**////Title: Healing Abandoned Mine Ecosystems with Biochar**

**////Standfirst:**

The Gold Rush of the 1800s is inextricably tied to USA history. Mining towns popped up wherever precious metals could be extracted, with many of these towns and mines now lying abandoned as ghostly reminders of the old wild west. Abandoned mine land poses a threat to environmental and human health, and methods to rehabilitate this land has gathered much interest over the past few years. Dr Carlos Rodriguez-Franco and Dr Deborah Page-Dumroese from the US Department of Agriculture have been evaluating the use of biochar as a sustainable method to remediate abandoned mine lands.

**////Main text:**

The mining of precious metals and extraction of natural gas and oil helped drive the economic development of western USA. Until 1970, mine operators were allowed to extract valuable resources and then abandon the land, wreaking havoc on the surrounding environment and risking human health by contaminating water and soil.

As of 2017, over 52,000 abandoned mines and over 97,000 additional old mine features were identified by the Department of Interior Bureau of Land Management, with around 22,500 of these potentially posing a risk to human health. Around 80% of the abandoned mines and mining features in western USA require investigation and restoration.

Biochar – a charcoal-like material that is produced from forest residues decomposed at high temperatures – has been gathering attention as a solution for restoring soil processes, and improving ecosystem health around abandoned mines. By amending mine sites with biochar, the physical and chemical properties of the soil can be restored or improved – including its pH, density, water retention, and nutrient cycling properties. Repairing the physical and chemical properties of soil is likely to enhance its microbe community, leading to more fertile soils.

In their recent research, Dr Deborah Page-Dumroese and Dr Carlos Rodriguez-Franco of the US Department of Agriculture synthesise the current knowledge on biochar’s efficacy as a soil amendment, both alone and in combination with other amendments.

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Biochar is produced by burning waste wood from commercial forestry operations in a special process that maximises carbon storage. The waste wood from commercial forestry has little value and would otherwise be burnt in large piles.

If done correctly, wood-based biochar production creates less air pollution and air-borne particles than standard burning processes, while also keeping much of the carbon locked in rather than releasing it into the atmosphere as carbon dioxide. As such, producing biochar helps to mitigate climate change while also decreasing health risks for nearby residents.

Wildfires, pest infestations and outbreaks of tree diseases pose a greater risk in forestry operations when large volumes of waste wood are not disposed of quickly and safely. Thus, wood-based biochar provides an opportunity to manage these risks at a time when the US Department of Agriculture’s Forest Service is increasing their forest harvesting activities.

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In their research, Dr Page-Dumroese and Dr Rodriguez-Franco found evidence demonstrating wood-based biochar’s potential to address a myriad of environmental issues. Biochar helps to bind heavy-metals and reduce the toxic chemicals deposited in the soil during mining activities, decreasing their impact on microbes, fungi, and plants. This soil improvement also extends to water quality, because of the reduction in the toxic substances leaching from the soils and into nearby water bodies. Local communities thus benefit from higher quality water and better health outcomes.

Reducing soil toxicity also encourages the return of soil microbes, bringing improved soil nutrient balance and productivity. The improved soil health encourages the growth of plants, accelerating the establishment of vegetation. Plant cover enhances the water-holding potential of the soil, thereby mitigating flooding risks for local communities. It also helps to prevent water and wind erosion, which in turn helps to sustain healthy vegetation and protects human health. Healthy soils and ecosystems have better carbon storage capabilities and reduced greenhouse gas emissions, thus further assisting with climate change mitigation.

Dr Page-Dumroese and Dr Rodriguez-Franco explain that the characteristics of wood-based biochar depend on the species of tree from which it originates, the production methods used, and the conditions during processing. This could impact the results achieved when using it as a soil amendment. Additionally, results are variable depending on the existing soil properties, metal contaminants, and plant species present in the area. Each abandoned mine has a unique combination of soil, rock, and pollutants, suggesting that soil amendments could be optimised for each individual site.

The researchers suggest that combining wood-based biochar with other composts, liquid fertilisers, or lime, could help to improve the soil amendment outcomes, reduce overall costs, and minimise the potential for dust emissions from the process.

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Previously, abandoned mine restoration professionals have been apprehensive about using wood-based biochar as a soil amendment. A lack of knowledge about the efficacy, safety, and application method has limited its uptake across western USA. Concerns exist over the potential of wood-based biochar containing harmful contaminants. However, Dr Rodriguez-Franco and Dr Page-Dumroese found no evidence of any harmful effects arising from compounds formed during the production of wood-based biochar, either for the environment or for human health.

Potentially harmful compounds, similar to those produced in industrial combustion processes, are generally formed in very low concentrations that fall below the current legal limits. The formation of these compounds can also be limited by controlling the temperature and length of time used to produce the biochar. Further research could help us understand which combinations of physical and chemical properties could create hazardous outcomes.

In the USA, biochar producers must follow air quality regulations that limit pollution from smoke, particles, and other pollutants released during production. Regulations also require that any listed toxic chemicals associated with biochar are reported. Biochar producers are required to have their products tested in qualified, independent laboratories. The test results are reported directly to the US Department of Agriculture who provide biochar certification as a ‘BioPreferred’ bio-based product.

The US Department of Agriculture runs the BioPreferred program, which is a voluntary program designed to increase the awareness and uptake of renewable bio-based products and improve environmental and human health. Many biochar producers are participating in the program, helping to increase the awareness of biochar and its use in soil amendment. Increasing the demand for biochar could encourage more research that ultimately improves the techniques for use in restoring abandoned mines.

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This SciPod is a summary of the paper ‘Woody biochar potential for abandoned mine land restoration in the U.S.: a review’, in Biochar. [doi.org/10.1007/s42773-020-00074-y](https://doi.org/10.1007/s42773-020-00074-y)

For further information, you can connect with Dr Deborah Page-Dumroese at [debbie.dumroese@usda.gov](mailto:debbie.dumroese@usda.gov) and Dr Carlos Rodriguez Franco at [carlos.rodriguez‑franco@usda.gov](mailto:carlos.rodriguez‑franco@usda.gov)