Berry Faculty Fellows Program
Final Report, December 31, 2017
Program Title: Using Oklahoma-sourced Biochar for Removal of Pesticides in Runoff
Investigator: Jason R. Vogel, Ph.D., P.E.

Background: Control and management of runoff quantity and quality from both rural and urban areas is an important concern for the people of Oklahoma and the nation. A popular and effective approach that is being strongly encouraged by the US EPA and the Oklahoma Department of Environmental Quality for runoff management and control uses the principals of low impact development (LID). LID is the practice of taking steps to minimize changes to the hydrologic cycle (runoff and infiltration after a storm) from development and integrates green space, native landscaping, and natural hydrologic functions to generate less runoff from developed land. The most common LID practice used today in Oklahoma is the bioretention cell (rain garden). A bioretention cell is essentially a depressed area in the landscape that allows water to pond up and infiltrate into the soils below, and therefore remove pollutants through a variety of processes. These soils may be comprised of parent soils or filter media that may include mulch, topsoil, and sand. Amendments such fly ash, drinking water residuals, or biochar may also be added to the filter media to target removal of particular pollutants. Biochar is a solid material obtained from thermochemical conversion of biomass in an oxygen-limited environment, and is a byproduct of many biofuel energy conversion processes. However, more research is needed to characterize and optimize the use of biochar for targeted removal of organics in filtration media. Another increasingly common practice for controlling stormwater runoff is the compost filter sock, in which compost overs (particles greater than 3/8" plus <5% fines) are places in filter socks to hold back and filter stormwater runoff. Compost filter socks have been shown by practitioners to last much longer and need much less maintenance that silt fence, a more common practice that is prone to failure without continuous maintenance. However, the water-quality impacts of potential leaching of nutrients through the socks are a questions. Recent research has indicated that biochar may limit leaching of nutrients from the socks (Iqbal, 2015). A pollutant class that has become more of a concern in runoff because of the potential for aquatic and drinking water impacts is organic compounds, such as pesticides, polycyclic aromatic hydrocarbons, personal care products, and pharmaceuticals. Recently, a few studies have investigated the pesticide removal capacity of biochar (Kookana, 2010; Kookana et al., 2013; Stenstrom et al., 2014).

This project will build on past and ongoing work that is investigating the use of bioretention and constructed wetlands to remove pesticides from nursery runoff. Results of this work will be disseminated through ongoing extension workshops with nursery operators, farmers, municipal officials, and other stakeholders. It is expected that the results of these experiments will be used to pursue further funding from the USDA Extension IPM program in the future. The results of this research will also be potentially applicable toward removal of other organic compounds with similar chemical properties, such as pharmaceuticals and personal care products.

Objectives: The primary objective of this research is investigation of the removal potential of adding Oklahoma-sourced biochar to filtration media for a suite of commonly-used pesticides with varying chemical properties and other common pollutants. This objective will be completed for two common stormwater controls—bioretention media and compost filter socks—in separate experiments.

Methods and Timeline:

Task One—Bioretention Media: The bioretention media experiments were design to over two years. During year one tests of media without biochar will be completed for comparison to tests with biochar, which will be completed in year two. Please note, that only a portion of the first year studies have been completed because Dr. Vogel left OSU partially through the first year of the study. For information purposes, however, those methods are still described in this section. For the biochar experiments, various Oklahoma-sourced biochars from feedstock such as switchgrass and Eastern Red Cedar were to be obtained through the laboratory of Dr. Ajay Kumar in the Biosystems and Agricultural Engineering department. Pesticide analysis were to be completed through a contract with the laboratory of Dr. Jason Belden in the OSU Integrative Biology department. These studies were to be completed through column studies using constant-head tests, using a pre-constructed column apparatus that utilizes constant head. Simulated runoff was created using deionized water and pesticides of interest at concentrations typically detected in agricultural, nursery, and/or golf course runoff. Composite samples were collected representing multiple pore volumes from the columns and analyzed for suspended sediment, turbidity, pH, specific conductance, and the selected. The specific variables studied was thickness of the saturated layer and antecedent dry period. All phase 1 tests were completed in duplicate for quality assurance purposes and to improve the significance of statistical tests that may be applied.

Task Two—Compost Filter Socks: The compost filter socks will also take place over two years, with control experiments (no biochar) taking place in year one for nutrient runoff only. In year two, additional experiments are to be conducted which look at the addition of biochar to the compost filter socks. These experiments will be completed in triplicate using a factorial design with four levels of sediment and nutrient concentrations on certified compost in filter socks donated by Minnick Materials in Oklahoma City. Tests will be run using a modified procedure based on ASTM Standard D5141 for testing the filtration efficiency of silt fence. For this test, the compost filter sock will be placed at the end of a pre-designed testing device as described in ASTM D5141 and a specific volume of water (still to be determined) of synthetic stormwater is released in less than 10 seconds. Representative inlet and outlet water samples are collected and analyzed for TSS, turbidity, nitrate, ortho-phosphate, pH, electrical conductivity, ammonia, total phosphorus, and total nitrogen. In addition, these same analytes will be analyzed in the parent compost material to determine leaching potential of the material. The analysis of the filtrate water samples will determine the efficiency of the compost sock at retaining sediment and nutrients, and investigate the synergistic or antagonistic effects of these. The results will provide construction managers with a quantitative base for sediment retention and nutrient removal or leaching from compost socks applied in construction sites for runoff management.

Results:

Project Change: PI Vogel accepted a position as the Director of the Oklahoma Water Survey at the University of Oklahoma on June 29, 2017. As a result, only the results of the first part of the planned experiments will be completed as part of this Fellows program. Column studies have been completed by Ph.D. student John McMaine, who defended his dissertation on July 25, 2017. The compost filter sock background testing was attempted during the summer of 2017, but unfortunately did not result in usable data because of errors in experimental setup.

Task Two research is being continued outside the scope of the Berry Fellows program by student researchers at the University of Oklahoma during the spring and summer semesters of 2018.

Task One—Bioretention Media Column Studies: A total of 18 column studies were completed for the control experiments without biochar by OSU Ph.D. student John McMaine. These included triplicate investigations of two levels of saturation (partially and fully), three antecedent dry periods (time between simulated storms; 1, 3, and 10 days, with 4 runs on each test). Additionally, two outflow samples representing the first pore volume and the second and third pore volume were collected for each run. In total, 180 samples were collected and analyzed during these experiments. While results are still unpublished and preliminary, analysis has shown that pesticide removal ranged from 45 to 98 percent reduction, with longer antecedent dry periods having a significant effect on increasing the removal rates. This result was especially apparent for the first pore volume that was released from the column, which is to be expected because the water had the longer retention time in the column, and therefore had more time for microbial and chemical processes to degrade the pesticide. Dr. McMaine is now employed as a tenure-track faculty member at South Dakota State University.

In addition to these column studies, some preliminary work was completed in the spring semester of 2017 by a BAE Freshman Research Scholar to select appropriate feedstocks for creating the biochar for the year planned two testing that would stand up to the physical stress that would be placed on the biochar during the mixing process. Basically, our team investigated whether mixing the biochar with sand would cause it to break down into powder, thus limiting the infiltration capacity of the media. Common Oklahoma materials that were explored included pecan hulls, eastern red cedar, and peach pits. Unfortunately the semester ended before the testing could be completed. Expectations, however, are that harder feedstocks such as peach pits will retain their strength and make the best biochar. This research will likely be continued at the University of Oklahoma in the future.

Task 2—Compost Filter Sock Testing: Similar to task one, only a portion of this study was completed before Dr. Vogel left in June 2017 for a new faculty position. Unfortunately the OSU student who was working on this task had technical difficulties during the summer of 2017 and did not provide any usable results. These experiments are currently being repeated by students at the University of Oklahoma, with results expected in late spring or summer of 2018.

A note from the Principal Investigator:

I wish to thank the donors of the Thomas E. Berry Faculty Fellows Program in Integrated Water Research and Management for their generous support of this program. I has been an extreme honor to serve as a Berry Fellow. The overall research that was begun as part of this program will continue through joint research at OSU and the University of Oklahoma, so your investment during the first year of my Fellow term will be valuable in my ongoing research program. Partially because of this ongoing research, I have been selected by the Biosystems and Agricultural Engineering department at OSU to remain affiliated with them as an Adjunct Associate Professor.