Exemption from H/C_{org} < 0.7 criterion for ash-rich biochars in the EBC guidelines and Global Biochar C-Sink Standard

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Background and rationale

The hydrogen to organic carbon (H/C_{org}) molar ratio is a readily measurable parameter for characterizing organic carbon compounds in biochar and a key indicator of the degree of polycondensation of the pyrogenic carbon matrix. The EBC analytical guidelines specify its determination by CHN elemental analysis (DIN 51732/ISO 29541) for hydrogen and total carbon, combined with ISO 925 for carbonate-C. Organic carbon is then obtained by subtracting carbonate-C (inorganic carbon) from total carbon. Hydrogen, on the other hand, receives no equivalent correction, so the H/C_{org} ratio retains total hydrogen in its numerator. Yet hydrogen in biochar is not exclusively organic. It is also bound in mineral phases - for example K_2HPO_4 in potassium-amended sludge, hydroxyl groups of mineral constituents, hydrates, and structurally bound crystal water. In ash-rich biochars this mineral-bound hydrogen can become large enough that the resulting H/C_{org} ratio no longer reflects the actual degree of aromatization and polycondensation. For this reason, the H/C_{org} criterion used (1) to define biochar (H/C_{org} < 0.70) and (2) to characterize biochars for the lower persistence class (H/C_{org} < 0.40) cannot be used for high-ash biochar (C_{org} < 50%). The EBC and Global Biochar C-Sink standards therefore adopted the following transitional provision:

Transitional provision

1. For biochars with C_{org} content < 50 % and a solid-state electrical conductivity (SEC) of ≥0.1 mS/cm, the biochar defining criterion H/C_{org} < 0.70 is repealed.

2. For biochars with C_{org} content < 50%, a mean Ro > 2.4%, and a heterogeneity score ≤ 8 the lower persistence class defining criterion H/C_{org} < 0.40 is repealed. These biochars may be registered under the lower persistence class, with a geologically persistent carbon (GPC) fraction of 75% and a semi-persistent carbon (SPC) fraction of 25%. This applies across the full Ro range above 2.4%; a mean Ro ≥ 3.8% does not confer the upper persistence class when H/C_{org} > 0.40.

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. (2026) 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.

The Ro of biochar correlates with the degree of polycondensation and is already used to assign biochars to the upper persistence class (Global Biochar C-Sink, Version 3.3). Since for high-ash biochars (C_{org} < 50%) the H/C_{org} ratio cannot be considered a reliable persistence predictor, Ro analysis becomes the more precise parameter. Alami Sounni et al. (2026) and Sanei et al. (2026) show that a mean Ro > 2.4% indicates fully pyrolysed material comparable to low-ash biochars (C_{org} > 50%) with H/C_{org} < 0.40. This anchor is consistent with the Ro to H/C_{org} relationship used in Section 3.6 of the Global Biochar C-Sink standard, where Ro ≥ 3.8% corresponds to H/C_{org} below approximately 0.25 for woody feedstock. Because biochar with H/C_{org} ≤ 0.40 is assigned to the lower persistence class (75% GPC, Section 3.5), an ash-rich biochar demonstrated by Ro to be equivalently pyrolysed is assigned to the same class. To exclude blended or incompletely pyrolysed material, the Ro determination follows the distributional safeguards of Section 3.6: at least 500 measured points from a CSI-endorsed laboratory and a heterogeneity score ≤ 8. The requirement that no more than 3% of points fall below Ro 2% (Section 3.6) is not applied here as the reactive fraction indicated by low-Ro points is already absorbed within the conservative 25% SPC allocation.

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

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