

What to do with the biochar: Products, Properties, and Markets

Tom Miles

Executive Director

United States Biochar Initiative

TR Miles Technical Consultants

tmiles@trmiles.com



**Biosolids Management Seminar
Biosolids PFAS Mitigation
Charlotte, NC
August 22, 2024**

**USBI
BIOCHAR.ORG**

Biochars from Biosolids Materials and Applications



Biosolids pellet 3-3-2 NPK



PFAS



Biosolids biochar 1-7-1 15%C



Bulk biosolids biochar



Concrete additive



Urban Soil Remediation



Ag Amendment



Use Biosolids Biochars to Improve Turf



Dead spots in grass



New growth in dead spots treated with Biosolids Biochar

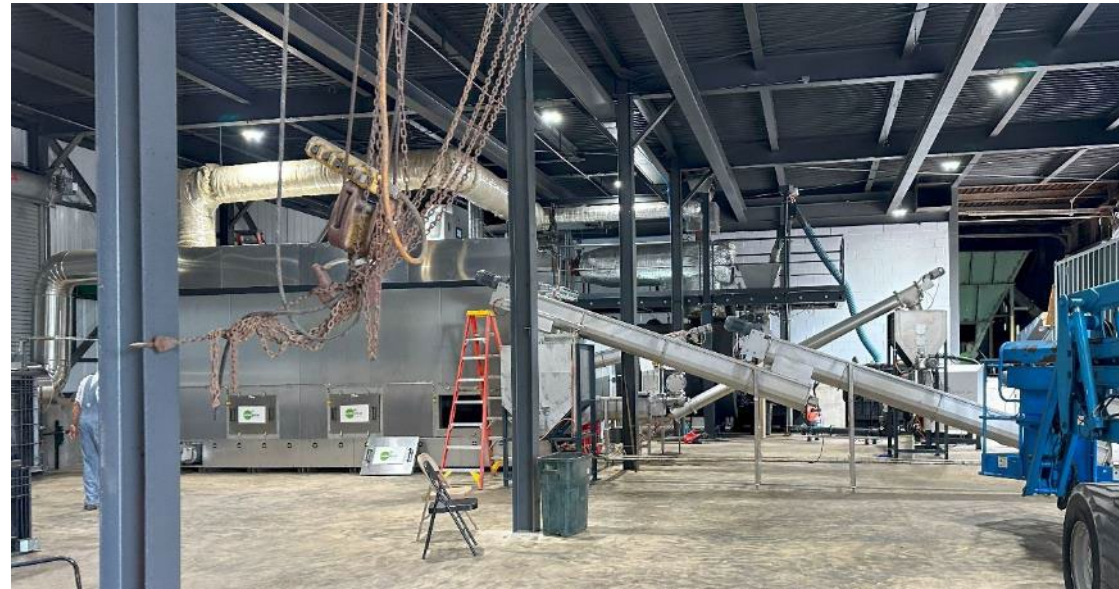


Healthy grass fertilized with 1% K Biosolids biochar. 1-7-1 NPK
No fertilizer.

Golf Course Superintendent:
Biochar biosolids perform like biosolids



Biosolids Biochar Facilities with PFAS Destruction 500-700° C



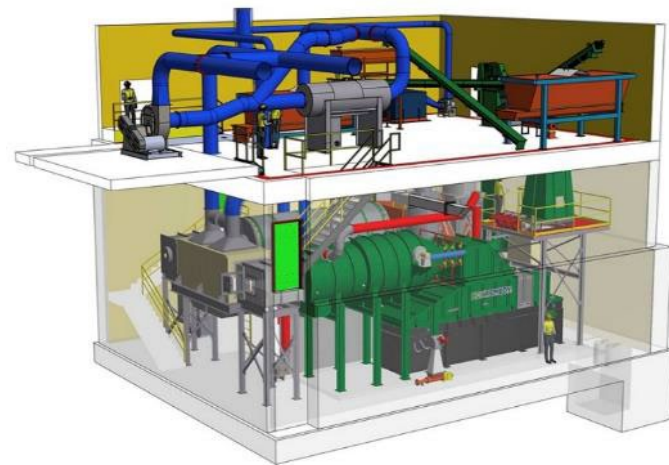
Illinois Farm – dry, pellet, pyrolyze
 UniversalDryingsystems.com Carbonisate™
 5000 tpy biosolids 675 t biochar
 30 yrs Biosolids from 3 WWTPs



Synagro, Baltimore, MD
www.chartechnologies.com
 Mobile development system
 1 dry tph 37,500 tpy biosolids
 Compost - Allgro™
 Pellet - Granulite™



Redwood City, CA Bioforcetech.com + Pyreg.de
 5000 tpy In operation 5 years OurCarbon™



City of Edmonds, WA
 Ecoremedy.com Flexchar™
 14,500 tpy



Derry Township, Hershey, PA
 Ecoremedy.com Flexchar™
 14,000 tpy



Earthcare Bethel, PA
 EarthcareLLC.com Ecochar™
 40,000 tpy



Ephrata, PA
 Bioforcetech.com
 OurCarbon™
 10,000 tpy



Biosolids Management Seminar: Biosolids PFAS Mitigation



Co-pyrolysis With Waste Adds Carbon And Energy

Reduce disposal costs. generate tipping fee revenue by co-processing hard to manage biomass



Clean Construction & Demolition



Green waste - Landfill



Forestry slash

Benefits:

- Carbon + minerals
- Energy recovery
- Carbon dioxide removal

Example: Wastewater Biosolids

- Traditionally land applied to agricultural soils
- Low carbon requires deewatering
- PFAS chemicals have led to landfilling being most common disposal.

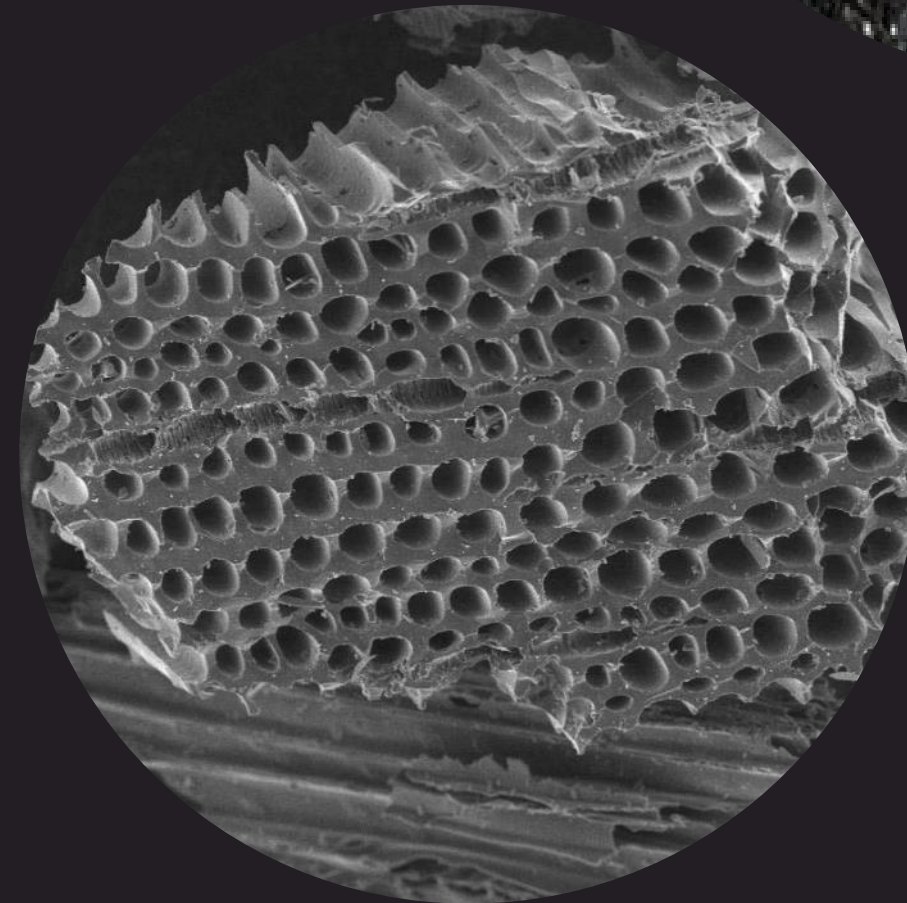
Biochar is a lower-cost solution:

- Well-designed production destroys PFAS
- Reduces total mass and shipping / disposal costs
- Biochar use in materials like concrete



Biochar: A Physical Material

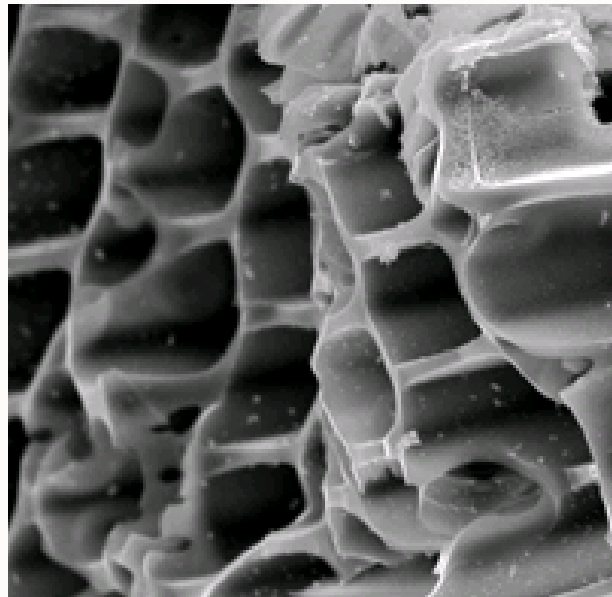
- **Granular black carbon, like charcoal**
- **Chemical structure is resistant to decay, with majority of C stable for 500+ years**
- **Properties depend on feedstock and production conditions**
- **Multiple beneficial end uses:**
 - **Soil health amendment**
 - **Ingredient in biochar-enhanced fertilizers**
 - **Potting soil media to replace peat, vermiculite**
 - **Environmental remediation and restoration**
 - **Media for water filtration**
 - **Additive to materials including concrete**



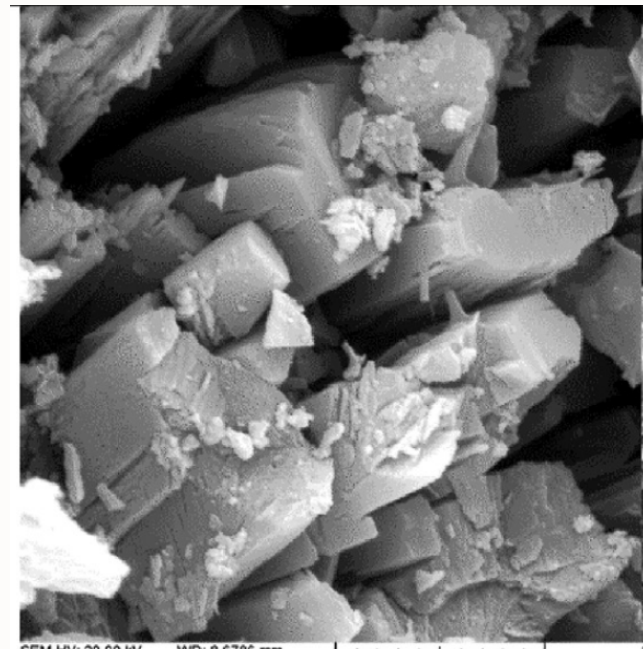
What Biochar Properties Are Needed By the Use?

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

International Biochar Initiative



Structure, Porosity, Surface Area

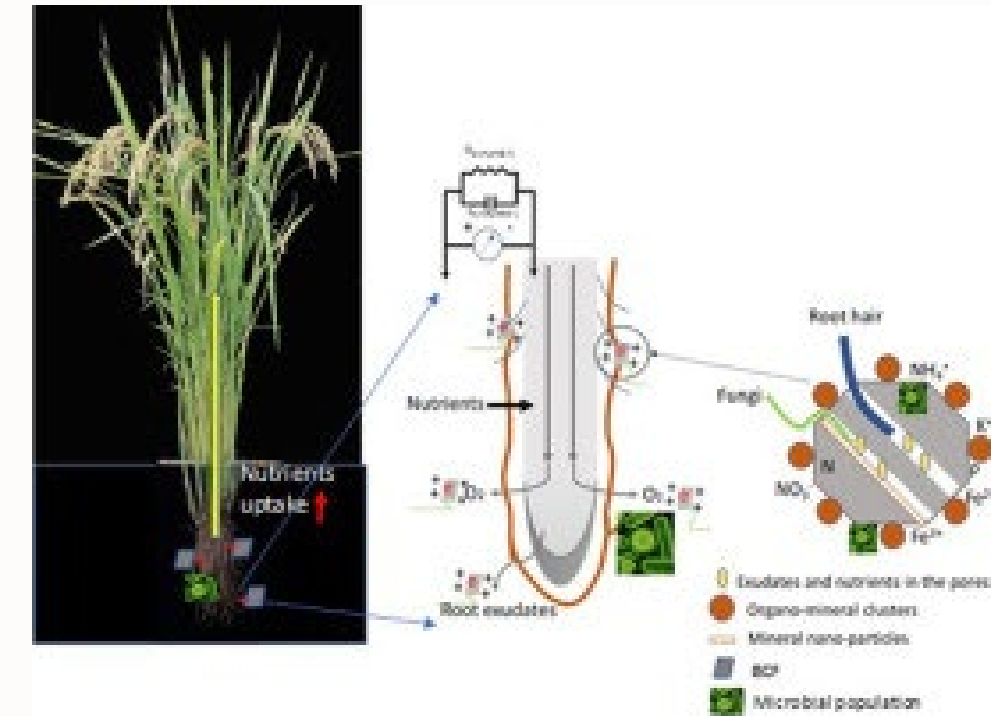


Minerals, Nutrients



Biology

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 electron donors and acceptors
Electron Storage Capacity



Biochar Feedstocks Determine Properties

Feedstock and production process affect properties

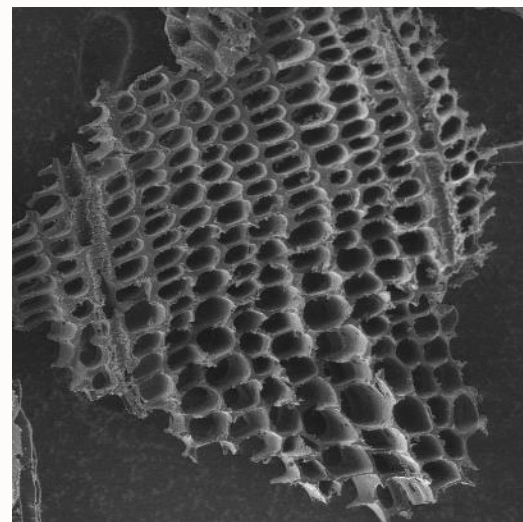
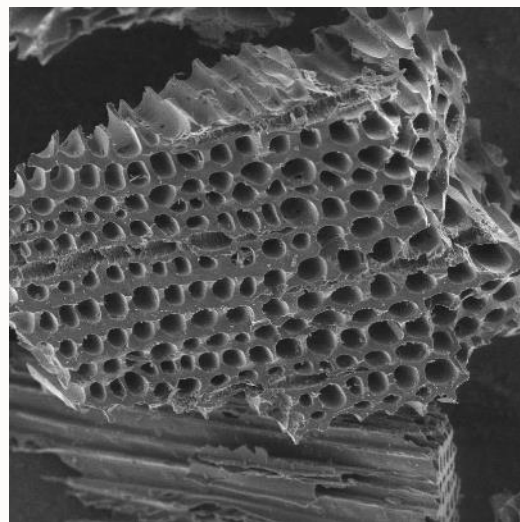
- Different end-uses for different biochars
- Potential to create engineered, “designer biochars”

Production Temperature

500 °C

650 °C

Douglas-fir

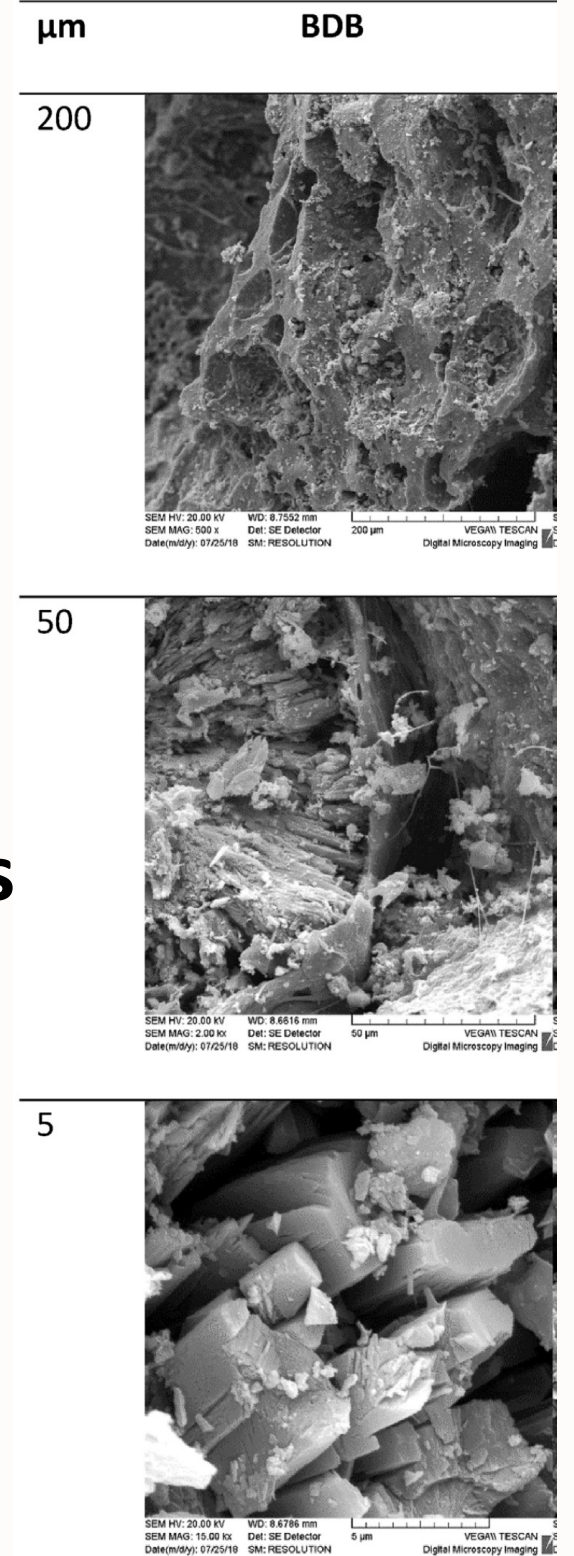


Wood
60-80% C

Myles Gray



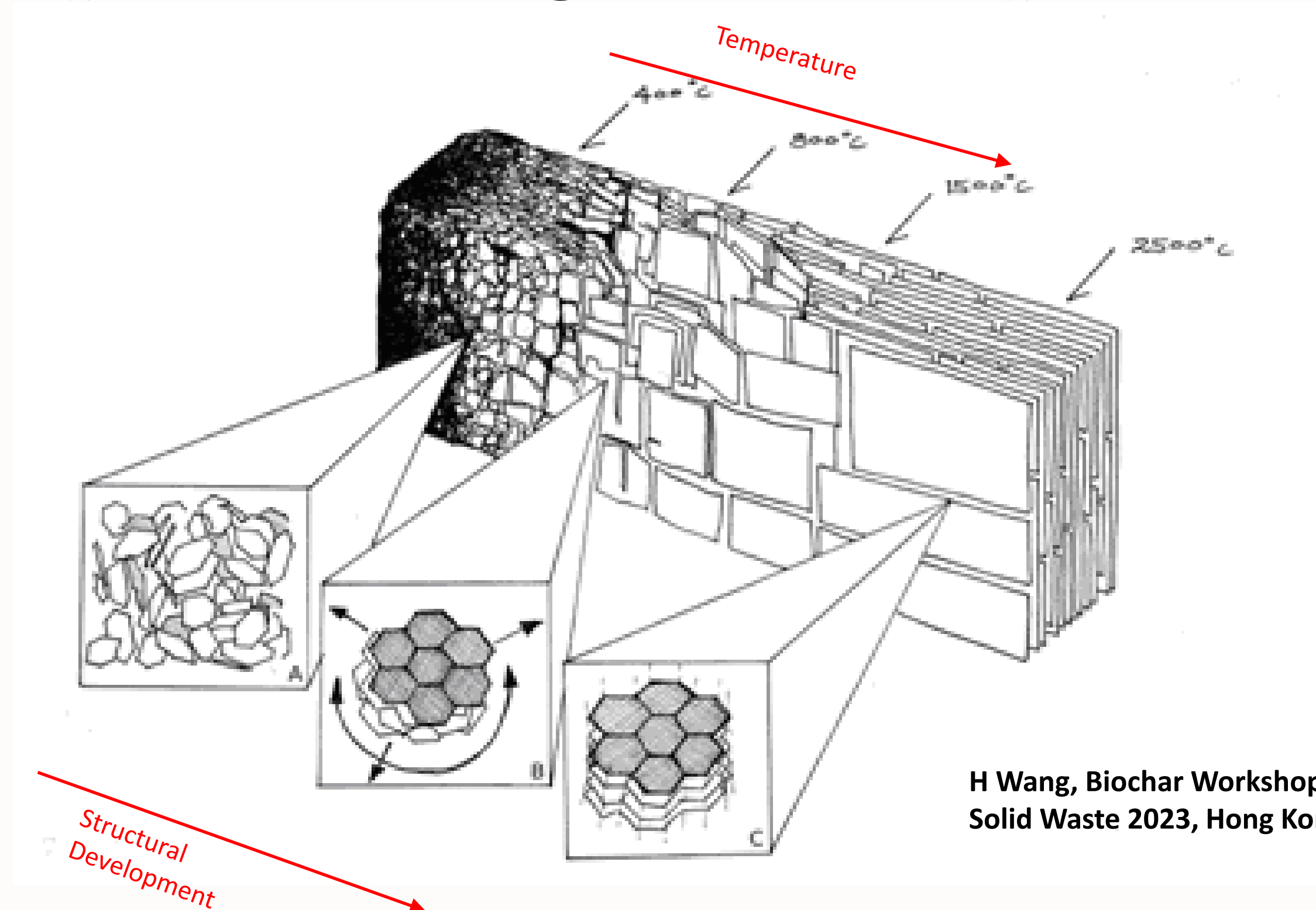
Biosolids
1-30% C



Biochar Carbon Properties Change With Temperature

As temperature increases

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

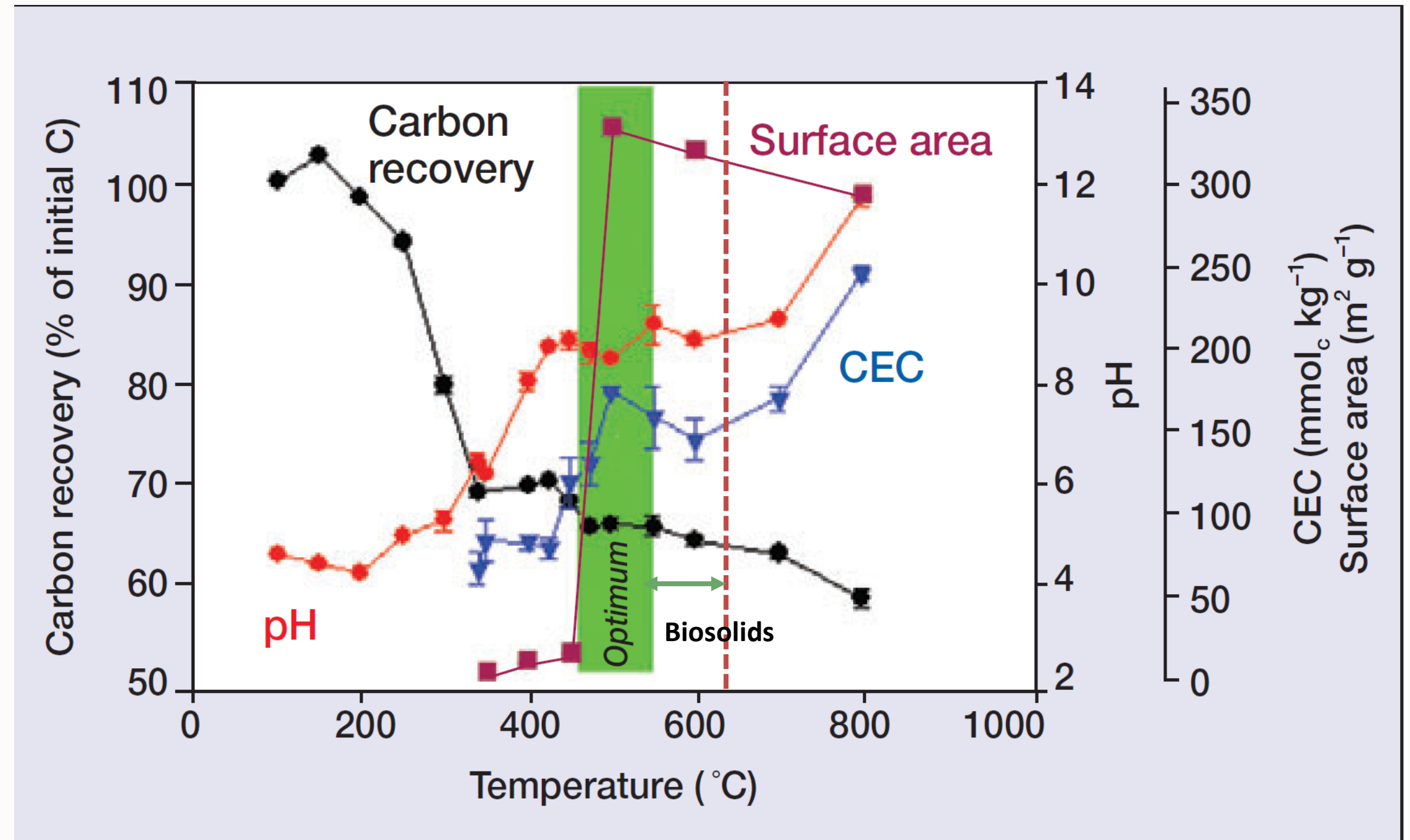


H Wang, Biochar Workshop,
Solid Waste 2023, Hong Kong

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)

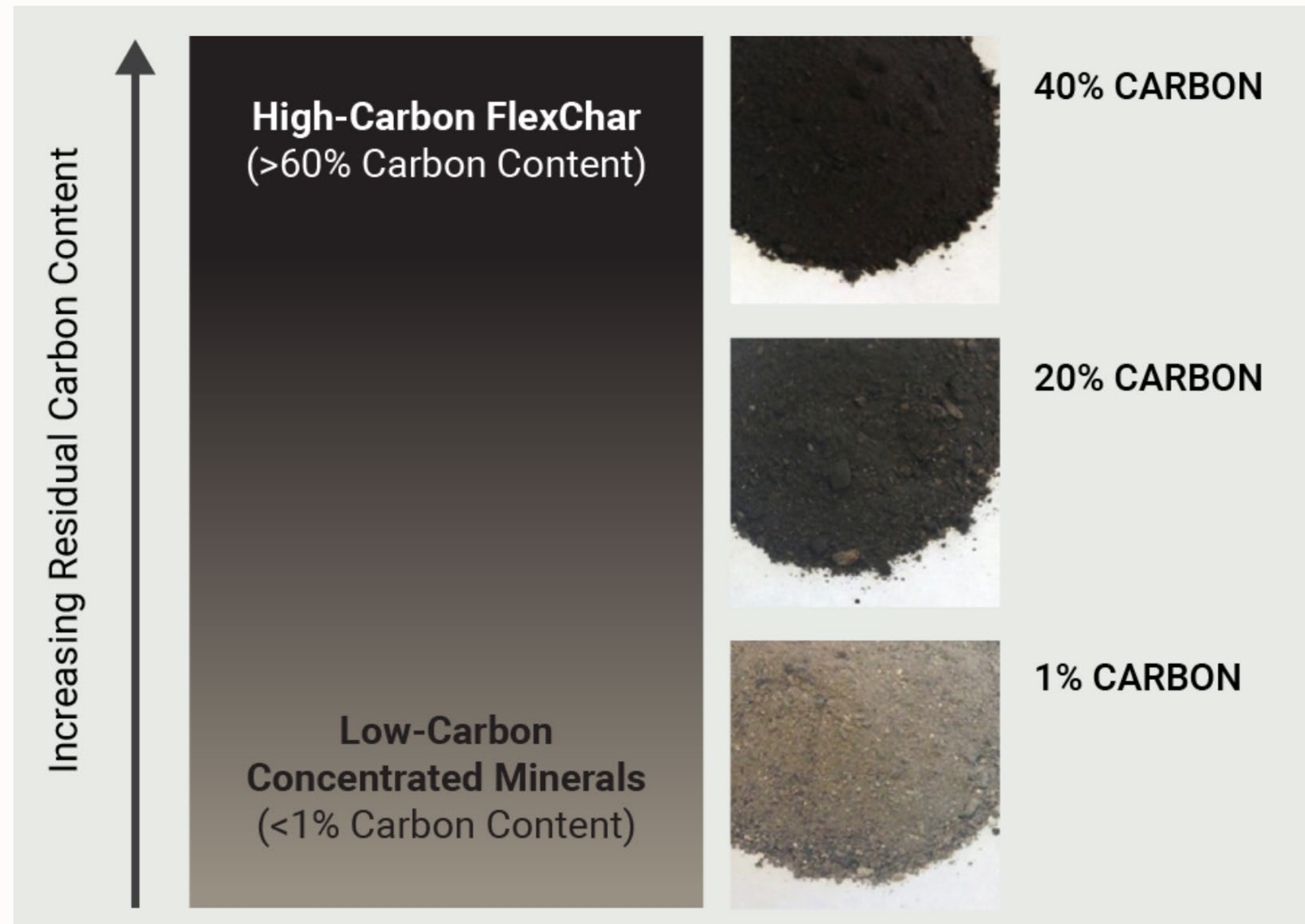
J. Lehmann *Front Ecol Environ* 2007; 5(7): 381–387



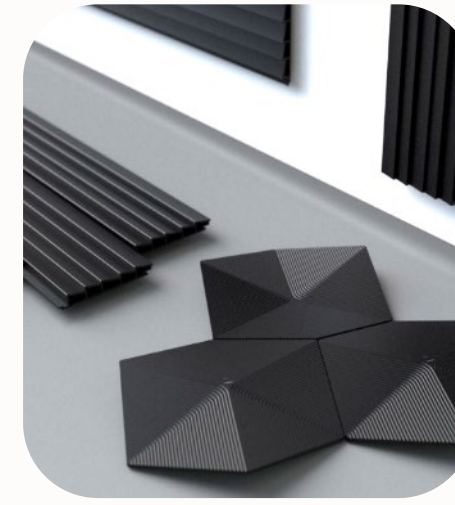
Balance Carbon and Minerals to Market Needs



Ecoremedy.com



Biochar Expands Uses For Biosolids



<u>Agriculture / Soil</u>	<u>Horticulture</u>	<u>Materials</u>	<u>Environmental</u>
<ul style="list-style-type: none"> Crop yield Soil water holding Soil carbon Soil health Fertilizer Needs GHG Pollutants 	<ul style="list-style-type: none"> Plant health Plant growth Fertilizer needs Peat / Perlite Embodied carbon 	<ul style="list-style-type: none"> Performance Cement needs Embodied carbon 	<ul style="list-style-type: none"> Plant growth Restoration rate Soil & water pollutants Odor management



Lower Volume and More Uses than Biosolids Alone

Biosolids Management Seminar: Biosolids PFAS Mitigation



Biochar as a Soil Amendment

Market Overview: Priority near-term and long-term market

- Likely largest market by tonnage, with climate relevant potential
- Leading end-use market to-date
- Market readiness is low to high, depending on agricultural system



Horticultural Growing Media

Market Overview: Priority short / medium term market

- High market readiness as a partial replacement for peat
- Benefits: Partial replacement for peat and perlite equal performance and better sustainability / climate impacts
- Market is moderate, but value and readiness are high

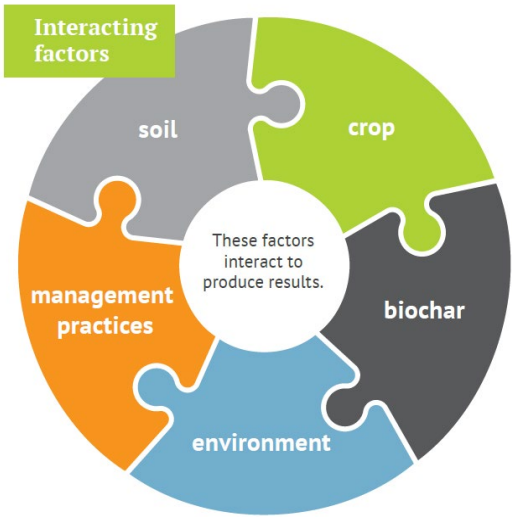


Biochar Enhanced Fertilizers

Market Overview: Priority long-term market

- Among largest markets by tonnage, with climate relevant potential
- Benefits: Simplifies application approach for farmers; optimizes impact at low application rates; reduces fertilizer needs
- Market readiness in US is moderate for home & garden, low for commercial agriculture but higher in Asia





US BIOCHAR INITIATIVE

BIOCHAR-US.ORG

BIOCHAR GUIDELINES FOR AGRICULTURE APPLICATIONS

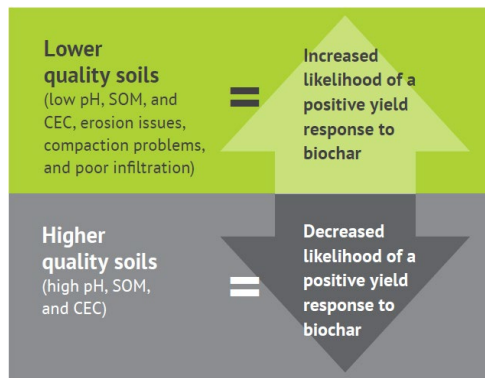
Practical insights for applying biochar to annual and perennial crops

Right source

Selecting the best biochar for your crop

Right place

Applying biochar to the soils that need it



Practical Implementation
Production Technology

Right rate

Applying the right amount

Right time

Identifying when to apply



Photo by Britt Fossum



Photo by David Laird

A sustainable soil amendment that: ¹⁻⁴

- builds soil organic carbon and soil health
- increases crop yields and soil moisture
- improves nutrient retention
- boosts microbial activity
- alleviates compaction
- reduces soil acidity
- sequesters carbon



USBI Learning Center



Landscaping, Turf, & Tree Care

Market Overview: Secondary, short-medium term market

- High market readiness in tree care and general landscaping
- Benefits: Improved plant health and survival;
- Reduced irrigation and fertilizer needs; Reduced embodied carbon of landscapes
- Market is moderate in size, but value and readiness are high



Composting

Market Overview: Priority short / medium term market

- High market readiness in food waste, manure
- Benefits: Reduced compost time, odor, GHG
- Market is moderate, but value and readiness are high



Remediation, Mine Restoration

Market Overview: Priority long-term market

- Among largest markets by tonnage, with climate relevant potential
- Benefits: Provide nutrients to soil restoration
- Market readiness in US immediate for sites planned with environmental permits.



Manage Urban Soil and Water With Biochars



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

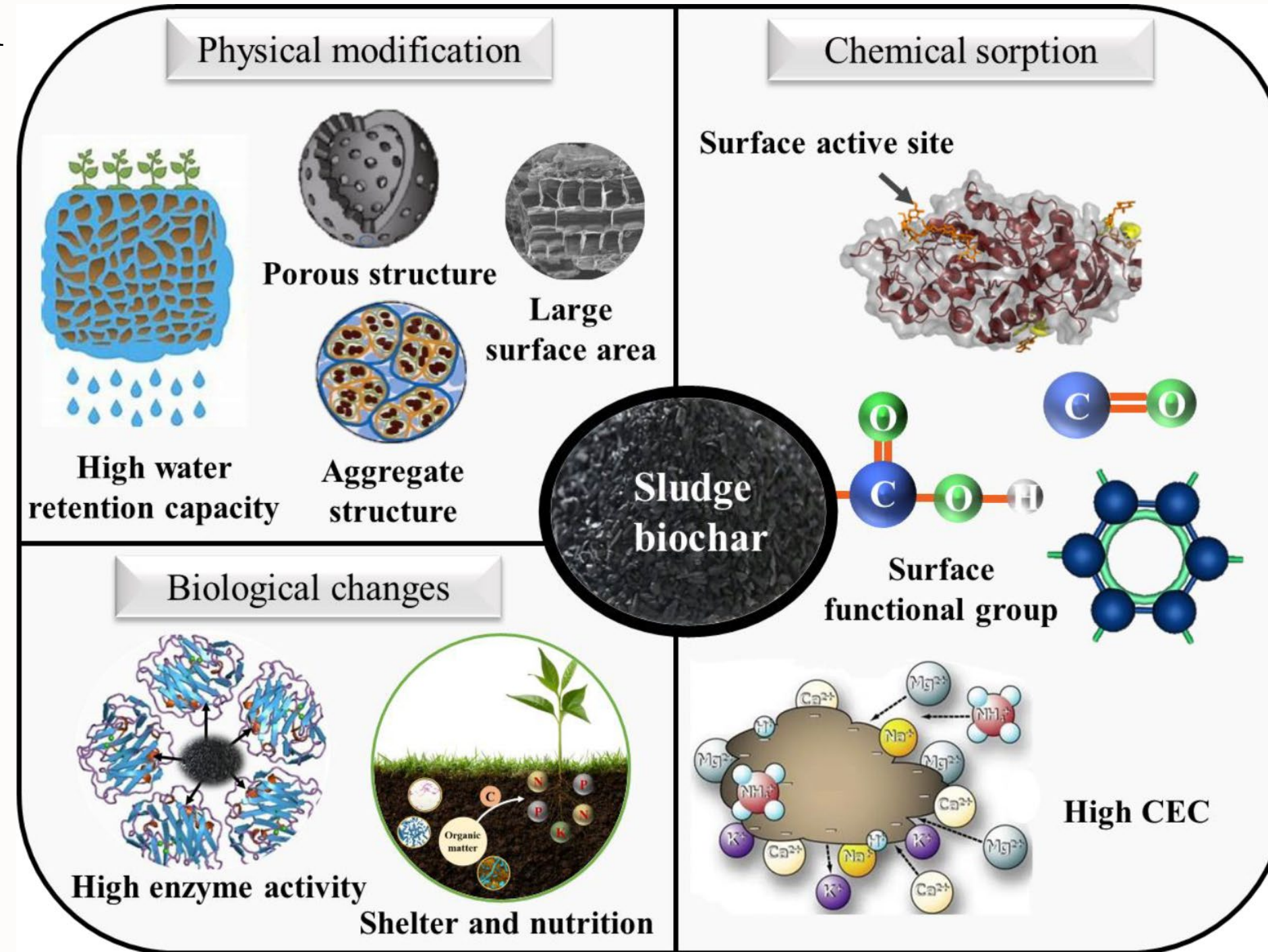


Courtesy Infinite Solutions

Geotechnical Solutions to compaction, drainage, aggregation, filtration



Biosolids Biochars Adsorption Mechanisms in Soil Remediation



L. Zhao. et. al 2023 Sewage sludge derived biochar for environmental improvement: Advances, challenges, and solutions. Water ResearchX18 (2023) 100167
www.sciencedirect.com/science/article/pii/S2589914723000038



Stormwater Management Green Infrastructure

Market Overview: Secondary, short to long term market

- Medium market readiness as a stormwater filtration media
- Benefits: Improved pollutant removal; Increased infiltration; Improved plant health in vegetated green infrastructure systems
- Market is moderate in size, but value and readiness are medium



Water Treatment and Filtration

Market Overview: Secondary, short to long term market

- Medium market readiness as wastewater media
- Benefits: PFAS, metal pollutant removal
- Market is moderate in size, but value and readiness are medium

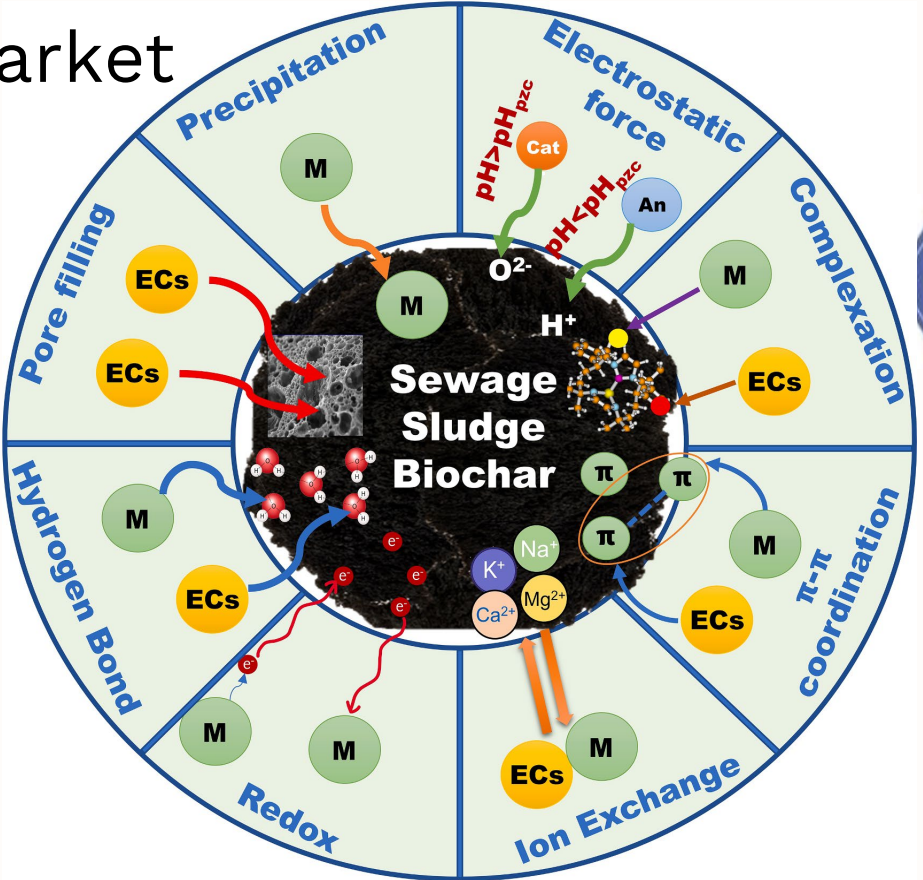


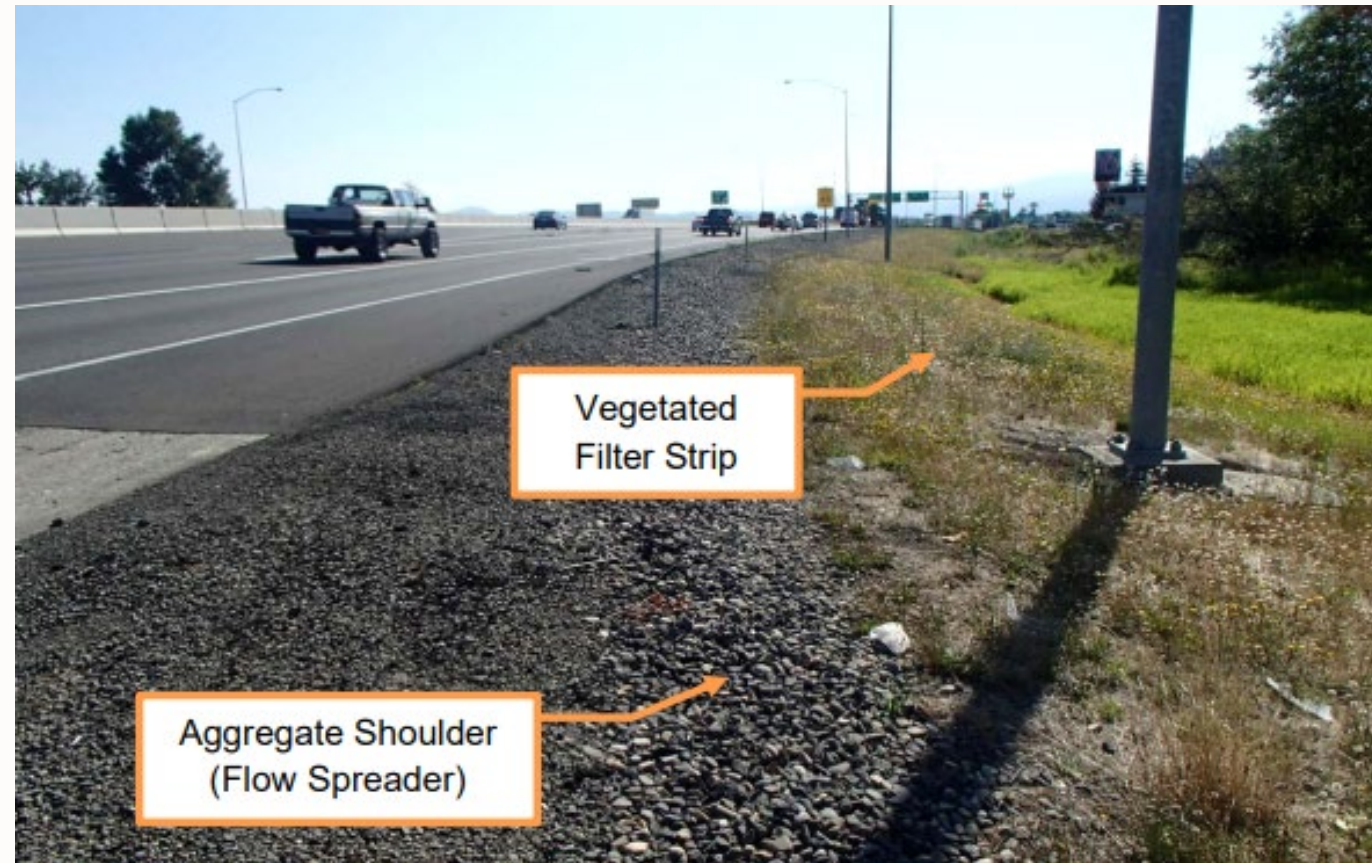
Fig. 2. Sewage Sludge biochar for remediation of wastewater loaded with: Emerging Contaminants (ECs); Metalloids (M); An (Anions); Cat (Cations). R. Khan et. al. 2023. Sewage sludge derived biochar and its potential for sustainable environment in circular economy: Advantages and challenges. Chemical engineering journal 471 (2023) 144495.



Green Infrastructure

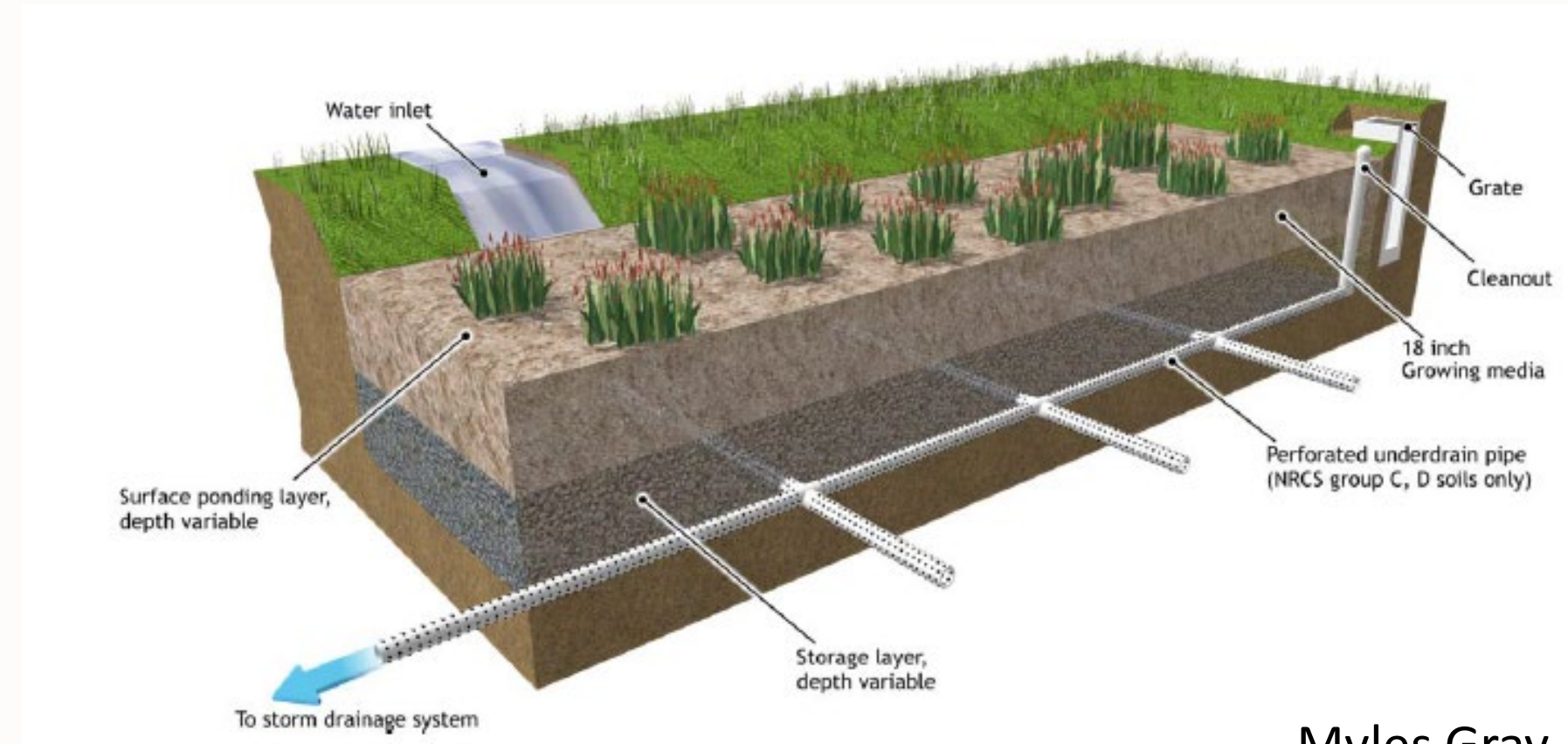
Hydrology, Pollutant Removal, & Co-Benefits

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



Concrete and Asphalt Additive

Market Overview: Primary, medium to long term market

- Low to medium market readiness
- Benefits: Reduced embodied carbon; Improved performance
- Market is very large in size, but value and readiness are lower



Pacificbiochar.com



Challenges and Opportunities

- Match the biochar products to markets:
Soil Amendment, Filter Media, Materials
- Monetize biosolids biochar qualities
 - Nutrient retention and efficiency
 - Macro and micronutrients
 - Reduce metals availability
 - PFAS/PFOS destruction
 - PFAS and metal capture
 - Increased microbial activity



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





Thank You!

Tom Miles

Executive Director

United States Biochar Initiative

tmiles@trmiles.com



Biosolids Management Seminar: Biosolids PFAS Mitigation

USBI
BIOCHAR.ORG