Biochar from waste biomass as a tool for carbon sequestration in the soil

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Biochar is a porous, carbonaceous material produced by pyrolytic carbonization of biomass and its storage in soils have been suggested as tools for mitigating climate change by sequestering carbon, while simultaneously improving the soil fertility and increasing crop yields [1].
Biochar can be produced from a wide range of sustainable biomass, including agricultural residues, timber and forestry residues, digestate from anaerobic digestion process and waste biomass such as sewage sludge and sorted domestic food waste.
The thermochemical treatments (slow and fast pyrolysis, gasification) of these feedstocks lead to the production of bio-oil, syngas and biochar, being the slow-pyrolysis (typically carried out at 500°C and long residence time) the one that provides the highest yields in the solid fraction.
The chemical-physical properties of biochar strictly depend on the process conditions used for its production, in particular on the temperature. Increasing the severity of the treatment increases the degree of condensation and aromaticity of the product which becomes more and more similar to a coal of fossil origin, ensuring high stability and resistance to degradation by soil microorganisms.
The carbon content in biochar is also determined by the process temperature, and increases with increasing severity, but at the expense of yields.
The stability of biochar in the soil is a key parameter for the calculation of the carbon credits obtainable by storing biochar in the soil and can be indirectly estimated on the basis of the residual oxygen content, which is considered a reliable marker of the rate of degradation processes. If the biochar is produced at temperatures above 500° C, the oxygen content will result lower than 20% with an estimated carbon stability in soil of around 1000 years [2].
Under these conditions, the CO_2 sequestration capacity is typically included in the range 2.5-3.2 t CO_2 equivalent/t biochar. (theoretical maximum = 3.6 t CO_2/t biochar).
Despite the high potentialities highlighted, the official methodology for calculating the carbon credits obtainable from biochar is currently under definition.
Furthermore, biochar has positive effects on the mechanical properties of the soil, especially for sandy and arid areas. Thanks to its high porosity, it increases water and fertilizers retention, which remain more available for plants improving the fertility of the soil also limiting the leaching of nitrates and phosphates to aquifers due to rains.
If, for regulatory reasons, the use of biochar on the soil would be not allowed, other application sectors are evaluation, such as blending in concrete composite manufacturing.
Eni has identified biochar as an important tool to meet the net zero emissions goal by 205,0 and is launching initiatives for its production from agricultural residues in Italy and Africa where there are ongoing activities for production of sustainable biofuels starting from waste biomass.

[1] Bossio D.A. et al. (2020) The role of soil carbon in natural climate solutions, Nature Sustainability vol. 3, pp. 391–398.
[2] Spokas, K.A. (2010) Review of the stability of biochar in soils: predictability of O:C molar ratios. Carbon Management. Vol. 1, pp. 289–303.