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Biomass management, global warming impact and the potential of carbonization

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Conversion of biomass carbon (C) to biochar via carbonization (pyrolysis) offer a sustainable method for managing organic residues and biomass. Depending on pyrolysis process, type of kiln and biomass, carbonization can lead to sequestration of up to 50% of the C compared to the low amounts retained after burning (about 3%) and composting (<10– 20% after 5–10 years)[1]. Gases from the pyrolysis process is burned and the emission from the kiln is mainly CO_2 - with much less soot than compared to conventional combustion. The produced biochar is a stable product, highly resistant to microbial degradation. Up to 80% of the carbon stored in biochar will remain after 100 years. In 2018 biochar was acknowledged by the IPCC as an important Negative Emission Technology (NET) in the fight against climate change.

According to IPCC Fifth Assessment Report 2014 (AR5)[2] in a 100-year time horizon the global warming potential relative to carbon dioxide (CO_2) of methane (CH_4) is 28 times and nitrous oxide (N_2O) 265 times higher. Composting contributes to relatively large emission of methane and nitrous oxide. Animal husbandry is globally, together with the energy sector, the largest source of methane emission in a 100-year perspective. Incineration of biomass and organic contributes to emission of CO_2, toxic carbon monoxide (CO), soot and other particle pollutants.

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Table below contains short description of organic waste management and their global warming impact

Description	CO_2 effect	Comments
Animal husbandry	None or very limited sequestration effect.	Methane (more harmful gas for the atmosphere) also produced.
Incineration	About 3 % of C present in biomass retained in ash.	Beside emission of CO2 also monoxide and soot and other particle pollutants.
Composting	Up to 10 – 20 % of C retained after 5 – 10 years.	Methane and nitrous oxide (more harmful gas for the atmosphere) also produced.
Biochar production	Up to 50% of C present in biomass is retained in the biochar. The biochar contains this C in high concentrations together with varying amount of ash. The C and ash content in the produced biochar depends on the type of biomass and pyrolysis conditions.	The heat produced from burning the pyrolysis gases sustain the pyrolysis process and excess energy can be used for other purposes (such as warm houses or heat water). The carbon in the biomass that is not transformed into biochar (> 50%) is mainly released as CO2. The process is carbon negative from the perspective of the natural carbon cycle (Negative Emission Technology) since it reduced the use of fossil fuels meanwhile a steady flow of carbon is being sequestrated.
Biochar C stability	Biochar is highly resistant to microbial degradation. Its C stability can be predicted by the presence of hydrogen relative to organic carbon (H/Corg)[3].	Biochar that obtain H/Corg values < 0,4 is estimated to have 80% of stable carbon left after 100 years.

1. Lehmann, J., Gaunt J., and Rondon M. (2006). Biochar sequestration in terrestrial ecosystems - a review, Mitigation and Adaptation Strategies for Global Change , Volume 11

2. Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H. Zhang, 2013: Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

3 Wang, T., Camps-Arbestain, M., & Hedley, M. (2013). Predicting C aromaticity of biochars based on their elemental composition. Organic Geochemistry, 62, 1-6. https://doi.org/10.1016/j.orggeochem.2013.06.012

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