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From laboratory to farm: Evaluating biochar-assisted composting for climate change mitigation and nutrient retention

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Abstract:

Composting is widely used for organic waste management; however, methane and nitrous oxide emissions, along with nutrient losses, limit its climate and agronomic benefits. This study evaluated biochars derived from agroforestry residues (walnut shell and wood chip) and their iron-modified forms, applied at 10% (w/w), across laboratory, backyard, and farm-scale composting systems. The focus was on CO₂-equivalent emissions (CH₄ and N₂O), nutrient dynamics, and plant bioassays. At the laboratory scale, biochar reduced CO₂-equivalent emissions and altered nutrient partitioning. Unmodified biochars increased carbon retention, while iron-modified biochars shifted nutrient stoichiometry toward higher N:P ratios. At the backyard scale, biochar-amended composts showed lower emissions than the control, with iron-modified biochars providing the strongest mitigation, alongside greater carbon retention and reduced availability of nitrogen, phosphorus, and dissolved organic carbon. At the farm scale, iron-modified biochar treatments reduced CO₂-equivalent emissions by ~8–10%, mainly through suppression of CH₄, while N₂O responses varied. Composting lowered C:N ratios, with further reductions in biochar-amended treatments. Plant bioassays showed increased shoot growth with compost, while biochar-amended composts maintained comparable performance; iron-modified biochars reduced biomass at higher rates, consistent with moderated nutrient availability. Overall, biochar-assisted composting improved emission mitigation and nutrient retention across scales.

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