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Methane-derived carbon black as a biochar alternative: Assessing long-term stability using accelerated ageing methods

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There is increased recent interest in the development of carbon-based materials to enhance plant growth, improve soil quality, remove contaminants from natural systems, and promote carbon sequestration and storage. In this study, we combine woody biomass and a highly recalcitrant and graphitic carbon byproduct of turquoise hydrogen production, to produce a carbonaceous composite via slow pyrolysis. Our hypothesis is that combining the recalcitrance and electrical conductivity of the graphitic carbon with the porosity, nutrient content, and surface functionality of the resulting woody biochar, will result in composite materials that outperform either material alone when used as a soil amendment. Preliminary morphological analyses (SEM/EDX) confirmed that the produced materials had a porous structure, with the graphitic carbon byproduct widely distributed and attached to the biochar surface. Unclear, however, is the long-term performance of these materials when exposed to ageing and weathering in the environment on decadal scales. To test the stability and environmental reactivity of the composites, we used accelerated ageing methods in the laboratory that simulate freeze-thaw cycles, wet-dry cycles, and chemical ageing in the environment. During the simulated laboratory ageing experiments, changes in composition, surface area, surface chemistry, porosity, morphology, and surface reactivity of the materials were monitored over time to understand how various ageing processes impact the long-term performance and stability of the composites in nature. Our results show that the accelerated ageing methods used here caused only modest increases in carbon content and a decrease in oxygen content, indicating that the composites are resistant to ageing. However, freeze-thaw cycles produced significant physical changes, including the formation of fractures and rupturing of the materials. Despite this fragmentation, the graphitic carbon byproduct remained attached to the surfaces of biochar particles. Our research contributes to a potential value-added pathway for solid waste byproducts from methane pyrolysis, supporting the development of this industry in Canada and beyond while promoting circular carbon utilization.