2024 NORTH AMERICAN BIOCHAR CONFERENCE — USBI — CALIFORNIA, USA

RIT | Golisano Institute for Sustainability

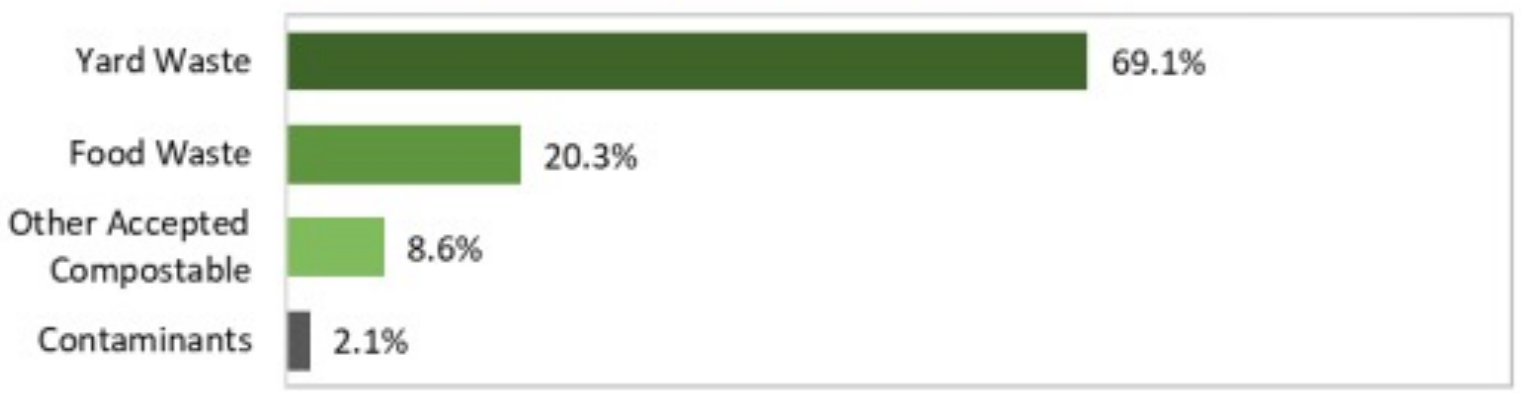
Pyrolysis as a valorization for plastic-contaminated organic waste streams

Yvan D Hernandez-Charpak
Harshal J Kansara
Diana Rodriguez Alberto
Carlos A Diaz-Acosta
Thomas A Trabold

February 14th, 2024

Organic waste valorization pathways

Figure 8. Compostability Group Composition: All Sectors



(Cascadia Consulting Group, 2023)

- Policy increasing separated waste streams for valorization
- Plastic contamination in organic waste streams in an increasing problem...

Plastic contamination in waste valorization streams

60%-75% of contaminants are plastics (ISWA, 2023)

0.3%-5% is the maximum plastic contamination (dry) (ISWA, 2023 ; EPA, 2021)

150-300 USD$/ton can be the cost of removal* (ISWA, 2023)

Contaminated feedstocks (ISWA, 2023)

*macro contaminants (>5mm)

Loss of revenue (quality decreases, costs increase) meaning rejection of the waste towards landfilling.

Pyrolysis for plastic-contaminated organic waste streams

Three RIT-driven case studies:

- Contaminated cafeteria food waste with plastic packaging
- Co-pyrolysis with agricultural mulch films
- Plastic bagged spend mushroom substrate

Cafeteria waste characterization

- Collected and sorted waste from cafeteria (3rd to 5th grade) during the 2017-2018 school year:
  - Food waste
  - Recyclables
  - Landfill waste

87%w

13%w

- Plastic utensils (PP, HDPE)
- Tetra Pak containers
- Chips and snack bags (metalized PP; metalized LDPE)

N_2
1000ºC
30 min

RIT | Golisano Institute for Sustainability

Control Laboratories

42 Hangar Way
Watsonville, CA 95076
www.biocharlab.com
Tel: 831 724-5422
Fax: 831 724-3188

- IBI standard H:C ratio
- Organic carbon
- pH
- Specific Surface Area

Food Waste

Internation... ...ogram

	...hod
Moisture (time of analysis)	...M D1762-84 (105c)
Bulk Density	
Organic Carbon	Combust-ASTM D 4373
Hydrogen/Carbon (H:C)	...y combustion/C(above)
Total Ash	...M D-1762-84
Total Nitrogen	Combustion
pH value	...USCC:dil. Rajkovich
Electrical Conductivity (EC20 w/w)	...USCC:dil. Rajkovich
Liming (neut. Value as-CaCO3)	...C 955.01
Carbonates (as-CaCO3)	...M D 4373
Butane Act.	...M D 5742-95
Surface Area Correlation	

All units mg/kg dry unless stated:		Results	Range of Max. Levels	Reporting Limit (ppm)	Method
Arsenic	(As)	ND	13 to 100	0.68	J
Cadmium	(Cd)	ND	1.4 to 39	0.27	J
Chromium	(Cr)	1.6	93 to 1200	0.68	J
Cobalt	(Co)	ND	34 to 100	0.68	J
Copper	(Cu)	1.5	143 to 6000	0.68	J
Lead	(Pb)	ND	121 to 300	0.27	J
Molybdenum	(Mo)	0.8	5 to 75	0.68	J
Mercury	(Hg)	ND	1 to 17	0.001	EPA 7471
Nickel	(Ni)	ND	47 to 420	0.68	J
Selenium	(Se)	ND	2 to 200	1.36	J
Zinc	(Zn)	43.1	416 to 7400	1.36	J
Boron	(B)	7.6	Declaration	6.78	TMECC
Chlorine	(Cl)	501	Declaration	20.0	TMECC
Sodium	(Na)	5682	Declaration	677.7	E
Iron	(Fe)	54	Declaration	33.9	E
Manganese	(Mn)	4	Declaration	0.68	J

	...hod
Moisture (time of analysis)	...TM D1762-84 (105c)
Bulk Density	
Organic Carbon	Combust-ASTM D 4373
Hydrogen/Carbon (H:C)	...ry combustion/C(above)
Total Ash	...TM D-1762-84
Total Nitrogen	Combustion
pH value	...IUSCC:dil. Rajkovich
Electrical Conductivity (EC20 w/w)	...USCC:dil. Rajkovich
Liming (neut. Value as-CaCO3)	...AC 955.01
Carbonates (as-CaCO3)	...TM D 4373
Butane Act.	...TM D 5742-95
Surface Area Correlation	

All units mg/kg dry unless stated:		Results	Range of Max. Levels	Reporting Limit (ppm)	Method
Arsenic	(As)	ND	13 to 100	0.67	J
Cadmium	(Cd)	ND	1.4 to 39	0.27	J
Chromium	(Cr)	1.5	93 to 1200	0.67	J
Cobalt	(Co)	ND	34 to 100	0.67	J
Copper	(Cu)	13.4	143 to 6000	0.67	J
Lead	(Pb)	ND	121 to 300	0.27	J
Molybdenum	(Mo)	4.2	5 to 75	0.67	J
Mercury	(Hg)	ND	1 to 17	0.001	EPA 7471
Nickel	(Ni)	1.9	47 to 420	0.67	J
Selenium	(Se)	ND	2 to 200	1.33	J
Zinc	(Zn)	10.3	416 to 7400	1.33	J
Boron	(B)	7.0	Declaration	6.65	TMECC
Chlorine	(Cl)	3855	Declaration	20.0	TMECC
Sodium	(Na)	5890	Declaration	665.3	E
Iron	(Fe)	250	Declaration	33.3	E
Manganese	(Mn)	6	Declaration	0.67	J

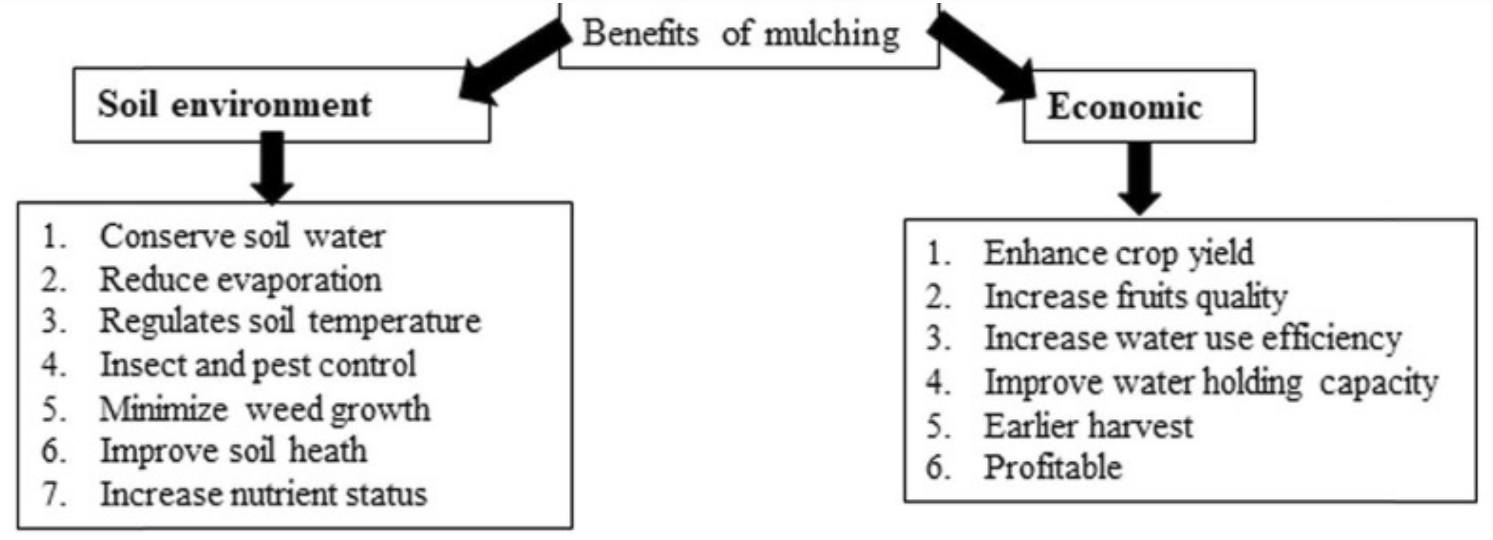
Pure FW

- Chlorine
(501 vs 3855 ppm)
- Iron
(54 vs 250 ppm)

Contaminated FW

Agricultural Mulch Films (AMFs)

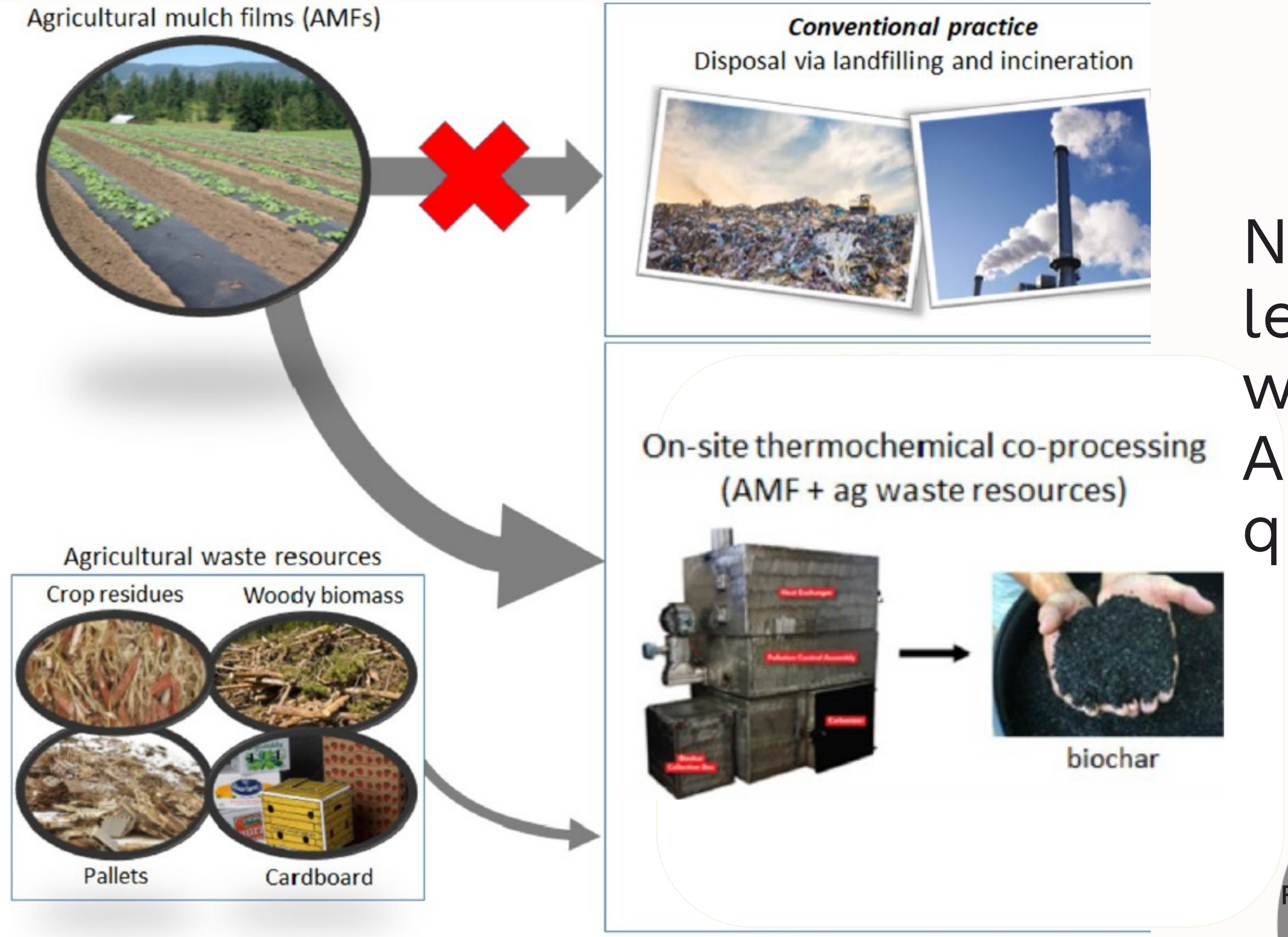
- **Increase** yield (Iqbal et al., 2020)
- >2 million t/year (Inglis et al., 2015)
- Most of it is **polyethylene** (PE) based.



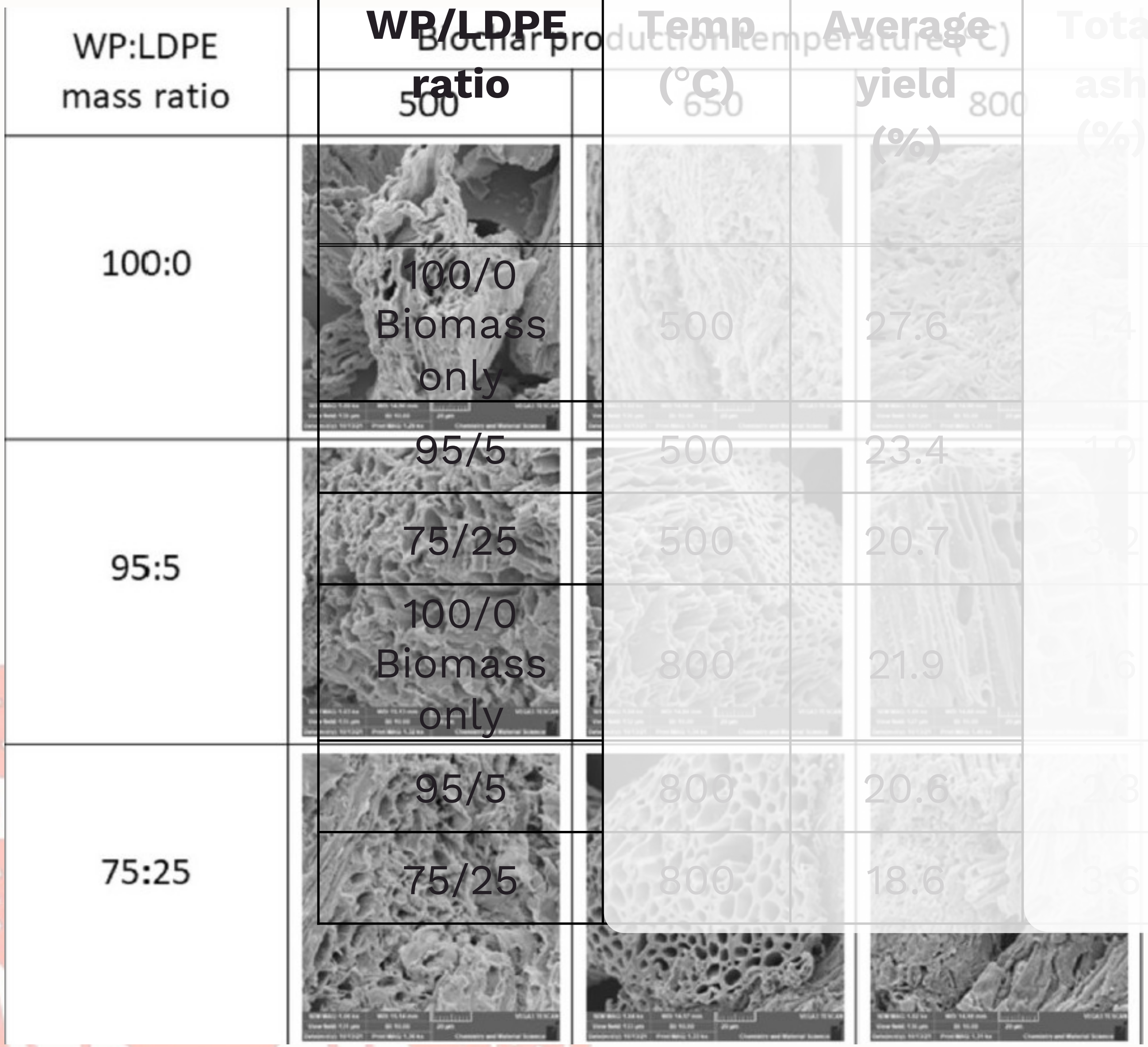
Benefits of mulching (adapted from Iqbal et al., 2020)

Feedstock characterization

- Co-pyrolysis based on the weight ratios

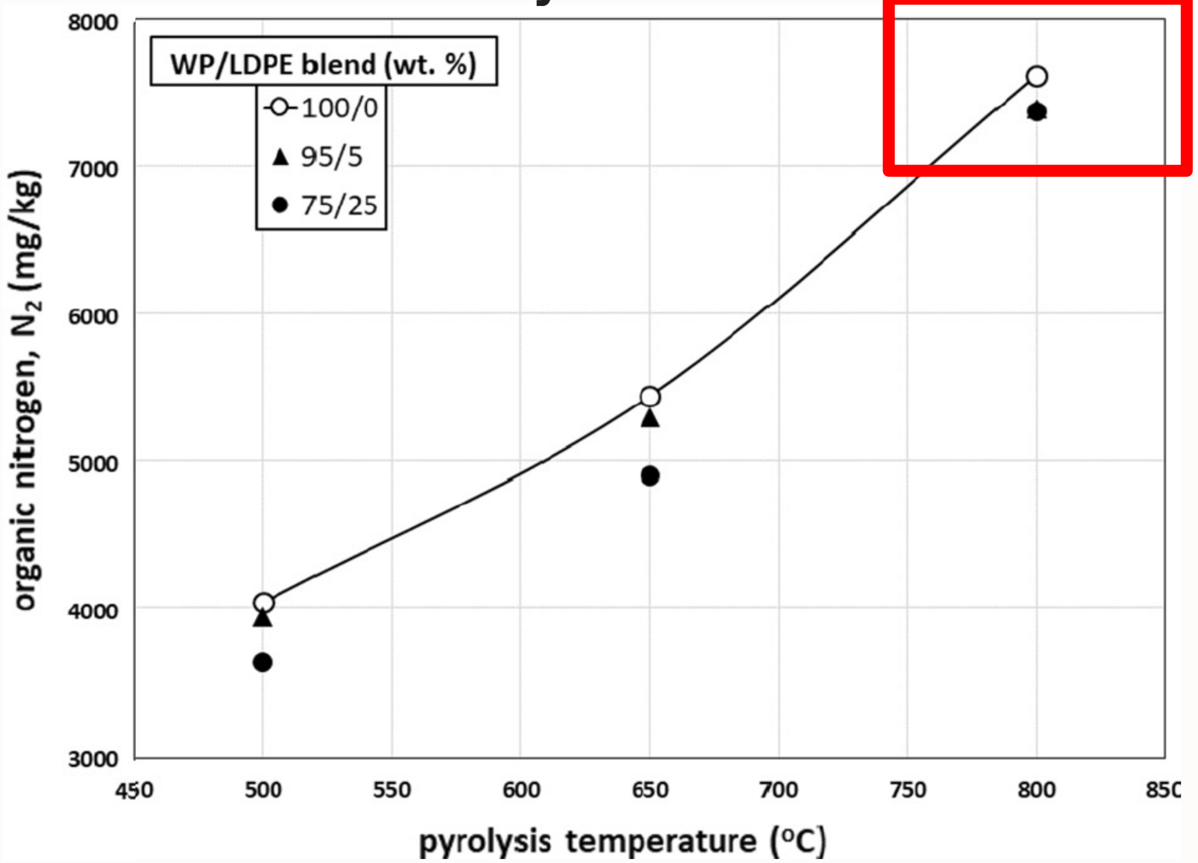


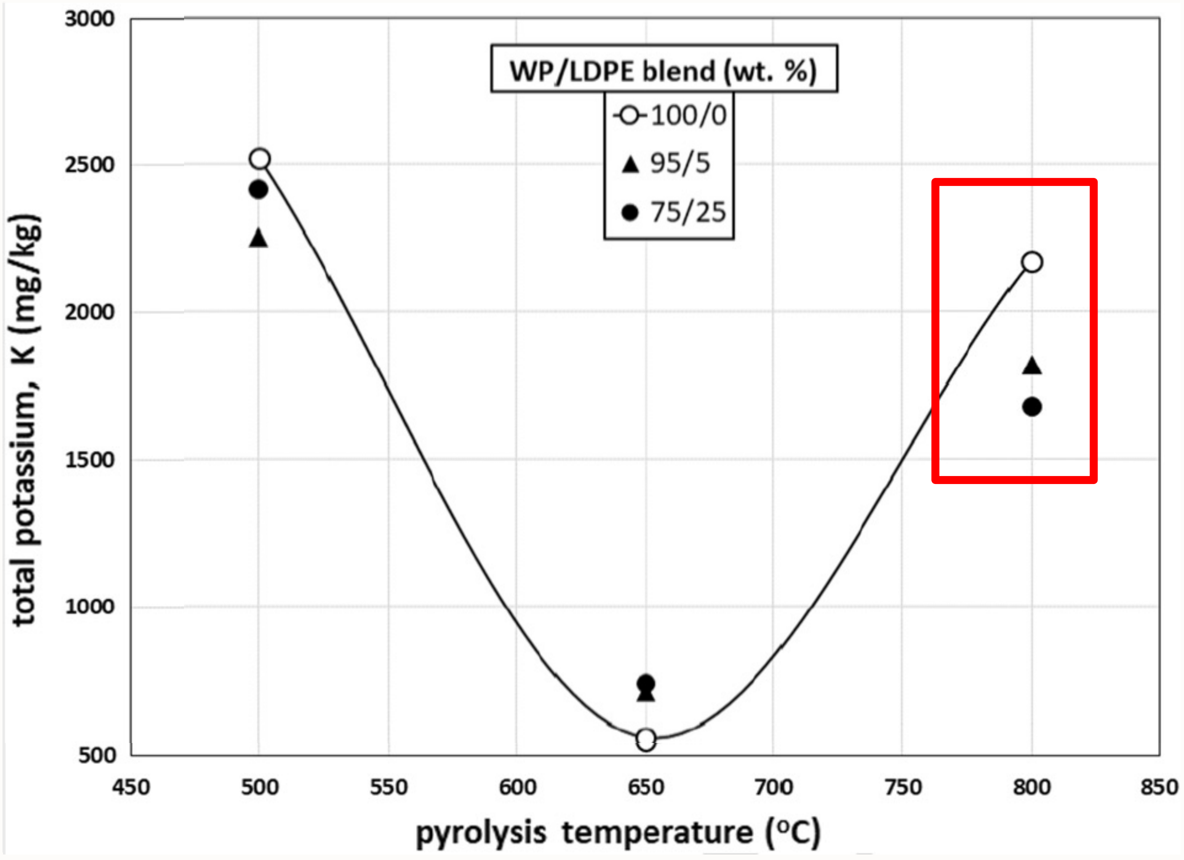
NYS has a lot of orchards, leaving considerable woody waste. **Co-pyrolysis** with AMFs, affects the BC quality?



WP/LDPE ratio	Temp (°C)	Average yield (%)	Total ash (%)	Bulk density (kg/m^3)	H:C	pH	EC (dS/m)	SSA (m^2/g dry)
100/0 Biomass only	500	27.6	1.4	233.9	0.56	4.40	0.11	207
95/5	500	23.4	1.9	213.0	0.52	11.1	0.12	237
75/25	500	20.7	3.2	289.9	0.54	10.5	0.14	238
100/0 Biomass only	800	21.9	1.6	[illegible]	0.23	5.93	0.49	118
95/5	800	20.6	2.3	[illegible]	0.23	7.22	0.52	133
75/25	800	18.6	3.6	[illegible]	0.24	8.04	1.09	131

Small pores formation by LDPE volatilization





Original Paper | Published: 20 April 2022

Biochar Derived from Pyrolysis of Common Agricultural Waste Feedstocks and Co-pyrolysis with Low-Density Polyethylene Mulch Film

Ibrahim Cisse, Yvan D. Hernandez-Charpak, Carlos A. Diaz & Thomas A. Trabold

Waste and Biomass Valorization **13**, 3913–3932 (2022) | Cite this article

HTT and feedstock is the main factor for nutrients

LDPE doesn't appear to affect nutrients present in the BC

Plastic bagged spend mushroom substrate

- IBI standard H:C ratio
- Organic carbon
- pH
- Specific Surface Area

	Units	Biochar type		
		Seneca Farms	Blue Oyster SMS	Blue Oyster SMS + 4% HDPE
Metals (mg/kg)	As	ND	0.2	0.5
	Cd	ND	0.2	0.1
	Cr	0.9	10.6	160.5
	Co	ND	1.3	7.0
	Cu	7.4	15.7	18.4
	Pb	0.3	2.3	1.9
	Mo	ND	1.9	3.6
	Hg	ND	0.0	0.0
	Ni	1.0	20.9	273.5
	Se	ND	0.0	0.3
	Zn	7.0	46.5	50.0
	B	8.4	39.0	33.3
	Cl	ND	209.6	131.9
	Na	ND	815.9	664.8
	Fe	215	1,567.0	3,723.9
	Mn	22	444.9	332.7
	K	3339	10,109	12,652
	P	239	3,959	2,827
Liming	% CaCO3	16.2	17.6	12.5
Carbonates	% CaCO3	1.8	8.0	6.0
Butane	g/100g dry	5.4	1.4	1.2
Surface Area	m2/g	304	176	171

- Nickel

(21 vs 274 ppm)

- Iron

(1567 vs 3724 ppm)

Conclusions

- **Plastic-contaminated** organic waste streams are a **logistical challenge.**
- **Biochar properties** do not to seem to be sensitive to plastic contamination (up to 10% weight), **Surface Area** appears to **increase!**
- **Chlorine** and other persistent chemicals are a continuous **challenge.**
- **Pyrolysis** may be the only alternative pathway for some **contaminated organic waste streams**

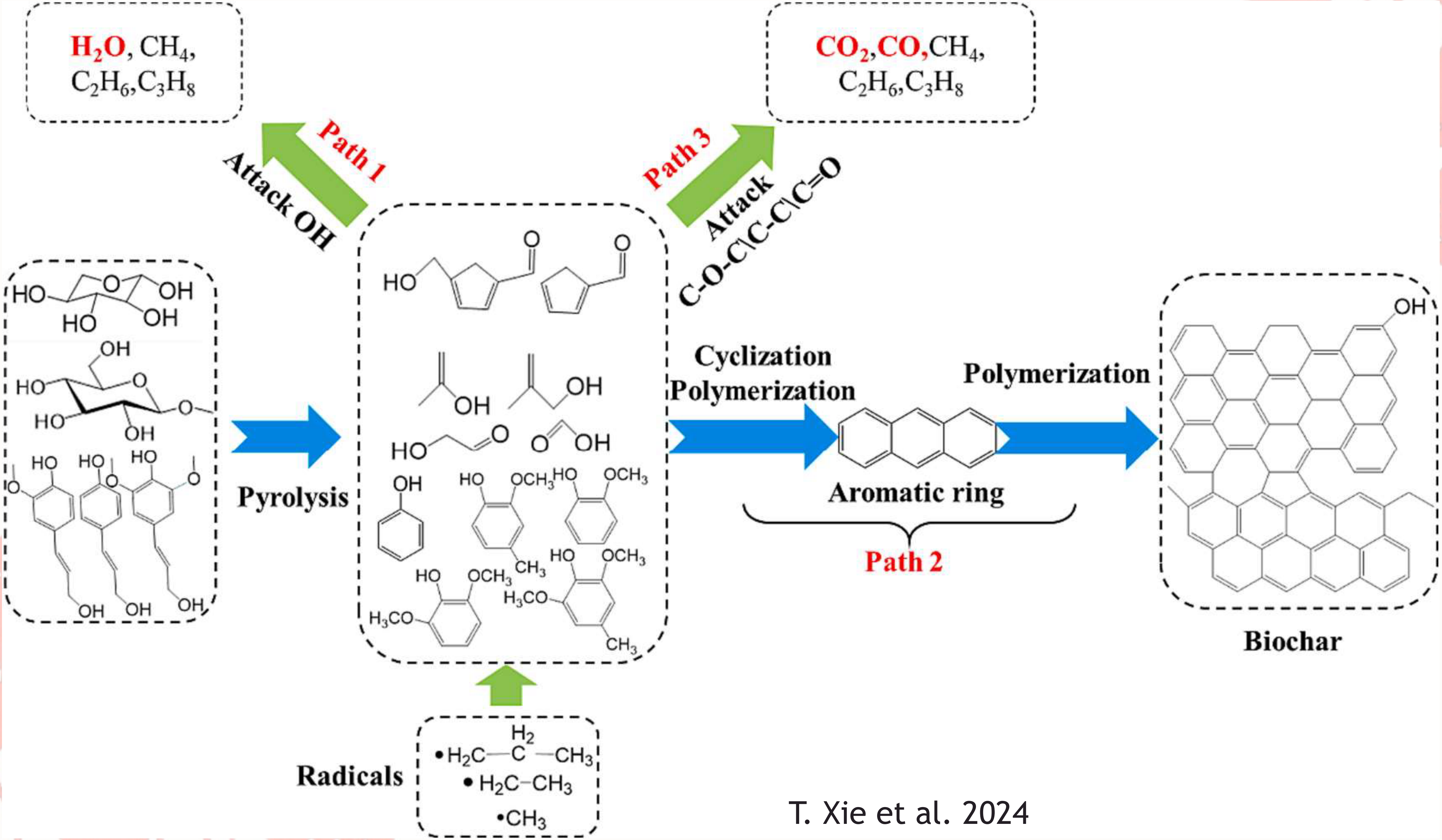
RIT | Golisano Institute for Sustainability

Thank you!
Questions?
yh7993@rit.edu

FOUNDATION FOR FOOD & AGRICULTURE RESEARCH

NEW YORK STATE OF OPPORTUNITY. | Empire State Development

2024 NORTH AMERICAN BIOCHAR CONFERENCE USBI



T. Xie et al. 2024