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A greenhouse gas and energy impacts assessment of engineered biochar from switchgrass pyrolysis in an auger reactor

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ABSTRACT A life cycle approach was used to assess greenhouse gas (GHG) emissions and energy balances of switchgrass pyrolysis in an auger reactor for biochar production, with bio-oil and syngas as co-products. The system boundaries included the cultivation of switchgrass, handling, transport, conditioning, pyrolysis, the amendment of biochar in soil to sequester carbon (C) and to reduce N_2O emissions, and the valorization of bio-oil and syngas as energy sources. Two pyrolysis scenarios were evaluated. Scenario A involves a lower pyrolysis temperature (459 °C) and a shorter solid residence (78 s) in the reactor as compared to scenario B (temperature and residence time of 591 and 104 s, respectively). Biochars were amended in two agricultural soils (loamy sand and silt loam) at a rate of 2 % (w/w) with N fertilizer and incubated for 45 days in order to evaluate their impact on soil GHG emissions. A negative GHG emissions balance of -2110 and -2561 kg CO_2e t^{-1} biochar was obtained for scenarios A and B, respectively. Biochar C sequestration contributed the most to the reduction of GHG emissions in scenario B due to the high C content and stability in biochar. However, scenario B resulted in a higher energy consumption (13,563 MJ t^{-1} biochar) than scenario A (2925 MJ t^{-1} biochar) due to a higher energy consumption of the pyrolysis unit. These results confirm that pyrolysis of switchgrass for biochar production can be a negative emission technology, but pyrolysis operating parameters should be selected carefully to minimize the energy consumption.

Keywords: Greenhouse gas, energy, pyrolysis, biochar, bio-oil, switchgrass