

Comparison of European Biochar Certificate Version 4.8 and IBI Biochar Standards Version 2.0 and Baseline Biochar Metrics Ver IX

- European Biochar Certificate first publication March 2012 <http://www.european-biochar.org/en/home>
- IBI Biochar Standards first publication May 2012 <http://www.biochar-international.org/characterizationstandard>
- Baseline Biochar Metrics, Ver X, dated Nov 18, 2016

Parameter	European Biochar Certificate V4.8	EBC Test Method	IBI Biochar Standards V2.0	IBI Test Method	Baseline Biochar Metrics Ver IX	BBM Test Method - see Baseline Biochar Metrics, Ver IX, dated Nov 4, 2016 for detailed instructions for individual metrics
Water Content	Status (Parameter) Criteria (Units)	DIN 51718 method A Two step: raw moisture at (40 ± 2)°C until constant mass; hygroscopic moisture in TGA crucible and nitrogen atmosphere at (106 ± 2) °C to constant mass.	Status (Parameter) Criteria (Units)	Required (Moisture content)	ASTM D1762-84 'Standard Test Method for Chemical Analysis of Wood Charcoal'. Moisture content at 105 °C for 2 hours.	Required in "Dry Biochar" Procedure as "Weight loss on Drying"
	Declaration (% of total mass, dry basis)	Declaration (% of total mass, dry basis)	Source of Error - does not remove moisture in micro-pores of biochar	Declaration (weight fraction of total mass, wet basis)	Dry at 145C to 155C as per ASTM D2867 "Standard Test Methods for Moisture in Activated Carbon" (available for purchase at http://www.astm.org/Standards/D2867.htm)	
Total Ash	Required	DIN 51719, ISO 1171 or EN 14775 – ashing at 550°C, heating at 5 K/min to 106°C under nitrogen atmosphere then at 5 K/min to 550 °C under oxygen, hold for 1h	Required	ASTM D1762-84 'Standard Test Method for Chemical Analysis of Wood Charcoal'. Ash at 750 °C for 6 hours.	Required in "Dry Biochar" Procedure as "Inorganic Dry Weight Fraction"	Dry at 145C to 155C as per ASTM D2867 "Standard Test Methods for Moisture in Activated Carbon" (available for purchase at http://www.astm.org/Standards/D2867.htm)
	Declaration		Declaration (% of total mass, dry basis)	Air dried and ground sample, dry at 105C for two hours, covered volatile matter to 950C, then ash at 750C for 6 hrs uncovered	Declaration (weight fraction of total mass, dry basis)	Open crucible ashing at 550C in air for two hours - similar to EBC Method
Volatile Matter	Required (Volatile Organic Compounds (VOCs))	Thermal-Gravimetric-Analysis (TGA) using Leco TGA 701 – total mass loss at 950°C	Optional (Volatile matter)	ASTM D1762-84 'Standard Test Method for Chemical Analysis of Wood Charcoal'. VM content at 950 °C for 10 minutes.	Required in "Dry Biochar" Procedure as "Volatile Dry Weight Fraction"	Dry at 145C to 155C as per ASTM D2867 "Standard Test Methods for Moisture in Activated Carbon" (available for purchase at http://www.astm.org/Standards/D2867.htm)
	Declaration (% of total mass, dry basis)		Declaration (% of total mass, dry basis)	Source of Error - Temp too high - volatilizes carbonates, lowers ash determination	Declaration (weight fraction of total mass, dry basis)	Vented crucible at 450C for two hours
C content	Required (Total C) Biochar ≥ 50% Bio Carbon Minerals (BCM) < 50% (% of total mass, dry basis)	Total C, H, N analysis by dry combustion IR-detection (DIN 51732, ISO 29541). Inorganic C analysis by determination of carbonate-C content with HCl, as outlined in DIN 51726, ISO 925. Organic C calculated as Total C – Inorganic C.	Required (Organic C) 10% Minimum Class 1: ≥60% Class 2: ≥30% and <60% Class 3: ≥10% and <30% (% of total mass, dry basis)	Total C and H analysis by dry combustion- IR detection. Inorganic C analysis by determination of CO ₂ -C content with 1N HCl, as outlined in ASTM D4373 'Standard Test Method for Rapid Determination of Carbonate Content of Soils'. Organic C calculated as Total C – Inorganic C.	Replaced by Resident Matter Declaration (weight fraction of total mass, dry basis) – calculated from total weight less Volatiles and Inorganics	This section concerns itself with measurements of properties that served as the basis for a proposed methodology to the American Carbon Registry for carbon offset credits. "The conclusion of the ACR peer reviewers was that the methodology should not be accepted since the scientific literature does not provide sufficient evidence of the stability of soil carbon sequestration in fields treated with biochar using H:Corg ratio correlations as cited in the International Biochar Initiative's Standard Test Method for Estimating Biochar Carbon Stability (BC>100)." (email response Nov 1, 2016 from ACR c/o Winrock.org to web query on "Current status of Biochar w/r/t offset credits") The Resident Matter metric is a more convenient and affordable indicator of stable carbon content in a biochar sample and is adopted in lieu of the previous C content approach.
Molar H/C _{org} ratio	Required 0.7 maximum (molar ratio)	see above for H and C _{org} determination	Required 0.7 maximum (molar ratio)	see above for H and C _{org} determination	Deleted	
Molar O/C ratio	Required 0.4 maximum (molar ratio)	O calculated from ash content, C, H, N, S (DIN 51733. ISO 17247)	Not required N/A		Deleted	
pH	Required Declaration If >10, the delivery slip must feature appropriate handling information	DIN ISO 10390 with 1:5 biochar to 0.01 M CaCl ₂ -solution, 60 min shaking, measuring directly in the suspension	Required Declaration (pH)	US Composting Council TM ECC Section 04.11, modified dilution of 1:20 biochar:deionized H ₂ O (w/v) and equilibration 90 minutes on the shaker, according to Rajkovich et al (2011).	Required in "As Is Biochar" Procedure as "Contact pH" Required in "Wetted Biochar" Procedure as "Extract pH"	Contact "As Is Biochar" with clean water, agitate for one hour, measure pH of clear filtrate Flood micropores of dried biochar with clean water by boiling twice, measure pH of clear filtrate
Electrical conductivity	Required Declaration (µS cm ⁻¹)	Method of the BGK (Federal quality community compost), volume 1, method III, C2 in analogy to DIN ISO 11265 Adding 1:10 H ₂ O to the sample, shaking for 1h, followed by filtration of the solution.	Required Declaration (ds m ⁻¹)	US Composting Council TM ECC Section 04.10, modified dilution of 1:20 biochar:deionized H ₂ O (w/v) and equilibration 90 minutes on the shaker, according to Rajkovich et al (2011)	Required in "As Is Biochar" Procedure as "Contact TDS/EC" Required in "Wetted Biochar" Procedure as "Extract TDS/EC"	Contact "As Is Biochar" with clean water, agitate for one hour, measure TDS/EC of clear filtrate, report in measured units Flood micropores of dried biochar with clean water by boiling twice, measure TDS/EC of clear filtrate, report in measured units
Liming equivalence	Not required		Required (if pH > 7) Declaration (% CaCO ₃)	AOAC 955.01 potentiometric titration on "as received" (i.e., wet) samples. Use dry weight to calculate % CaCO ₃ and report "per dry sample weight".	Optional (recommended) if Inorganics (Ash) level > 20 wt % or Contact or Extract pH > 8 Declaration (CaCO ₃ equivalent)	Standard soil analysis for calcium carbonate equivalent and liming characteristics

Macro-nutrients	Required (Total N)	Dry combustion-IR detection following the same procedure for total C and H (DIN 51732)	Required (Total N)	Dry combustion-IR detection following the same procedure for total C and H	Not required - Not Recommended - studies have shown most biochar N is part of the aromatic graphitic matrix and not bio-available	Report Total N with statement "Note: A significant portion of the measured Total N is typically not bio-available"
	Declaration (% of total mass, dry basis)		Declaration (% of total mass, dry basis)			
	Required (Total P, K, Mg, Ca)	Digestion with Lithium metaborate on ash 550 °C according to DIN 51729-11 and determination with ICP-OES according to DIN EN ISO 11885 or ICP-MS according to DIN EN ISO 17294	Optional (Total P and K)	Modified dry ashing followed by ICP (Enders and Lehmann 2012). 500 °C ashing followed by HNO ₃ and H ₂ O ₂ digestion and determination by ICP-OES analysis	Optional (Total P and K), (recommended) if Inorganics (Ash) level > 20 wt %	Standard soil analysis for fertilizer values, optional micronutrients
	Declaration (% of total mass, dry basis)		Declaration (% of total mass, dry basis)		Provide standard soil analysis from outside lab	
	N/A	N/A	Optional (Mineral N (ammonium and nitrate)) Declaration (mg kg ⁻¹)	2M KCl extraction, followed by spectrophotometry (Rayment and Higginson 1992)	Optional (Mineral N (ammonium and nitrate)) Declaration (mg kg ⁻¹)	2M KCl extraction, followed by spectrophotometry (Rayment and Higginson 1992)
			Optional (Available P) Declaration (mg kg ⁻¹)	2% formic acid followed by spectrophotometry as described by Wang et al (2012)	Optional (Available P) Declaration (mg kg ⁻¹)	2% formic acid followed by spectrophotometry as described by Wang et al (2012)
Liming equivalence	Not required		Required (if pH > 7)	AOAC 955.01 potentiometric titration on "as received" (i.e., wet) samples. Use dry weight to calculate % CaCO ₃ and report "per dry sample weight".	Optional (recommended) if Inorganics (Ash) level > 20 wt % and/or Contact or Extract pH > 8	Standard soil analysis for calcium carbonate equivalent and liming characteristics
			Declaration (% CaCO ₃)		Declaration (CaCO ₃ equivalent)	
Bulk density	Required	Bulk density: DIN 51705	Not required	N/A	Required - density metrics provided for As Is, Dry, and Wetted Biochars	see Individual BBM Procedures for: As Is Bulk Density, Dry Bulk Density, Wetted Biochar Density
	Declaration		N/A		Declaration (weight per volume, appropriate units)	
Particle size distribution	Not required	N/A	Required	Progressive dry sieving with 50mm, 25mm, 16mm, 8mm, 4mm, 2mm, 1mm, and 0.5mm sieves.	Optional and Recommended: if greater than 10 wt % particles over 1/4 "	Progressive dry sieving with 50mm, 25mm, 16mm, 8mm, 4mm, 2mm, 1mm, and 0.5mm sieves.
	N/A		Declaration (% in each size class)		Declaration (weight % in each size class)	
Surface area	Required (Specific surface area)	milled < 50µm, 2h outgassing at 150°C, vacuum, N ₂ adsorption, multi-point BET method	Optional (Total surface area and external surface area) Declaration (m ² g ⁻¹)	ASTM D6556 'Standard Test Method for Carbon Black - Total and External Surface Area by Nitrogen Adsorption'	Replaced by Adsorption Capacity Assay	see BBM Procedures Appendix A on Adsorption Capacity Options: GACS or Propane or Butane Activity (based on ASTM D5742: Standard Test Method for Determination of the Butane Activity of Activated Carbon)
	Declaration (preferably higher than 150 m ² g ⁻¹)				Declaration (wt % of challenge gas per unit weight of dry biochar)	
				Source of Error - BET-N2 is not recommended for micro-porous materials; surface area does not accurately predict biochar adsorption properties		
Water Holding Capacity	Optional	Water holding capacity determining by soaking and drying the sample (E DIN ISO 14238). WHC calculated as mass percentage of saturated and dry mass.	Not required	N/A	Replaced by Water Holding Ratio Ratio of weight of water in drained mass to weight of dried biochar	see BBM Wetted Biochar Procedures: Fully wetted biochar is drained for one hour, then total weight of wetted drained mass and dry mass of biochar determined
Heavy Metals, metalloids and other elements	Required Metals: Pb, Cd, Cu, Ni, Hg, Zn, Cr see original document	All metals: microwave acid digestion with HF/HNO ₃ and determination of the metals with ICP-MS (DIN EN ISO 17294-2) Hg: DIN EN 1483 Water quality - Determination of mercury - Method using atomic absorption spectrometry (H-AAS)	Required Metals: Pb, Cd, Cu, Ni, Hg, Zn, Cr, Co, Mo Metalloids: B, As, Se, Others: Cl, Na	All elements except Hg and Cl: i. Microwave-assisted HNO ₃ digestion, or ii. HNO ₃ digestion, followed by determination with iii. ICP-AES, or iv. Flame AAS (according to US Composting Council TMECC Sections 04.05 and 04.06) Hg: US EPA 7471 Mercury in Solid or Semi-Solid Waste (Manual Cold Vapor Technique) Cl: water soluble elements followed by ion chromatography or ion-selective electrode (per manufacturers instructions)	Optional: if any specific reason to expect heavy metal contamination; Recommend: if required by regulatory authority for specific biochar application	Recommend: appropriate analytical procedure for specific heavy metals of concern at detection level below regulatory threshold
PAHs	Required - see original document	Soxhlet-extraction with toluene with GC/MS or HPLC	Required - see original document	Soxhlet-extraction with toluene then US EPA 8270 SVOCs by GC/MS	Optional: for PAHs, PCBs and PCDD/Fs if any specific reason to expect individual contaminates should be present; Recommended: if required by regulatory authority for specific biochar application	Recommend analytical procedure for bio-available/leachable assay, Recommend against Soxhlet-extraction with toluene with GC/MS or HPLC
PCBs	Required - see original document	Soxhlet-extraction with toluene with HRGC-HRMS	Required - see original document	US EPA 8082 - PCBs by GC or EPA 8275 - PAHs & PCBs via TE/GC/MS		
PCDD/Fs	Required - see original document	Soxhlet-extraction with toluene with HRGC-HRMS	Required - see original document	US EPA 8290 - HRGC/HRMS		
Germination inhibition	Not required N/A	N/A	Required Pass/Fail	OECD methodology (1984) using three test species, as described by Van Zwieten et al (2010)	Deleted	Inadequate scientific literature to support analytical method and provide conclusive insights into biochar properties; method excessively dependent on choice of seeds and remaining soil matrix; analysis results excessively application-specific