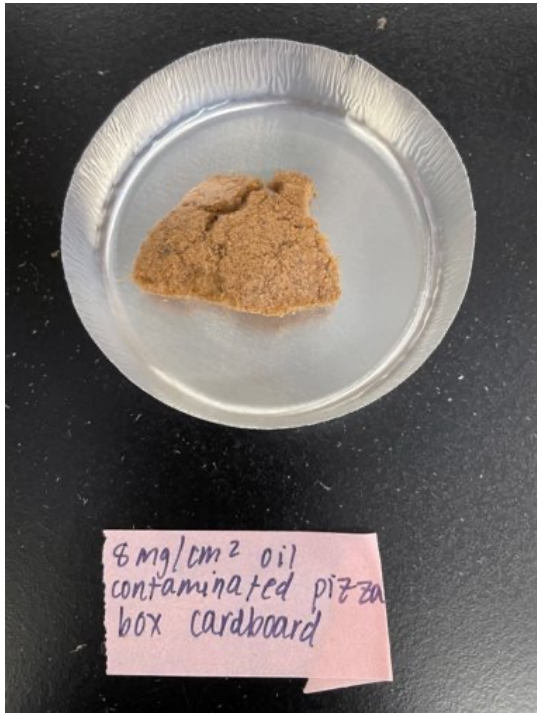
26.4 mg/cm^2

- Collect NIR, Raman, and XRF data
- Correlate spectral data to concentration and yield

2– Progress and Outcomes – Preprocessing







- Contaminants also have impact on preprocessing operations such as grinding
- Uncontaminated or lightly contaminated carboard is free flowing
- At 8 mg/cm^2 the material starts clumping and could lead to flowability issues

3 – Impact

- *China's National Sword Policy (2018)*
  - *Banned mixed paper and plastics unless contamination <0.5%*
  - *Typical materials recovery facilities contamination levels 15-20%*
  - *Many U.S. cities discontinued or scaled back recycling programs*
  - *Value per ton of mixed paper and plastics became negative*
- *A solution*
  - *Mixed paper and plastics could be feedstocks for fermentation and fast pyrolysis conversion to SAF*
  - *Provide markets for displaced materials*
  - *Contribute to a circular economy*
- *Dissemination of Results*
  - *Work with RRS to reach industry stakeholders*
  - *Publications in high impact journals and trade journals*
  - *Presentations at trade shows and conferences*
- *DEI*
  - *Understanding the needs and impacts to these communities*

https://www.recyclingtoday.com/article/swana-arf-report-highlights-national-sword-impact-solutions/

Summary

- *Approach*
  - *Tasks designed to identify cost effective approaches to convert MSW to SAF*
  - *Targeted Go/No-Go decision point*
  - *Mitigation strategies developed for identified risks*
- *Progress*
  - *Sourced waste from a rural community and agreement with Sho-Ban almost complete*
  - *Demonstrated socioeconomic factors can predict MSW generation*
  - *Demonstrated decontamination methods are less than $25/ton and can improve conversion yields at least 20-30%*
- *Impact*
  - *China's National Sword policy collapsed existing waste recycling markets*
  - *Waste industry is looking for solutions*
  - *SAF Grand Challenge calls out using 55 million tons/year MSW to meet goals*

Quad Chart Overview

Timeline

- *Project start date: 10/01/2021*
- *Project end date: 9/30/2024*

	FY22 Costed	Total Award
DOE Funding	*$733,749*	*$2,850,000*
Project Cost Share *		none

Project Goal

The goal of this project is to develop cost effective decontamination strategies for non-recycled MSW that enables these materials to be utilized as feedstocks for sustainable aviation fuels

End of Project Milestone

Preprocessing decision matrices to process and decontaminate MSW streams for fermentation and pyrolysis pathways to aviation and marine fuels. Demonstrate these unit operations for MSW sourced from underserved communities

Funding Mechanism

2021 Lab Call

TRL at Project Start: 3:
TRL at Project End: 4:

Project Partners*

- Resource Recycling Systems

*Only fill out if applicable.

Additional Slides

Responses to Previous Reviewers' Comments

- Concern about biohazards
  - INL's safety staff have been engaged to better understand likely biohazards
- Future directions for the project
  - The SEED project was successfully converted to a three year AOP project with expanded scope to explore variability of this feedstock
- Changing landscape of waste
  - We have a subcontract with Resource Recycling Systems who provides consultation to the waste industry to better understand this issue.
- Go/No-Go – none during the review period

Note: This slide is for the use of the Peer Reviewers only – it is not to be presented as part of your oral presentation. These Additional Slides will be included in the copy of your presentation that will be made available to the Reviewers.

Publications, Patents, Presentations, Awards, and Commercialization

Publications

- Brown RM, Hoover AN, Klinger JL, Wahlen BD, Hartley D, Lee H and Thompson VS (2022). *Decontamination of Mixed Paper and Plastic Municipal Solid Waste Increases Low and High Temperature Conversion Yields.* Front. Energy Res. 10:834832. doi: 10.3389/fenrg.2022.834832
- Brown RM, Hoover AN, Klinger JL, Wahlen BD, and Thompson VS (2023). *Decontamination Strategies to Increase Fuel and Product Conversion Yields of Municipal Solid Waste.* [Manuscript submitted for publication].

Conference presentations:

- "MSW Decontamination: Methods to Improve Biofuel Yields," *Waste Conversion Technology Conference*, San Diego, CA, August 2022.
- "Decontamination of Mixed Paper and Plastic Municipal Solid Waste Increases Low and High Temperature Conversion Yields," *Symposium on Biomaterials, Fuels and Chemicals*, New Orleans, LA, April 2022.

Patents

- Methods of removing water from a solid porous material via solvent-driven pore displacement – File 10/12/2022

Note: This slide is for the use of the Peer Reviewers only – it is not to be presented as part of your oral presentation. These Additional Slides will be included in the copy of your presentation that will be made available to the Reviewers.

Idaho National Laboratory

Battelle Energy Alliance manages INL for the U.S. Department of Energy's Office of Nuclear Energy. INL is the nation's center for nuclear energy research and development, and also performs research in each of DOE's strategic goal areas: energy, national security, science and the environment.