Using Biochar to Achieve Chesapeake Bay (and Watershed) Water Quality Goals and Climate Resiliency: The Path to Scale

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BIOCHAR INDUSTRY: MYTHS, FICTION & FACTS

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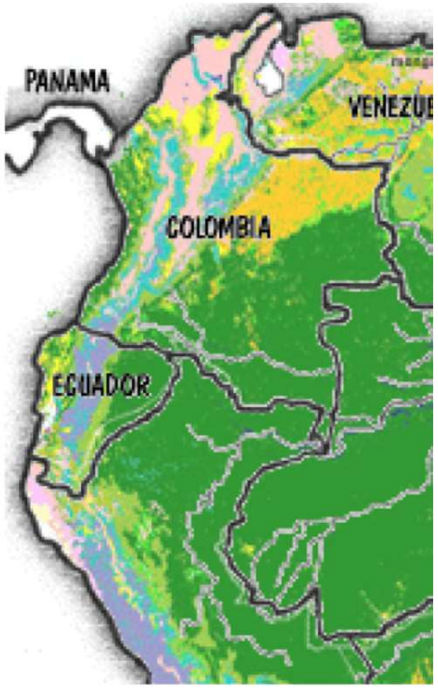
AN OLD TECHNOLOGY, RE-DISCOVERED

TERRA PRETA OR "DARK EARTH"

- Dates back more than 2500 years
- 1st documented in Amazon by James Orton (1870)
- 1st researcher of Terra Preta soils by Wim Sombroek (1966)
- International Awareness 2001-2002 led by Johannes Lehmann, Cornell
- Still actively being created in small clusters throughout Southeast Asia and Africa

BLACK GOLD OF THE AMAZON

Fertile, charred soil created by pre-Columbian peoples sustained surprisingly large settlements in the rain forest. Secrets of that ancient "dark earth" could help solve the Amazon's ecological problems today.



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AN OLD TECHNOLOGY, RE-DISCOVERED

TERRA PRETA OR "DARK EARTH"

- Iowa soils – some of the most fertile in the world
- Natural biochar formed by prairie fires
- Root zone excludes oxygen, producing char, not ash
- Primarily lost from Industrial Agriculture, Dust Bowl and Fire Suppression

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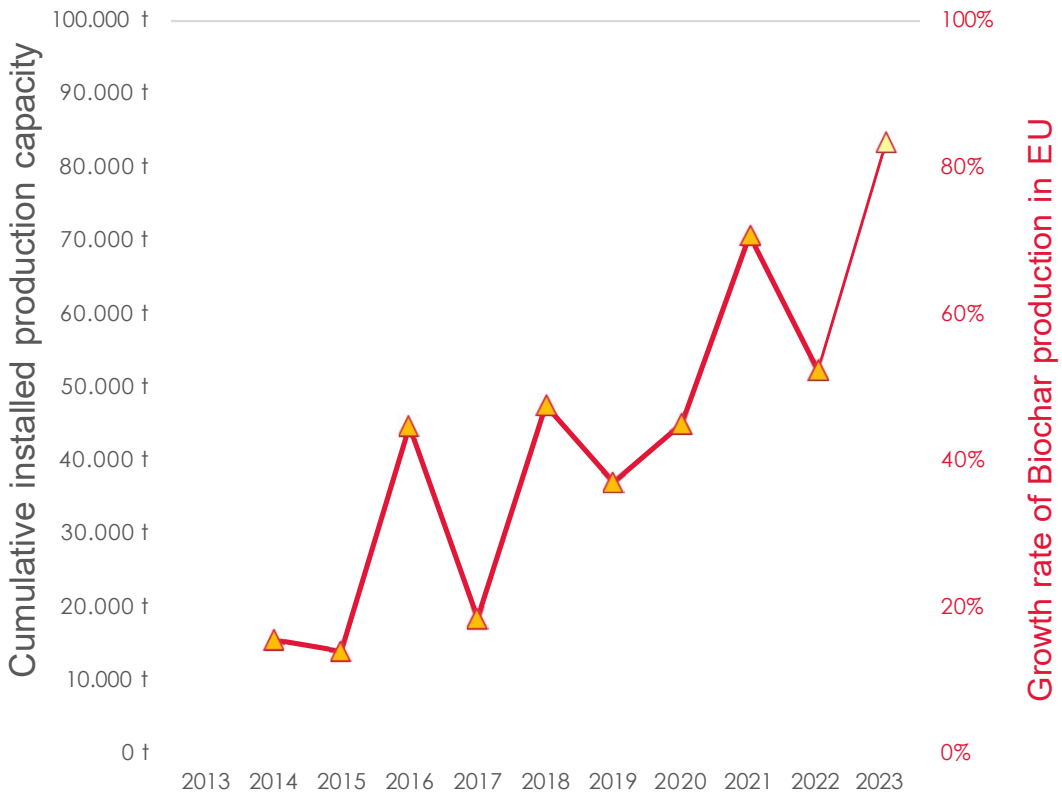
Biochar market growth and growth rates

Cumulative Biochar production capacity in Europe



www.biochar-industry.com/market-overview/ © EBI 2023

- By end of **2022, the cumulative number** of production plants in Europe has **grown to 130 installations**
- Biochar production capacity continues to show **strong growth**. In 2022 it **grew by 52% to 53.000 t** Biochar
- **3y CAGR** was **56%** (2019 - 2022)
- For 2023 we expect **the production capacity** to **grow to > 90.000 t**, equivalent to above **80% growth rate**
- **3y CAGR** is expected to grow to **68%** (2020 - 2023)

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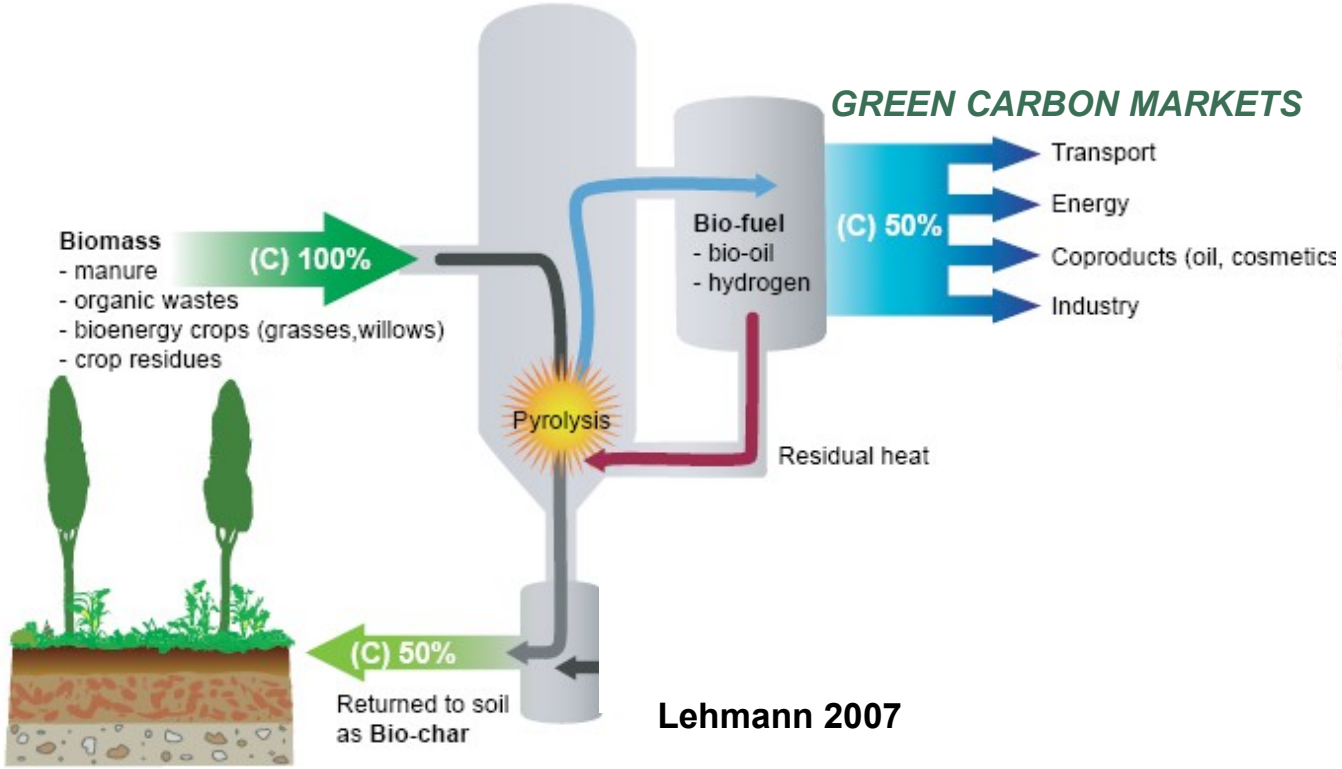
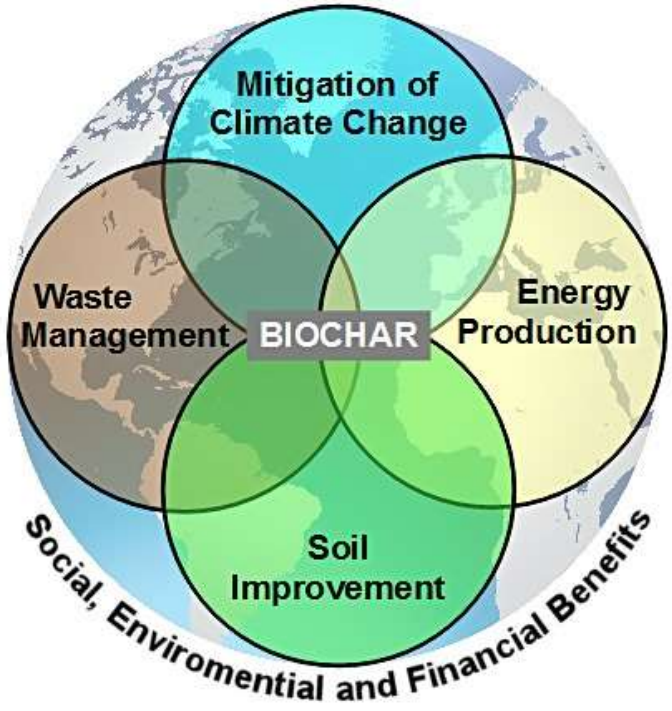
BIOMASS & BIOCHAR PRODUCTION

- **Removes Carbon Dioxide from the Atmosphere**
- **Offsets carbon emissions from fossil fuels**



Lehmann 2007



1 mt CO_2e = 1 Carbon Dioxide Removal Certificate (CDR or CORC™)
Net removal 2.0-3.2 mtCO_2e/mt Biochar

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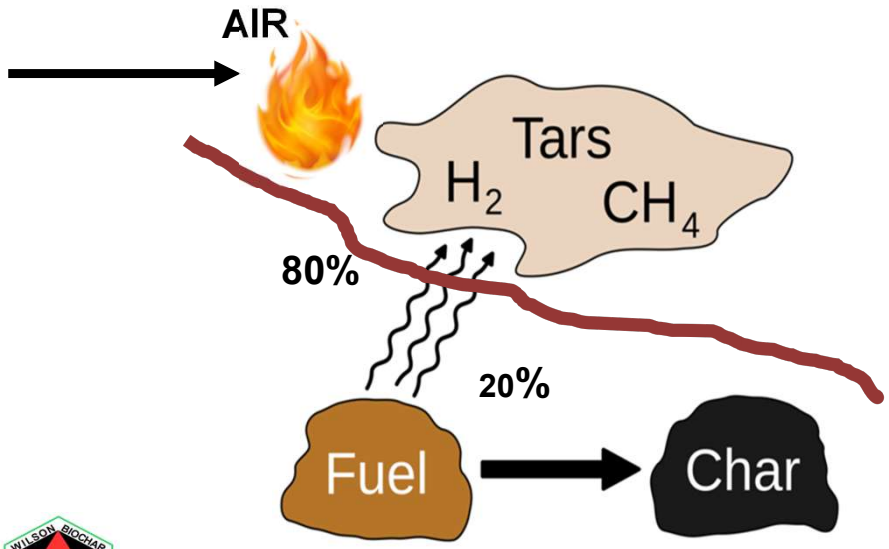
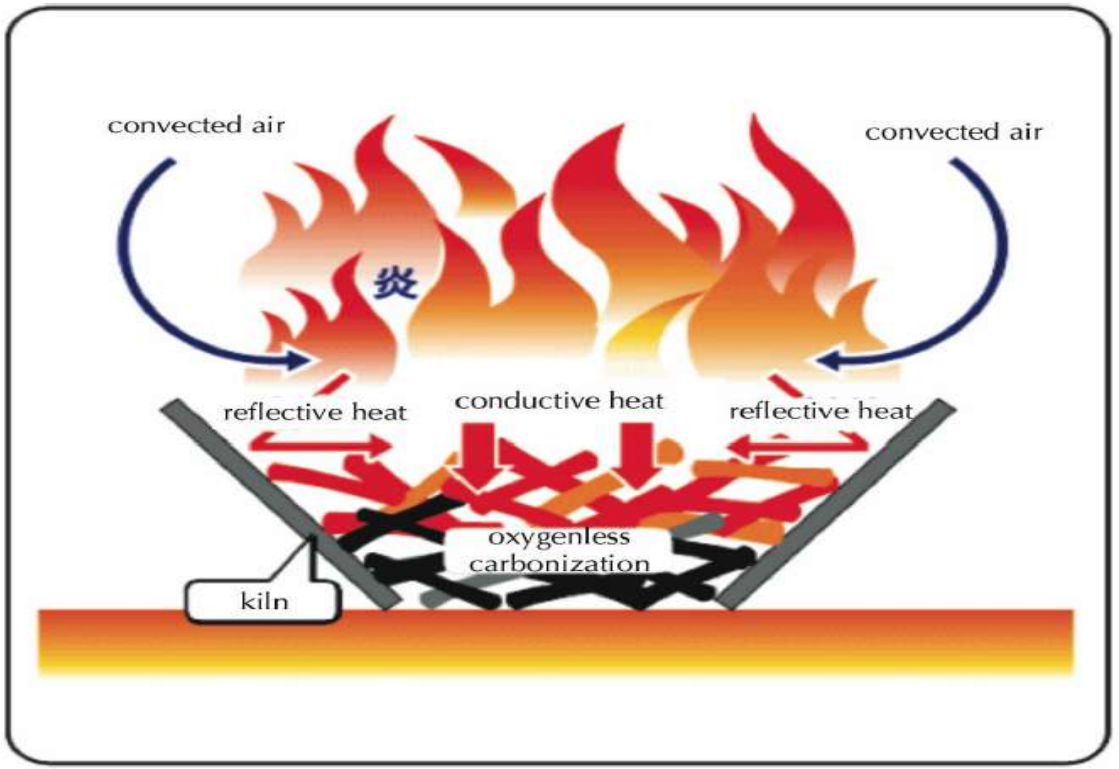
THERE IS NO 'BURNING' OR 'INCINERATION' IN THE PROCESS

Heat Converts Solids to Gas Leaving Char

Pyro-lysis: from pyro (fire) and lysis (separation)



Flame Cap Kilns Make Char by Limiting Oxygen at Base of Fire



Moki Kiln Japan Biochar Assn., biochar.jp

PAHs, Dixons, Furans and Metals from waste fuels are regulated and controlled though design and operation

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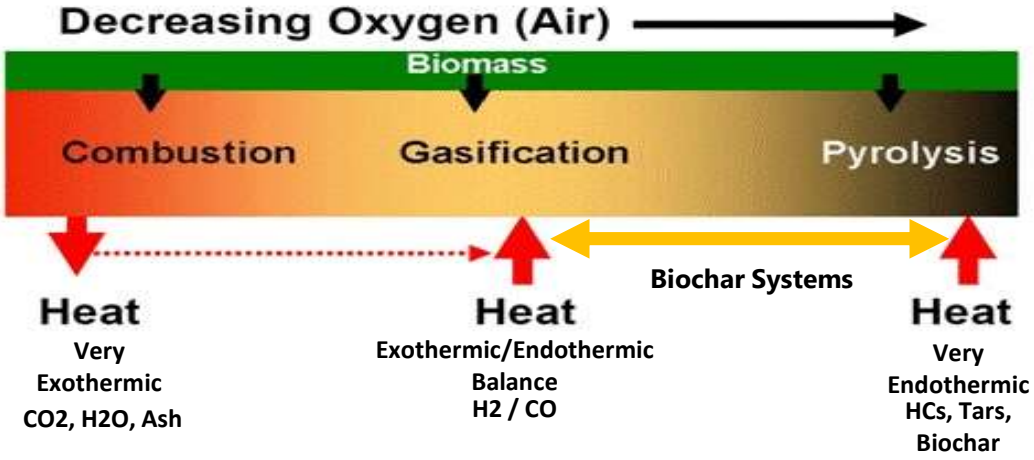
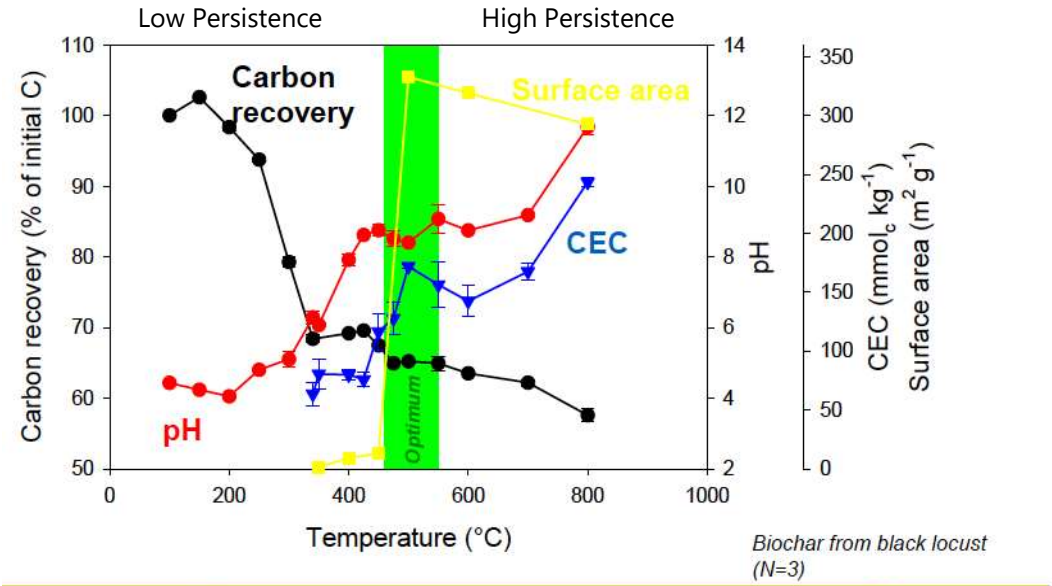
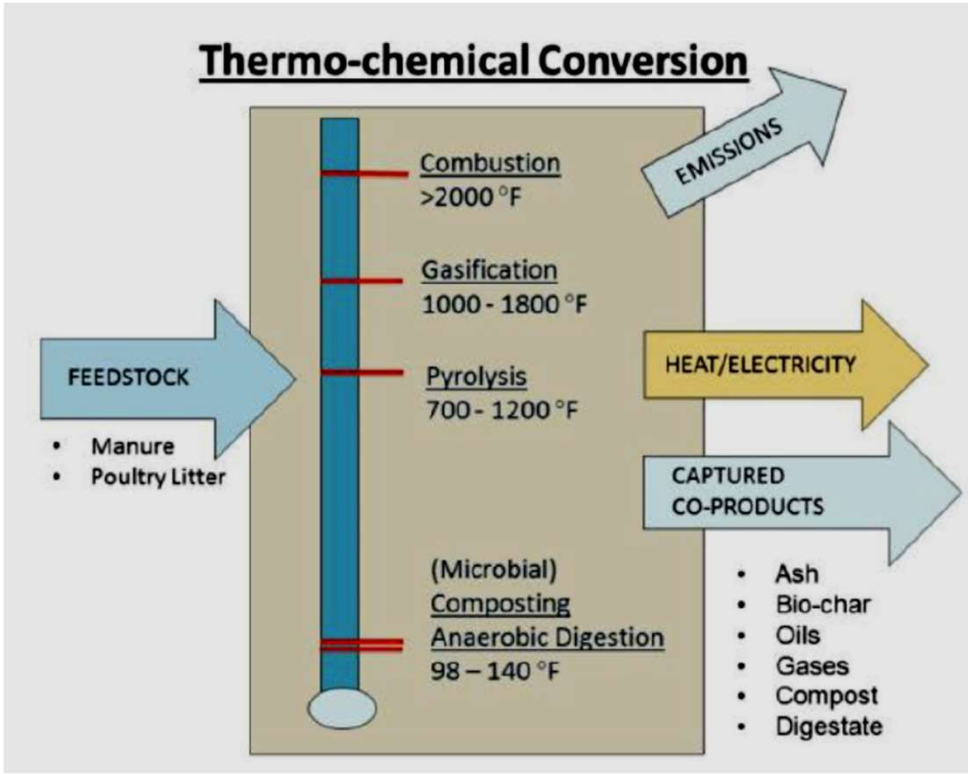




Lehmann, 2007, *Frontiers in Ecology and the Environment* 7, 381-387

Cornell University



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ENGINEERED SYSTEMS FOR BIOMASS & BIOCHAR PRODUCTION

"Ring of Fire"
Wilsonbiochar.com

CharBoss
airburners.com

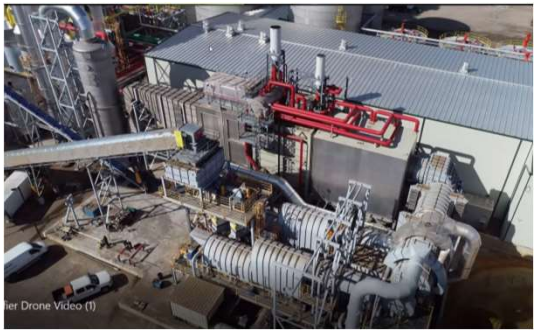
Carbonator 6050
tigercat.com

Pyreg 500
Pyreg.de

Biomacon
Biomacon.com

Earthcare, LLC
Earthcarellc.com

Oregon Biochar Solutions
Chardirect.com



15,000 TPY + 7 MWe+steam
ICMInc.com

Biochars are produced at scale to industry specifications in North America, Europe, Asia and the Pacific.

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FIT TO PURPOSE BIOCHAR(S)

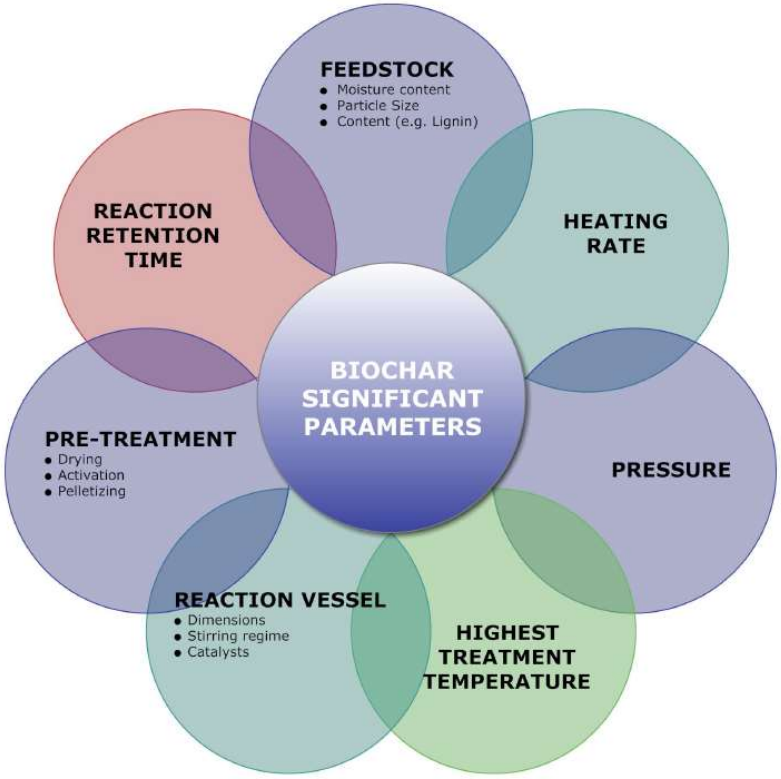
Raw Biochar

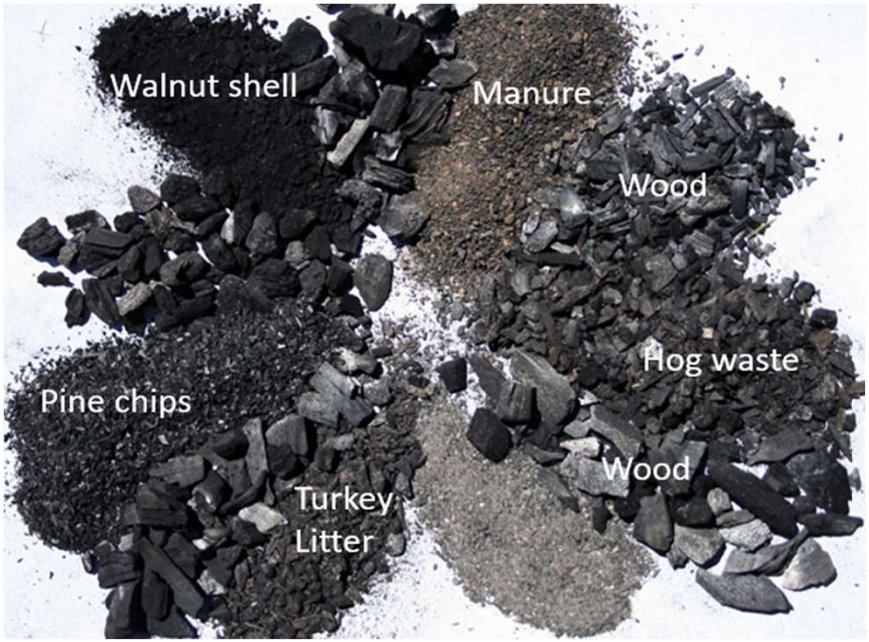
Pelletized Biochar

Granular Biochar

Blended Biochar

Liquid Biochar





BIOCHAR MARKETS

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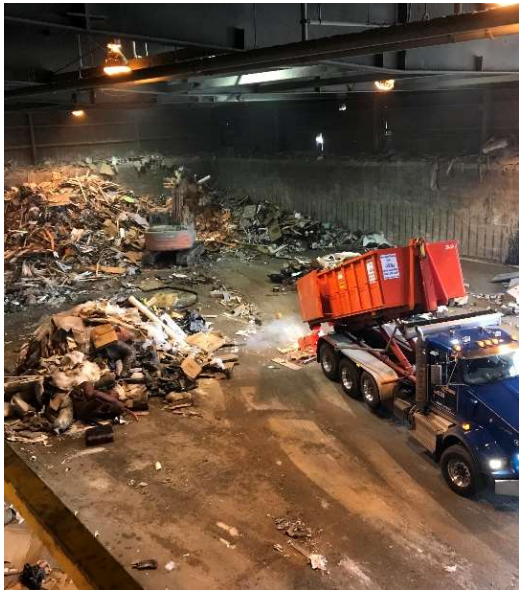
ALL BIOMASS CAN BECOME BIOCHAR, DOESN'T MEAN IT SHOULD



IBI certified biochar™

CERTIFIED BIOCHAR EBC EUROPEAN BIOCHAR CERTIFICATE (EBC)

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BIOCHAR CERTIFICATION PROCESS

- The biomass feedstocks shall not be sourced from post-consumer or post-industrial sources treated with any paint, sealer or potentially toxic chemical.

- The biomass feedstocks shall be limited to the woody by-products from forestry operations, including cut residues left after a timber harvest, cut trees that are not marketable as lumber and wood chips from biomass reduction operations (i.e. power-line maintenance) and urban tree management operations.

- Biochar must have an International Biochar Initiative (IBI) Certification and/or has been tested using the IBI Biochar Standards (23 November 2015) for Testing Category A (Basic Utility) and Category B (Toxicant Assessment) properties.

- As part of Category B testing, Polycyclic Aromatic Hydrocarbon (PAHs), Dioxins/Furans (PCDD/Fs), and Polychlorinated Biphenyls (PCBs) results must be provided upon request.

IBI certified biochar™

CERTIFIED BIOCHAR EBC EUROPEAN BIOCHAR CERTIFICATE (EBC)

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BIOCHARS MADE FOR CONSISTENT QUALITY STANDARDS

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

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

Biochar Quality Complies with Accepted Standards

- **Physical**
- **Chemical**
- **Environmental**

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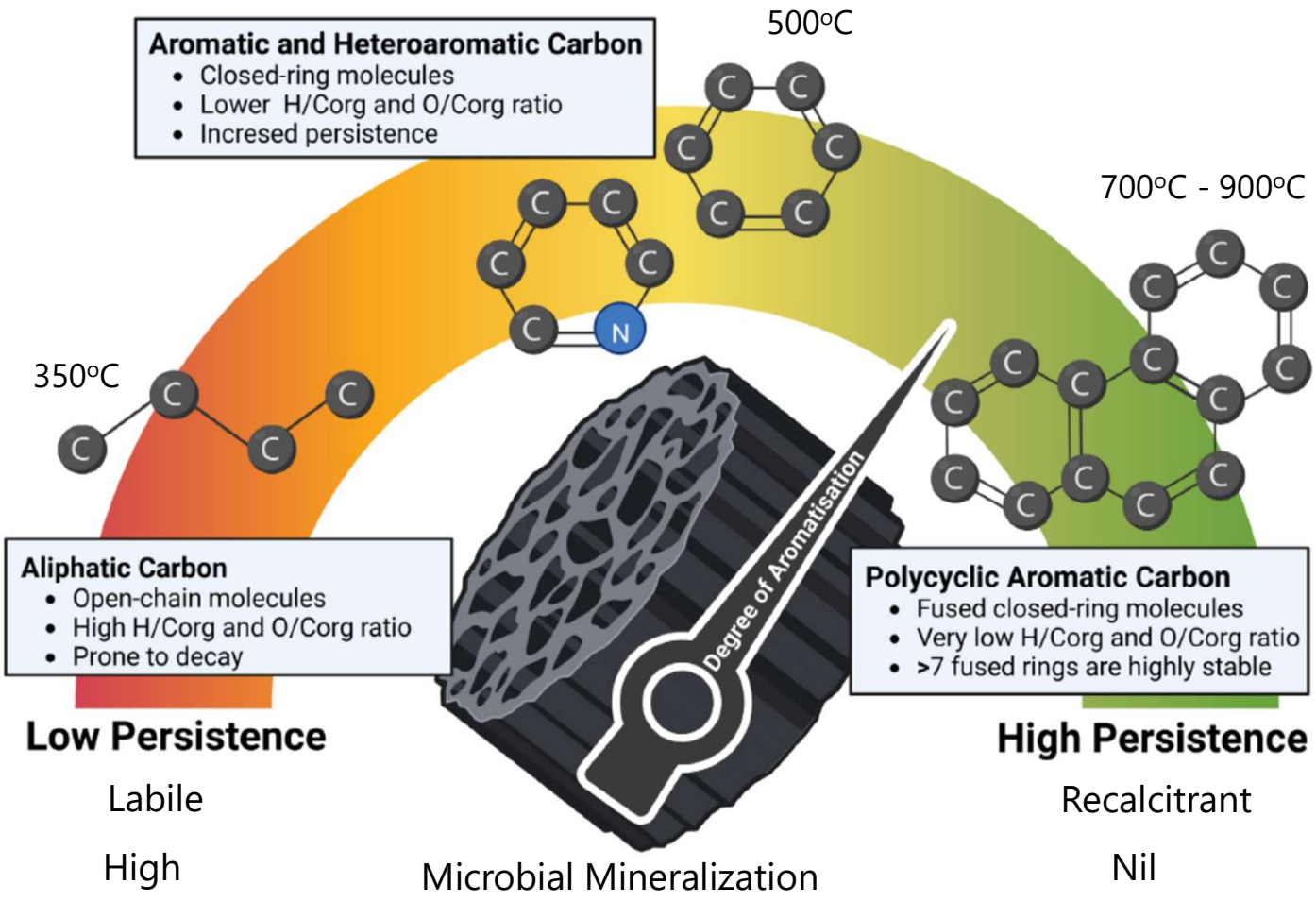
BIOCHAR'S PERSISTENCE



Using Organic geochemistry and petrology methodologies determine that biochar:

- With increasing temp., carbon increase, H/C & O/C decrease
- At 500°C+ 97% TOC is almost infinitely geochemically stable lasting 1000 years or longer
- Limited semi persistent carbon (SPC) has been found to last 50 to 100 years.

(1) Schmidt HP, Abiven S, Hageman N, Meyer zu Drewer J: Permanence of soil applied biochar. An executive summary for Global Biochar Carbon Sink certification, the Biochar Journal 2022, Arbaz, Switzerland, www.biochar-journal.org/en/ct/109, pp 69-74

(2) Peterson, H.I., Lassen, L., Rudra, A., Nguyen, L.X., Do, P.T.M., Sanei, H.: Carbon stability and morphotype composition of biochars from feedstock in the Mekong Delta, Vietnam, International Journal of Coal Geology, April 4, 2023, 104233.

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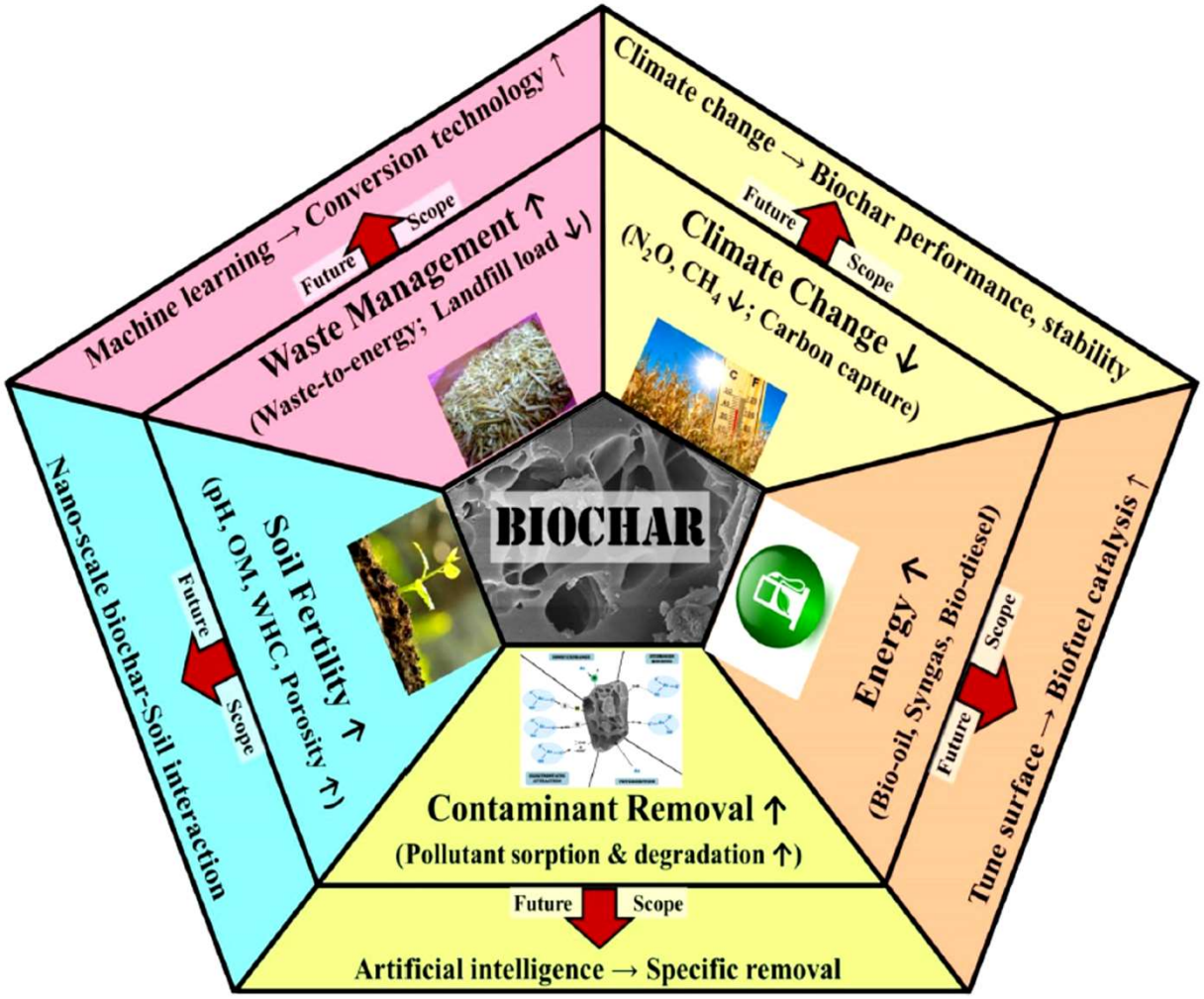

(1)

BIOCHAR RESEARCH METRICS

- 1ST recorded 'biochar' publication – 1998
- DEC 2022 – 27,925 publications
- 2,375 Biochar review articles
- 80% published in last 5 years
- 67% of publications in past 3 years
- Primary topics – pollutant removal, soil improvements, waste management, energy production and climate mitigation
- Future – AI could be critical in producing Fit-to-Purpose Biochar

(1) Abhishek Kumar, et. al., Multifaceted applications of biochar in environmental management: a bibliometric profile, Biochar (2023) 5:11, https://doi.org/10.1007/s42773-023-00207-z

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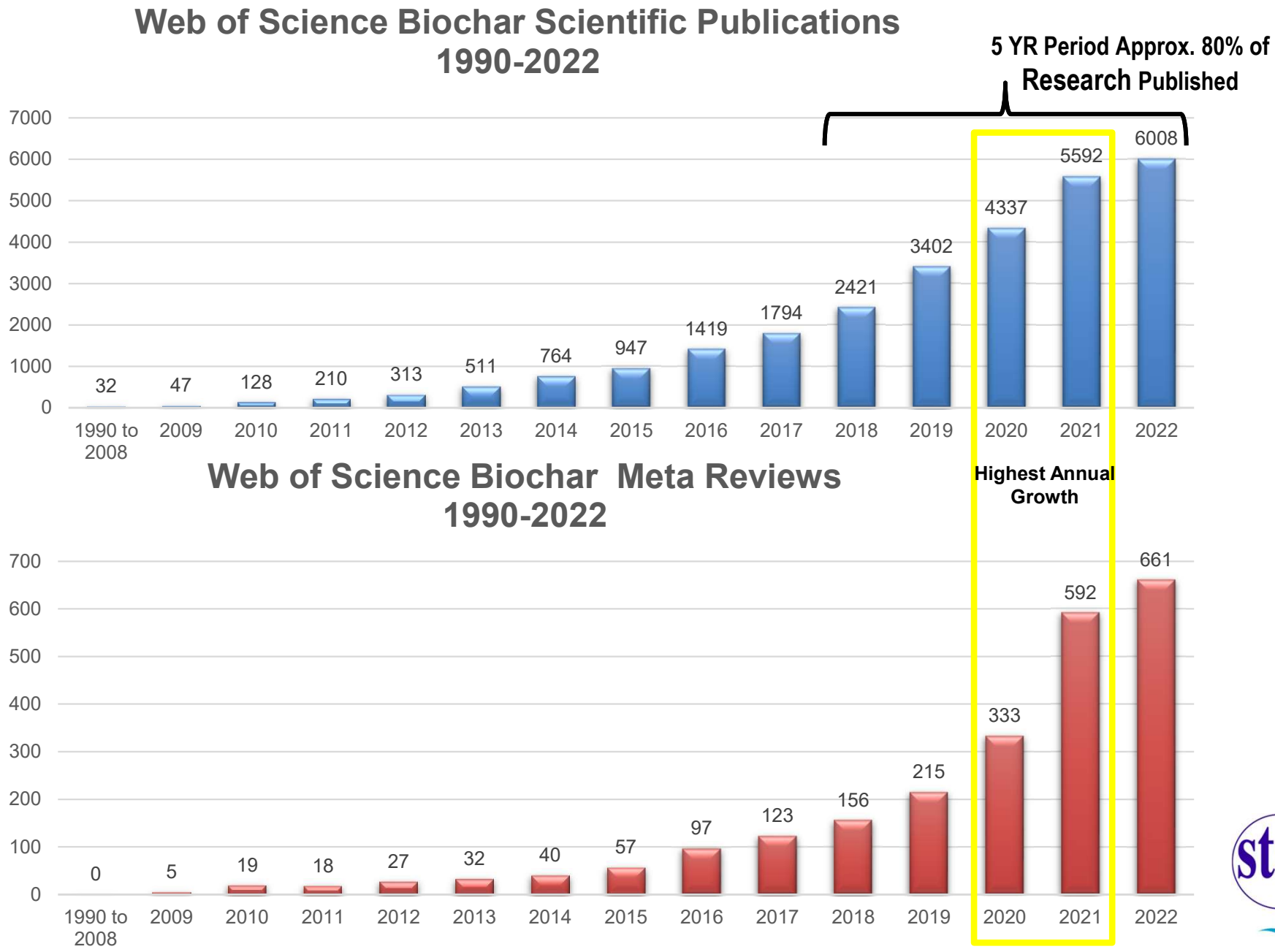

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Biochar Agronomic and Environmental Benefits from 26 Reviewed Meta-Analyses

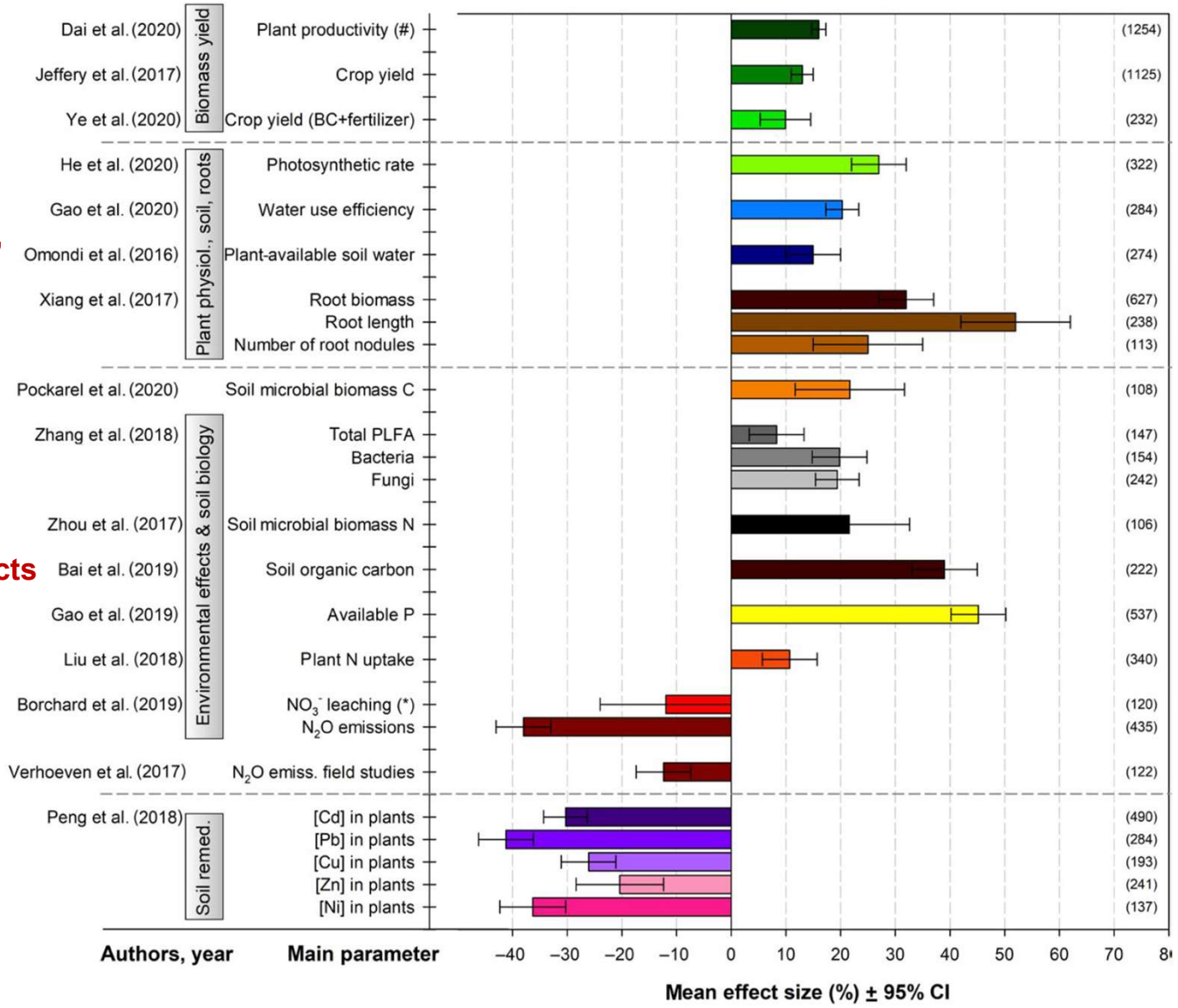
(Schmidt et. al. 2021)

Biomass Yield

Plant Physiology, Soil & Roots

Environmental Effects & Soil Biology

Soil Remediation



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BIOCHAR RESEARCH VRS. APPROVED BMP (1990-2022)

WoS BMP Global Search	
STREAM PRACTICES	28,670
BIOCHAR	**27,925**
FOREST PRACTICES	27,800
INFILTRATION PRACTICES	15,837
ALTERNATIVE PRACTICES	8,449

STREAMS PRACTICES	
Channel Restoration	9,062
Stream Restoration	7,871
Channel Stabilization	7,350
Stream Stabilization	1,844
Urban Stream Restoration	1,212
Urban Channel Restoration	496
Streambank Erosion	434
Stream Daylighting	225
Streambank Stabilization	100
Urban Stream Stabilization	76

FORESTS PRACTICES	
Reforestation	8,320
Forest Buffer	7,829
Urban Tree Planting	6,238
Riparian Buffer	2,850
Tree Pits	2,533
Expanded Tree Pits	30

INFILTRATION PRACTICES	
Infiltration Basin	5,021
Rain Garden	2,506
Infiltration Bed	2,038
Grass Buffer	1,696
Grass Channels	1,364
Bioretention	1,324
Vegetative Filter Strip	528
Infiltration Trench	483
Seepage Pit	387
Dry Well	274
Dry Swale	122
Bioswales	94

ALTERNATIVE PRACTICES	
Street Sweeping	5,018
Urban Soil	1,633
Living Shorelines	933
Floating Treatment Wetlands	652
Woodchip Bioreactors	169
Impervious Disconnection	29
Regenerative Stormwater Conveyance	15

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BIOCHAR HISTORY IN THE CBw & MID-ATLANTIC REGION

Pre-1990

Early Terms

- Terra preta (dark earth)
- Horticultural Charcoal
- Agriculture Charcoal
- Agrichar (Got Trademark)
- Biochar rebranding (1987)

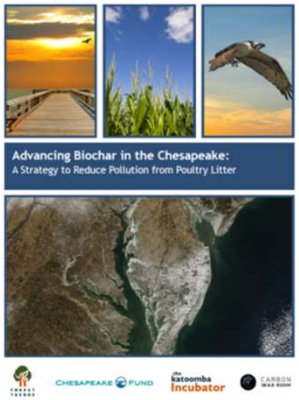
1990–2008

- FRYE ENERGY, LLC, VA Poultry Litter to Char (2007)
- First Biochar Paper Published in 1989

2009

- U.S. Biochar Initiative Founded
- S. River/S. Fork Shenandoah Mercury Remediation Demo, VA

2010



- Advancing Biochar in the Chesapeake Report (2010)
- Biochar in Agriculture Systems, (Virginia Tech – Fact Sheet).
- Laboratory Study of Aeration Properties of Biochar Amended Soils (UD - Research)

2014

- Anchorage Canal Drainage Area Retrofit, Inland Bays, DE

2015

- Forest Hill Park Stormwater Retrofit Construction, VA
- Talbot Co. Bioreactors, CWP, MD
- Poultry litter biochars to slowly release nutrients in soils for plant growth, (UD – Research)

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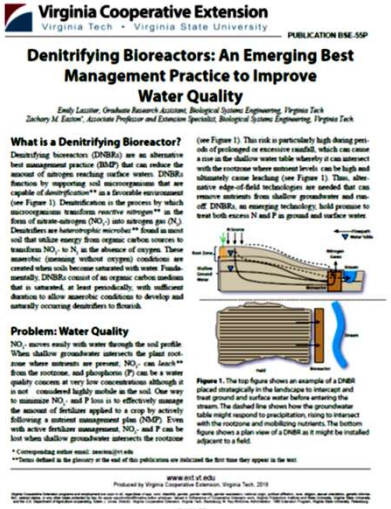
BIOCHAR HISTORY IN THE CBw & MID-ATLANTIC REGION



2016

- Diamond Hill Sand Filter, MD
- Bethel Korean Church, MD
- Oakland View Farms biochar enhanced bioreactor, MD
- Manure Treatment Technologies, CB Program's
- Wood biochar amended to laboratory soils for nutrient removal (UD – Research)

2017

- Stockly Center Stormwater Retrofit, Inland Bays, DE

2018

- Denitrifying bioreactors: An emerging best management practice to improve water quality (Virginia Tech – Fact Sheet)
- PA Governor's Residence Rain Garden, PA
- USBI 2018 Biochar Conference, Wilmington, DE

2019

Big Year for Biochar Projects

- Choptank Electric Wetland Mitigation Vegetation Enhancement, MD
- Furnace Creek Stream Restoration, MD
- Tiber Watershed Biochar Study, MD
- Elizabeth River Project, VA
- Poultry litter & wood biochars for amendment to bioretention soil media / Wood biochar amended to roadway soils along DE896, DE / Wood biochar amended to roadway soils in laboratory & DE896, DE (3 UD – Research)
- Manure de Force, WV (NCRD/IREED – Report)
- WV Phase 3 WIP for Chesapeake Bay TMDL, WV

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BIOCHAR HISTORY IN THE CBw & MID-ATLANTIC REGION

MARYLAND DEPARTMENT OF NATURAL RESOURCES

2020
Forest Action Plan

Part I: Forest Resource Assessment

2020

- Anchorage Canal Drainage Area Stormwater Wetland Retrofit, DE
- Models to predict biochar impact on water retention and repellency in soil, DE (UD – Research)
- Wood biochar amended to soils adjacent to two parking lots, MD (UD – Research)
- Biochars and their capacity for electon storage (UD – Research)
- MasBio – Sustainable biomass to value-added bioproducts (WVU – Research)
- MD DNR Forest Action Plan – Part 1 Forest Resource Assessment, MD

2021

- Symphony Woods Conservation Landscape, MD
- Hanover School District – Turf to Meadow Conversion, PA
- Lofting Farm biochar enhanced bioreactor swale, PA

2022

- S. River & S. Fork Shenandoah River Mercury Remediation Restoration, VA
- Scaling Up Biochar Applications for Accelerated Stormwater Runoff Reduction in the Chesapeake Bay, NFWF/CWP
- MFP Biochar Production, PA
- Atlantic Biocarbons Brokerage, PA
- USBI/MassBio Biochar & Bioenergy Conference, Morgantown, WV

2023

- Biochar innovation study on kiln produced biochar, MD (Howard EcoWorks)
- Wood biochar amended to vegetated strips next to two roadways along DE301 + amended to a dry detention basin, DE (DelDOT) | Wood biochar amended to bioretention soil media (laboratory) | Wood biochar amended to vegetated strips next to I-95, MD (MDTA) (UD – Research)
- Waverly Biochar Facility, Lynchburg Biochar Facility, SWVA Biochar Facility, VA – In development
- Carbon Atlantic International, PA – Production Startup

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FEDERAL / STATE LEGISLATION ACTIVITIES

- Biochar in the Infrastructure Investment and Jobs Act, (H.R. 3684 – 117th Congress (2021-2022) https://www.congress.gov/117/plaws/publ58/PLAW-117publ58.pdf $200 Billion Secretary of Interior & Agriculture
- Biochar Act of 2021 (H.R 2581 – 117th Congress (2021-2022) https://www.congress.gov/117/bills/hr2581/BILLS-117hr2581ih.pdf
- National Biochar Research Network Act of 2022 by Grassley, Tester, Thune and Brown https://www.grassley.senate.gov/imo/media/doc/biochar_research_network_act_of_2022.pdf
- USBI has been educating congressional staff (for Senators and Congressmen) in collaboration with other organizations
  - 2023 US Farm Bill – US Biochar Coalition is working to get biochar and carbon credits into next bill
- Other programs
  - NRCS 808/336 – Soil Carbon Amendments, USDA Climate-Smart Commodities, USFS Wood Innovations Program.
  - Washington State – SB/HR 5961 incentives state & local governments to use biochar in government contracts
  - Colorado State – Looking to use biochar in abandoned gas/oil well as part of capping (BILL PASSED)

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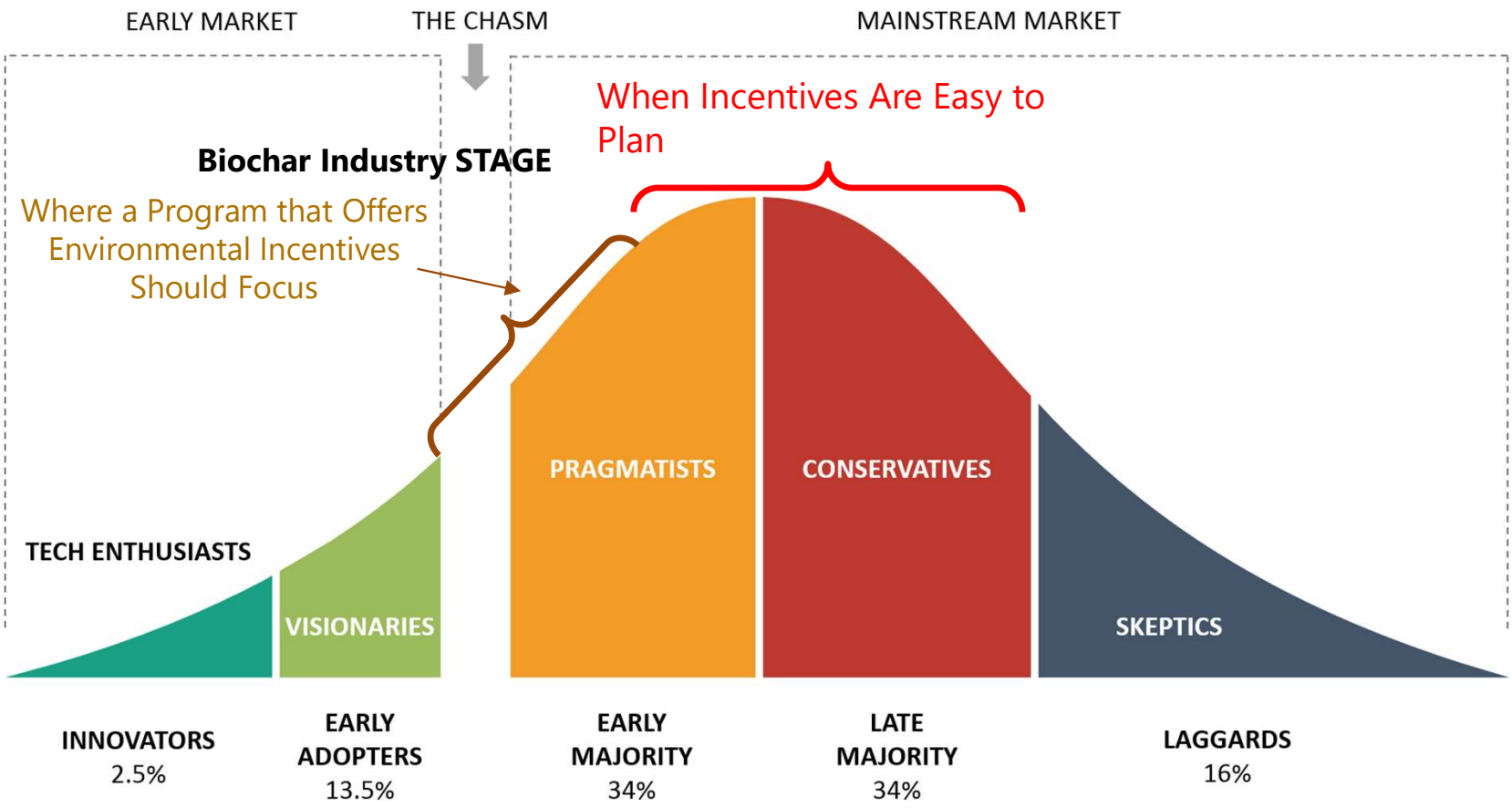
CONSERVATION TECHNOLOGY ADOPTION CURVE



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CAN'T PUT THE TOOTHPASTE BACK INTO THE TUBE

Advancing Biochar in the Chesapeake:
A Strategy to Reduce Pollution from Poultry Litter

FOREST TRENDS · CHESAPEAKE FUND · the katoomba Incubator · CARBON WAR ROOM

2010

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CAN'T PUT THE TOOTHPASTE BACK INTO THE TUBE


CBP/TRS – 311 – 16

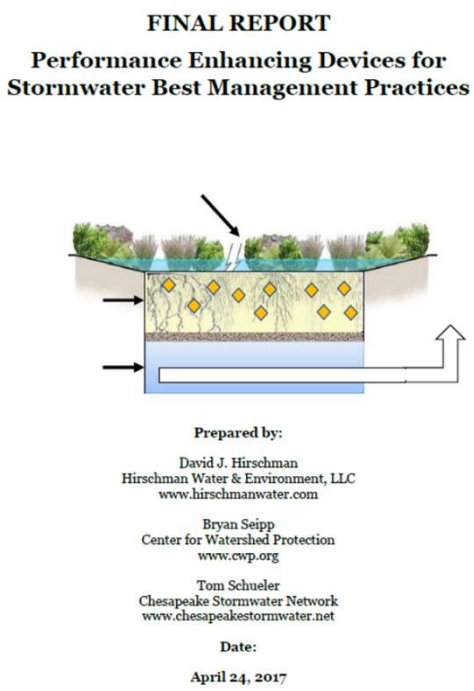
Manure Treatment Technologies

Recommendations from the Manure Treatment Technologies Expert Panel to the Chesapeake Bay Program's Water Quality Goal Implementation Team to define Manure Treatment Technologies as a Best Management Practice

Chesapeake Bay Program

September 2016

2016


FINAL REPORT

Performance Enhancing Devices for Stormwater Best Management Practices

Prepared by:

David J. Hirschman
Hirschman Water & Environment, LLC
www.hirschmanwater.com

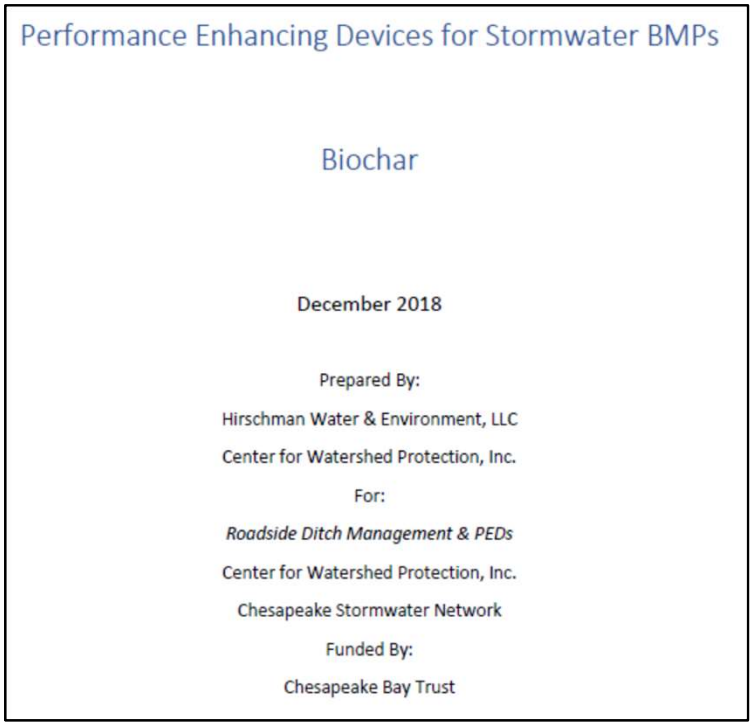
Bryan Seipp
Center for Watershed Protection
www.cwp.org

Tom Schueler
Chesapeake Stormwater Network
www.chesapeakestormwater.net

Date:

April 24, 2017

2017


Performance Enhancing Devices for Stormwater BMPs

Biochar

December 2018

Prepared By:

Hirschman Water & Environment, LLC

Center for Watershed Protection, Inc.

For:

Roadside Ditch Management & PEDs

Center for Watershed Protection, Inc.

Chesapeake Stormwater Network

Funded By:

Chesapeake Bay Trust

2018

THE ABOVE DOCUMENTS DISCUSSED THE BENEFITS & OPPORTUNITIES OF BIOCHAR IN MANAGING THE NUTRIENTS IN THE CHESAPEAKE BAY WATERSHED

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CAN'T PUT THE TOOTHPASTE BACK INTO THE TUBE

MARYLAND DEPARTMENT OF NATURAL RESOURCES

2020
Forest Action Plan

Part I: Forest Resource Assessment

2020

"One of the potential uses of biochar is reducing stormwater runoff, as biochar improves water infiltration in soil. This could lead the Maryland Department of the Environment or the Chesapeake Bay Program to credit practices that use biochar as increasing reductions in stormwater or addressing total maximum daily loads (TMDLs)."

"…there are potential opportunities to utilize biochar sourced from wood waste throughout Maryland and the Chesapeake Bay Watershed as a tool to reduce stormwater and nutrient runoff. However, the uses of biochar are limited by approved crediting from the Chesapeake Bay Program. The Bay Program has not yet evaluated or approved biochar under the Bay Program's expert panel process and it is not currently eligible for credit in the Woodland (sic) (Watershed) Incentive Program (WIP)." Pg 57

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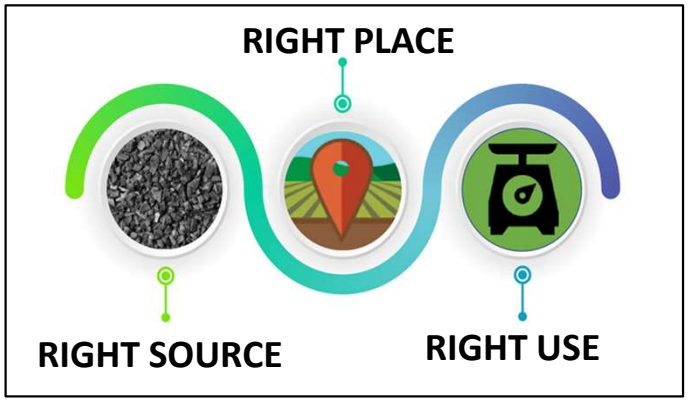
CWP/NFWF INSR 2022 GRANT
Scaling Biochar in the Chesapeake Bay

Goals of the project is to justify that biochar should be added, and provide information such as:

- Design criteria
- Credit calculation
- Materials specification
- Reporting, tracking, and verification requirements

Potential uses include

- Revive compacted or degraded BMPs
- Retrofit Infiltration BMPs
- Incorporate into tree plantings and conservation landscaping
- Soil amendment on residential turf



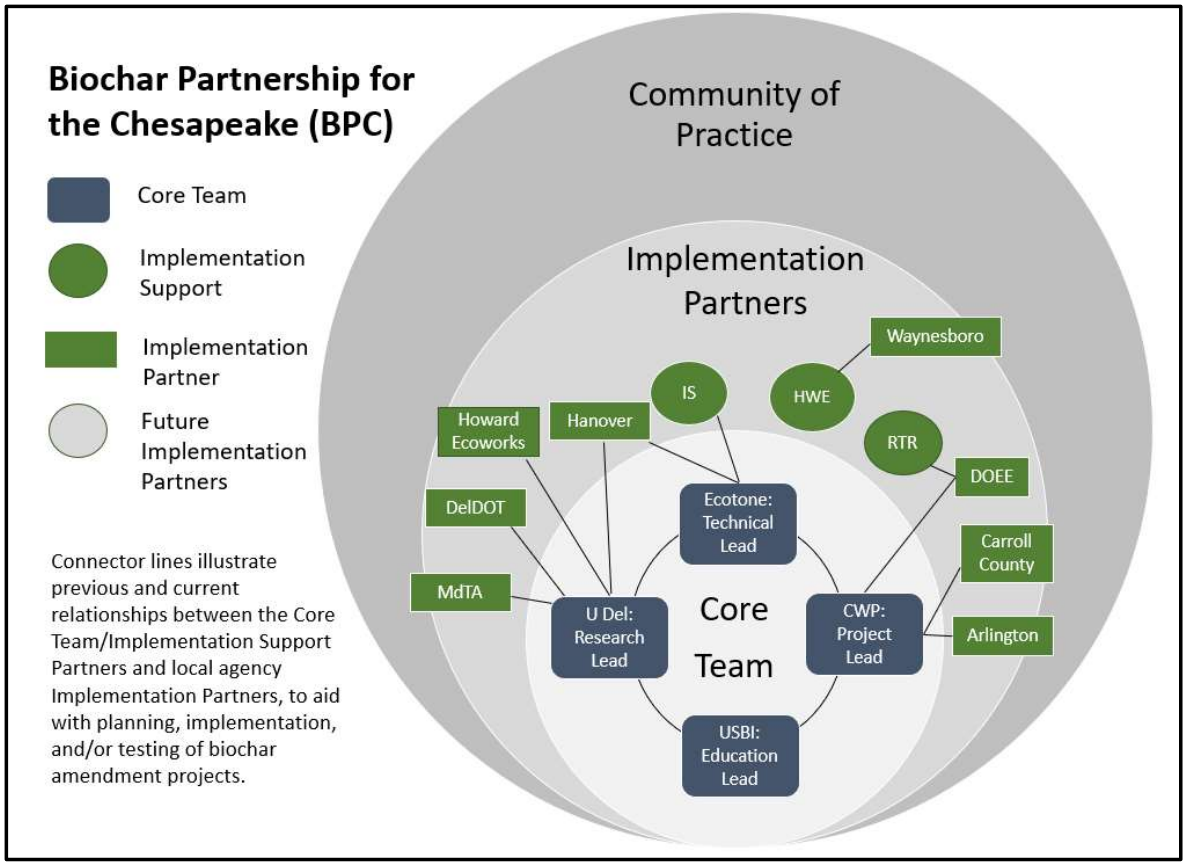
THE TEAM IS LOOKING FOR PROJECT PARTNERS

Using Biochar to Achieve Chesapeake Bay (and Watershed) Water Quality Goals and Climate Resiliency: The Path to Scale

Chesapeake Bay Stewardship Fund

CWP/NFWF INSR 2022 GRANT
Scaling Biochar in the Chesapeake Bay

CENTER FOR WATERSHED PROTECTION



Core Team
- Center for Watershed Protection
- University of Delaware
- Infinite Solutions
- USBI

Implementation Support
- Infinite Solutions
- Hirschman Water and Environment
- Howard Ecoworks

Implementation Partners
- Carroll County, MD
- District Department of Energy and Environment
- Arlington County, VA
- City of Waynesboro, VA
- Borough of Hanover, PA
- DelDOT
- MdTA
- Looking for additional partners

I ♥ biochar
biochar-us.org

BIOCHAR – SAFE, SCALABLE AND SHOVEL READY!

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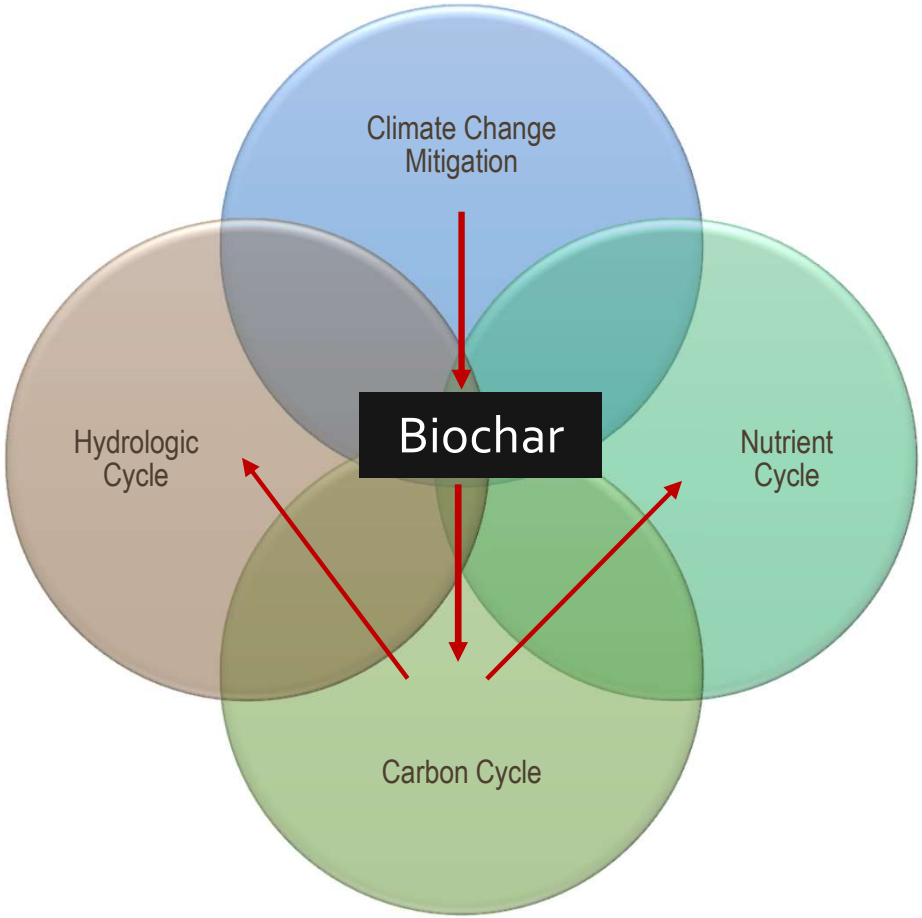
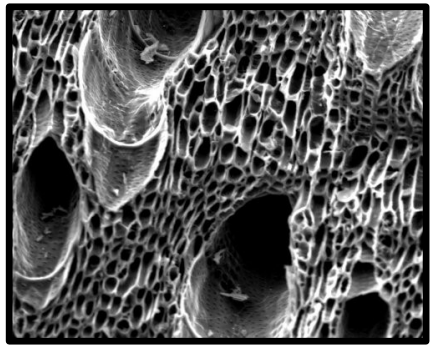
BIOCHAR – SAFE, SCALABLE AND SHOVEL READY!

The time is now to consider –

1. **Biochar credit in existing appropriate BMPs and protocols**
2. **Integration of biochar in Chesapeake Bay model for nutrients and climate**





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Question & Answers

Chuck Hegberg, Sr. Project Consultant
RES, LLC / US Biochar Initiative (Vice-Chair)
chegberg@res.us , www.res.us

Tom Miles, Executive Director
US Biochar Initiative
USBiochar@gmail.com
www.biochar-us.org

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