Exemption from H/C_{org} < 0.7 criterion for ash-rich biochars in the EBC guidelines

by Nikolas Hagemann and Hans-Peter Schmidt, ithaka institute

Background and rationale

The H/Corg molar ratio is an important and readily measurable parameter for the characterization of organic carbon compounds in biochar and serves as a key indicator of the degree of polycondensation of the pyrogenic carbon matrix. The EBC determines the molar H/Corg ratio from CHN analysis according to DIN 51732/ISO 29541 (total carbon) in combination with ISO 925 (carbonate-C) to correct for inorganic carbon. However, the measured total hydrogen is not corrected for hydrogen bound in mineral phases (e.g., K_2HPO_4 in potassium-amended sewage sludge, hydroxyl groups of mineral constituents, hydrates, or structurally bound crystal water). For ash-rich biochars, mineral-bound hydrogen contribution can become large enough that the resulting H/C_{org} molar ratio no longer reflects the actual degree of aromatization and polycondensation of the pyrogenic carbon matrix - and therefore no longer corresponds to the quantity that the H/C_{org} criterion is intended to capture.

Transitional provision

For biochars with C_{org} < 50 % and a solid-state electrical conductivity (SEC) of ≥0.1 mS/cm, the criterion H/C_{org} < 0.7 shall be considered fulfilled, irrespective of the measured H/Corg value.

All other requirements of the EBC - in particular the limit values for contaminants and the criteria for assignment to the individual certification classes - remain fully in force.

Legal requirements regarding the H/C or H/C_{org} ratio, as well as requirements in the national annexes of the EBC, remain unaffected.

Scientific basis

The EU Fertilising Products Regulation (EU 2019/1009) already addresses this artefact by requiring H/C_{org} to be determined on an ash-free basis for biochars with a carbon content below 50 %; a corresponding standardized method by the European Committee for Standardization (CEN) is, however, still pending.

The SEC of biochar correlates closely with the degree of polycondensation and increases exponentially with pyrolysis severity (Hagemann et al., 2025). Values of ≥ 0.1 mS/cm are reached for straw biochar produced at 450 °C (H/C_{org} = 0.42) and wood biochar produced at 600 °C (H/C_{org} = 0.35), i.e., well below the 0.70 threshold. A high SEC observed despite a high ash content is therefore a robust indicator that the pyrogenic carbon matrix is sufficiently aromatized and that the measured hydrogen excess originates from mineral-bound hydrogen. Importantly, ash acts as an electrical insulator within the biochar matrix and systematically lowers SEC: Grafmüller et al. (submitted) demonstrate a linear decrease in SEC when biochar is mixed with ash or other mineral matter at increasing ratios. Consequently, the threshold of 0.1 mS/cm is a conservative criterion: ash-rich biochars must achieve this SEC value despite their high mineral content, which can only occur if the pyrogenic carbon itself is highly aromatized.

Validity

This transitional provision remains in force until a standardized method for the direct determination of H/C_{org} on a demineralized sample has been established (H_{org}/C_{org}) and incorporated into the EBC analytical guidelines.

References

Grafmüller, J., Hagemann, N., Clemens, F., Bucheli, T. D., Bartsch, V., Kray, D., Spahr, S., Meiller, M., & Schmidt, H.-P. (submitted). Electrical conductivity of biochar: Method optimization and insights from an industrial data set. Carbon Trends.

Hagemann, N., Schmidt, H.-P., Bucheli, T. D., Grafmüller, J., Vosswinkel, S., Herdegen, V., Meredith, W., Uguna, C. N., & Snape, C. E. (2025). Proxies for use in biochar decay models: Hydropyrolysis, electric conductivity, and H/Corg molar ratio. PLOS ONE, 20(9), e0330206. https://doi.org/10.1371/journal.pone.0330206