Innovative Biochar Boards for Environmental Remediation and Other Applications

USDA Forest Products Laboratory: Qiangu Yan and Zhiyong Cai,
Zhiyong.cai@usda.gov,

Innovativeness and Current State of Technology: Biochar is a porous carbonaceous material derived from biomass feedstock, woody wastes, and agricultural residues. Pristine biochar contains surface functional groups that enable biochar's wide applications in many environmental fields including soil remediation, wastewater treatment, and carbon sequestration. Biochar is generally made into particulates like powders or small granules. Powdered biochar cannot be recycled or reclaimed after use and is usually difficult to remove or recovered from water treatment reservoirs and soil applications. To enhance the utilization of biochar, scientists from USDA Forest Products Laboratory developed a process to produce innovative biochar composite boards by gluing biochar particles with natural binders (lignin, starch, carbohydrates, and tannins) after thermal treatment (baking, pyrolysis, carbonization, or graphitization). These produced biochar composite boards contain high carbon content, high porosity, large geometric, and adsorption surface areas rich of functional groups, low density, high corrosion resistance to chemicals, strong mechanical strength, low thermal expansion, tunable thermal conductivity, and excellent flammability resistance. This green product is 100% biomass waste, with no petroleum-based binders.

Supporting the Priorities of USDA Science and Research Strategies: These innovative biochar composite boards support all five key science priority areas. Priority 1: Accelerating Innovative Technologies & Practices (Objectives 1.1 - 1.5); Priority 2: Driving Climate-Smart Solutions (Objectives 2.1 - 2.5); Priority 3: Bolstering Nutrition Security & Health (Objective 3.3); Priority 4: Cultivating Resilient Ecosystems (Objective 4.5); and Priority 5: Translating Research into Action (Objective 5.1).

Impacts to Climate, Farmers and Consumers: This innovative technology uses agricultural or forest waste as the sole feedstock to produce porous biochar composite boards. The carbon content in the biochar boards is 85.9 - 99.3 wt%. Approximately, 3.18 to 3.68 tons of atmospheric CO_2 is sequestered into 1 ton biochar boards. This technology can benefit farmers through: Valorization of agricultural wastes to new products; Remove contaminants like heavy metals, PFAS, pesticide, herbicide, and antimicrobial residues from water, soil, and manure; Improve the indoor air quality of livestock farms and industrial facilities.

Current and projected impacts: The unique properties of biochar boards create significant potential applications: filters for air/water purification, adsorbents for gas, metal ion separation, reclaimable adsorbents from contaminated wastewater and soil, mining adsorbents, catalyst support, insulation panels, core composite for structural insulated panels, fire-proof panels/fire barriers, sound-proof panels, radio frequency absorption panels, and corrosion-resistant tiles. Currently, biochar composite boards tested for heavy metals and PFAS removal from contaminated water are excellent adsorbents without any stirring/agitation or forced filtration. The preliminary results show: 100% Hg was removed from 2 ppm contaminated water in 48 hours (tested and reported by USGS lab), 99% Pb and 99 % Hg were removed from a mixture heavy metal solution in 24 hours, and 95% (1 hr) or over 97% (24 hrs) PFAS was removed by a biochar composite board from contaminated water (tested and reported by University of Missouri).

Link to USDA: This innovative technology was developed by scientists of USDA Forest Service, Forest Products Laboratory with support of Bipartisan Infrastructure Law (BIL) funding from Forest Service.