Quarterly Progress Report

March 1, 2025 to June 1, 2026

PROJECT TITLE: Quantifying and Minimizing the Environmental Impact of Agricultural Plastic Mulch Film Burning

PRINCIPAL INVESTIGATOR(S):
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PROJECT WEBSITE:
https://pmtl.coe.miami.edu/research/hinkleycenter/index.html

Work Accomplished During This Reporting Period

1. Analysis of data for burning agricultural plastics in the tube furnace

The data collected regarding the burning of agricultural plastic in the tube furnace were analyzed during this period. The burning was performed using two types of field-collected used plastic mulch film (**Fig. 1**, one being aluminized polyethylene with a thickness of 1.0 mil, and the other being black polyethylene with a thickness of 1.1 mil, both obtained from Berry Global Inc.). The plastic samples were burned under controlled temperatures between 550 and 800 °C. The burning residues were shipped to the University of Florida for microplastic analysis. Preliminary findings include:

- A higher temperature results in a higher modified combustion efficiency (MCE, **Fig. 2**), with MCE = $[CO_2]/([CO] + [CO_2]$. This is because a higher temperature enhances the reaction kinetics for the oxidation of carbon monoxide. The burning of black plastic mulch has a higher MCE, likely due to its thin single layer structure that can facilitate the transport of O_2 for more efficient burning.
- We further examined the emission factors (EFs) of air pollutants, which is calculated by

  $$EF_i = \Delta m_i / \Delta m_b \quad (1)$$

  where Δm_i is the increase of mass for pollutant I, and Δm_b is the mass of burned plastic mulch film. Smoke pollutants Δm_i is further calculated by

  $$\Delta m_i = \Delta C_i \times Q \times t \quad (2)$$

  where ΔC_i is the change of concentration in the smoke, Q is the flowrate through the tube furnace reactor or the open burning reactor (corrected to standard conditions), and t is the sampling time.

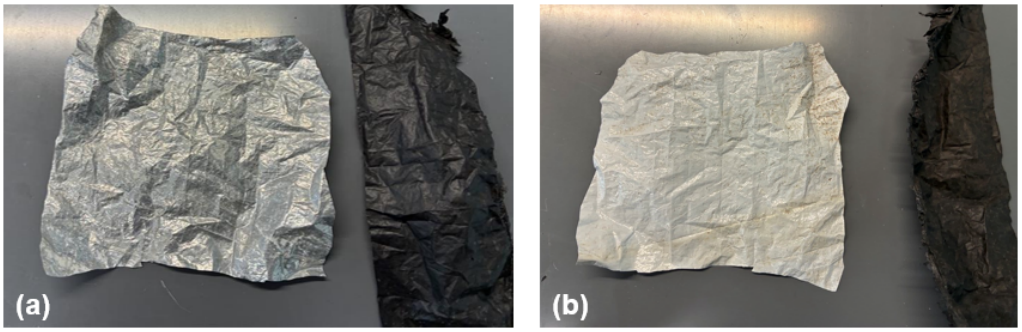

Fig. 1. Two types of agricultural plastic films examined in this project. The white colored plastic is aluminized on one side (with grey color) for enhancing reflectivity and pest control. The aluminized plastic has a thickness of 1.0 mil, and the black plastic has a thickness of 1.1 mil.

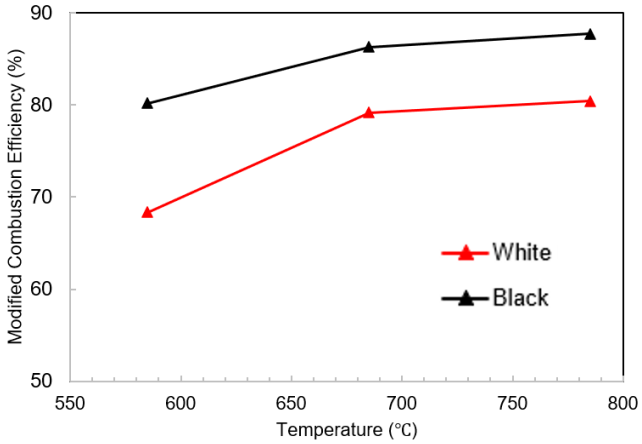

Fig. 2. Modified combustion efficiency (MCE) as a function of burning temperatures for white plastic (red line and symbols) and black plastic (black line and symbols).

- Overall, we observed that a higher burning temperature can lead to lower EFs of gaseous pollutants, such as CO, NOx, and SO_2 (**Figs. 3a** to **3c**). This suggests that in practice, the burning method that can lead to a higher combustion temperature (e.g., with torches or adding igniting fuels) can reduce the formation of gaseous pollutants.
- However, the EFs of NOx and SO_2 are significant. The EFs of SO_2 is even higher than that of CO, which is unexpected because polyethylene is hydrocarbon and does not contain elements of S or N. This result suggests that contamination on the plastics, e.g., soil, fertilizer, or pesticide can lead to formation of unwanted gaseous pollutants.
- Overall, the burning of black plastic mulch samples has a higher emission factor for particulate matter (PM) than the white plastic mulch (**Fig. 2**), likely due to the more efficient burning of the plastic due to its thin and elastic texture. However, a clear temperature dependence cannot be observed, which is likely due to the impact of texture on burning characteristics. We are currently conducting more experiments to confirm this result.

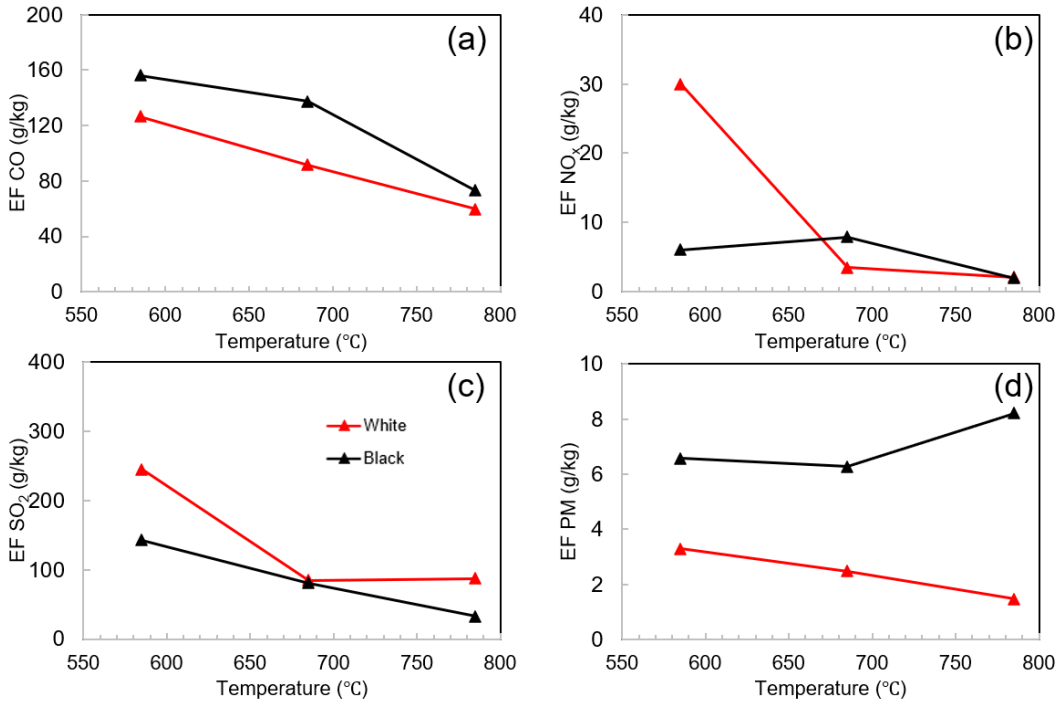

Fig. 3. Emission factors of CO, NOx, SO_2, and PM as a function of burn temperature for the plastic mulch samples.

- We also compared the concentrations of gaseous pollutants against those established by the EPA's National Ambient Air Quality Standards (NAAQS). As expected, the pollutant concentrations all exceeded the standards. However, the SO_2 concentration is significantly above (being three orders of magnitudes above) the NAAQS standard. This result highlights the potential need to consider the influence of soil contamination on SO_2 emission during the open burning of plastic mulch films.

	Average	Max	NAAQS
CO	58 ppm	162 ppm	9 ppm
NO_2	2.7 ppm	9.0 ppm	0.1 ppm
SO_2	29.0 ppm	74.0 ppm	0.075 ppm

Table 1. Average and maximum concentrations of CO, NOx, and SO_2 generated from the burning experiments and concentrations established by the NAAQS for references.

2. <u>Abundance and Chemical Composition of Microplastics identified in Plastic Mulch Samples</u>

Burned white and black plastic mulch samples were prepared by concentrating particles onto 0.7 µm glass fiber filters (GF/F) using vacuum filtration. The physical characteristics of the particles were examined using a stereomicroscope, while chemical

characterization was conducted using Pyrolysis Gas Chromatography Mass Spectrometry (Py-GC/MS). Blank tests using empty plastic containers for storing burned samples were performed as part of the quality assurance process and showed negligible microplastic contamination, supporting the reliability of the results. Preliminary findings include (**Figs. 4 and 5**)-

- Microplastics were detected in all samples analyzed.
- Samples were separated using a 25 µm sieve, and most of the detected microplastics were larger than 25 µm.
- Black plastic mulch samples exhibited a higher occurrence of microplastics than white plastic mulch samples.
- Higher temperature results in greater microplastic abundance.
- Polyethylene (PE) was identified as the dominant polymer in white plastic mulch, whereas polystyrene (PS) was the predominant polymer in black plastic mulch.
- Particles with various shapes (fibers, pellets, fragments) were observed (**Fig. 5**).
- To identify potential sources, additional experiments will be conducted, including analysis of original plastic mulch and evaluation of potential degradation. Additional experiments using white plastic mulch will also be performed to replicate and confirm the current findings.

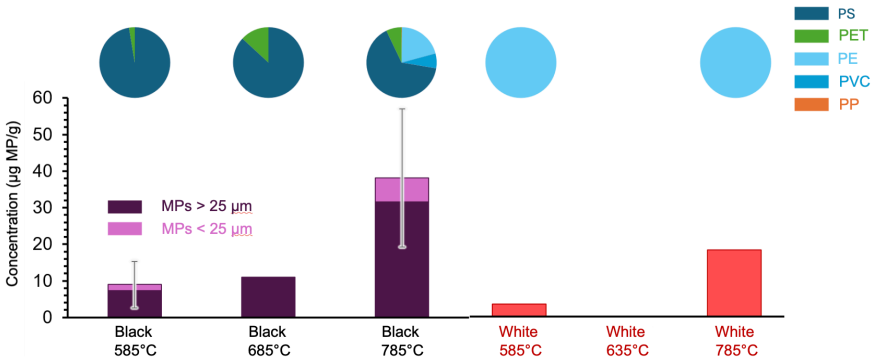

Fig. 4. Abundance and Chemical Properties of Microplastics in White and Black Plastic Mulch Samples.

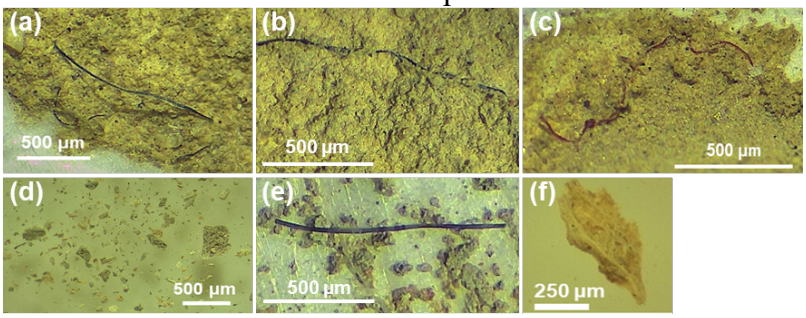

Fig. 5. Microscopic images of burned plastic mulch samples at different temperatures. Black plastic mulch: (a) 585°C, (b) 685°C, and (c) 785°C; white plastic mulch: (d) 585°C, (e) 685°C, and (f) 785°C.

2. TAG Meeting #2 (May 22, 2026)

A virtual TAG meeting was held with 10 attendees. Members included

- Gene Jones, CEO of Southern Waste Information eXchange
- Sam Sugerman, Sustainability Manager in agricultural sector
- Samir Elmir, Division Director, Florida Department of Health Miami-Dade Environmental Public Health and Engineering
- Jiannan Chen, Assistant Professor, Department of Civil, Environmental, and Construction Engineering, University of Central Florida
- Tim Townsend, Program director of the Hinkley Center for Solid and Hazardous Waste Management, Professor, Department of Environmental Engineering Sciences, University of Florida
- Yang Wang, Assistant Professor, Department of Chemical, Environmental and Materials Engineering, University of Miami
- Sungyoon Jung, Assistant Professor, Department of Environmental Engineering Sciences, University of Florida
- Amir Sharafudin, Graduate Student, Department of Chemical, Environmental and Materials Engineering, University of Miami
- Jiayu Li, Assistant Professor, Department of Mechanical and Aerospace Engineering, University of Miami
- Lisa Wasko DeVetter, Professor, Small Fruit Horticulture, Northwestern Washington Research and Extension Center, Mount Vernon (NWREC)

The attendees include representatives from health and policy sector, the agricultural plastics sector, solid waste divisions, and academic institutions. The meeting video and report were posted on the project website. Key TAG feedback included:

- Conduct open burning experiments using diesel fuel as the ignition liquid
- Analyze raw plastic samples to identify potential sources of polystyrene and PVC
- Conduct metal analysis for the soil samples
- Analyze the potential reasons for increased PM emissions at higher temperatures because this is related to the best practice for plastic burning
- Dr. DeVetter will help the team connect with outreach organizations to broaden the impact of research findings

Work Planned for the Next Reporting Period

In the next reporting period, we will complete the open burning combustion experiments, add furnace combustion experiments (as needed), and conduct further pollutant data analysis. The detailed tasks include the following:

- Complete controlled open-burn experiments using liquid fuels (diesel fuel).
- Complete full analysis of PM mass, size distribution, and $CO/CO_2/NOx/SO_2$.
- Continue microplastic identification using stereomicroscopy, SEM-EDS, and Py-GC/MS.
- Compare emission factors against EPA NAAQS and FDEP Soil Cleanup Target Levels.
- Begin preparing emission factor tables for PM, gases, and microplastics.

Metrics

Personnel involved in this quarter:

Name	Role	Department	Institution
Yang Wang	Assistant Professor	Department of Chemical, Environmental and Materials Engineering	University of Miami
Sungyoon Jung	Assistant Professor	Department of Environmental Engineering Sciences	University of Florida
Amir Sharafudin	Graduate Student	Department of Chemical, Environmental and Materials Engineering	University of Miami
Kazi Tahsina Habib	Graduate Student	Department of Environmental Engineering Sciences	University of Florida
Courtni Spencer	Undergraduate Student	Department of Chemical, Environmental and Materials Engineering	University of Miami

Technical Awareness Group (TAG) list

Name	Affiliation	Sector
Gene Jones	CEO of Southern Waste Information eXchange	Private
Sam Sugerman	Sustainability Manager in agricultural sector	Private
Samir Elmir	Division Director, Florida Department of Health Miami-Dade Environmental Public Health and Engineering	Public
Nicholas Ciancio	Chief of Resilience Engineering & Environmental Compliance, Department of Solid Waste Management	Public
Elizabeth Kromhout	Environmental Administrator, Florida Department of Environmental Protection	Public
Linda Braam	Engineer, Lee County Solid Waste Department	Public
Lisa Wasko DeVetter	Associate Professor, Department of Horticulture, Washington State University	Researcher
Marwa El-Sayed	Associate Professor, Department of Civil Engineering, Embry-Riddle Aeronautical University	Researcher
Jiannan Chen	Assistant Professor, Department of Civil, Environmental, and Construction Engineering, University of Central Florida	Researcher