Biochar: Applications and Research

Products, Properties, and Markets

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United States Biochar Initiative

- 501 (c)(3) non-profit dedicated to **increasing production and use of biochar** in North America
- Focus Areas:
  - Biochar market development
  - Biochar standards development
  - Technical support
  - Education and outreach
  - Annual conference
  - Carbon Dioxide Removal advocacy

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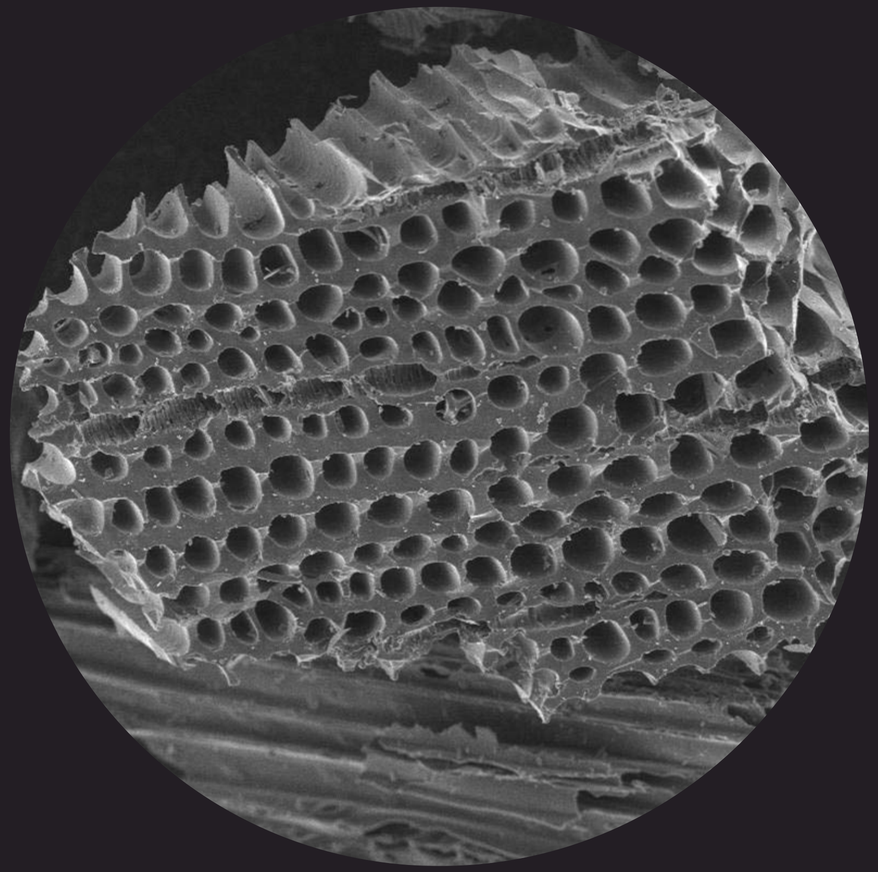
Biochar: Material and Applications

Biochar: A Physical Material

- Granular black carbon, like charcoal
- Chemical structure is resistant to decay, with majority of C stable for 1,000+ years
- Properties depend on feedstock and production conditions
- Has multiple beneficial end uses:
  - Soil health amendment
  - Ingredient in biochar-enhanced fertilizers
  - Potting soil media to replace peat
  - Environmental remediation and restoration
  - Media for water filtration
  - Additive to materials including concrete



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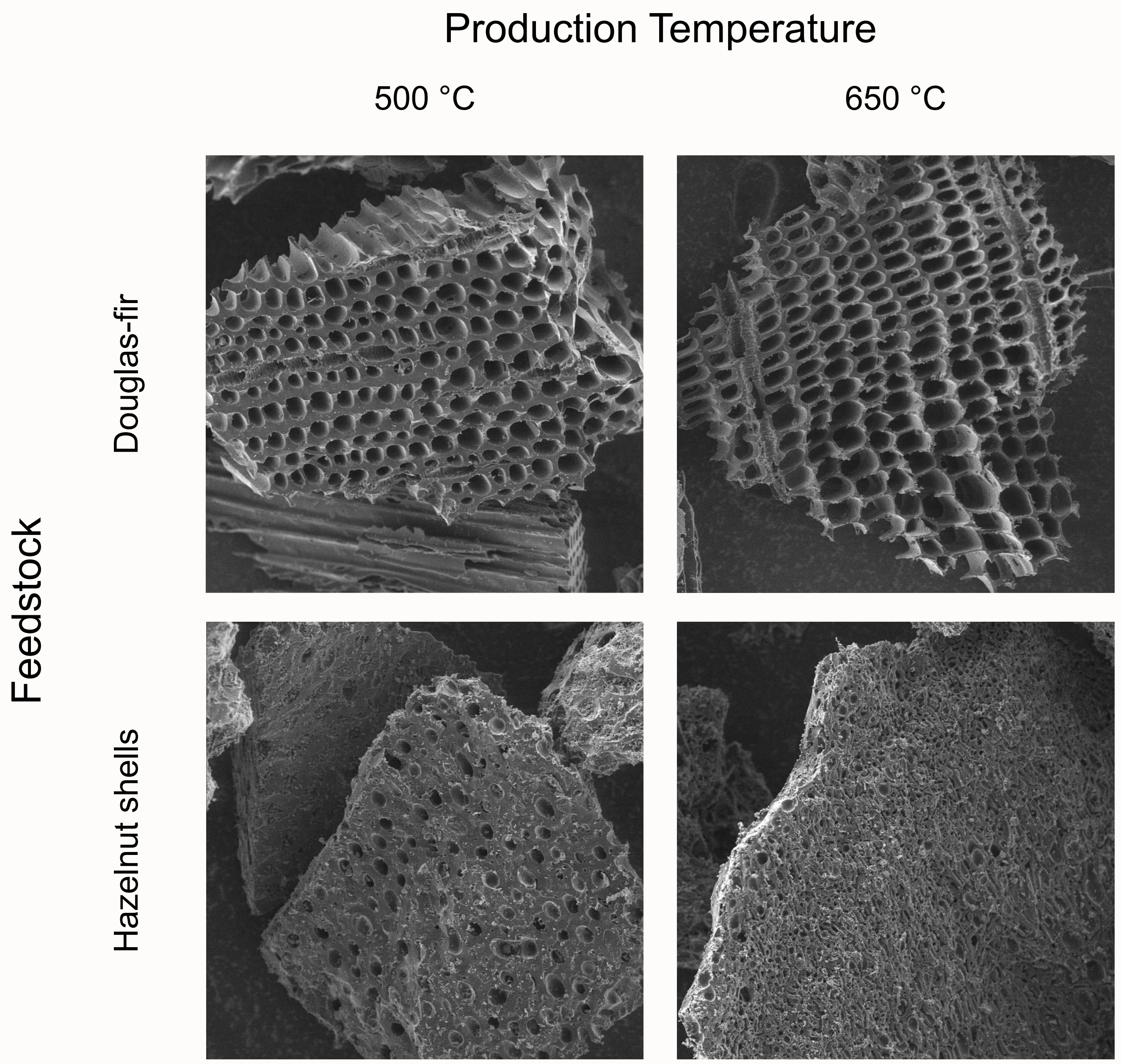
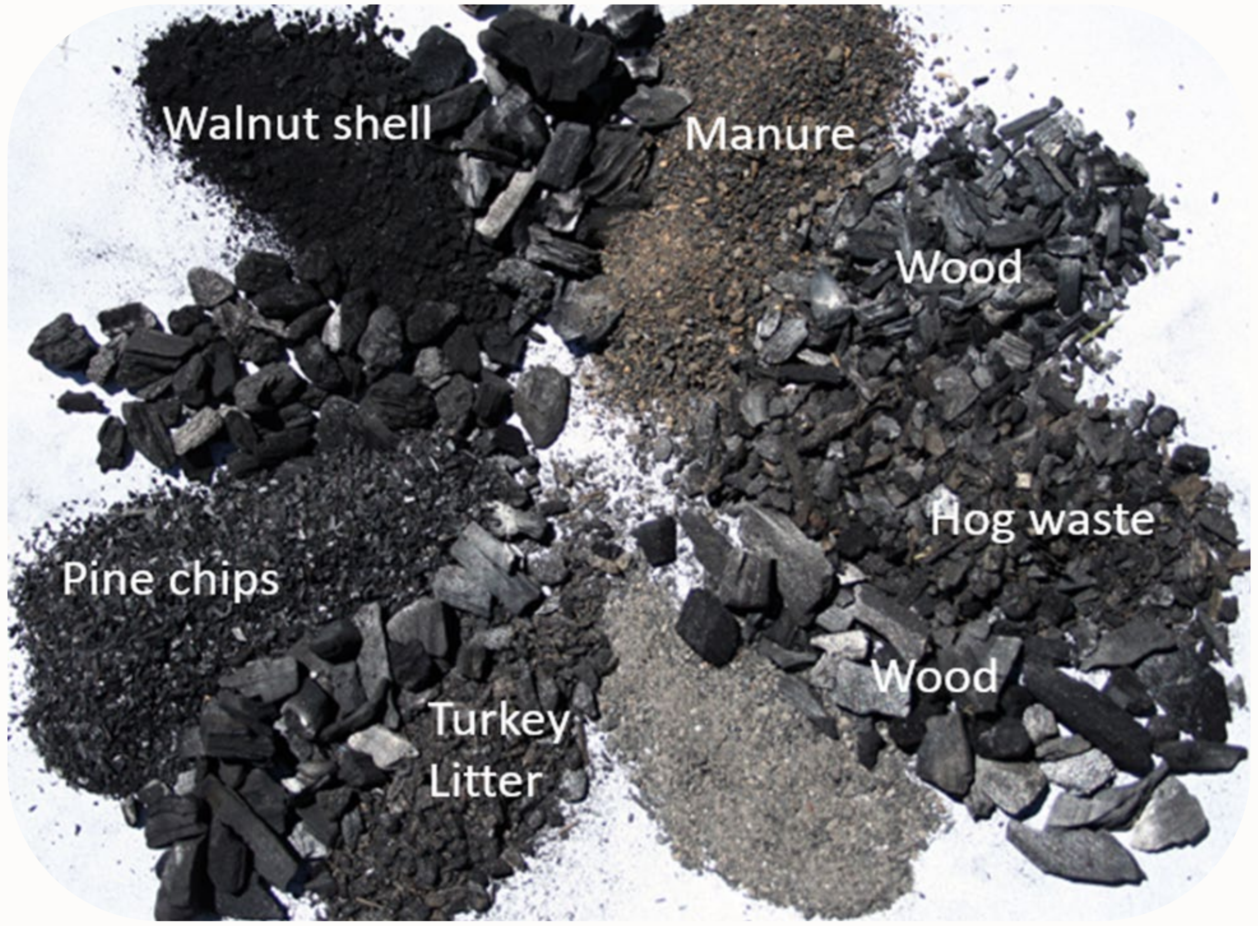
Biochar Material Properties



Myles Gray

Feedstock and production process affect properties

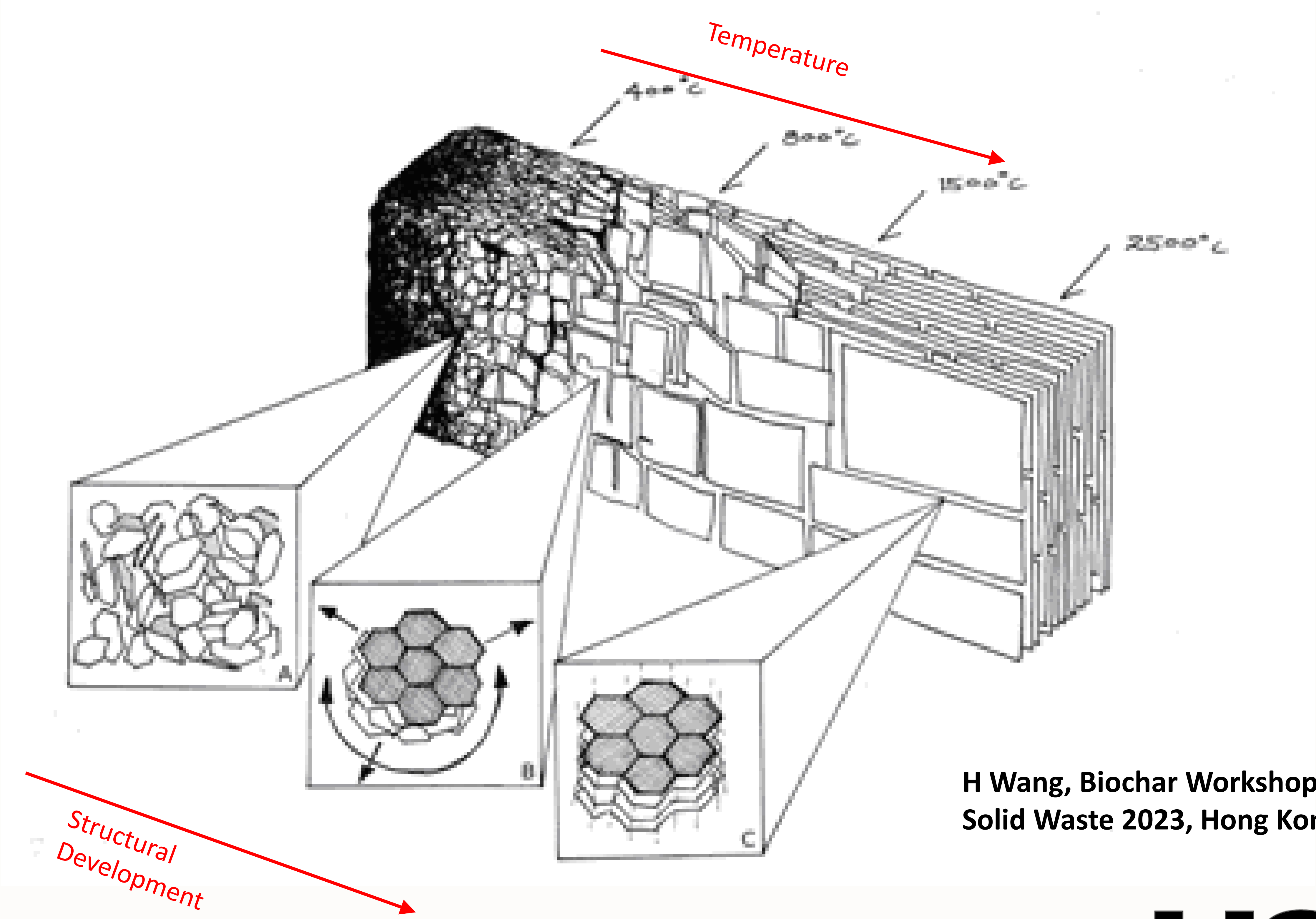
- Different end-uses for different biochars
- Potential to create engineered, “designer biochars”



Biochar Properties Change With Temperature

As temperature increases

- ➢Biochar yield decreases
- ➢Fixed carbon increases
- ➢Surface area increases
- ➢Ash content increases

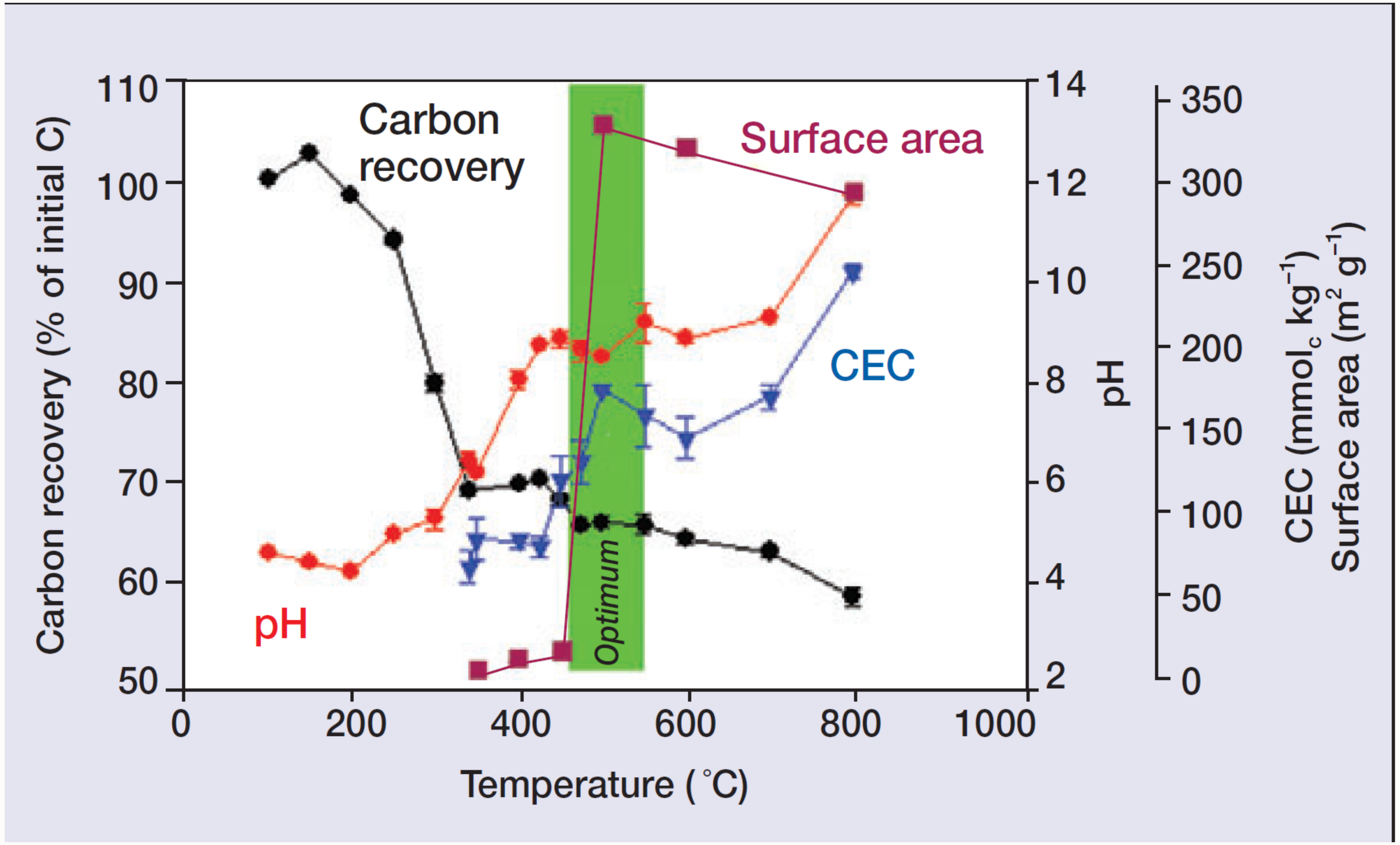


H Wang, Biochar Workshop, Solid Waste 2023, Hong Kong

Process Conditions Alter Properties

To enhance biochar yield:

- ➢Lower temperatures
- ➢Higher pressures
- ➢Longer vapour residence time
- ➢Slower heating rate
- ➢Larger particle size

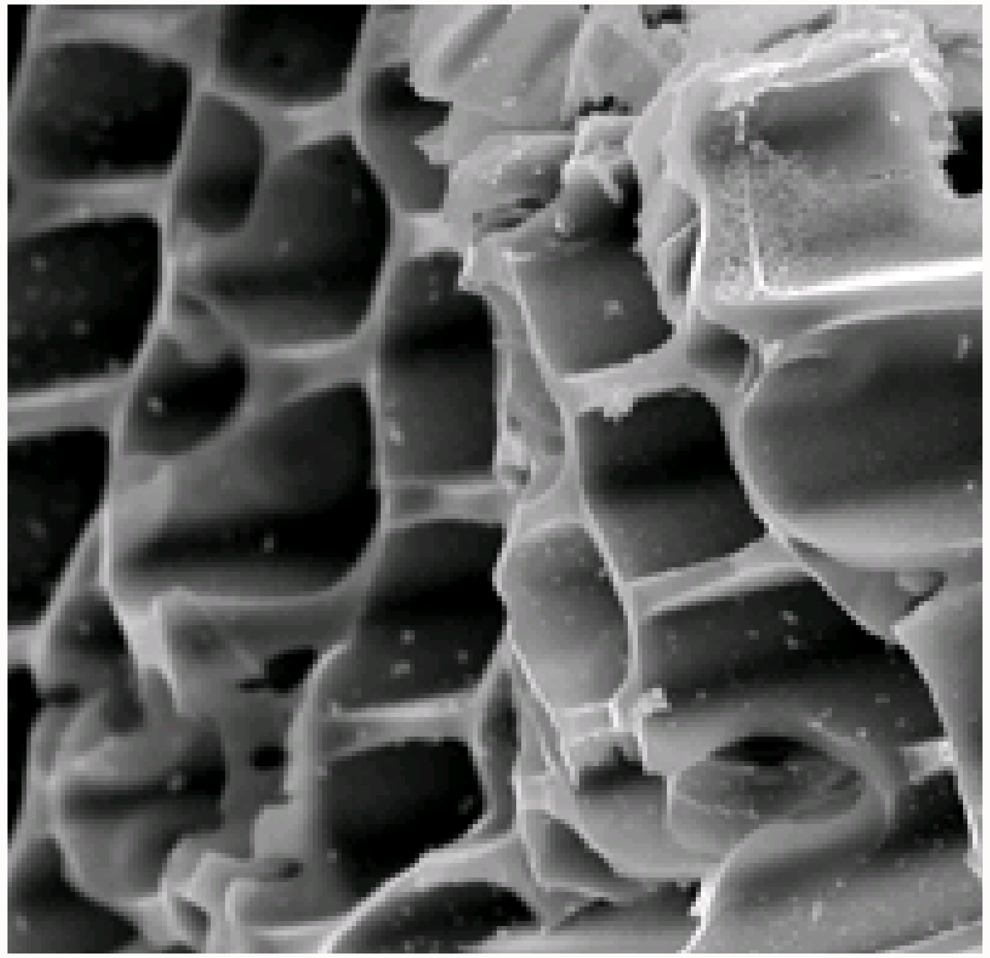


Temperature effects on Black Locust (Robinia pseudacacia L)

J. Lehmann Front Ecol Environ 2007; 5(7): 381–387

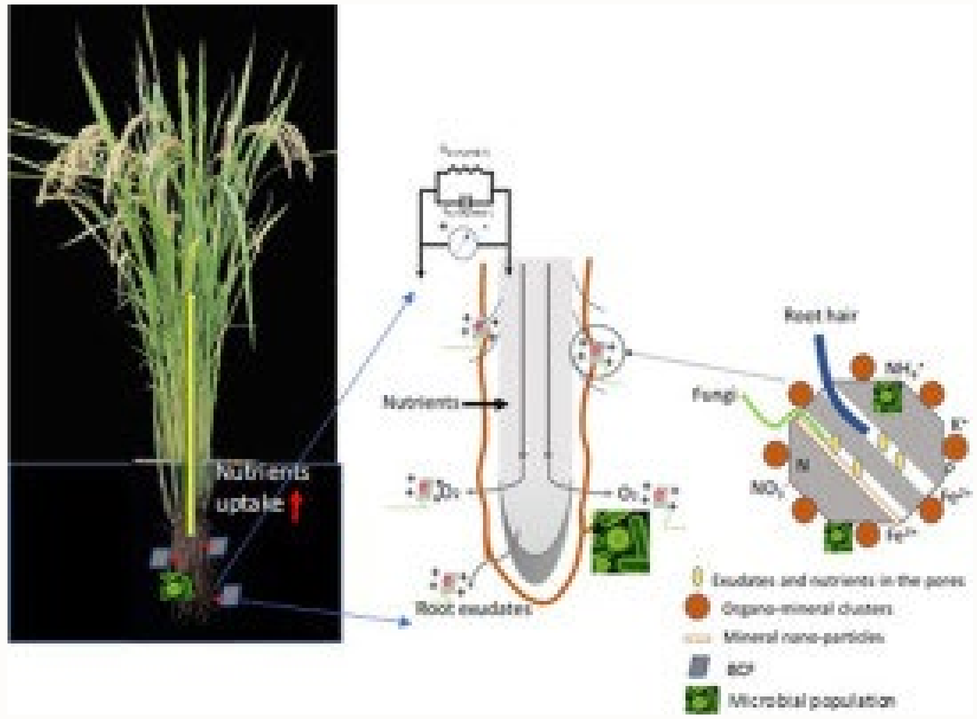
What Biochar Qualities Do You Need?

Biochars are fine-grained, highly porous charcoals that help soils retain nutrients and water. International Biochar Initiative



Collins 2009

Mycorrhizal fungal hyphae growing from spore base invade large charcoal pores Ogawa 2004

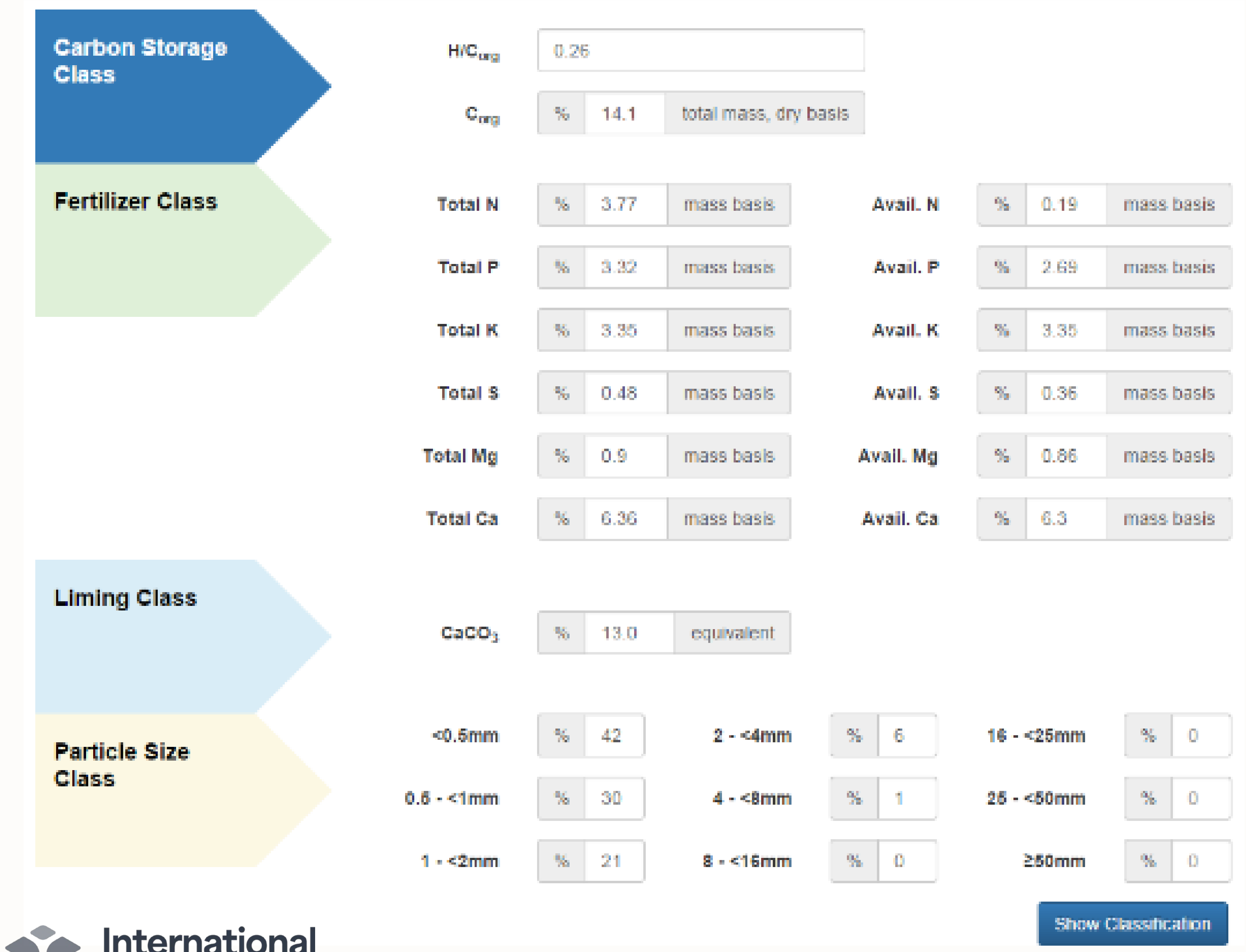


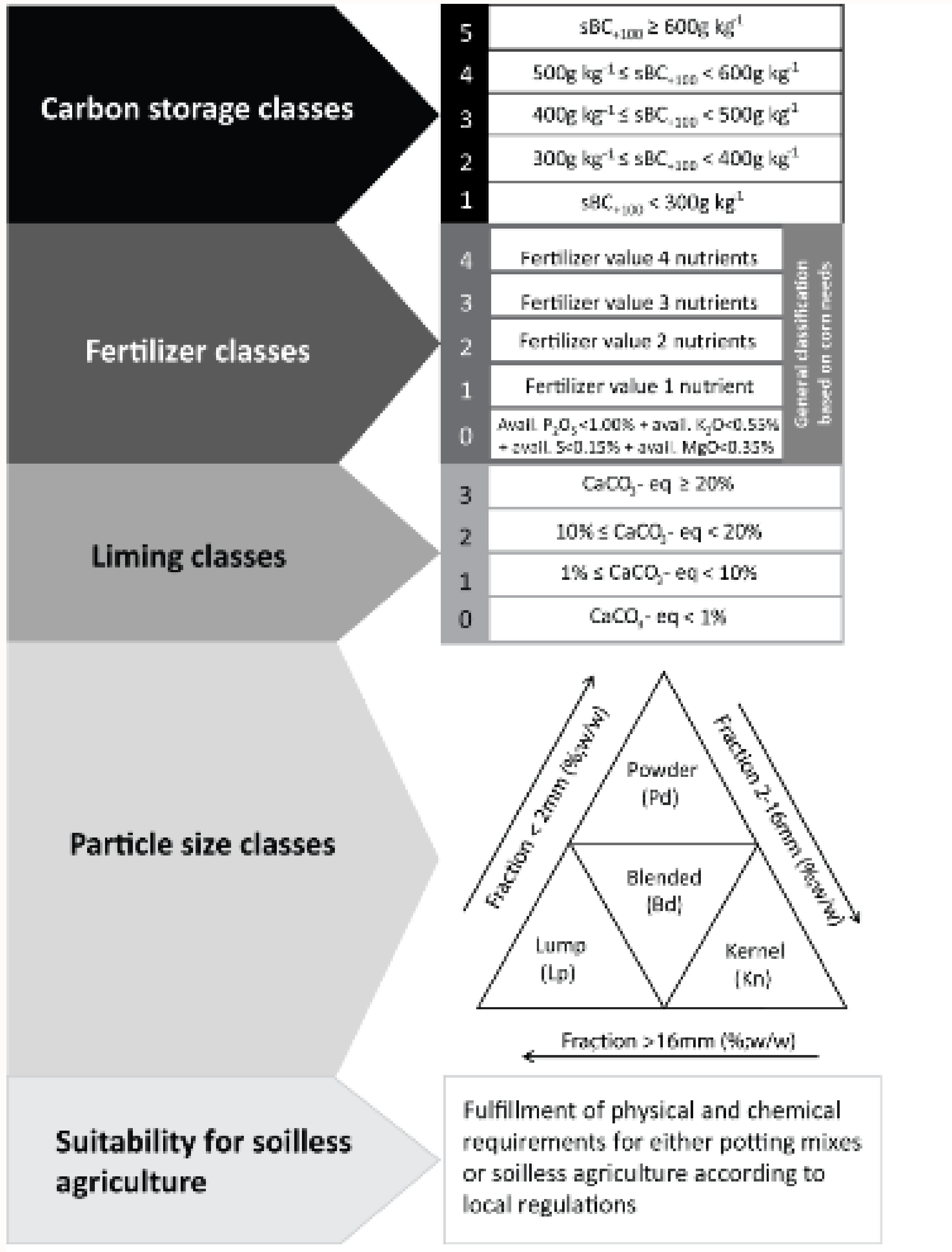
Biochar-based fertilizer redox potential, eH

Chew et al. 2020 bit.ly/30TQnIB

Biochars are "electric"

Developing Biochar Decision Tools





Biochar Classification Tool
biochar-international.org/resources/biochar-classification-tool/

International Biochar Initiative

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Verify Biochar Quality

Physical

Chemical

Environmental

Date Received:	12/8/2022
Sample ID:	SOFTWOOD BIOCHAR 01
Lab ID. Number:	XXXXX-01

General Properties	Result	Units	Method
Moisture (as received)	65.5	% wet wt.	A
Bulk Density	6.6	lb/cu ft (dry)	
Organic Carbon	87.5	%	B
Hydrogen/Carbon (H:Corg)	0.21	Molar Ratio	B
pH value	8.87	units	C
Electrical Conductivity	0.985	dS/m	C
Liming (as-CaCO3)	7.3	% CaCO3	I
Carbonates (as-CaCO3)	2.2	% CaCO3	J
Butane Act.	10.0	g/100g dry	G
Surface Area Correlation	451	m^2/g	G

Particle Size Distribution	Result	Units	Method
< 0.5 mm	13.1	%	F
0.5 - 1 mm	17.4	%	F
1 - 2 mm	32.9	%	F
2 - 4 mm	34.5	%	F
4 - 8 mm	2.0	%	F
8 - 16 mm	0.0	%	F
16 - 25 mm	0.0	%	F
25 - 50 mm	0.0	%	F
> 50 mm	0.0	%	F

Primary Nutrients		Result	Units	Method
Nitrogen	N	0.72	%	E
Phosphorus	P	0.07	%	E
Potassium	K	0.74	%	B

Secondary Nutrients		Result	Units	Method
Calcium	Ca	7410	mg/kg	E
Magnesium	Mg	972	mg/kg	E
Sulfur	S	211	mg/kg	E

Proximate Analysis		Result	Units	Method
Carbon	C	87.8	%	B
Hydrogen	H	1.56	%	B
Nitrogen	N	0.72	%	B
Sulfur	S	0.02	%	E
Oxygen	O	5.3	%	Calc
Ash	Ash	4.6	%	A
		100.0	% Total	

EPA 503 Metals		Result	Units	MRL	Method
Arsenic	As	0.62	mg/kg	0.45	H
Cadmium	Cd	**ND**	mg/kg	0.18	H
Chromium	Cr	39.9	mg/kg	0.45	H
Cobalt	Co	1.4	mg/kg	0.45	H
Lead	Pb	0.83	mg/kg	0.18	H
Mercury	Hg	**ND**	mg/kg	0.001	K
Molybdenum	Mo	0.48	mg/kg	0.45	H
Nickel	Ni	19.9	mg/kg	0.45	H
Selenium	Se	**ND**	mg/kg	0.90	H
Zinc	Zn	13.6	mg/kg	0.90	H

Other Elements		Result	Units	MRL	Method
Sodium	Na	553	mg/kg	451	E
Chlorine	Cl	442	mg/kg	20	D
Aluminum	Al	901	mg/kg	45.1	E

Pacific Biochar

Trace Nutrients		Result	Units	MRL	Method
Copper	Cu	7.8	mg/kg	0.45	H
Zinc	Zn	13.6	mg/kg	0.90	H
Iron	Fe	1307	mg/kg	22.5	E
Manganese	Mn	190	mg/kg	0.45	H
Boron	B	18.9	mg/kg	4.5	H

* "ND" stands for "not detected" which means the result is below the Method Reporting Limit (MRL).

Method
A ASTM D1762-84
B Dry Combustion - LECO
C TMECC (2001) 4.10 & 4.11, 1:20 dilution
D 1:20 dilution, Ion Chromatography
E EPA3050B/EPA 6010
F ASTM D 2862 Granular
G Surface area correlation based on 'Analytical Options for Biochar Adsorption...' (McLaughlin et al, 2012)
H EPA3050B/EPA 6020
I AOAC 955.01
J ASTM D 4373
K EPA 7471

Analyst: XXXX

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Markets: Standards and Certifications

National and international standards, developed through official processes, are critical

Standards exist, but have limitations:

- Carbon Standards International
- International Biochar Initiative

USBI Approach:

- Develop North American standards that are
  - Trusted by industry and researchers
  - Feasible for US laboratories and biochar producers
  - Developed through official process including advisory board and public comments
  - Low cost to support early-stage industry

Key Limitation: Laboratories

- Existing biochar standards use diverse laboratory methods that are difficult for accredited US labs
- Few US laboratories offer biochar analysis

Standards that follow ISO or ASTM Methods are key

ISO

ASTM

Feedstock-Particle Size-Moisture-Ash

Type	Size	Range mm	Moisture %	Carbon %	Ash %	Density Lb/CY
Fine	3mm	0.5-4	6%	82%	8%	270
Fine	3mm	0.5-4	35%	82%	8%	284
Mixed Granular	4-150 mesh	0.1-5	67%	78%	14%	464
Dry Powder	<40 Mesh	.005-.03	2.5%	94%	6%	678
Power Plant Ash	40-5 mesh	0.1-4	18%	14%	78%	788
Power Plant Carbon	40-2.5 mesh	.1-8	4%	50%	25%	234

Fine

Dry Powder

Biochar Solutions LLC

Biochars are Delivered in Bulk to Many Markets

2 CY 400 lb dry

- High carbon
- Low Volatiles
- Low Ash
- Low Fines
- Good Flowability

80 CY 8-10 t

Oregon Biochar Solutions
www.chardirect.com

From Factory To Use

PACIFIC BIOCHAR

Pacificbiochar.com

Biochar End-Uses

Agriculture / Soil	Horticulture	Materials	Environmental
Crop yield Soil water holding Soil carbon Soil health Fertilizer Needs GHG Pollutants	Plant health Plant growth Fertilizer needs Peat / Perlite Embodied carbon	Performance Cement needs Embodied carbon	Plant growth Restoration rate Soil & water pollutants Odor management

Increased Use of Biochars in Urban Soil Repair

Urban Soil Repair - Highway /Toll Plaza Biochar Filter Strip, MD & DE

Maryland Transportation Authority

DelDOT

Dare to be first. University of Delaware

TERRA AERATION

Compaction, drainage, aggregation, filtration

Courtesy Infinite Solutions

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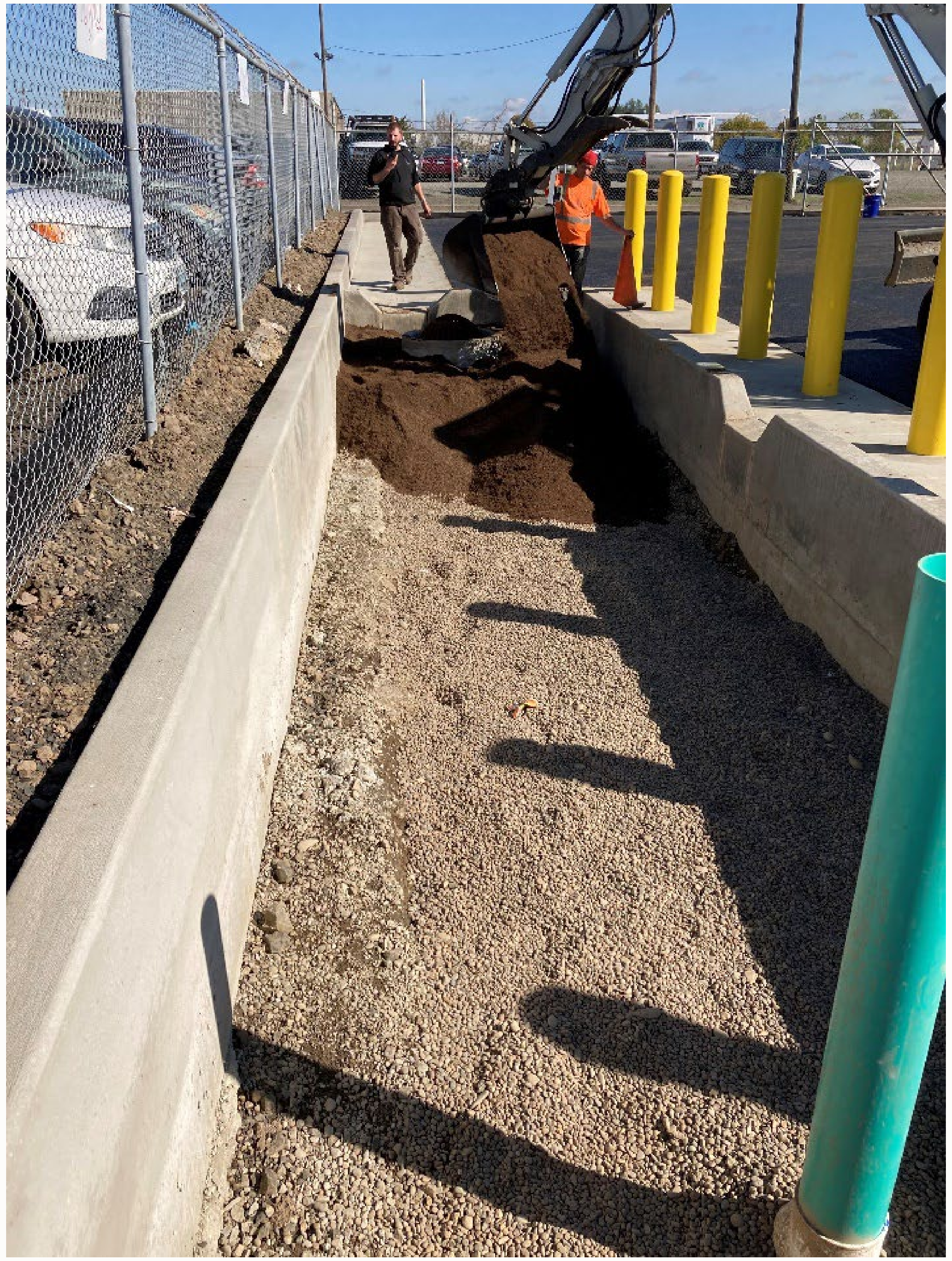
Engineered Solutions for Specific Pollutants

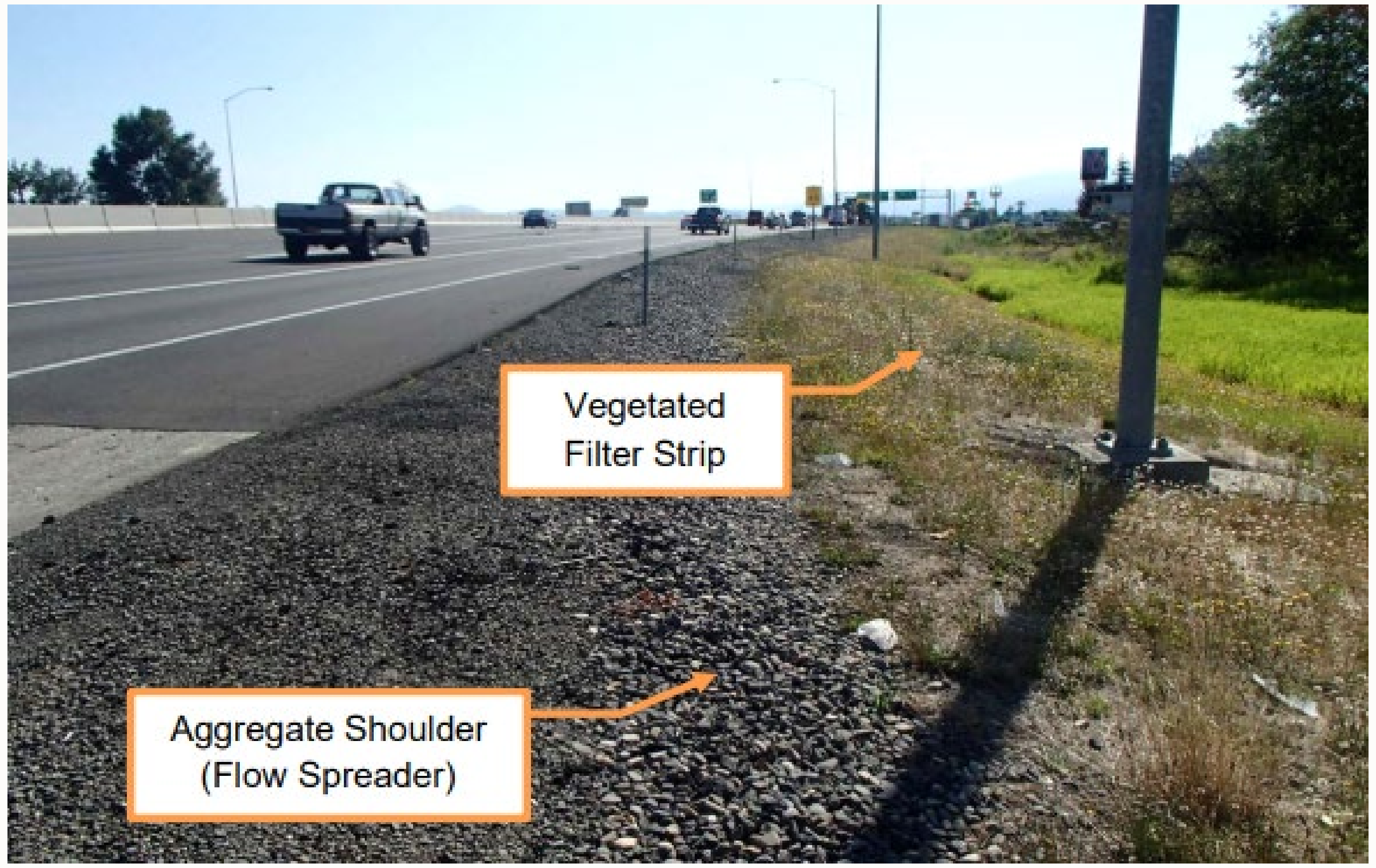


Biochar Stormwater Management, Myles Gray, PE, USBI Program Director
biochar-us.org/usbi-biochar-stormwater-management-mnbi-09-29-23

Green Infrastructure

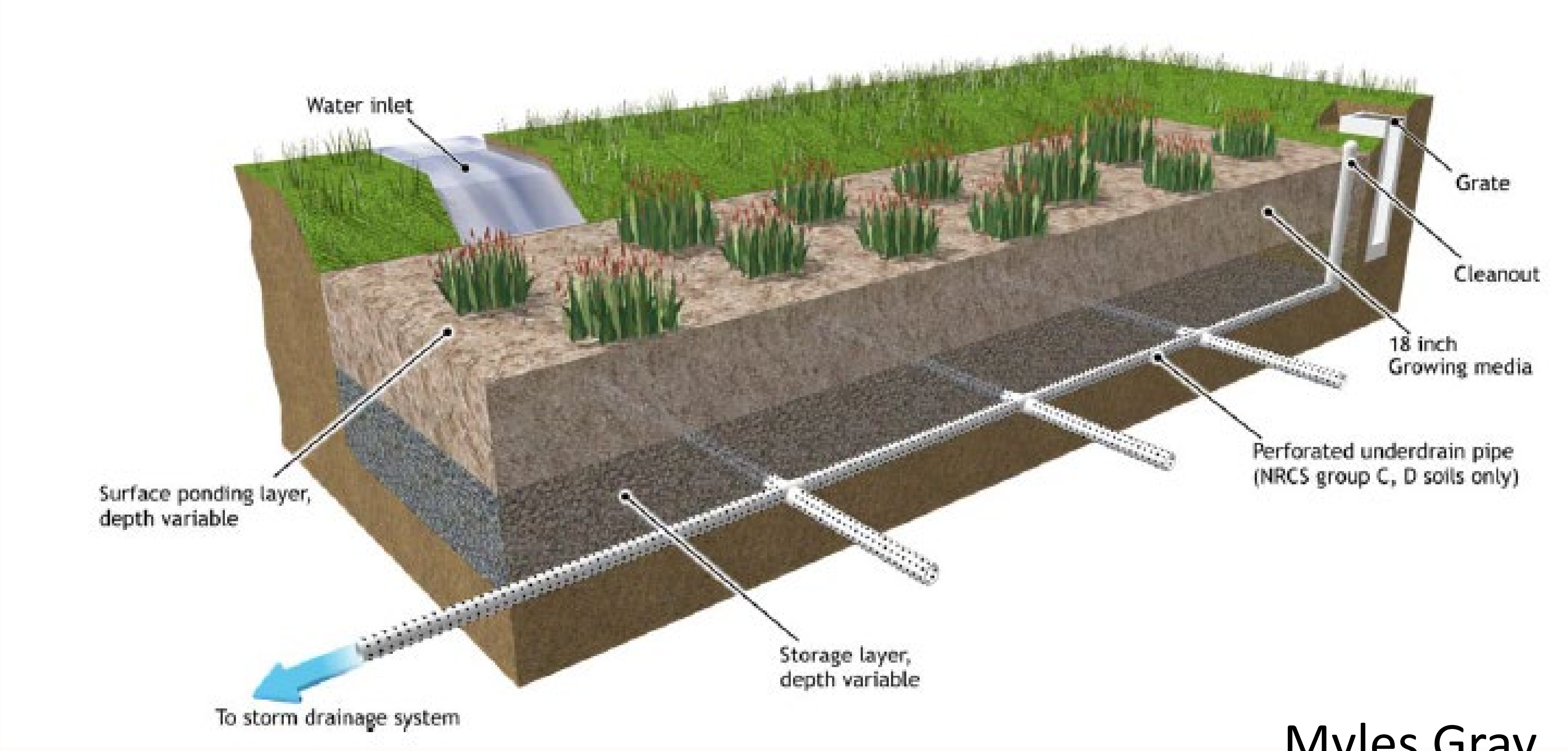
Hydrology, Pollutant Removal, & Co-Benefits

Vegetated Filter Strip



Green Infrastructure BMPs are vegetated treatment systems that harness plants and sandy soil to manage hydrology and remove pollutants

Bioretention



Myles Gray

PROS	CONS
Good pollutant removal	Larger footprint
Infiltration to mitigate hydromodification	Can initially export pollutants
Co-benefits	Often high maintenance cost

Biochar Stormwater Management, Myles Gray, PE, USBI Program Director
biochar-us.org/usbi-biochar-stormwater-management-mnbi-09-29-23
Fact sheet biochar-us.org/stormwater-management

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Feedstock: Focus on True Waste Feedstocks

Reduce disposal costs or generate tipping fee revenue by processing hard to manage biomass

Construction & Demolition

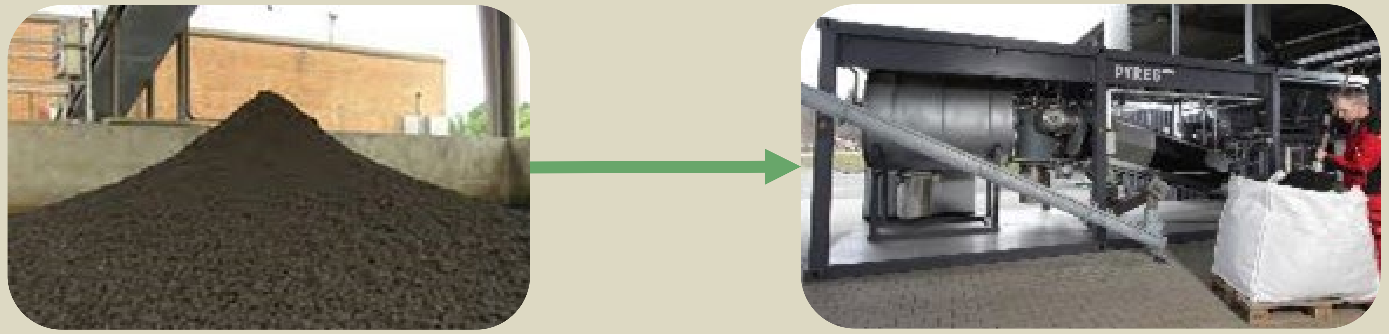
Green waste - Landfill

USBI Approach:
- Increase awareness among industries with waste issues
- Provide technical assistance

Forestry slash

Example: Wastewater Biosolids
- Traditionally land applied to agricultural soils
- PFAS chemicals have led to landfilling being most common disposal.

Biochar is a lower-cost solution:
- Well-designed production destroys PFAS
- Reduces total mass and shipping / disposal costs
- Biochar use in materials like concrete



Biochar Production: Mobile to Industrial Scale

Carbonator 6050
tigercat.com

ARTIchar
artichar.com

Pyreg 500-6000
Pyreg.de

ICM Inc
icminc.com

CharBoss
Airburners.com

Biomacon
Biomacon.com

Airex
Airex.com

Syncraft
Syncraft.at

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Markets: Biochar as a Soil Amendment

Scaling up deployment of federal cost share incentives for farmers

USDA Programs

- NRCS payments can provide funding for farmers to apply biochar
- Program recently launched
- Significant IRA and Farm Bill funding, but impact thus far unclear

USBI Approach:

- Pilots and demonstrations
- Knowledge sharing and awareness with focus on growers and agribusiness
- USDA funded projects
  - Biochar Atlas
  - Climate SMART Beef
  - DOE project with Washington State University
  - Chesapeake Scaling Up Biochar project

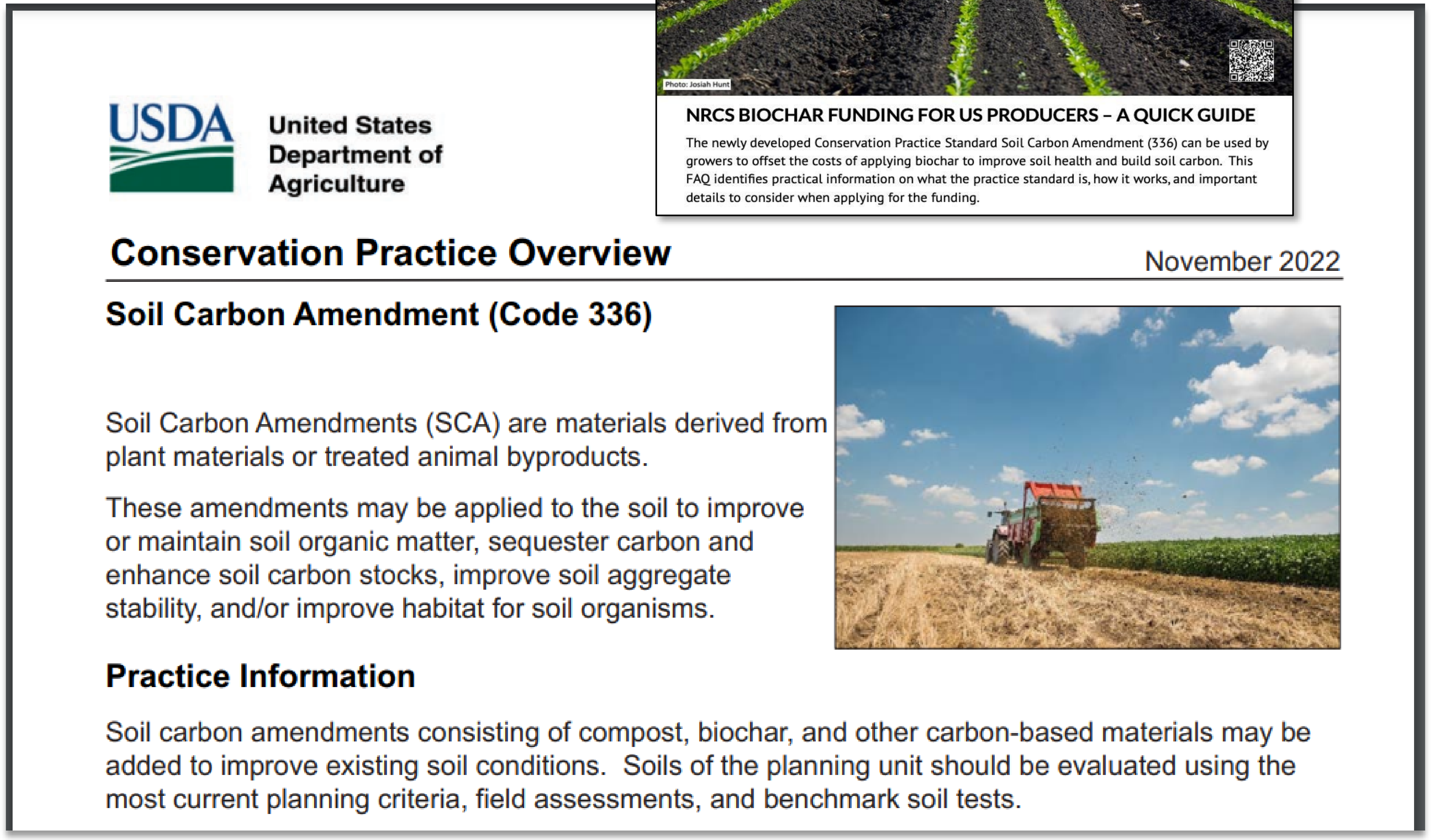
US BIOCHAR INITIATIVE BIOCHAR-US.ORG

NRCS BIOCHAR FUNDING

QUICK GUIDE FOR US PRODUCERS

NRCS BIOCHAR FUNDING FOR US PRODUCERS – A QUICK GUIDE

The newly developed Conservation Practice Standard Soil Carbon Amendment (336) can be used by growers to offset the costs of applying biochar to improve soil health and build soil carbon. This FAQ identifies practical information on what the practice standard is, how it works, and important details to consider when applying for the funding.



USDA United States Department of Agriculture

Conservation Practice Overview November 2022

Soil Carbon Amendment (Code 336)

Soil Carbon Amendments (SCA) are materials derived from plant materials or treated animal byproducts.

These amendments may be applied to the soil to improve or maintain soil organic matter, sequester carbon and enhance soil carbon stocks, improve soil aggregate stability, and/or improve habitat for soil organisms.

Practice Information

Soil carbon amendments consisting of compost, biochar, and other carbon-based materials may be added to improve existing soil conditions. Soils of the planning unit should be evaluated using the most current planning criteria, field assessments, and benchmark soil tests.

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Markets: Beyond Soil Amendment

Focus on key markets identified during global survey

Biochar-enhanced fertilizers

Growing media

Composting

Restoration

USBI Approach:

- Support and promote industry-led projects
- Lead and support grant-funded technology R&D projects with end-use subject matter experts

Filtration

Materials

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USBI IBI Global Market Survey biochar-us.org/market-report

USBI BIOCHAR.ORG

Co-Products: Focus on the Future

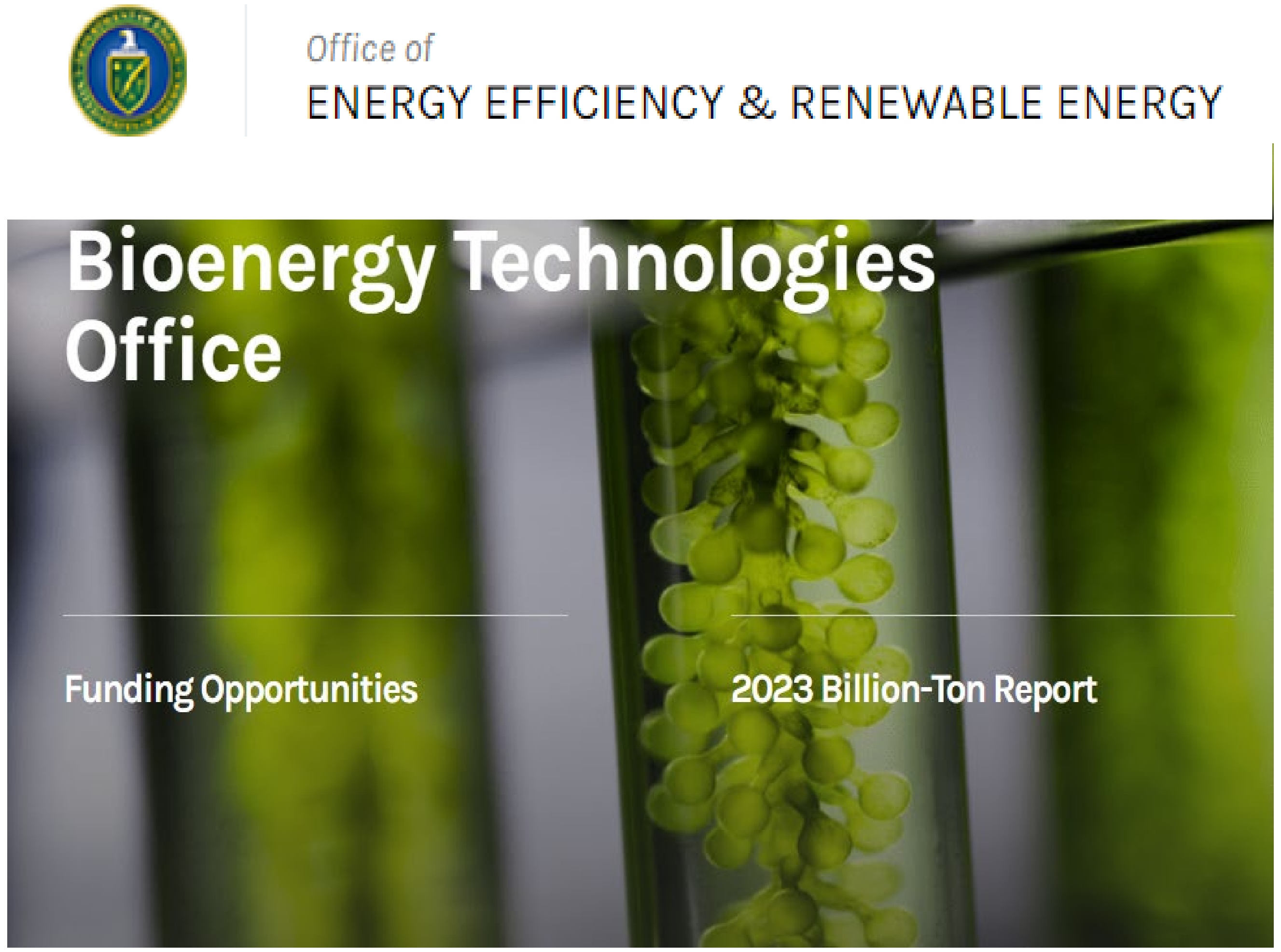
Creative approaches to produce heat, fuels, and hydrogen offer opportunity

Electricity is a preferred pygas use, but:

- Permits and interconnections are slow
- Wholesale rates are low in many areas

Alternative pygas uses:

- Process heat
- Liquid fuel production (e.g., SAF)
- Liquid for carbon sequestration
- Hydrogen
- Precursors for materials



USBI Approach:

- Collaborate with experts to assess pathways
- Coordinate funding opportunities with DOE

Thank You!

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