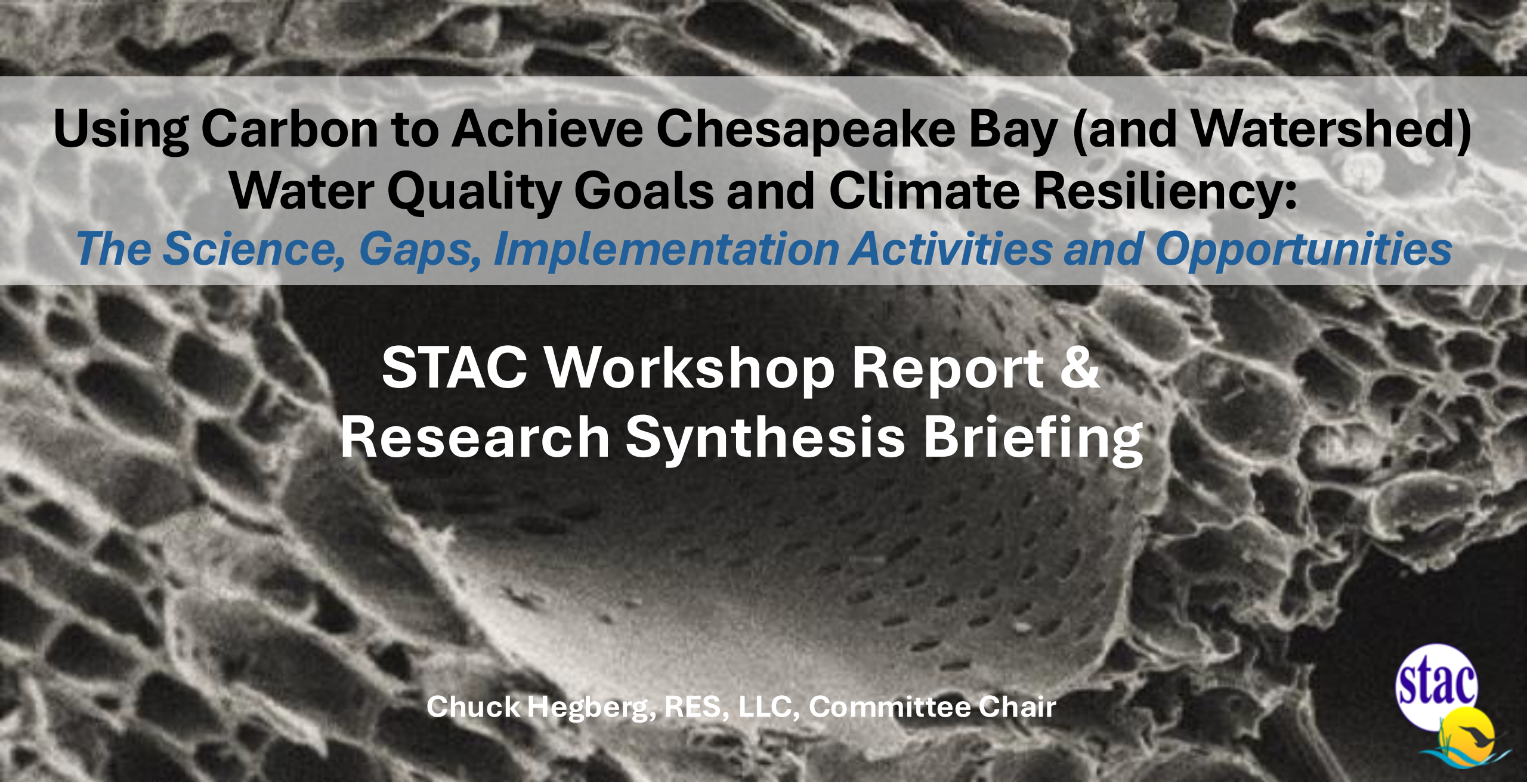


Using Carbon to Achieve Chesapeake Bay (and Watershed) Water Quality Goals and Climate Resiliency:

The Science, Gaps, Implementation Activities and Opportunities

STAC Workshop Report & Research Synthesis Briefing

Chuck Hegberg, RES, LLC, Committee Chair

October 15, 2024

Workshop Objective & Goals

To convene a workshop with leading national and local experts to *elevate the use of biochar in practice Bay-wide* by evaluating and *translating current research for integration into current Chesapeake Bay protocols*.

Workshop Goals

1. Evaluate and Synthesis Current Biochar Research
2. Translate Biochar Research & Empirical Evidence into Protocols, Standards & Specifications
3. To Promote Biochar Adoption & Use in the CBw
4. Advance Empirical Evidence for Biochar Protocols, Standards & Specifications
5. Foster Networking & Collaboration (Community of Practice)
6. Identify Actionable Recommendations

Biochar Workshop Attendees		
	DAY 1	**DAY 2**
ROMOTE	82	92
IN PERSON	54	45
TOTAL	136	137

Workshop Steering Committee, Technical Experts & Practitioners

Workshop Steering Committee

- Jason Hubbart, Ph.D.*, West Virginia University (Workshop co-chair)
- Chris Brosch*, DE Department of Agriculture
- Charles Hegberg, USBI/RES, LLC (Workshop Chair)
- Jennifer Egan, UM Environmental Finance Center (Workshop co-chair)
- Tom Miles, USBI/TR Miles Consultants, Inc.
- Paul Imhoff, University of Delaware
- Wayne Teel, James Madison University
- David Wood, Chesapeake Stormwater Network
- Dominique Lueckenhoff, Hugo Neu, Inc.
- Kenneth Pantuck, USA EPA Region 3

Technical Subject Matter Experts

- Gary Shenk*, USGS
- Carol Wong, PE, Center for Watershed Protection
- Larry Trout, PE, Straughan Environmental Services
- Brandon Smith, Ph.D., Allied Soil Health Services
- Kristin Trippe, Ph.D., USDA
- Debbie Aller, Ph.D., Cornell University
- Sabina Dhungana, USDA Forest Service, (formerly VA Dept of Forestry)
- Carolyn Voter, Ph.D., University of Delaware
- Jim Doten, City of Minneapolis (Technical & Guest Speaker)
- Isabel Lima, Ph.D., USDA ARS
- Charles Glass, Ph.D., PE, Maryland Environmental Services (Guest Speaker)
- Mark Johnson, Ph.D., US EPA
- Sean Sweeney, PR, Barton & Loguidice

Acknowledgements

- Meg Cole, STAC Coordinator, Chesapeake Research Consortium
- Tou Matthews, STAC Projects Manager, Chesapeake Research Consortium
- Rachel Tardiff, Rachel Tardiff, LLC
- UM CCC Student Support
- US Biochar Initiative – Travel & Lodging Accommodations for many of the biochar subject matter experts.

Biochar in CBw – Condensed Timeline

Pre - 1990
- Biochar name rebranding (1987)
- 1st Biochar Paper Published (1989)
- Frye Energy, LLC – 1st Poultry Litter to Char

2009
- US Biochar Initiative Established
- S. River/S. Fork Shenandoah Mercury Remediation Demo, VA

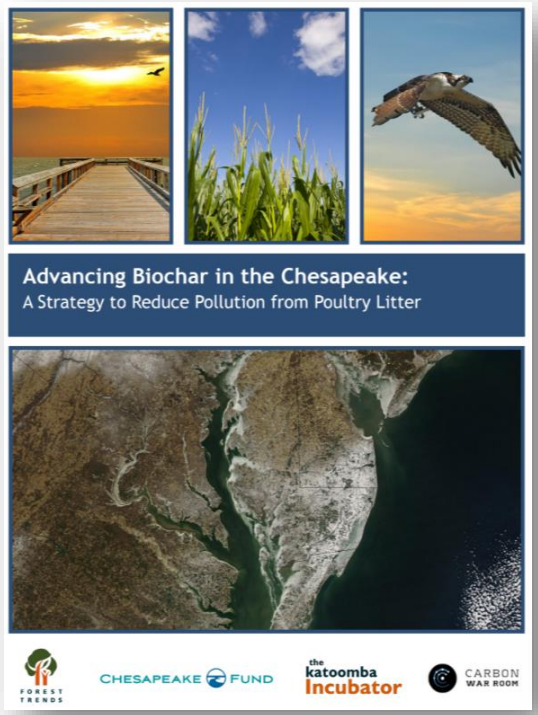
2010
- Advancing Biochar in the Chesapeake Report (**207 Published Papers**)
- University of Delaware begins biochar research

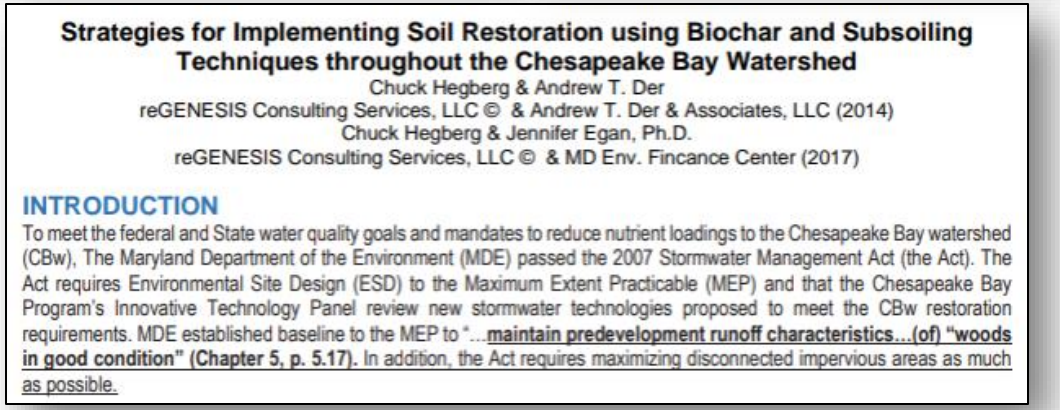
2014
- CBP STAC Biochar Review (1st Biochar Consideration) (**2,005 Published Papers**)
- Strategies for Implementing Soil Restoration using Biochar and Subsoiling Techniques throughout the CBw Strategy White Paper

2014-2023
- CBw Biochar Research & Installations Expanded.
- Leaders – UD, DelDOT, MDTA, several non-profits and consulting firms

2022-2024
- CBP STAC Workshop, Report & Presentation (2nd Biochar Consideration) (**34,288 Published Papers – 2023**)
- Scaling Up Biochar Applications for Accelerated Stormwater Runoff Reduction in the CBw" grant NFWF (#0602.22.074143).

10-year Gap





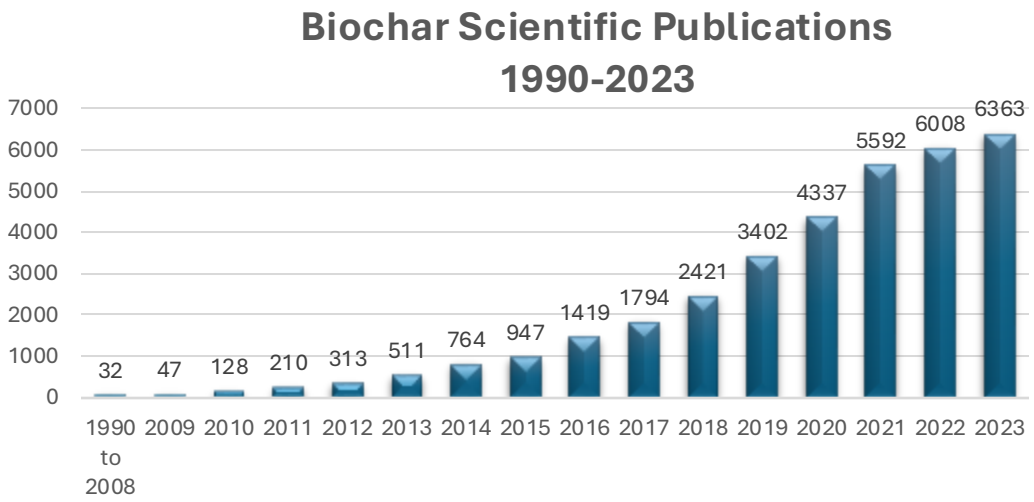
Strategies for Implementing Soil Restoration using Biochar and Subsoiling Techniques throughout the Chesapeake Bay Watershed

Chuck Hegberg & Andrew T. Der
reGENESIS Consulting Services, LLC © & Andrew T. Der & Associates, LLC (2014)
Chuck Hegberg & Jennifer Egan, Ph.D.
reGENESIS Consulting Services, LLC © & MD Env. Fincance Center (2017)

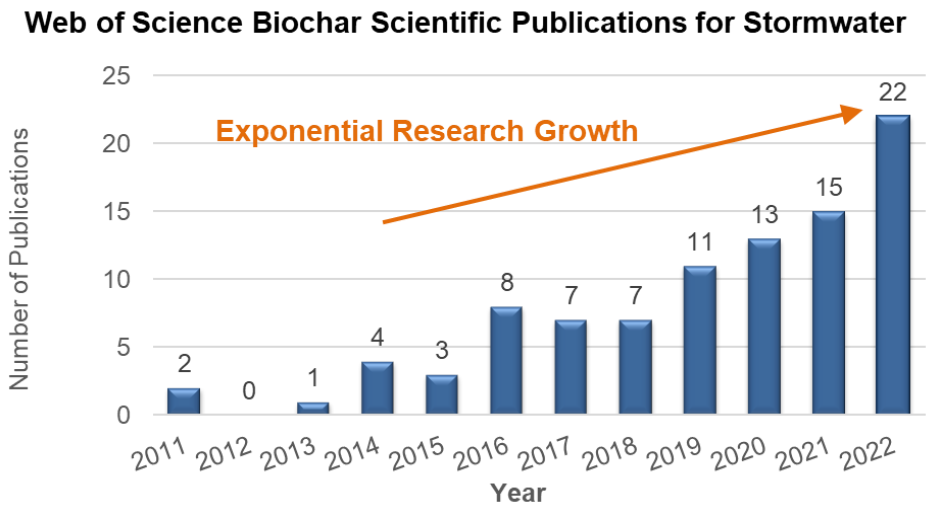
INTRODUCTION

To meet the federal and State water quality goals and mandates to reduce nutrient loadings to the Chesapeake Bay watershed (CBw), The Maryland Department of the Environment (MDE) passed the 2007 Stormwater Management Act (the Act). The Act requires Environmental Site Design (ESD) to the Maximum Extent Practicable (MEP) and that the Chesapeake Bay Program's Innovative Technology Panel review new stormwater technologies proposed to meet the CBw restoration requirements. MDE established baseline to the MEP to "…**maintain predevelopment runoff characteristics…(of) "woods in good condition" (Chapter 5, p. 5.17).** In addition, the Act requires maximizing disconnected impervious areas as much as possible.

Biochar Momentum in Research



Web of Science Biochar Research (1990-2023)



Growth in number of scientific publications of biochar applications for stormwater management (WoS)

Web of Science Biochar Research versus Approved BMPs (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

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

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

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

Biochar Workshop Recommendations

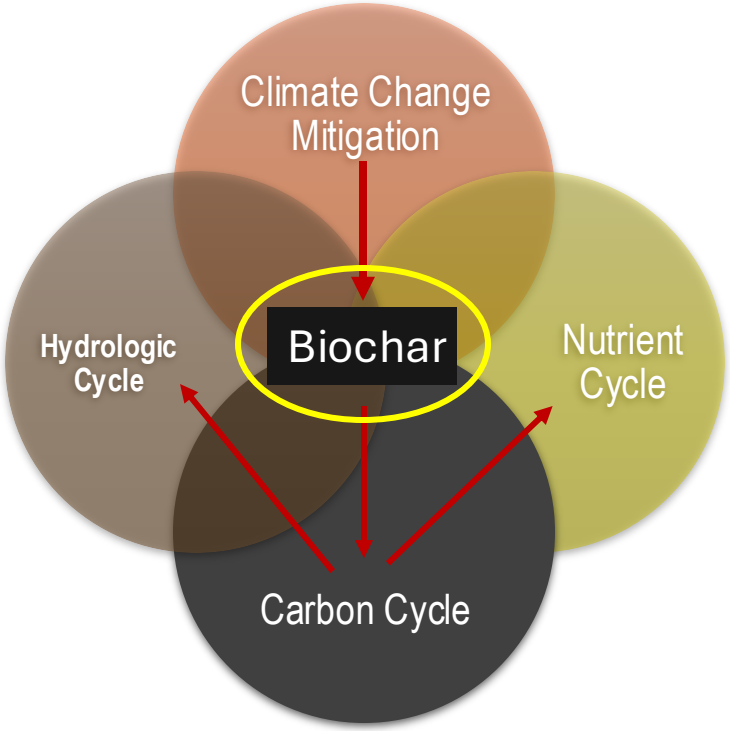
- **Recommend and expand applied research and knowledge filling:**
  - **Prioritize Biochar Research** - Focus on practical and field-scale studies to advance biochar knowledge.
  - **Commit to Science-Backed Solutions** - Investment in scientific research to address biochar application gaps.
  - **Support Data Collection** - Collect field data to validate biochar's benefits and best practices.
  - **Understand Contextual Effectiveness** - Assess biochar's effects in diverse Chesapeake Bay watershed scenarios.
  - **Refine Biochar Protocols** - Use research insights to improve biochar usage guidelines.
- **Support scaling up scientifically effective application of biochar use:**
  - **Expand Biochar Use Across Sectors** - Implement biochar in agriculture, forestry, and urban areas within the watershed.
  - **Address Contaminants** - Apply biochar to mitigate emerging and toxic substances.
  - **Develop Biochar Guidelines** - Establish clear guidelines for biochar application across various contexts.
  - **Set Biochar Standards** - Create standards to ensure biochar's effectiveness and safety.
  - **Accredit Biochar Practices** - Introduce accreditation programs to certify biochar application methods.

Biochar Workshop Recommendations

- **Support pursuing biochar enhancement credit for approved BMP Protocols:**
  - **Integrate Biochar in Nutrient Models** - Include biochar impacts in Chesapeake Bay nutrient management tools.
  - **Inform Policy with Biochar Data** - Use biochar data to guide policymakers and stakeholders on water quality strategies.
  - **Understand Biochar's Role** - Clarify biochar's contributions to water quality and climate resilience.
  - **Follow CBP Urban Stormwater Guidelines** - Adopt CBP's process for incorporating biochar into urban BMPs.
- **Provide letters of support to expand collaborative partnerships**
  - **Strengthen Multi-Sector Collaboration** - Unite government, academia, NGOs, and businesses around biochar adoption.
  - **Streamline Biochar Research** - Coordinate research activities to optimize biochar use.
  - **Share Best Practices** - Disseminate successful biochar applications and case studies.
  - **Accelerate Biochar Projects** - Fast-track biochar initiatives through joint funding and resources.
  - **Build a Biochar Community of Practice** - Create networks to support and promote biochar integration.

Key Biochar Workshop Take Aways

1. **Advancing Without CBP Crediting:** Biochar projects occurring despite the absence of CBP crediting mechanisms.
2. **Fostering a Carbon-Negative Economy:** Creating a cross-sectoral carbon-negative economy with biochar at its core.
3. **Selective Biomass Conversion:** All biomass can become biochar, not all should.
4. **Biochar Quality Variability:** Acknowledging biochar is made from waste so and addressing the varying qualities requires quality control.
5. **Optimal Biochar Utilization:** Emphasize the right source, location, and usage for effective biochar application.
6. **Research and Analysis Imperative:** Comprehensive practical research and field-scale analysis to better understand biochar's impact is paramount.
7. **User Education:** Highlighting the need for user-focused technical education and implementation guidance.
8. **Establishing Standards:** Addressing the significant need for formal biochar protocols and standards to facilitate implementation and growth.
9. **Supply Challenges:** Addressing the shortage of certified biochar to meet regional demand.
10. **Capitalizing on Federal Support:** Urging the CBP to utilize federal support and funding to its full potential.



Presentation Discussion

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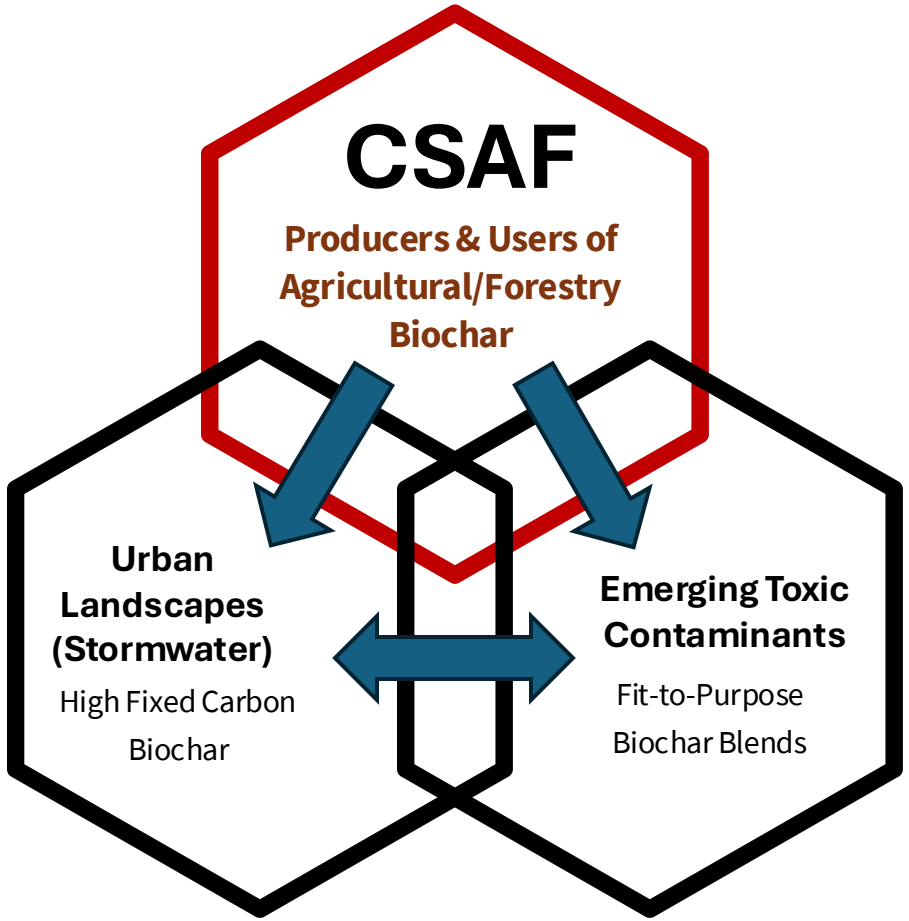
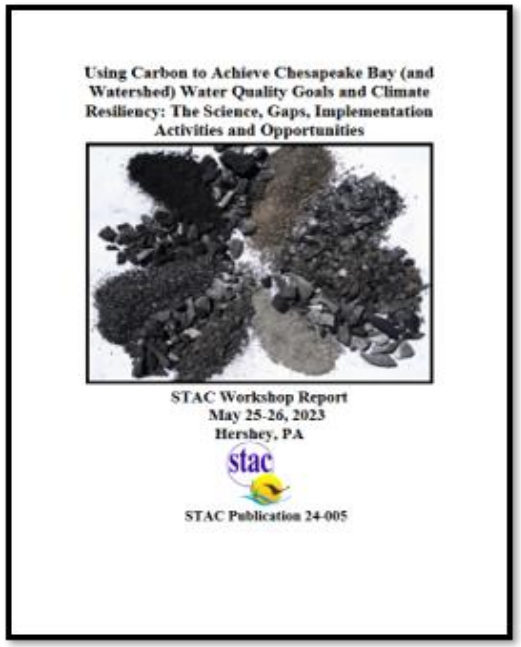


Link to Report


Using Carbon to Achieve Chesapeake Bay (and Watershed) Water Quality Goals and Climate Resiliency: The Science, Gaps, Implementation Activities and Opportunities

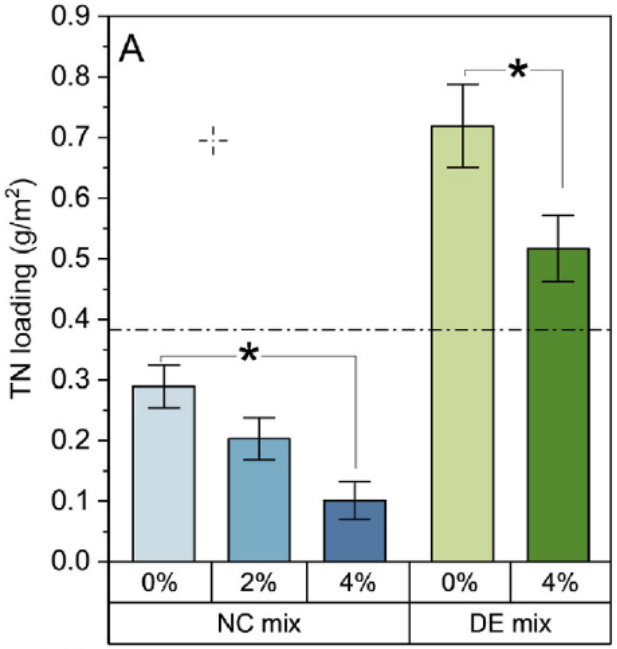
STAC Workshop Report
May 25-26, 2023
Hershey, PA

STAC Publication 24-005

Urban Landscapes (Stormwater) High Points

Bioretention Engineered Media

- **Biochar Effectively Reduces Nutrients:** Proven to decrease nitrogen in more than 90% of bioretention lab studies, indicating a need for field studies to validate lab results (Biswal et al., 2022).
- **Biochar Boosts Hydraulic Conductivity and Nutrient Removal:** Enhanced bioretention media improved hydraulic conductivity by 50%, nitrate removal by 500%, and infiltration rates by fourfold (Imhoff, P.T., 2017; Tian, J., et al., 2018).
- **Biochar vs. Compost:** Offers long-term stormwater management benefits by improving soil structure, compaction issues and reducing nutrient leaching, outperforming compost (Imhoff, P.T., et al., 2018; Owen et al., 2023; Akpinar et al., 2023a; 2023b).
- **Wood Biochar's Prominence in Research:** 84% of bioretention studies focused on wood biochar, reducing or replacing compost, with efficiency in total nitrogen removal ranging from 32-64% (Biswal et al., 2022; Akpinar et al., 2023a; 2023b).



Effect of biochar amendment (0, 2, and 4% by mass) on total nitrogen (TN) loading from two bioretention media – NC mix (without compost) and DE mix (with compost). Influent TN loading is horizontal dashed line. Biochar amendment decreased TN loading from both media, although TN in DE mix exceeded influent when compost present. Taken with permission from Akpinar et al. (2023b).

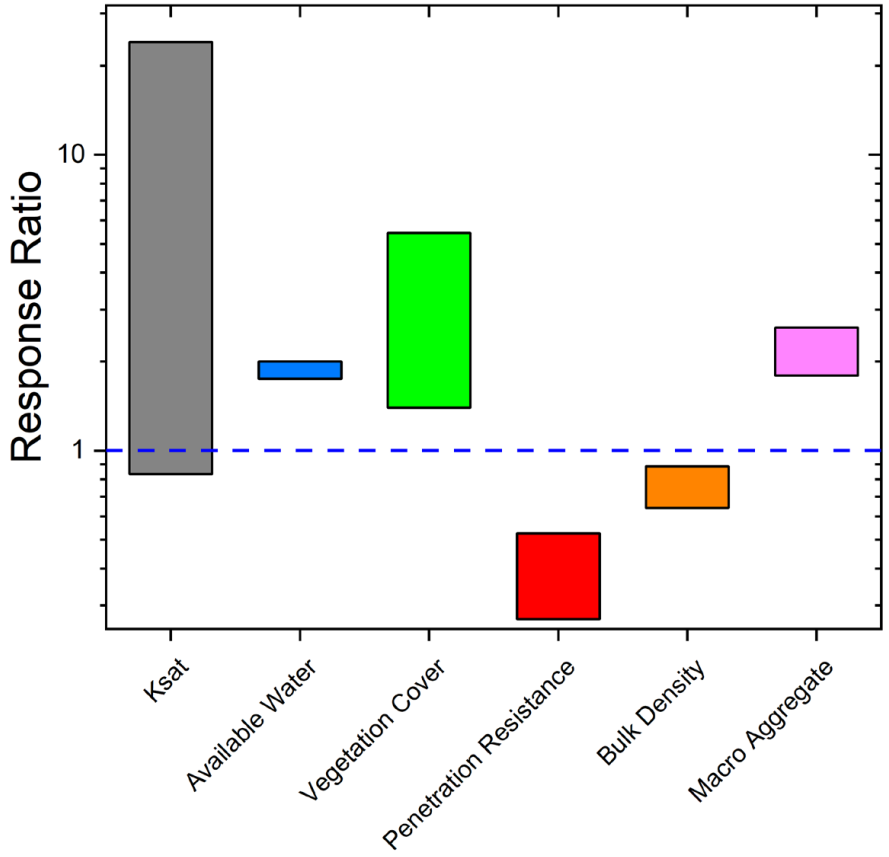
Pollutant	Reduction Range with Biochar
Heavy Metals	27 – 100%
Total Nitrogen	32 – 64%
Total Phosphorus	45 – 94%
Microorganisms	Log10 = 0.78 – 4.23
Organics (PAHs, etc.)	54 – 100%

Percent reduction of pollutants in bioretention when amended with biochar (Biswal et al., 2022)

Urban Landscapes (Stormwater) High Points

Biochar Amendment Soils (Coarse Grained Soils)

- **Runoff Reduction with Biochar:** Applications in Delaware and Maryland show biochar reduces stormwater runoff by 80% on average, influenced by the ratio of impervious to pervious surfaces. Effective in compacted soils and boosting natural soil aggregation (Imhoff, P.T., et al., 2017; 2018; 2019; 2020).
- **Soil and Water Benefits of Biochar:** Biochar amendments have shown to elevate soil infiltration and water-holding capacity by 25-27% depending on biochar porosity.
- **Biochar Amendment Ratios for Impervious Surfaces:** Amending a 30 cm layer of soil with a 2% biochar mixture at an impervious to pervious (IP:P) ratio between 8:1 and 12:1 is effective for treating stormwater from 1-acre of impervious roadway (Akpinar et al., 2023, Imhoff, P.T., et al., 2017).

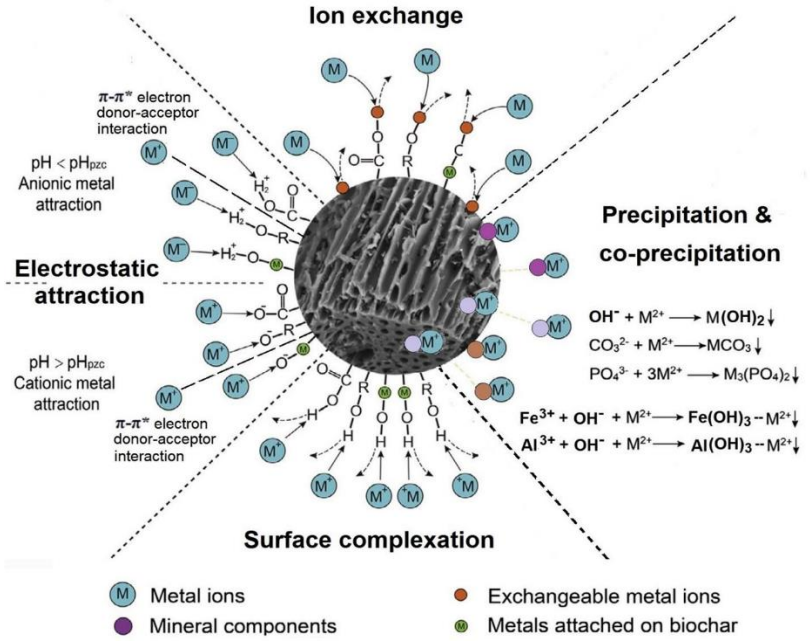


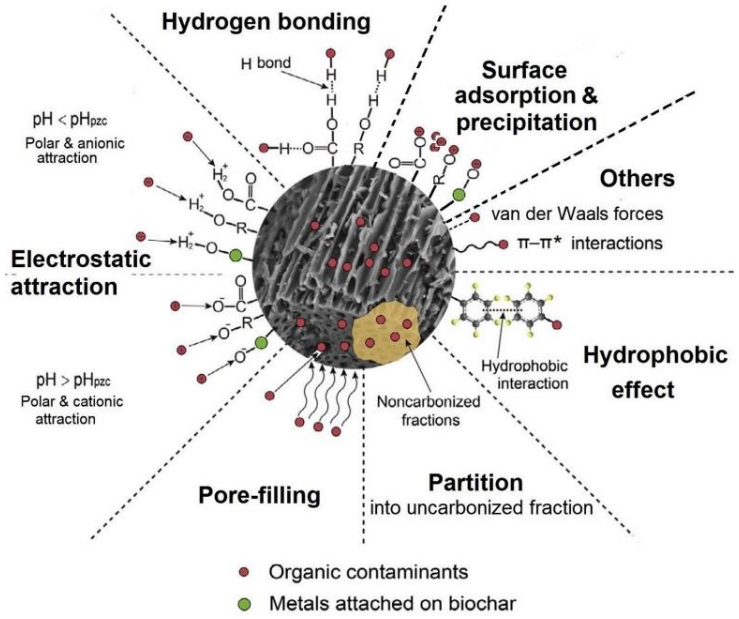
The range of response ratios for K_{sat} and related soil parameters for all sites except MDTA US-279. Data are based on measurements more than 1 year after 4% biochar incorporation. K_{sat} response ratio <1.0 indicates that biochar amendment decreased infiltration, observed at only one site where gravel was in the native soil but not in the biochar amended region. (Akpinar et al., 2023)

Emerging Toxic Contaminants (ETC) High Points

- **Biochar's Role in Contaminant Reduction:** Serves as a cost-effective and environmentally friendly solution for remediating soil and water contaminated with heavy metals, dyes, organic compounds and PFAS (Qiu et al., 2022).
- **Biochar in Heavy Metal Stabilization:** Amendments can stabilize heavy metals in soils, transforming them into less bio-accessible forms and reducing ecotoxicity, thus promoting safer crop cultivation and public land use (Guo et al., 2020).
- **Biochar for Organic Contaminant Remediation:** Effective in adsorbing and decomposing soil contaminants, biochar improves microbial activity and soil health, aiding the breakdown of organic pollutants (Guo, 2020).
- **"Green" Fit-to-Purpose Carbon:** Biochars made from different materials are able to serve specific remediation purposes,
  - wood/plant residues preferred for organic pollutants,
  - higher mineral content from manures and sludge are better for heavy metals (Ji et al., 2022).

Major mechanisms through which biochar stabilizes heavy metals in contaminated soils. Guo, et. Al., 2020. Graph modified from Tian et al., 2015





Major mechanisms through which biochar stabilizes organic contaminants in soil. Guo et al., 2020, Graph modified from Tian et al. 2015)