

Material Attributes of MSW that Impact the Quality for Hydrothermal Processes (HTP): Pathways and Feedstock End-Uses

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Wan-Ting (Grace) Chen

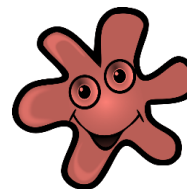
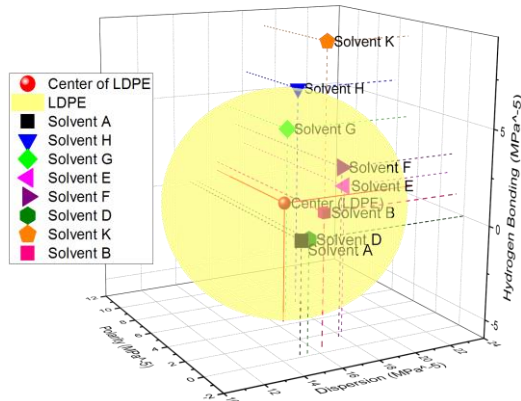
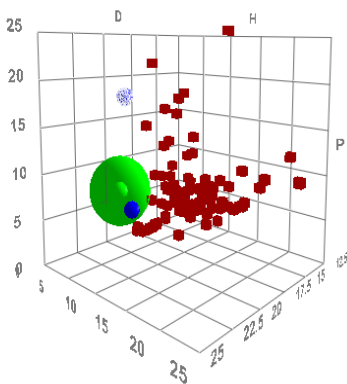
University of Massachusetts Lowell



OUTLINE

- Introduction
 - The PERL group at UMass Lowell
 - Material characteristics in MSW
 - Hydrothermal processing (HTP)
- High-ash MSW feedstock
 - Mixed-culture Algae from Wastewater
 - Plastic Waste
- High-fat MSW feedstock
- Recommendations

Hydrothermal Processes Selective Solvent Extraction Biodegradation



Raw Materials from Polymer

 Clean Fuels	 Solvents, Monomers
 Dyes, Flame Retardants	 Pristine Polyolefins

Plastics and Environment
Research Laboratory

PERL



ONGOING RESEARCH PROGRAMS AT THE PERL GROUP

- Plastic Recycling
 - Hydrothermal processes to convert ocean plastic waste into fuels, aromatics, or monomers.
 - Smart solvent formulations to extract valuable plastics, additives, and metals.
 - Microplastic pollutants mitigation and separations.
- Bioplastic Development
 - Biodegradable mulch films from soy waste.
 - Degradation mechanism in packaging barrier materials.
 - Biobased polymers and biocrude oil converted from biowaste.



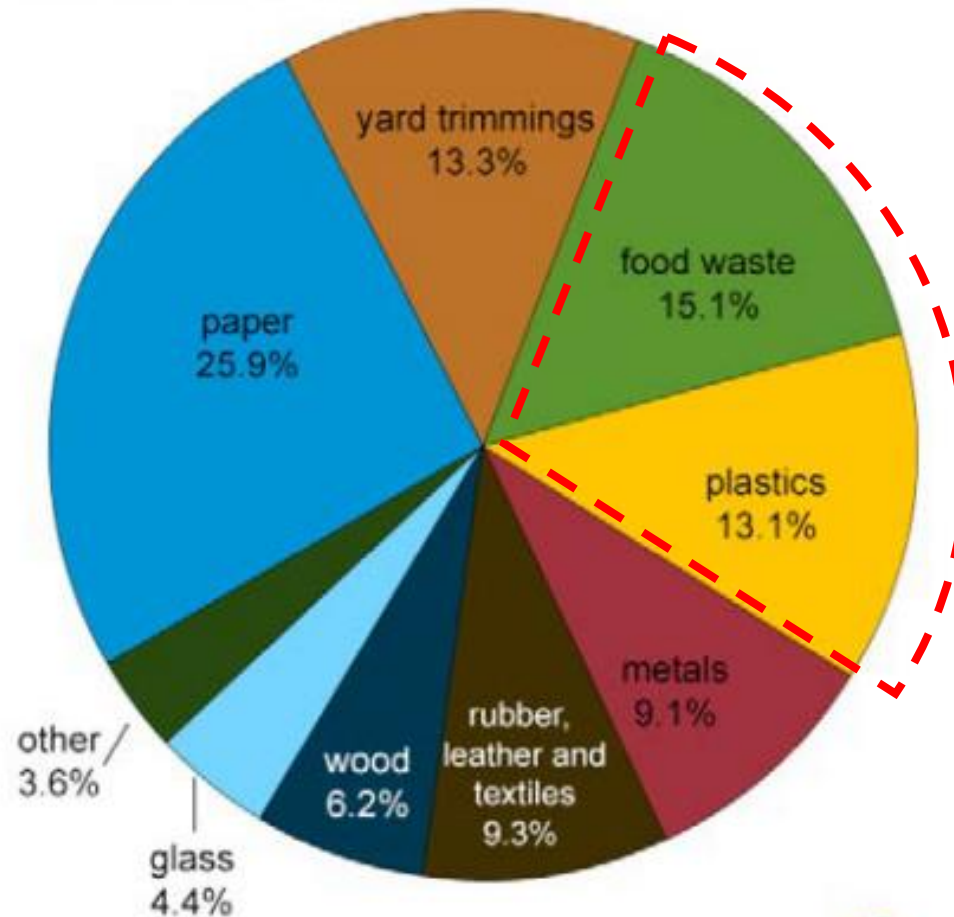
LCA/TEA

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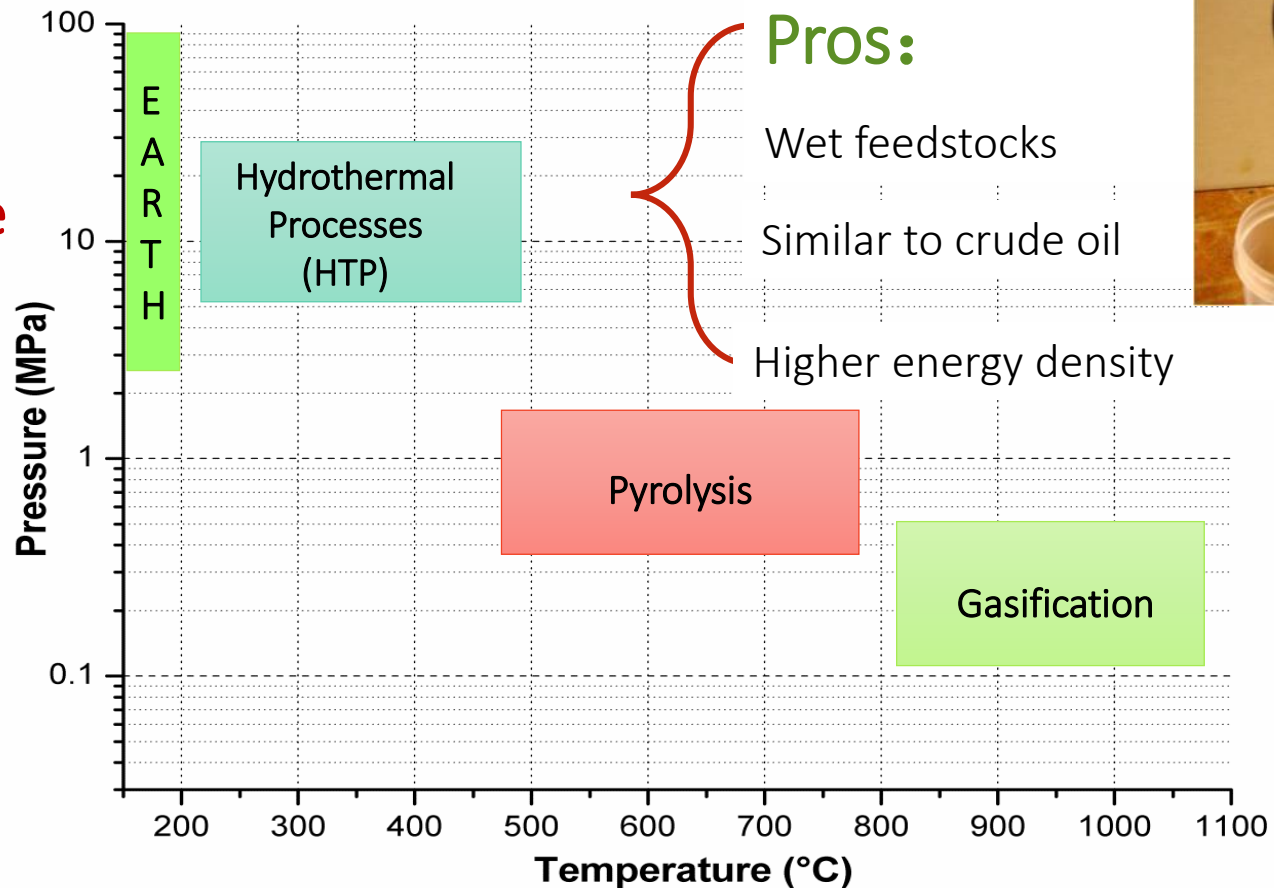
TOTAL MSW GENERATION IN THE U.S. BY TYPES OF WASTE (2015)

Total = 262 million tons

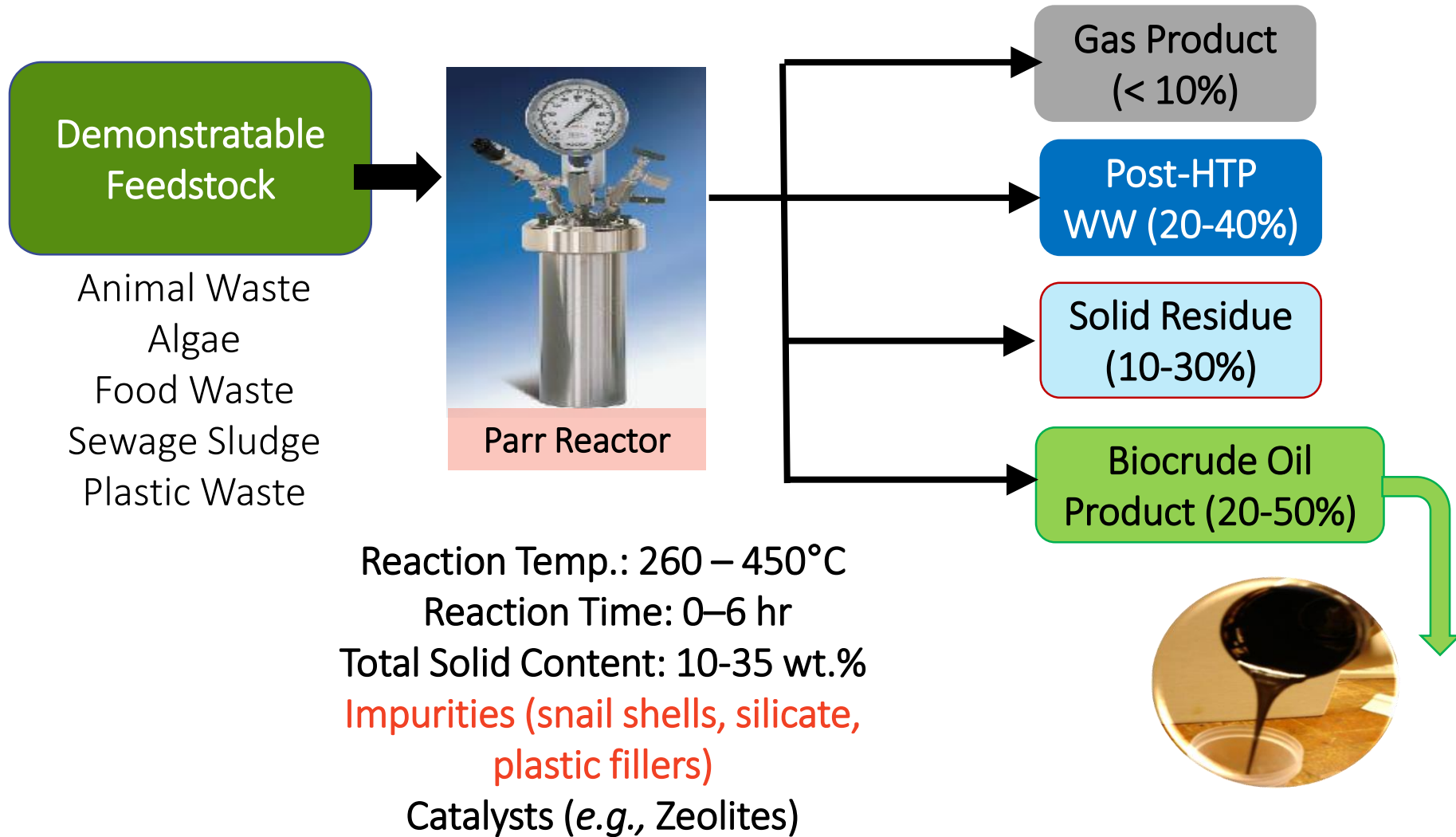


HYDROTHERMAL PROCESSES (HTP) MIMICS MOTHER NATURE'S MILLIONS-OF-YEARS PROCESS

Cons:
High Pressure



Hydrothermal Processes (HTP) of Different Types of MSW



OUTLINE

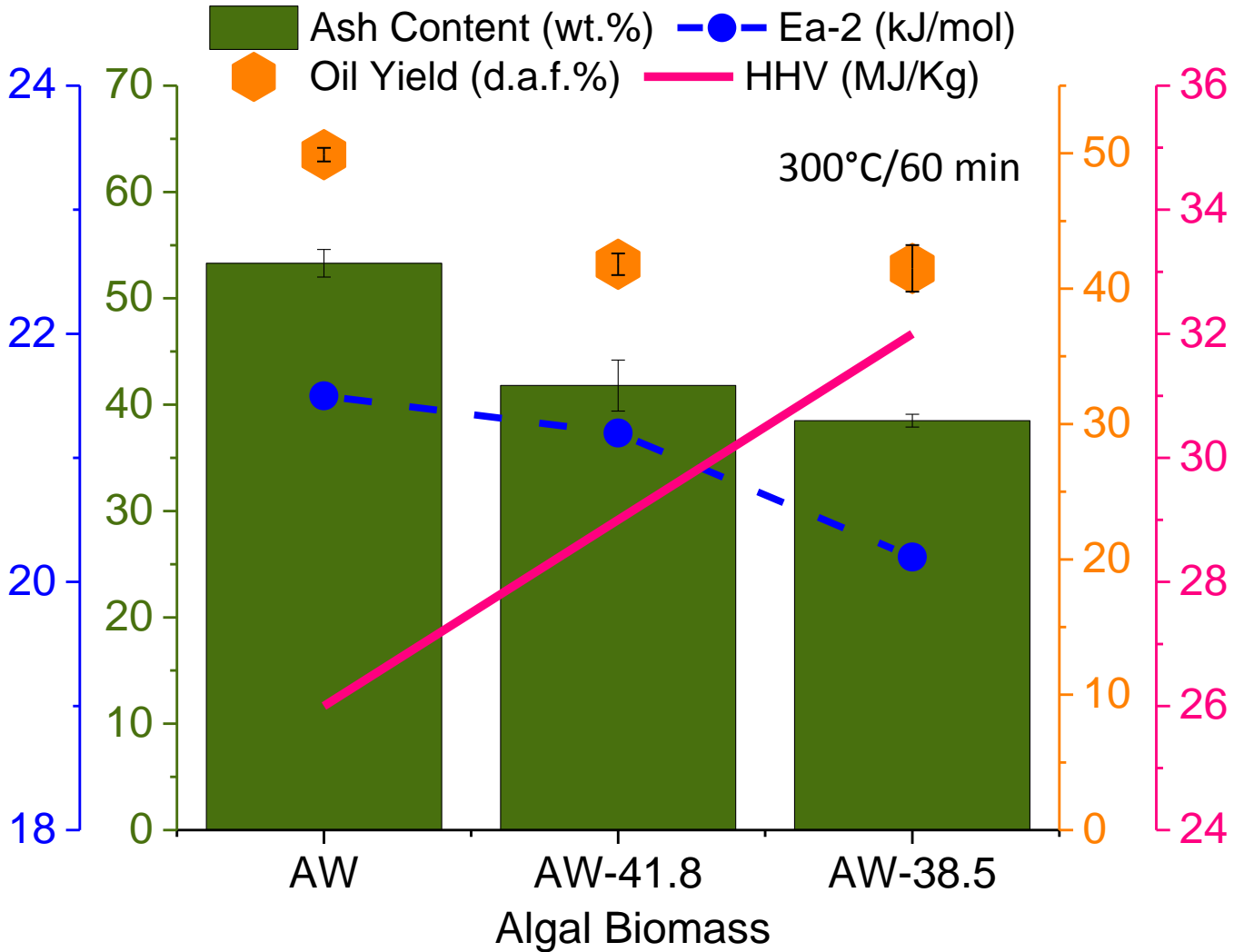
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Elucidate the Effect of Ash Contents on HTP of High-Ash Biomass

Hypothesis: Biocrude oil quality would be negatively affected by increasing the ash contents in algal biomass (Chen et al., 2014a and b).

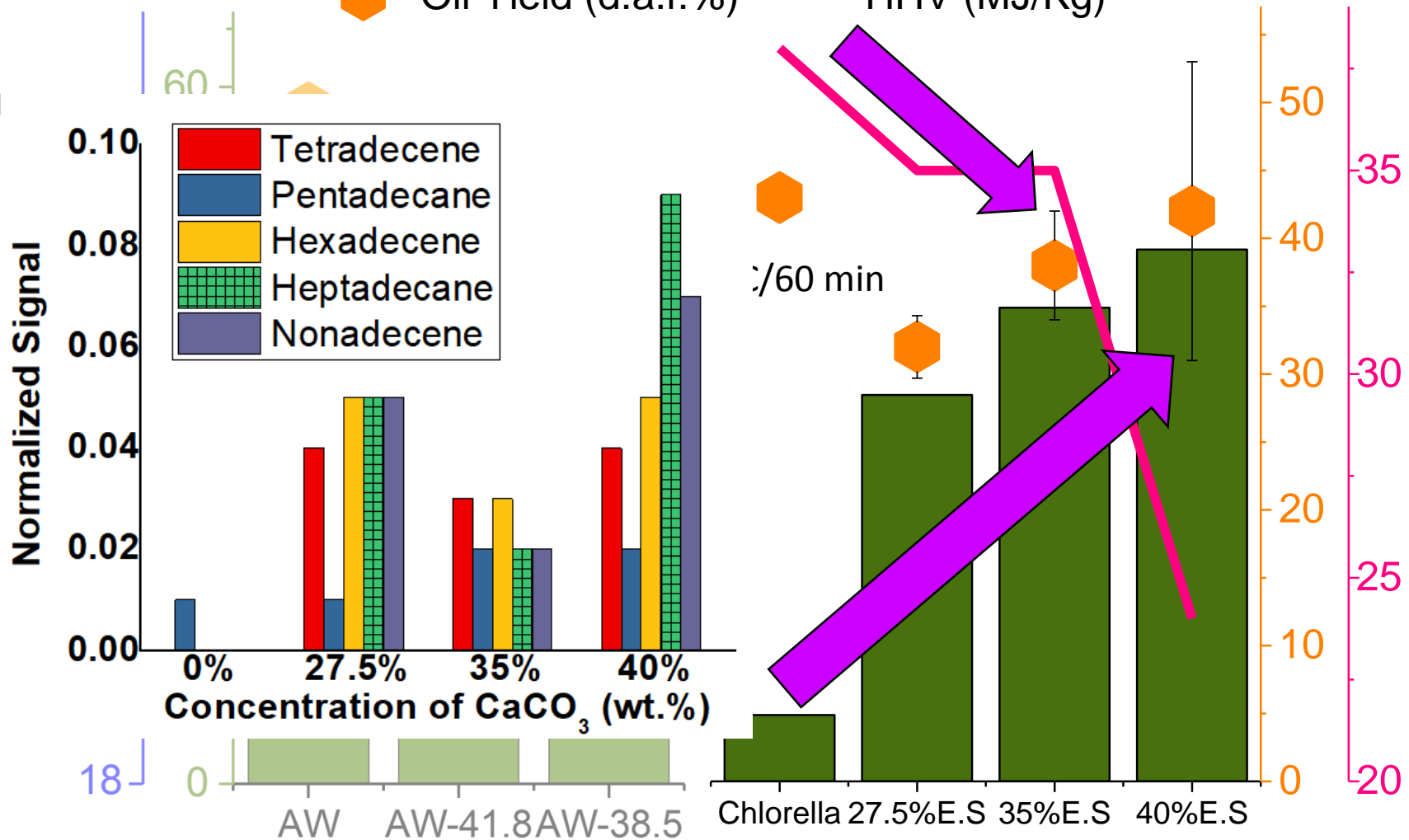
Action items to examine the hypothesis: Biomass with different amounts of ash contents was used to study the effect of ash contents on HTP.

Decreasing Ash Contents Increases the Heating Value of Biocrude Oil



Increasing Ash Content Decreased the Heating Value of Algal Biocrude Oil via HTP

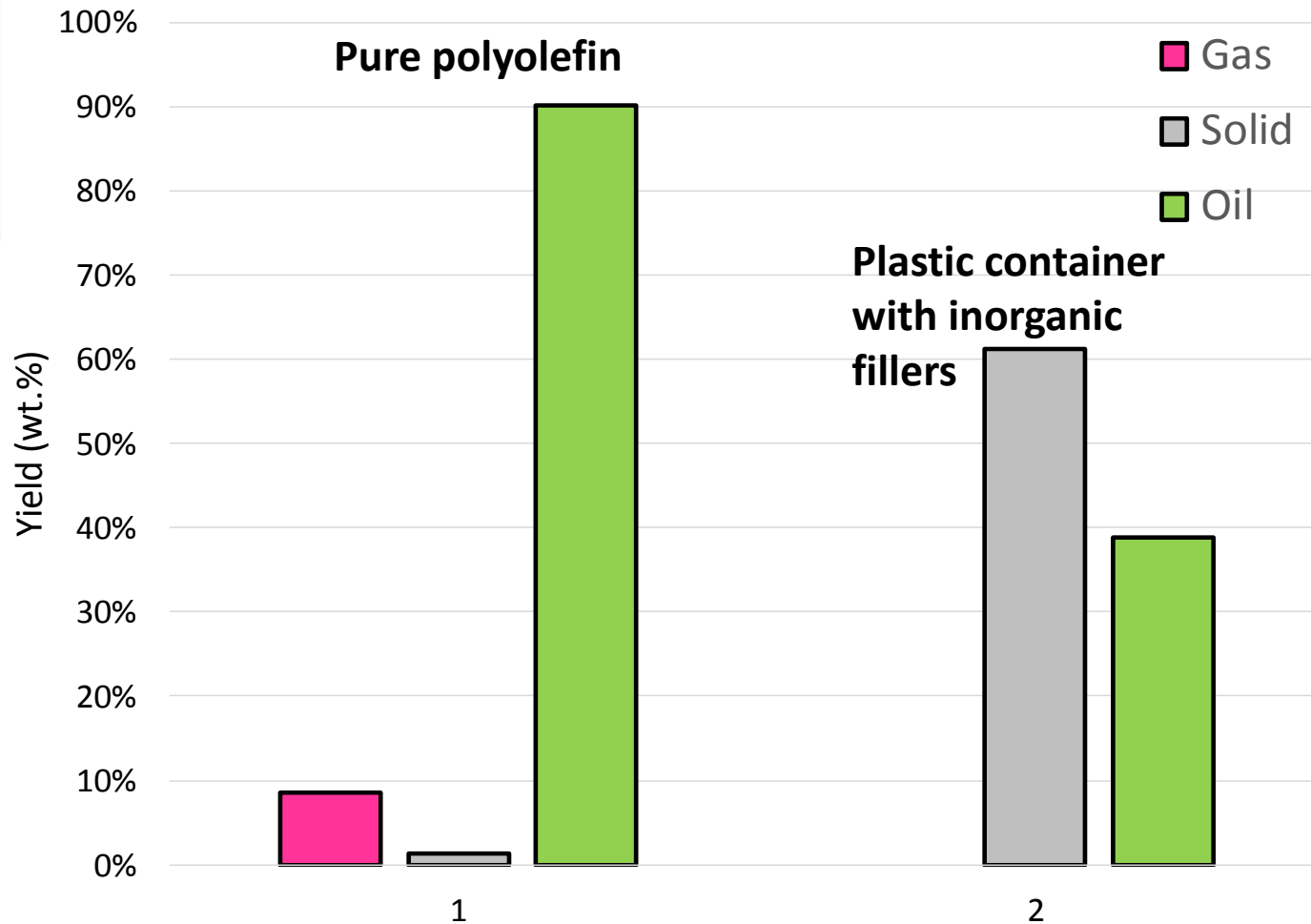
■ Ash Content (wt.%) —●— Ea-2 (kJ/mol)
⬡ Oil Yield (d.a.f.%) — HHV (MJ/Kg)



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ON-GOING PROJECT: HTP OF POLYOLEFIN-BASED WASTE (PP WASTE AT 425°C FOR 4H)



Elucidate the Effect of Ash Contents on HTP of High-Ash MSW Feedstock

Hypothesis: Biocrude oil quality would be negatively affected by increasing the ash contents in algal biomass, according to previous studies (Chen et al., 2014a and b).

Action items to examine the hypothesis: HTL of pure algae with different amounts of representative ash contents was conducted to examine the effect of ash contents on HTL processes.

Summary:

1. HTP can tolerate high-ash biomass (<40%) while producing decent quality of biocrude oil.
2. Ash contents may catalyze the oil formation under HTP.

OUTLINE

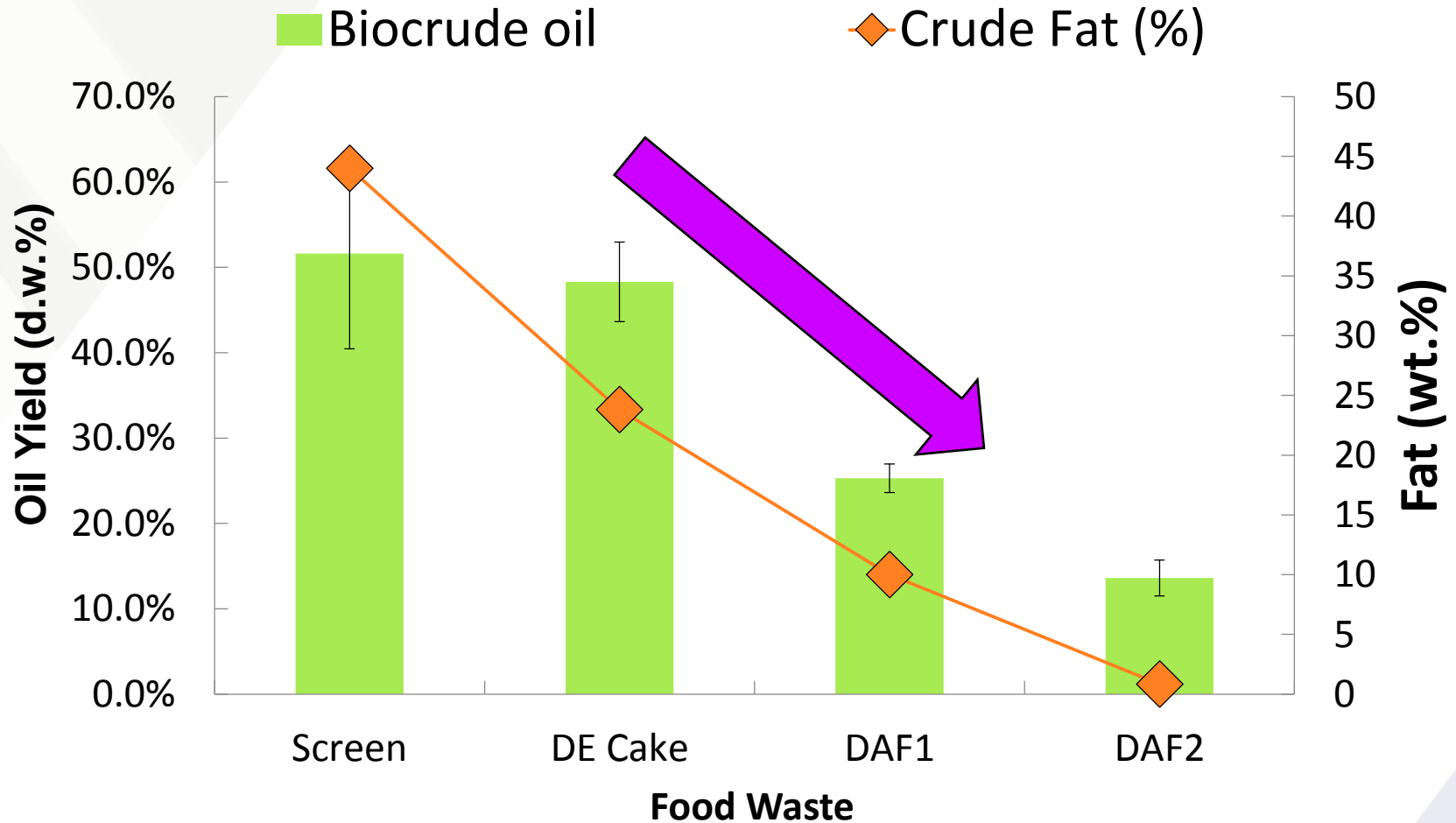
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Elucidate the Effect of Biochemical Compositions on HTP of High-Fat Biomass

Hypothesis: Biocrude oil quality would be positively affected by increasing the crude fat contents in food waste biomass (Chen et al., 2018; Zhang & Chen, 2017).

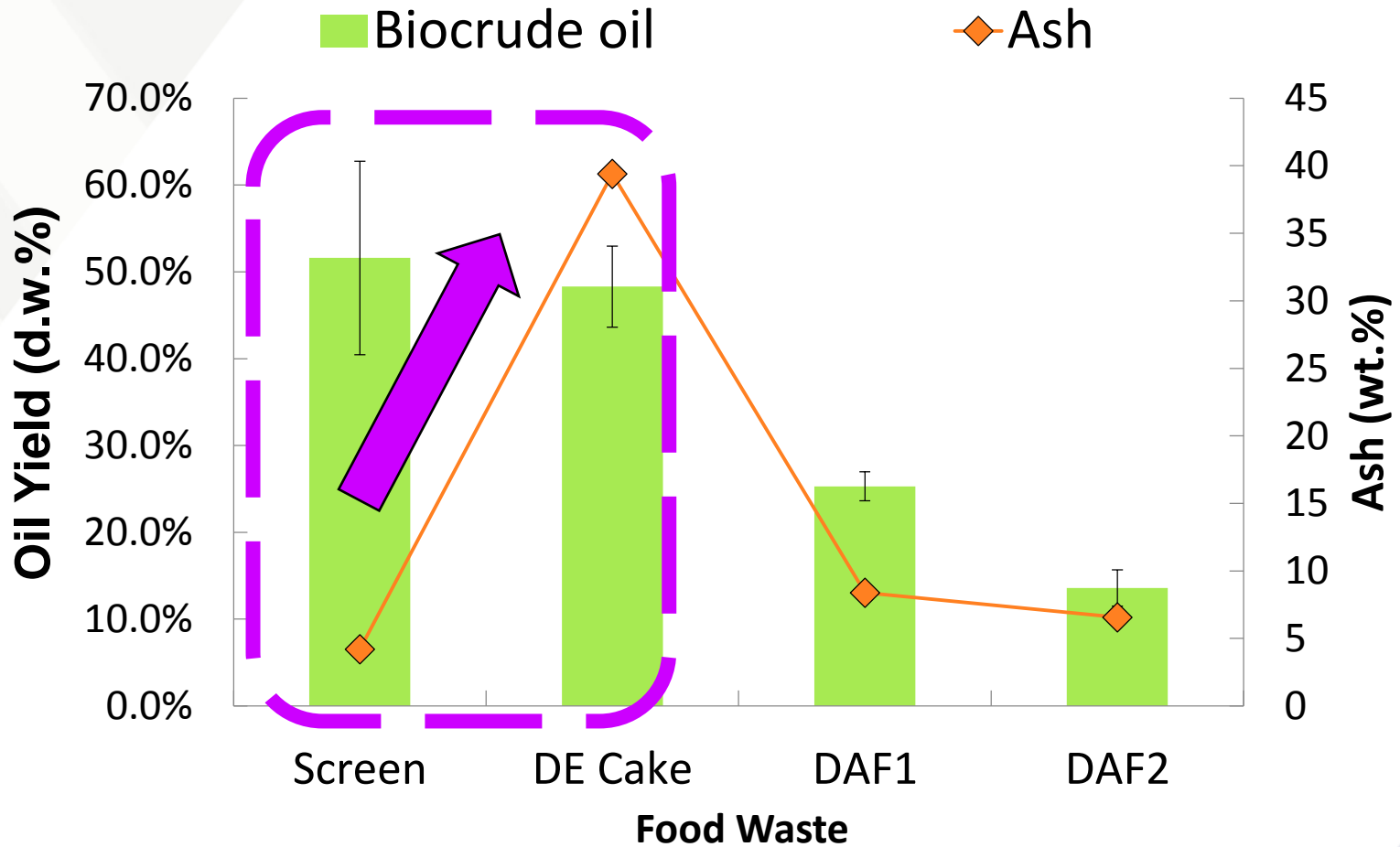
Action items to examine the hypothesis: Food waste with different amounts of crude fat was used to study the effect of crude fat contents on HTP.

IMPACT OF CRUDE FAT CONTENT ON BIOCRUDE OIL YIELD (280°C, 30 MIN)



Zhang & Chen. Direct Thermochemical Liquefaction for Energy Applications, Chapter 5 2017, 127-168

IMPACT OF ASH CONTENT (SILICATE) ON HTP OF FOOD WASTE (280°C, 30 MIN)



Zhang & Chen. Direct Thermochemical Liquefaction for Energy Applications, Chapter 5 2017, 127-168

Elucidate the Effect of Biochemical Compositions on HTP of High-Fat Biomass

Hypothesis: Biocrude oil quality would be positively affected by increasing the crude fat contents in food waste biomass, according to previous studies (Chen et al., 2018).

Action items to examine the hypothesis: HTP of food waste with different amounts of crude fat was conducted to examine the effect of crude fat contents on HTP.

Summary:

1. When the crude fat increased, the biocrude oil yield increased.
2. HTP can tolerate high ash content (<40%) MSW feedstock (food waste).

Unresolved questions:

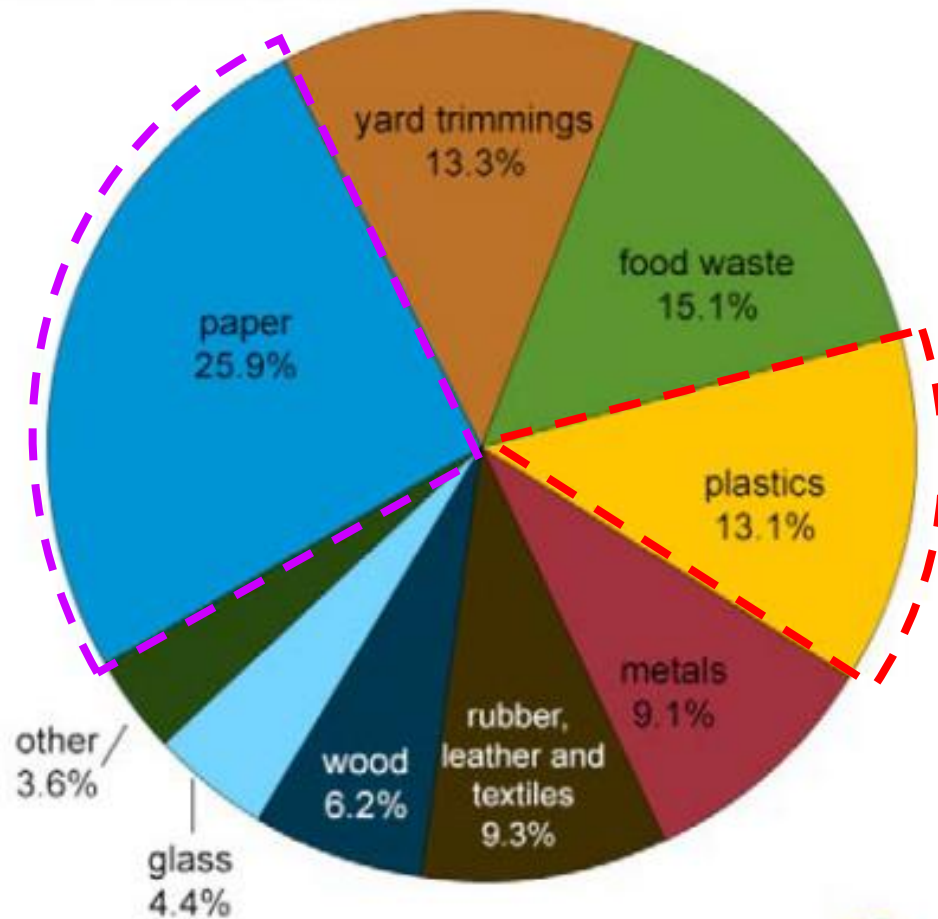
1. What are the most abundant ash contents in MSW?
2. What is the impact of different ash contents?
 - How the major ash content interacts with other biomolecules under HTP?

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RECOMMENDATION--1

Total = 262 million tons



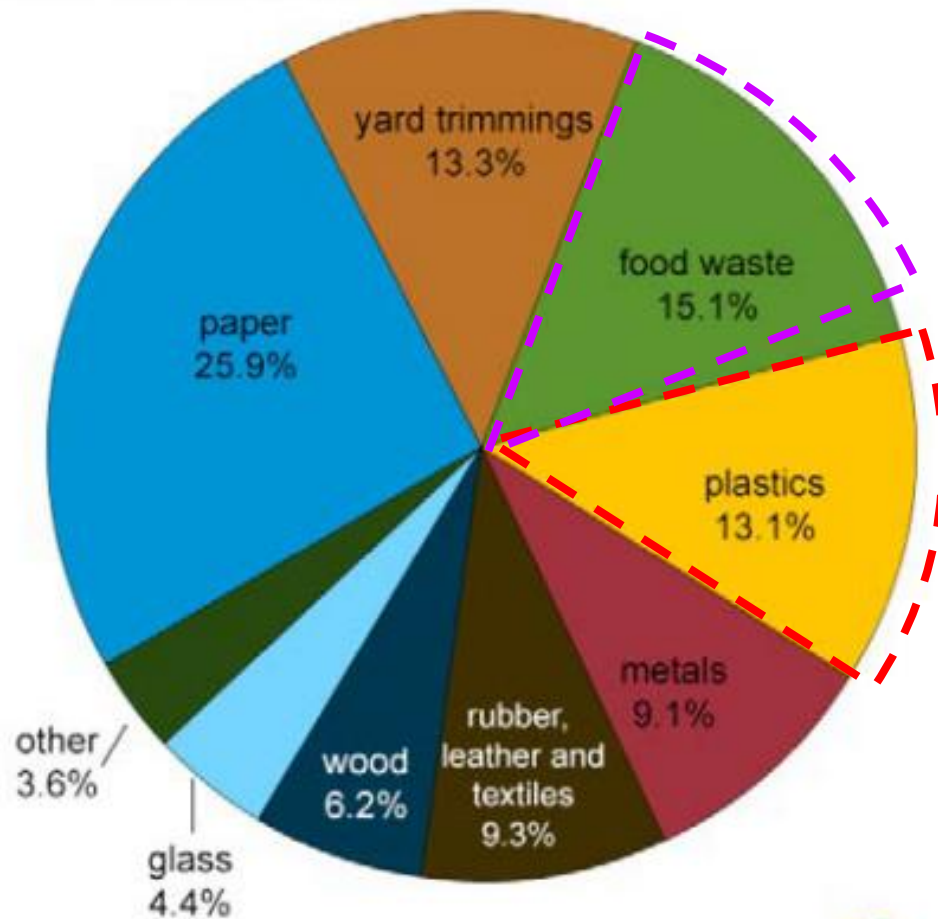
- More research is needed to elucidate the contamination-tolerance levels for plastic additives under HTP.

- Study the impact of the impurities in plastic waste on HTP.
- Plastic additives such as plasticizers and flame retardants that may be regulated.



RECOMMENDATION--2

Total = 262 million tons



- **More research is needed to elucidate the interaction between food waste and plastic waste.**

- Once the plastic and food wastes are contaminated with each other, they cannot be recovered by conventional methods.
- The existence of plastic waste slows down the composting/AD processes and pollutes the composting and AD products.
- Identifying methods that can simultaneously deal with plastic and food wastes is a key.



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THANK YOU AND ANY QUESTIONS?



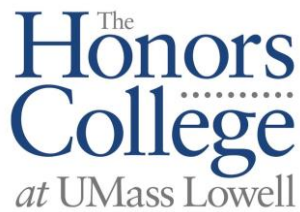
- We are seeking feedback, collaborations and commercialization partners.
- Feel free to contact us:
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HARNESSING EMERGING RESEARCH OPPORTUNITIES TO EMPOWER SOLDIERS



INDEPENDENT UNIVERSITY ALUMNI ASSOCIATION