LOI # 9

Name: Dr. Ruth M. Sofield (lead), Myles Gray, and Dr. Dylan Ahearn

Organization: Western Washington University, U.S. Biochar Initiative (USBI), Herrera Environmental Consultants

Study Title: Toward a Procurement-Ready Biochar Specification for 6PPDQ Removal from Stormwater

Which topics from the SWG's priority list (Appendix A) do you propose to address?

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What type of project is being proposed?

Targeted laboratory batch isotherm study with supporting market characterization

Short description of the proposed project

6PPD-quinone (6PPDQ) is a tire-derived contaminant of emerging concern that impairs urban aquatic ecosystems. While biochar is increasingly deployed in stormwater treatment, agencies lack a procurement-ready specification tying measurable biochar properties and production parameters to 6PPDQ removal performance. We propose a collaborative study led by WWU (PI: Dr. Ruth Sofield), in partnership with Herrera and the U.S. Biochar Initiative, to (1) systematically evaluate a representative set of commercially available biochars spanning feedstocks (e.g., wood, agricultural residues, wastewater treatment biosolids) and pyrolysis conditions (e.g., temperature, residence time, oxygen levels); (2) quantify batch equilibrium jar-test performance to assess sorption capacity; and (3) assess sorption kinetics through sorption isotherms and coefficients for each material under stormwater-like chemistries (DOC, ionic strength, pH). We will compare performance results with material properties (e.g., ash/mineral content, pH, O/C and H/C ratios, CEC, surface area) to identify the physicochemical attributes that best predict 6PPDQ removal. Outcomes include a procurement-ready biochar specification, design guidance, a coefficient library, and a standard jar-test protocol suitable for vendor QA/QC and agency verification. Findings will be delivered in practitioner-focused formats to enable Permittees and Ecology to confidently select biochar that is demonstrably effective for 6PPDQ mitigation in stormwater applications.

What type of information will be collected or analyzed for this proposed study?

The study will generate a comprehensive dataset that links biochar material properties to 6PPDQ pollutant removal performance. There is a considerable body of literature which has assessed biochar characteristics relative to sorption of metals and other conventional pollutants, but we are aware of only two studies (below) addressing 6PPDQ removal and neither compared removal to characteristics such as feedstock and processing methods. We will leverage available data in the literature and then measure equilibrium removal of 6PPDQ through replicate batch jar tests across environmentally realistic concentration ranges, constructing sorption isotherms and calculating sorption coefficients for each biochar type. In parallel, we will characterize the physical and chemical attributes of each material, including feedstock, production conditions, proximate and ultimate analyses (e.g., ash content, volatile matter, fixed carbon), pH, electrical conductivity, cation exchange capacity, and elemental ratios such as O/C and H/C. Each biochar will be sieved to produce a uniform particle size among the test materials, consequently this variable will be held constant.

To ensure relevance to field conditions, we will also document contextual water quality parameters (dissolved organic carbon [DOC], pH, ionic strength) and, where appropriate, co-analytes such as metals or nutrients that may influence sorption behavior. Some biochars can export phosphorus and metals, consequently, we will also assess the potential for pollutant leaching from biochar. This integrated approach will allow us to identify the physicochemical drivers of 6PPDQ removal and develop predictive relationships between biochar properties and treatment performance, while also developing a recommendation for a biochar that will not result in leaching of other pollutants of concern.

Two studies addressing 6PPDQ removal:

Akinleye, TO and Shi, X. Exploring the Use of an Engineered Biochar for 6PPD-q Adsorption in Roadside Soils: A Preliminary Study. Presented at Transportation Symposium on Environment, Energy, and Livable Economies. Denver, CO. August 25-28, 2004.

Hildebrandt, A, Hu X, Germeau, H, Gonzalez, G, Yih, F, Rideout, C, Kolodziej, EP. Evaluation of 6PPD-Quinone Sorption to Treatment Media and Engineered Soil Mixtures, Prepared for Washington State Department of Ecology, by University of Washington, Tacoma, Tacoma, WA.

What are the anticipated measurable outcomes and key deliverables that will be produced by the proposed study and how will they be used by Permittees and the Washington State Department of Ecology?

This project will produce a suite of actionable resources designed to enable stormwater managers and regulatory agencies to confidently select and implement biochar for 6PPDQ removal. The primary outcome will be a procurement-ready biochar specification that translates measurable material properties such as feedstock type, pyrolysis conditions, and surface characteristics, into performance expectations for stormwater treatment. Complementing this specification, we will develop a comprehensive library of sorption coefficients and isotherm parameters for diverse biochars, complete with uncertainty bounds to support screening-level design and predictive modeling. To ensure reproducibility and vendor accountability, the study will establish a standardized batch jar-test protocol for 6PPDQ , including QA/QC elements suitable for laboratories and suppliers. All findings will be synthesized into a technical memorandum and a final report including decision matrices that link material properties to pollutant removal performance, accompanied by an open-access data package for integration into agency guidance and future SAM scopes. Finally, we will deliver technology-transfer products, including a practitioner-focused webinar, a concise slide deck, and a two-page field guidance sheet, to facilitate rapid uptake by Permittees and consultants, ensuring that results move beyond research into practical application.

List the permittees or agencies you are proposing to coordinate with.

Project Team

- Western Washington University (WWU): Lead scientific institution; PI: Dr. Ruth Sofield
- U.S. Biochar Initiative (USBI): Market scan, specification development, manufacturer coordination; contact: Myles Gray
- Herrera Environmental Consultants: Study design, stormwater science, data analysis, technology transfer; contact: Dr. Dylan Ahearn

The Project Team will create a technical advisory committee (TAC) of Phase I/II Permittees and nationally-recognized biochar experts/materials providers to review the proposed material property ranges, nominate candidate products, and review deliverables, ensuring results translate directly to permitting and procurement decisions. The following are currently committed to serving on the TAC if the grant were to be awarded:

Bridget Ulrich, PhD., University of Minnesota Natural Resources Research Institute

Eli Mackiewicz – City of Bellingham

Danhui Xin – Southern California Coastal Water Research Project