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

Draft Final Report

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Report # XXXXX

Project Title:

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

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Project Website

https://pmtl.coe.miami.edu/research/hinkleycenter/index.html

Project Duration

September 1, 2025 to August 31, 2026.

Abstract

Agricultural plastic mulch film is widely used in Florida to improve crop yield, soil moisture retention, weed control, pest control, and nutrient management. At the same time, used plastic mulch film is difficult to manage after harvest because it is bulky, degraded by sunlight, and heavily contaminated with soil and agricultural residues. Recycling rates remain low, and the soil content of used mulch can be much higher than the contamination level accepted by recycling facilities. In Florida, open burning of polyethylene agricultural plastic is allowed under state law for certain agricultural operations. However, limited data exist on pollutant emissions from realistic burning of field-collected, soil-contaminated plastic mulch film. This project quantified air and soil-related pollutants from controlled burning of agricultural plastic mulch film using a tube furnace reactor and planned open burning reactor experiments. The study measured gaseous pollutants, particulate matter, burn residues, and microplastics using real-time aerosol instruments, gas analyzers, filter sampling, stereomicroscopy, and pyrolysis-gas chromatography/mass spectrometry. Results show that burning temperature and plastic type strongly influence modified combustion efficiency, carbon monoxide, nitrogen oxides, sulfur dioxide, particulate matter, and microplastic abundance. Higher temperatures improved combustion efficiency and reduced carbon monoxide, nitrogen oxides, and sulfur dioxide emission factors in furnace experiments, but particulate matter and microplastic trends were more complex and depended on plastic type and residue chemistry. Microplastics were detected in all burned residue samples, with most particles larger than 25 micrometers and higher abundance at higher temperatures. The results provide a first dataset for evaluating the environmental implications of agricultural plastic mulch burning and support future guidance for farmers, waste managers, regulators, and researchers.

Key Words

Agricultural plastics; plastic mulch film; open burning; particulate matter; microplastics; emission factor; polyethylene; sulfur dioxide; carbon monoxide; waste management

METRICS REPORTING

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Metrics

1. TAG input on the final report: To be determined after the final TAG meeting
2. Research publications: A peer-reviewed manuscript based on this Hinkley Center project is in preparation. No published article from this project is listed at the time of drafting. However, the research team is working on the manuscript summarizing the project findings to be submitted to Environmental Science and Technology Air.
3. Research presentations: The project was presented to the Technical Awareness Group during the TAG meetings. Amir Sharafudin also presented preliminary results in the poster session of the SWANA FL Winter Conference & Hinkley Center Research Forum. Amir Sharafudin will also present the project results at the 2026 Annual Conference for American Association for Aerosol Research.
4. Citations: No external citations to project publications are available at the time of drafting because project manuscripts are still in preparation.
5. Leveraged funding: The project results are being used to develop future proposals to NSF Environmental Engineering, NSF Combustion and Fire Systems, USDA programs related to sustainable agricultural waste management, Florida DEP, and other agencies. Planned future topics include expanded air and soil pollutant characterization, small-scale waste-to-energy feasibility, and recycling/reuse technologies for soil-contaminated agricultural plastics.
6. New collaborations: The project initiated and strengthened collaboration between the University of Miami and University of Florida, engaged the Southern Waste Information eXchange, involved solid waste and public health stakeholders, and opened discussion with UF Gulf Coast Research and Education Center regarding field soil sampling and possible future field measurements.
7. Use by FDEP or other stakeholders: Stakeholder use is still emerging because the project is at the draft final reporting stage. Stakeholders have used TAG meetings to guide the research toward practical questions, including whether burning methods can reduce emissions, whether plastic film properties influence emissions, and how results may be translated into farmer-facing guidance. Further stakeholder use is expected after final report review and dissemination.

ACKNOWLEDGEMENTS

The project team acknowledges the Hinkley Center for Solid and Hazardous Waste Management for supporting this work. We thank Gene Jones and the Southern Waste Information eXchange for providing agricultural plastic mulch film samples and practical insight into agricultural plastic management. We thank the Technical Awareness Group members for their time, review, and suggestions.

Student Researchers

Amir Sharafudin, Ph.D. student in the Department of Chemical, Environmental and Materials Engineering at the University of Miami, conducted combustion experiments, aerosol and gas measurements, and emission factor analysis. His research interests include combustion emissions and air quality measurement.

Kazi Tahsina Habib, Ph.D. student in the Department of Environmental Engineering Sciences at the University of Florida, conducted microplastic sample processing and analysis. Her work focuses on environmental microplastic characterization.

Courtni Spencer, undergraduate student in the Department of Chemical, Environmental and Materials Engineering at the University of Miami, assisted with project background research, regulatory review, and laboratory activities.

Technical Awareness Group Members

Name	Title/Affiliation	Sector
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Sam Sugerman	Sustainability Manager in agricultural sector	Private
Samir Elmir	Division Director, Florida Department of Health Miami-Dade Environmental Public Health and Engineering	Public
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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym	Definition
APS	Aerodynamic particle sizer
CO	Carbon monoxide
CO2	Carbon dioxide
EF	Emission factor
FDEP	Florida Department of Environmental Protection
GC/MS	Gas chromatography/mass spectrometry
MCE	Modified combustion efficiency
MP	Microplastic
NAAQS	National Ambient Air Quality Standards
NOx	Nitrogen oxides
OC/EC	Organic carbon/elemental carbon
PE	Polyethylene
PM	Particulate matter
PP	Polypropylene
PVC	Polyvinyl chloride
Py-GC/MS	Pyrolysis-gas chromatography/mass spectrometry
SEM-EDS	Scanning electron microscopy-energy dispersive spectroscopy
SMPS	Scanning mobility particle sizer
SO2	Sulfur dioxide
TAG	Technical Awareness Group
WTE	Waste-to-energy

EXECUTIVE SUMMARY

Agricultural plastic mulch film is an important material in specialty crop production, particularly in Florida, where mulch films are used in tomato, pepper, eggplant, strawberry, muskmelon, watermelon, and cucumber production. Plastic mulch films improve agricultural productivity by controlling weeds and pests, retaining soil moisture, regulating soil temperature, and improving nutrient uptake. However, after harvest, used mulch film becomes difficult to manage because it is bulky, fragmented, and contaminated with soil, pesticides, fertilizers, and field debris. Soil residue can comprise a large fraction of collected used mulch weight, while recycling facilities generally require much lower contamination levels. These characteristics limit recycling and reuse, making landfilling, stockpiling, in-field burial, and burning common end-of-life pathways.

Open burning of agricultural plastic mulch is a practical disposal method for some growers because it reduces volume and weight. In Florida, state regulations permit open burning of certain polyethylene agricultural plastics used in crop production. However, open burning can generate air pollutants, residual soil contaminants, and microplastics. Before this project, there were limited data specifically on emissions from realistic burning of field-collected, soil-contaminated plastic mulch film. Existing plastic-burning literature provides important context, but clean plastic burning cannot fully represent used agricultural mulch because soil residue and agricultural contaminants alter combustion temperature, combustion efficiency, residue chemistry, and pollutant formation.

This project was designed to quantify and minimize environmental impacts of agricultural plastic mulch film burning. The research used controlled laboratory combustion systems, including a tube furnace reactor and an open burning reactor. Furnace experiments provide controlled temperature and flow fields, while open burning experiments are intended to represent practical field-burning conditions such as liquid-fuel-assisted and torch-assisted burning. The team measured gaseous pollutants, particulate matter, organic and elemental carbon, and burn residues. The University of Florida team analyzed microplastics using stereomicroscopy and Py-GC/MS.

Major progress of this project included project website development, establishment of combustion and sampling systems, calibration of real-time particle and gas instruments, completion of tube furnace experiments, shipment of residues to the University of Florida, microplastic analysis of original and burned samples, and TAG meetings. The project also generated a poster presentation at the SWANA FL Winter Conference & Hinkley Center Research Forum. TAG members provided practical guidance on plastic film specifications, additives, film thickness, field measurement opportunities, health-risk implications, raw plastic sample analysis, metal analysis, and farmer-facing outputs.

The tube furnace results show that higher burning temperature generally increased modified combustion efficiency. Black plastic mulch showed higher combustion efficiency than the white/aluminized plastic, likely because of differences in material structure and air access during burning. Higher temperature reduced emission factors for CO, NOx, and SO2 in the furnace experiments, suggesting that more complete combustion can reduce some gaseous pollutants. However, SO2 concentrations and emission factors were unexpectedly high for a polyethylene-based material, indicating that soil, fertilizer, pesticide, or additive contamination may contribute to sulfur-containing emissions. The results also show that black plastic mulch generated higher PM emission factors than the white/aluminized mulch under the measured conditions, and the PM response did not follow a simple temperature trend.

Microplastic analysis showed that MPs were detected in all burned residue samples, with the majority of particles larger than 25 micrometers. Microplastic abundance increased with temperature. Later microplastic analysis of six sample conditions indicated that white plastic mulch showed higher MP occurrence than black plastic mulch, and PVC was the predominant polymer identified in burned residue samples, likely due to the inclusion of additional plastic materials in the original plastic mulch. The original plastic samples were dominated by PE, with additional PP and PMMA detected and approximately one-quarter of the original sample products remaining unidentified by Py-GC/MS. Burned samples contained very low measured polymer mass relative to total residue, suggesting that most residue may be carbonaceous soot, soil, or other non-polymer material. These results emphasize that burning does not simply eliminate plastic; it can redistribute carbonaceous residues and microplastic-like particles into ash and soil-associated materials.

The project has several practical implications. For growers, results suggest that burning condition, film type, and contamination level matter. For waste management professionals, the results highlight the need for preprocessing, sorting, soil removal, and careful evaluation before considering alternatives such as recycling, landfilling, or waste-to-energy. For regulators, the findings provide a preliminary dataset on a waste stream that is legally and practically important in Florida but not well characterized. For researchers, the data provide a foundation for future studies on field emissions, health risk assessment, soil contamination, and alternative management pathways.

1. INTRODUCTION

1.1 Background and project significance

Plastic mulch film is a major component of agricultural plastic use. It is widely used because it improves crop production while reducing weed pressure, pest pressure, and water and nutrient loss. In Florida, plastic mulch film is especially important for vegetable and fruit production, including tomato, pepper, eggplant, strawberry, muskmelon, watermelon, and cucumber. Florida is a leading state in plastic mulch use, with approximately 80,000 acres of mulched vegetables reported in the literature. The user also noted a working estimate of approximately 100,000 acres of agricultural plastic film in Florida.

Figure 1. Examples of plastic mulch film use and removal in crop production. Source image adapted from the project proposal.

Although plastic mulch has agronomic benefits, used mulch film presents end-of-life challenges. Used mulch can be contaminated with soil and agricultural residues, can be degraded by sunlight, and can be collected in bulky rolls or bales. These properties make it difficult to recycle and costly to landfill. Recycling facilities generally require low contamination levels, while used mulch film can contain high soil residue. Landfilling is also challenged by the weight and bulk of used mulch, which increases transportation cost, tipping fee, and landfill handling needs.

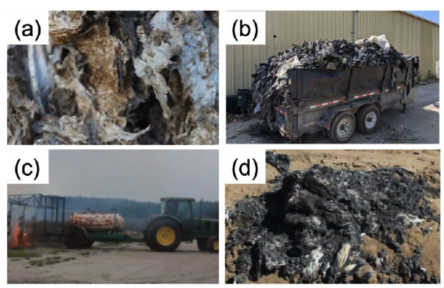


Figure 2. Used plastic mulch film management challenge and field burning examples. Source image adapted from the project proposal.

1.2 Burning as a management pathway

Because recycling, reuse, and landfilling are difficult for soil-contaminated mulch, burning is used by some growers to reduce mass and volume. Polyethylene agricultural plastics used in connection with crop growing, harvesting, and maintenance may be disposed of by open burning under Florida law. Burning may be conducted in piles with liquid fuel assistance or on farmland using flame torches. These practices may be economical for growers, but they can generate air pollutants and leave burn residues in soil.

The major scientific gap addressed by this project is that existing plastic-burning studies focus mostly on clean commodity plastics or mixed municipal waste plastics. Used agricultural mulch differs because it contains soil, fertilizer, pesticide residues, film additives, and field weathering effects. These factors can alter combustion efficiency, particulate matter formation, gaseous emissions, sulfur- and nitrogen-containing emissions, and microplastic residue.

1.3 Project objectives and scope

The project had two primary objectives:

1. Quantify emission factors of air pollutants and microplastics from agricultural plastic mulch film burning using controlled combustion systems.
2. Identify burning conditions and material factors that influence pollutant emission and can inform lower-impact management practices.

The study focused on controlled laboratory measurements. The project did not conduct cellular toxicology or quantitative health risk assessment, although TAG members recommended that the emission data could support future health risk modeling. Field measurements were discussed with the UF Gulf Coast Research and Education Center, but logistics prevented field sampling during the reporting period. Therefore, the findings should be interpreted as controlled laboratory results that can guide future field validation.

2. METHODS

2.1 Overall experimental design

The project combined combustion experiments at the University of Miami with microplastic analysis at the University of Florida. Used agricultural plastic mulch films were burned under controlled conditions. The generated smoke was diluted, passed through a cyclone to remove particles larger than 10 micrometers, and measured by online particle and gas instruments. Filter and residue samples were collected for offline analysis. Burn residues were shipped to the University of Florida for microplastic identification and quantification.

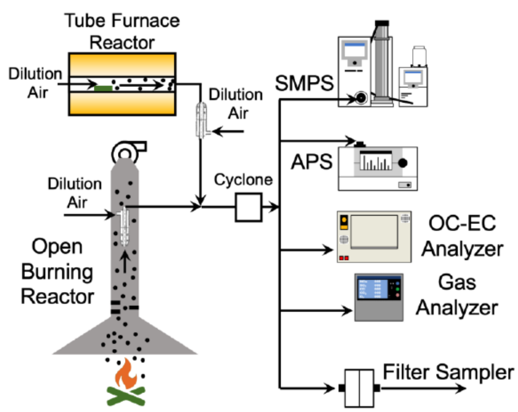


Figure 3. Experimental system for tube furnace and open burning reactor measurements. Source image adapted from the project proposal.

2.2 Plastic mulch film samples

The furnace experiments used two types of field-collected used plastic mulch film obtained from Berry Global Inc. One material was a white/aluminized polyethylene film with a thickness of 1.0 mil, and the other was a black polyethylene film with a thickness of 1.1 mil. The white plastic is a double-layer material and the black plastic is a single-layer material. TAG feedback emphasized that film thickness, color, additives, and reflective layers may affect burning behavior and pollutant emission.

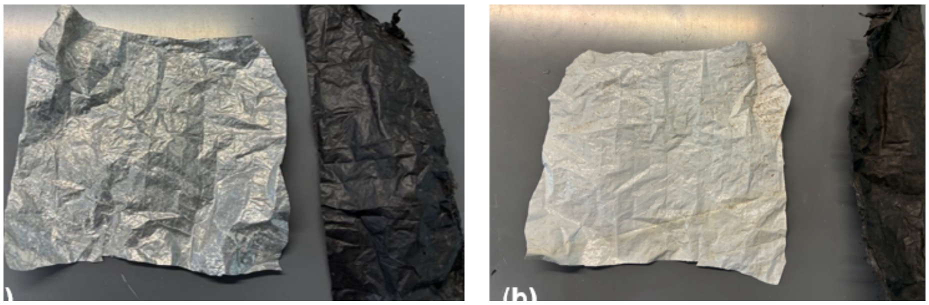


Figure 4. Plastic mulch films examined in furnace experiments: white/aluminized polyethylene and black polyethylene.

2.3 Tube furnace combustion experiments

The tube furnace reactor was used to provide controlled temperature and flow fields. We deployed a quartz tube furnace with a controllable wall temperature. The furnace design allows plastic samples to be burned under specified temperatures and air flow rates, reducing variability relative to open burning. The completed furnace experiments focused on temperatures between approximately 550 and 800 °C, with additional experiments spanning broader conditions.

Parameter	Value/Description
Plastic types	White/aluminized PE and black PE agricultural plastic mulch
Representative temperatures	585, 685, and 785 °C in analyzed final datasets
Flow and sampling	Controlled air flow through reactor; diluted sampling downstream
Measurements	CO, CO2, NOx, SO2, PM size distribution, PM mass, residues, microplastics

2.4 Open burning reactor

We also included an open burning reactor under controlled laboratory conditions. Larger amounts of field-collected plastic mulch film are placed on a metal mesh and ignited with diesel as the liquid fuel. Exhaust is collected using an inverted funnel and stack, and the smoke is diluted and analyzed similarly to furnace emissions.

2.5 Air pollutant measurements

The project used real-time and offline methods to quantify air pollutants. Particle size distributions were measured with a scanning mobility particle sizer for 10 to 600 nm particles and an aerodynamic particle sizer for 0.5 to 10 micrometer particles. Particulate matter was collected on filters for mass-based emission factors and OC/EC analysis. Gas analyzers measured CO, CO2, NOx, and SO2. The project calculated emission factors by normalizing pollutant mass emitted to the mass of plastic mulch burned.

Pollutant/Property	Instrument or Method	Output
Particle size distribution	SMPS and APS	Number size distribution from nanometer to micrometer range
PM mass	Filter collection and microbalance	Mass concentration and PM emission factor
Carbon content	OC/EC analyzer	Organic carbon and elemental carbon
CO and CO2	Gas analyzer	Combustion efficiency and emission factors
NOx and SO2	Gas analyzer	Gaseous emission factors
Microplastics	Stereomicroscope and Py-GC/MS	Particle morphology, size class, polymer identity, and abundance

2.6 Microplastic analysis

The University of Florida team analyzed the physical and chemical properties of microplastics in burn residues. Physical characterization used a stereomicroscope at 5x magnification to identify size, color, and shape, with a stated detection limit above 20 micrometers. Chemical characterization used Py-GC/MS with a Frontier Laboratories multi-shot pyrolyzer coupled with Agilent GC/MS instrumentation. The standard reference plastic detection limits including PMMA (20 ng), PS (25 ng), PE (0.4 microgram), PP (95 ng), PET (2 microgram), PVC (1 microgram), PC (0.8 microgram), PA66 (0.6 microgram), and PA6 (0.8 microgram). Based on TAG feedback and early data, later microplastic analysis separated particles into two categories using a 25 micrometer sieve: particles larger than 25 micrometers and particles smaller than 25 micrometers. The final analysis included white and black plastic mulch samples at 585, 685, and 785 °C.

3. RESULTS

3.1 Project website, stakeholder engagement, and milestones

The project website was created to share the project description, project documents, TAG members, TAG meeting recordings, and Hinkley Center acknowledgement. The team established the furnace and open burning reactor systems, calibrated major particulate matter and gas measurement instruments, and finalized sampling protocols. The team completed tube furnace experiments, shipped burn residues to the University of Florida, analyzed pollutant data, and held two TAG meetings.

TAG Meeting #1 included participants from the agricultural plastics sector, Florida DEP, public health, solid waste management, academia, and the Hinkley Center. Key feedback included the need to consider film specifications, additives, thickness, possible field measurements, health aspects, and farmer-facing outputs. TAG Meeting #2 included additional technical feedback, including suggestions to use diesel fuel in open burning experiments, analyze raw plastic samples, conduct soil metal analysis, and examine why PM emissions may increase under certain higher-temperature conditions.

3.2 Modified combustion efficiency

Modified combustion efficiency increased with burning temperature for both white/aluminized and black plastic mulch. The black plastic mulch showed higher MCE than the white/aluminized plastic across the measured temperature range. This likely reflects differences in film structure and combustion behavior, including the thinner and more elastic texture of black plastic and potentially better oxygen access during burning. The higher MCE at higher temperature indicates more complete oxidation of carbon monoxide to carbon dioxide.

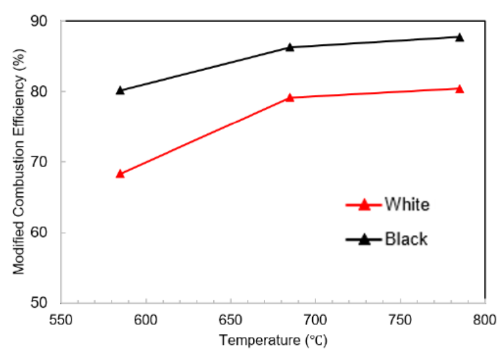


Figure 5. Modified combustion efficiency as a function of burning temperature for white/aluminized and black plastic mulch samples.

3.3 Gaseous pollutant emission factors

The furnace experiments showed that higher burning temperature reduced the emission factors of CO, NOx, and SO2. CO emission factors declined with temperature for both white and black plastic mulch, consistent with improved oxidation at higher temperature. NOx and SO2 also generally declined at higher temperature, although the relative behavior differed by plastic type.

The SO2 results were notable because polyethylene is a hydrocarbon polymer and should not inherently contain sulfur. The observation of significant SO2 emission factors suggests that soil, fertilizer, pesticide residues, additives, or other contamination on the used agricultural plastic contributed to sulfur-containing emissions. This finding is important because it indicates that emission behavior of used mulch cannot be inferred from clean polyethylene alone.

3.4 Particulate matter emission factors

Black plastic mulch generated higher PM emission factors than white/aluminized plastic mulch in the furnace experiments. This trend may be associated with differences in material texture, film structure, and combustion efficiency. The PM temperature trend was more complex than the gaseous pollutant trends. For black plastic, PM emission factor increased at the highest temperature condition, whereas white/aluminized plastic showed a decreasing PM trend. This complexity was identified by the TAG as a key issue because PM emissions are central to practical burning guidance.

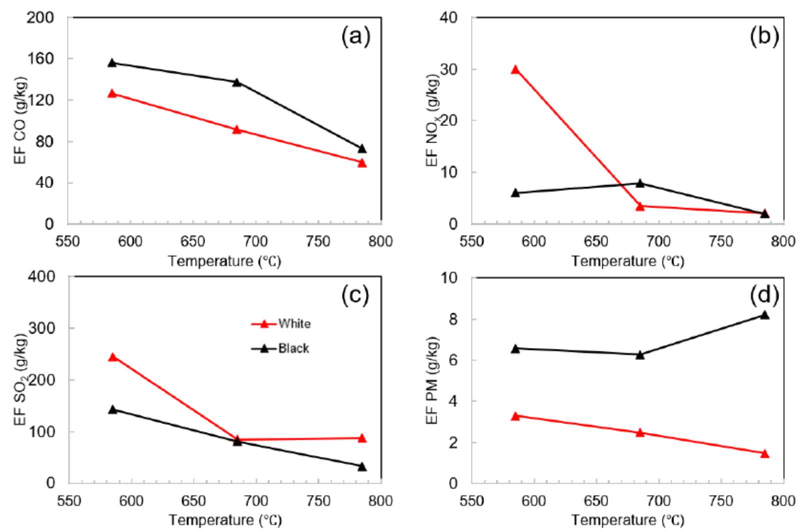


Figure 6. Emission factors of CO, NOx, SO2, and PM as a function of burning temperature for the plastic mulch samples.

3.5 Comparison with NAAQS reference concentrations

The project compared average and maximum gas concentrations measured during burning experiments with NAAQS reference values. The results showed that measured concentrations exceeded reference values, which is expected because furnace outlet concentrations are source-level measurements rather than ambient downwind concentrations. However, the comparison highlights the potential magnitude of source emissions. SO2 was especially high relative to its reference value, reinforcing the need to evaluate soil contamination, fertilizer residues, pesticide residues, and film additives as contributors to sulfur emissions.

Pollutant	**Average concentration**	**Maximum concentration**	**NAAQS reference concentration**
CO	58 ppm	162 ppm	9 ppm
NO2	2.7 ppm	9.0 ppm	0.1 ppm
SO2	29.0 ppm	74.0 ppm	0.075 ppm

3.6 Microplastic abundance and morphology

Microplastics were detected in all burned residue samples. After separating particles by a 25 micrometer sieve, most detected microplastics were larger than 25 micrometers. MP abundance increased with increasing temperature. Our results indicate that white plastic mulch showed higher MP occurrence than black plastic mulch. PVC was the predominant polymer identified in all burned sample types, which is likely because of the inclusion of PVC in the original plastic material and the low incinerability of PVC. MPs appeared as fibers, pellets, and fragments. The microscopic images showed many grey particles in white plastic burn residues and black fibers in black plastic burn residues.

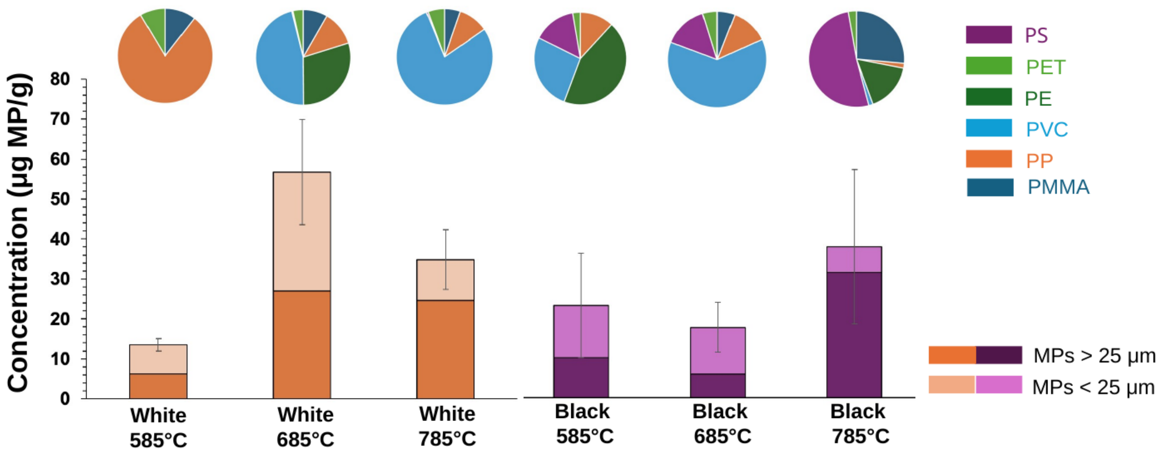


Figure 7. Microplastic abundance and polymer composition in burned plastic mulch residues at 585, 685, and 785 ℃.

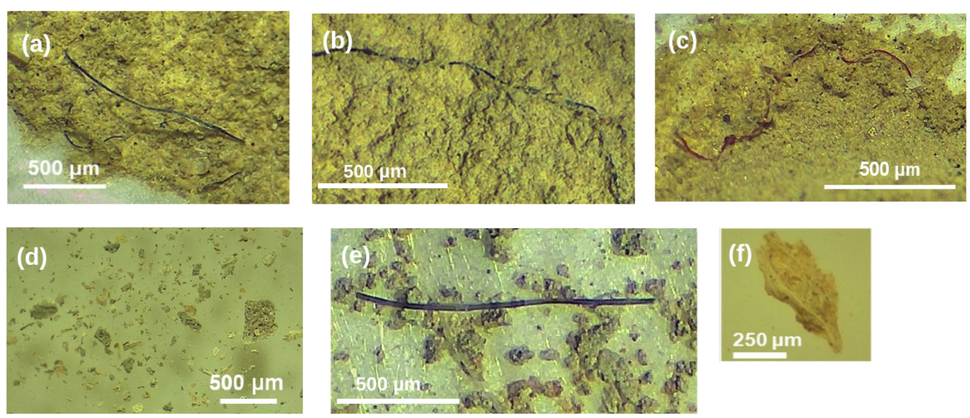
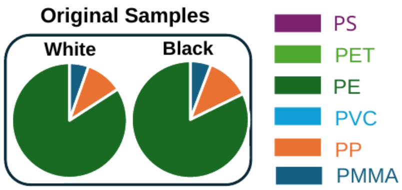


Figure 8. Microscopic images of burned plastic mulch samples. Black plastic mulch: 585, 685, and 785 ℃; white plastic mulch: 585, 685, and 785 ℃.

3.7 Chemical composition of original and burned samples

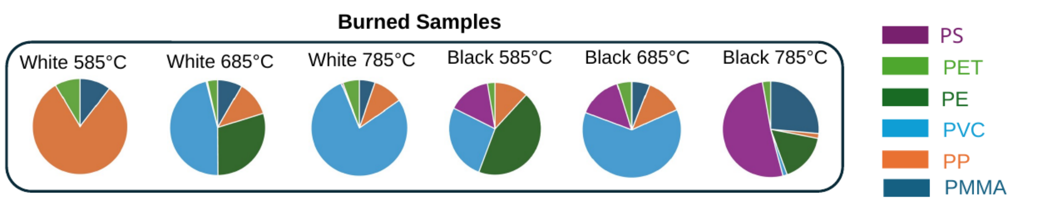
The original plastic mulch samples were analyzed by Py-GC/MS. Based on initial mass, approximately 75% of the products were identified as polymers. PE accounted for approximately 78% of the detected polymers for white plastic mulch and 70% for black plastic mulch, while other polymers such as PP and PMMA were also identified. Approximately 25% of original sample products were unknown products that could not be identified as polymers by Py-GC/MS. These results support the project assumption that PE is the major polymer, while also showing that commercial agricultural mulch can contain additional polymer signatures or additives.



		White		Black	
		% Based on Initial Mass	% Based on Detected MPs	% Based on Initial Mass	% Based on Detected MPs
Original	PMMA	0.212450909	4.77	0.279145532	5.07
	PP	0.412125988	9.23	0.580222697	9.80
	PVC	0	0.00	0	0.00
	PS	0	0.00	0	0.00
	PE	78.069933	63.31	70.617304	61.81
	PET	0	0.00	0	0.00
	Total Plastics	78.6945099		71.47667223	
	Unknown Products	21.3054901		28.52332777	

Figure 9. Chemical composition of original plastic mulch samples measured by Py-GC/MS.

Burned samples contained multiple polymer signatures, including PMMA, PP, PVC, PS, PE, and PET, depending on temperature and sample type. The measured polymer mass in burned residues represented a very small portion of the total residue mass, while most residue was likely carbonaceous soot and soil. Our observation also supports the interpretation that combustion formed or concentrated non-polymer residue, including soot and soil-associated materials.



		585		685		785	
		% Based on Initial Mass	% Based on Detected MPs	% Based on Initial Mass	% Based on Detected MPs	% Based on Initial Mass	% Based on Detected MPs
White	PMMA	0.000082	10.50	0.00024	8.30	0.000093	5.31
	PP	0.00064	80.93	0.00034	11.89	0.00018	10.02
	PVC	0	0.00	0.0013	46.21	0.0014	78.54
	PS	0	0.00	0.000012	0.41	0.00009	0.51
	PE	0	0.00	0.00084	29.70	0	0.00
	PET	0.000067	8.57	0.000099	3.49	0.000099	5.62
	Total MPs	0.00079		0.0028		0.0018	
	Soot/Soil	99.99		99.99		99.99	
Black	PMMA	0	0.00	0.000047	5.92	0.00050	26.43
	PP	0.00023	11.83	0.00012	12.24	0.000063	1.65
	PVC	0.00051	26.66	0.00062	62.68	0.000054	1.43
	PS	0.00029	14.98	0.00014	14.41	0.0019	51.32
	PE	0.00084	43.87	0	0.00	0.00062	16.36
	PET	0.000051	2.66	0.000047	4.76	0.00011	2.81
	Total MPs	0.0019		0.00098		0.0033	
	Soot/soil	99.99		99.99		99.99	

Most of the residue might be carbonaceous soot.

Figure 10. Chemical composition of burned plastic mulch samples measured by Py-GC/MS.

3.8 Summary of findings

Finding	Interpretation	Implication
Higher temperature increased MCE	More complete oxidation occurred at higher temperature	Higher-temperature burning may reduce CO and some gases
Black plastic showed higher MCE	Film structure and oxygen access likely influenced burning	Film specification must be considered in guidance
SO2 emissions were	Soil, fertilizer, pesticide, or additives	Used mulch cannot be treated as clean

unexpectedly high	may contribute sulfur	polyethylene
Black plastic generated higher PM EF	PM formation depends on texture and combustion behavior	PM guidance requires additional validation
MPs detected in all burned residues	Burning did not eliminate all plastic-related particles	Residue management remains important
MP abundance increased with temperature	Higher temperature may increase fragmentation or residue concentration	Burning optimization must consider both air and residue pollutants

4. CONCLUSIONS

This project generated one of the first controlled datasets on pollutant emissions from burning field-collected agricultural plastic mulch film. The results show that agricultural plastic mulch burning is not equivalent to burning clean polyethylene. Plastic type, film structure, thickness, reflective layers, and contamination can alter combustion efficiency and pollutant emissions. Used plastic mulch can generate gaseous pollutants, particulate matter, and microplastic-containing residues under laboratory-controlled burning conditions.

The key conclusion is that higher furnace temperature improved modified combustion efficiency and reduced CO, NOx, and SO2 emission factors. However, higher temperature did not universally reduce all pollutants. PM emissions were higher for black plastic mulch and did not follow a simple monotonic temperature trend across all conditions. Microplastic abundance increased with temperature, and MPs were present in all burned residue samples. Therefore, a burning condition that reduces gaseous pollutants may not necessarily minimize particulate matter or microplastic residues.

A second important conclusion is that soil and agricultural contamination likely play an important role in emission chemistry. The unexpectedly high SO2 emissions suggest contributions from soil, fertilizer, pesticide, additives, or other non-polyethylene components. This finding supports additional analysis of raw plastic, adhered soil, metals, sulfur-containing compounds, and field contamination before finalizing management guidance.

For practical use, the results suggest that agricultural plastic burning guidance should not only specify whether burning is allowed, but also consider material type, contamination level, ignition method, combustion temperature, worker exposure, residue handling, and downwind impacts. The project does not yet support a single universal best burning method because air pollutant and residue pollutant trends differ. Instead, the most scientifically defensible recommendation is to minimize open burning where feasible, improve collection and preprocessing options, and pursue future research that links laboratory emission factors to field measurements and exposure modeling.

Recommendations for future work

1. Conduct field measurements during real agricultural plastic mulch burning to validate laboratory emission factors and characterize downwind exposure.
2. Complete and compare open burning experiments using relevant ignition methods, including diesel fuel and torch-assisted burning, as suggested by TAG members.
3. Develop farmer-facing guidance that balances practical constraints, cost, pollutant reduction, personal protection, and residue cleanup.
4. Evaluate preprocessing methods, including shaking, washing, dry separation, and electrostatic approaches, to reduce soil contamination and improve recycling or WTE feasibility.
5. Use emission factors from this project to support future health risk assessment and air dispersion modeling.

5. REFERENCES

To be updated

Cassou, E. Agricultural Pollution - Plastics. 2018.

Chen, L.W.A., Moosmuller, H., Arnott, W.P., Chow, J.C., Watson, J.G., Susott, R.A., Babbitt, R.E., Wold, C.E., Lincoln, E.N. and Hao, W.M. "Emissions from laboratory combustion of wildland fuels: Emission factors and source profiles," Environmental Science & Technology 41: 4317-4325 (2007).

Cheng, K., Hao, W., Wang, Y., Yi, P., Zhang, J. and Ji, W. "Understanding the emission pattern and source contribution of hazardous air pollutants from open burning of municipal solid waste in China," Environmental Pollution 263: 114417 (2020).

Cruz, M.B., Saikawa, E., Hengstermann, M., Ramirez, A., McCracken, J.P. and Thompson, L.M. "Plastic waste generation and emissions from the domestic open burning of plastic waste in Guatemala," Environmental Science: Atmospheres 3: 156-167 (2023).

EPA. AP-42: Compilation of Air Emissions Factors from Stationary Sources. 2024.

EPA. National Ambient Air Quality Standards (NAAQS) Table. 2024.

FDEP. Table II - Soil Cleanup Target Levels. 2024.

Gullett, B.K., Wyrzykowska, B., Grandesso, E., Touati, A., Tabor, D.G. and Ochoa, G.S. "PCDD/F, PBDD/F, and PBDE emissions from open burning of a residential waste dump," Environmental Science & Technology 44: 394-399 (2010).

Hall, D., Wu, C.-Y., Hsu, Y.-M., Stormer, J., Engling, G., Capeto, K., Wang, J., Brown, S., Li, H.-W. and Yu, K.-M. "PAHs, carbonyls, VOCs and PM2.5 emission factors for pre-harvest burning of Florida sugarcane," Atmospheric Environment 55: 164-172 (2012).

Hochmuth, G., Hochmuth, B. and Olson, S. New technologies in mulching for vegetable production in Florida. Citrus and Vegetable Magazine. 2002.

Jung, S., Raghavendra, A.J. and Patri, A.K. "Comprehensive analysis of common polymers using hyphenated TGA-FTIR-GC/MS and Raman spectroscopy towards a database for micro- and nanoplastics identification, characterization, and quantitation," NanoImpact 30: 100467 (2023).

Kasirajan, S. and Ngouajio, M. "Polyethylene and biodegradable mulches for agricultural applications: a review," Agronomy for Sustainable Development 32: 501-529 (2012).

Levitan, L. Reducing dioxin emissions by recycling agricultural plastics: Creating viable alternatives to open burning. 2005.

Moore, J. and Wszelaki, A. Plastic mulch in fruit and vegetable production: Challenges for disposal. Washington State University Extension Fact Sheet FA-2016. 2016.

Shen, M., Hu, T., Huang, W., Song, B., Qin, M., Yi, H., Zeng, G. and Zhang, Y. "Can incineration completely eliminate plastic wastes? An investigation of microplastics and heavy metals in the bottom ash and fly ash from an incineration plant," Science of the Total Environment 779: 146528 (2021).

Steinmetz, Z., Wollmann, C., Schaefer, M., Buchmann, C., David, J., Troger, J., Munoz, K., Fror, O. and Schaumann, G.E. "Plastic mulching in agriculture. Trading short-term agronomic benefits for long-term soil degradation?" Science of the Total Environment 550: 690-705 (2016).

Wang, Z., Richter, H., Howard, J.B., Jordan, J., Carlson, J. and Levendis, Y.A. "Laboratory investigation of the products of the incomplete combustion of waste plastics and techniques for their minimization," Industrial & Engineering Chemistry Research 43: 2873-2886 (2004).

Wu, D., Li, Q., Shang, X., Liang, Y., Ding, X., Sun, H., Li, S., Wang, S., Chen, Y. and Chen, J. "Commodity plastic burning as a source of inhaled toxic aerosols," Journal of Hazardous Materials 416: 125820 (2021).