Research Brief 347: High-Temperature Biochar for Arsenic Remediation

Adding biochar produced at a high temperature may be an effective way to immobilize arsenic in sediment, according to researchers partially funded by the NIEHS Superfund Research Program (SRP). The study, conducted by researchers from the University of North Carolina at Chapel Hill SRP Center, also provided further insight into the conditions that influenced the effectiveness of biochar for soil remediation.

Biochar is a substance formed by heating organic matter, such as plant material, at high temperatures in the partial or total absence of oxygen. The material can be mixed into soil to adsorb and bind to certain contaminants like arsenic — a naturally occurring element linked to a variety of health issues, including cancer, cardiovascular disease, and respiratory problems.

However, biochar can degrade over time, releasing organic carbon, which can convert arsenic into a water-soluble, more easily dispersed form. Although biochar is often used to remediate arsenic-contaminated soil, not much is known about how to improve its efficacy.

The researchers hypothesized that heating the biochar to different temperatures would affect the chemical composition of the material. According to the team, changing the composition of biochar may affect how much organic carbon is released and impact the biochar's ability to remediate arsenic.

To test their hypothesis, the team produced biochar by heating sugarcane straw at three different temperatures. The biochars were mixed with soil contaminated with arsenic and allowed to age for 30 days.

Each biochar and soil mixture, along with a control of only soil, went through two cycles of flooding with water for 30 days before draining for 10 days. Finally, the researchers collected water and soil samples after each flooding cycle to analyze for arsenic and organic carbon content.

Results showed that heating biochar to higher temperatures made the material less likely to release organic carbon. The lack of organic carbon means less arsenic will be converted into its mobile form, the authors explained. Higher temperatures also created more pores in the biochar particles, increasing the surface area available to adsorb arsenic.

The research team also found that biochar significantly decreased the amount of dissolved arsenic in water compared to the soil without biochar after the second flooding cycle, but not the first cycle. They hypothesized that biochar may help regulate reduction and oxidation potential in soil, which can affect if arsenic remains dissolved in water or precipitates out. Reduction and oxidation (redox) potential measures the ability of a chemical species to gain or lose — reduce or oxidize, respectively — an electron under certain conditions.

To test this, they used probes in soil and water to measure the redox state for each mixture and found that soils amended with high temperature biochar became less reduced during the second flooding cycles. The redox state may change the physical and chemical properties of the biochar, causing it to immobilize arsenic more efficiently, the scientists explained.

According to the authors, this study demonstrates that biochar, particularly biochar formed at higher temperatures, is an effective soil additive for arsenic remediation. They recommend that more studies be carried out to examine how the movement of electrons affects biochar efficacy and the environmental conditions necessary for electron movement, such as the presence of water or pH of the soil.

If you'd like to learn more about this research, visit the Superfund Research Program website at niehs.nih.gov/srp. From there, click on the Research Brief title under the banner, and refer to the additional information listed under the research brief. If you have any questions or comments about this month's podcast, send an email to srpinfo@niehs.nih.gov.

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