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Biochar and carbon sequestration potential

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EcoTopic AB is a Sweden based consultancy firm working with biochar production & application since 2012

Biochar and carbon sequestration

In 2018 biochar was acknowledged by the IPCC (the Intergovernmental Panel on Climate Change) as an important Negative Emission Technology (NET). The carbon sequestration potential (100 years) for different biochar is calculated with the three factors below:

1. Amount of organic carbon in biochar

The amount of carbon in biochar depends on the type of biomass that is carbonized and the pyrolysis (production) temperature. Higher degrees result in a more condensed carbon structure and increased presence of aromatic carbon[1] (stable carbon rings). The more aromatic structures the higher the resistance to biodegradation. Inorganic carbon that may be present in biochar is not part of the condensed aromatic structure and is not expected to remain in soil for 100 years.

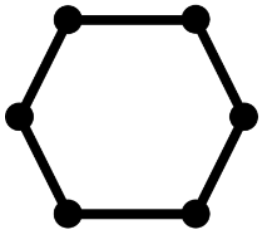

FIGURE 1 AROMATIC CARBON RING

2. Stability of carbon in biochar for 100s of years (BC_{+100})

Aromaticity of biochar is strongly correlated to its carbon stability[2] and can be predicted by the presence of hydrogen relative to organic carbon (H/C_{org}) in biochar[3]. These elemental components of biochar can be measured using an elemental analyzer. Biochar with low H/C_{org} values are graphite-like materials, which exhibit high stability and resistance to biodegradation.

The ratio between the molar value and the mass value for hydrogen and carbon respectively determines the stability of biochar. The H/C_{org} value is calculated with the formula H/C_{org} = (mH/MH)/(mC/MC)

The method to assess stability through H/C_{org} values does not provide an absolute measure of stability but is acknowledged as a reliable method by the the *International Biochar Initiative* and the *European Biochar Certificate*. Biochar that obtain H/C_{org} values <0,4 is estimated to have 80% of stable carbon left after 100 years. Biochar that obtain values within the range of 0,4 - 0,7 is estimated to have 60% of stable carbon left after 100 years. Biochar that obtain H/C_{org} values higher than 0,7 are not considered to be biochar[4].

[1] Lehmann, J., Czimczik, C., Laird, D. and Sohi, S. (2009) Stability of Biochar in the soil. In Lehmann, J. and Joseph, S. (Eds.) Biochar for environmental management, Science and technology. London: Earthscan.
[2] Singh, B.P., Cowie, A.L,, Smernik, R.J. (2012). Biochar carbon stability in a clayey soil as a function of Feedstock and Pyrolysis temperature. Environmental Science & Technology 46 (21), pp 11770–11778 DOI: 10.1021/es302545b.
[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
[4] Schmidt, H.-P. (den 25 09 2020). 'European Biochar Certificate -Guidelines for a Sustainable Production of Biochar.' . Hämtat från European Biochar Foundation (EBC): http:european-biochar.org

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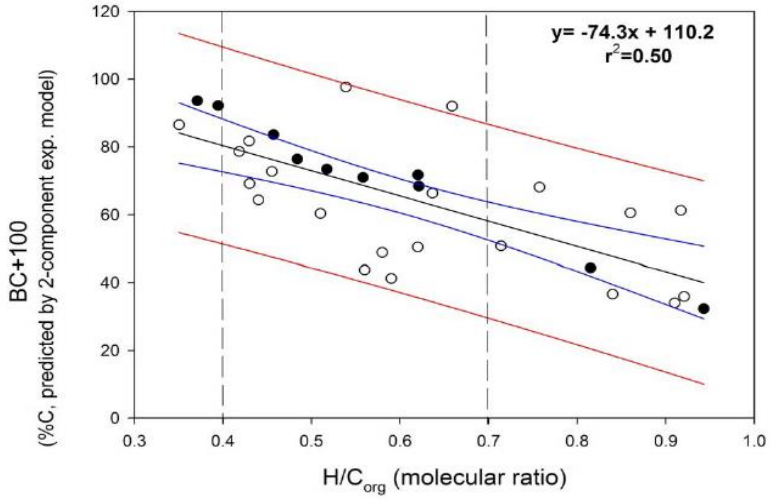

FIGURE 2 THE CORRELATION BETWEEN H/CORG AND BIOCHAR C PREDICTED TO REMAIN AFTER 100 YEARS. SOURCE: SINGH ET AL., 2012 (CLOSED CIRCLES) AND ZIMMERMAN, 2010 AS EXTENDED IN ZIMMERMAN AND GAO, 2013[5] (OPEN CIRCLES).

3. Carbon dioxide equivalents (CO2-eq) per kg of stable carbon in biochar

If all available carbon in biochar was oxidised into carbon dioxide the theoretical calculation would be as follows:

1 kg of carbon + 2,67 kg of oxygen give 3,67 kg of carbon dioxide and heat (1 kg of C = 3,67 CO2-eq)

In the table below fictive examples of the CO_2 equivalents for biochar are calculated with variations in carbon content and stability ratio (H/C_{org}).

	Biochar in weight	1: Carbon content (organic carbon)	2: Stability (H/C_{org})	CO_2-eq / kg C	= CO_2-eq / kg biochar
Biochar 1	1 kg	80% (x 0,8)	0,4 (x 0,8)	x 3,67	2,35
Biochar 2	1 kg	90% (x 0,9)	0,3 (x 0,8)	x 3,67	2,64
Biochar 3	1 kg	70% (x 0,7)	0,5 (x 0,6)	x 3,67	1,54
Biochar 4	1 kg	50% (x 0,5)	0,7 (x 0,6)	x 3,67	1,10

TABLE 1 FICTIVE EXAMPLES OF CO2 EQUIVALENTS FOR DIFFERENT BIOCHAR

[5] Zimmerman, Andrew & Gao, Bin. (2013). The Stability of Biochar in the Environment. 10.1201/b14585-2.

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