The Removal of Phosphorus from Agricultural Runoff Using Biochar

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Algal blooms and eutrophication in runoff water deposits are problems that many landowners are facing due to the leaching of phosphorus from land applied fertilizers. Not only does this release an unwanted smell to the environment, but it also leads to the starving of oxygen and nutrients from these bodies of water, resulting in the death of these ecosystems.

Biochar is a charcoal like substance that is made by exposing biomass, or organic wastes, to high pressures and temperatures. The high porosity and number of functional groups in biochar prove to be a good candidate of phosphorus absorption. This study analyzes the effectiveness of phosphorus absorption through biochar as well as the effectiveness of phosphorus absorption through biochar impregnated with metal ions.

The first steps taken to analyze biochar absorption were characterization tests. These tests were done in order to obtain a higher level of understanding of the structure and chemical makeup of biochar. It was found that biochar has a very high carbon content, specific surface area, and cation exchange capacity. Carbon has been proven to be very effective in previous absorption studies (Almanassra 1, 2021), as well as samples with high specific areas. The high cation exchange capacity proves to show that when exposed to the metal cations in the impregnation step, the biochar has a higher chance to actually bond with these metals.

The first experiments conducted were phosphorus leaching tests. These tests were performed to determine whether or not the biochar, after washing and drying for 24 hours, still had traces of phosphorus. It was found that biochar was still releasing phosphorus, but not at a level that would affect any samples.

Nonmodified biochar was simply washed and dried before phosphorus testing. In this study biochar was impregnated using the same method with 4 different metals, Aluminum, Calcium, Iron, and Magnesium. Using a 5wt% metal loading, a solution was prepared by mixing the selected metal chloride salt with 100mL of de-ionized water on a stirring plate. The biochar was then added once the metal salt was completely dissolved and allowed to stir for 3 hours. After the solution was stirred for 3 hours, the solution was immediately placed in the 105ºC oven for the complete removal of water. The dried biochar was then placed into a 530ºC muffle furnace for ten minutes to finish the metal impregnation.

A 5% phosphorus solution was then made by mixing monobasic potassium phosphate with deionized water. All biochar samples, including non-modified, and 4 different impregnated biochars, were then added to 50mL centrifuge tubes at a concentration of 2g biochar/ 20 mL phosphorus solution. These centrifuge tubes were allowed to shake at 350rpm and 40ºC for three hours. All samples were then filtered using a vacuum filtration system, separating the solid biochar from the liquid phosphorus solution, and then analyzed using Hach's high range total phosphorus kit (Hach, Loveland, CO, 2013). This kit comes with prepared reagent tubes. The addition of the sample and premade chemical reagents to this tube results in a color change and this color change is measured by the DR900 to determine phosphorus levels in the sample.

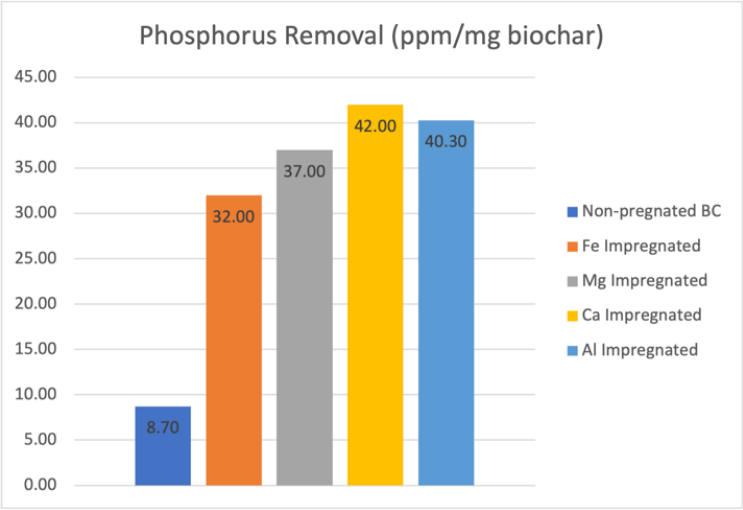

Fig. 1. Results from one complete P-removal test

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The recorded data from one full phosphorus test including non-modified biochar and all four modified biochars can be seen in Fig. 1. It was found that biochar with no modifications removes a small amount of phosphorus per gram of biochar, showing that it does have the capability to remove large amounts of phosphorus from runoff water when biochar is applied in larger quantities. It was also found that all of the biochars impregnated with metals removed a much larger amount of phosphorus, making them a better candidate for phosphorus removal in larger applications. This means that, when applied to areas with high levels of phosphorus runoff, biochar holds the capability to effectively remove phosphorus from runoff water, resulting in fewer cases of eutrophication and algal blooms as well as a healthier environment overall.

Statement of Research Advisor

Sarah performed literature review, developed experimental design, collected data and analyzed. Sarah also worked extremely well interacting with other members of the group.
- *Sushil Adhikari, Biosystems Engineering*

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Sarah E. Tyndall is a senior-year student pursuing a B.B.S.E. degree in Biosystems Engineering at Auburn University. She has played key research roles in phosphorus removal using biochar, and hydrothermal liquefaction aqueous phase projects in her lab. She is also an avid lover of music and was a member of the Auburn University Marching band for 3 years.

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