Guidelines for Specifications of Biochars for Use in Soils

DRAFT VERSION

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Disclaimer

The International Biochar Initiative (IBI) *Guidelines for Specifications of Biochars for Use in Soils* have been prepared with the intent of providing stakeholders and commercial entities with guidelines to specify biochar materials according to relevant, reliable, and measurable characteristics. Producers who follow these *Guidelines for Specifications of Biochars for Use in Soils* do so voluntarily. In no way shall the IBI or its associates be responsible for the use or misuse of information and guidance provided in this document. This document prescribes tests and thresholds to identify certain qualities and characteristics of biochar materials. No portion of this document is intended for use as a sustainability or production process guideline. Further documentation and guidance is necessary to identify appropriate sustainability practices and/or safe and effective production processes.

The benefits of a given biochar material vary widely with the material and with crop, soil, and climate factors. This document makes no claims regarding the potential benefits of any given biochar material in any particular application. Caution and careful investigation is warranted when selecting biochar for an application.

The *IBI Guidelines for Specifications of Biochars for Use in Soils* are intended to be revised and updated as the science and body of knowledge surrounding biochar continues to evolve. Please ensure that you are using the most up-to-date version found on the website of the International Biochar Initiative: http://www.biochar-international.org.

Foreword

The *Guidelines for Specifications of Biochars for Use in Soils* provide a standardized definition of biochar and biochar characteristics related to the use of biochar as a soil amendment. They have been developed by the International Biochar Initiative (IBI) in collaboration with a wide variety of industry and academic experts and through public input on an international level. The *Guidelines for Specifications of Biochars for Use in Soils* were created to encourage further development of the biochar industry by providing standardized information regarding the characterization of biochar materials to assist in achieving more consistent levels of product quality. In addition to providing product definition and qualitative specification guidelines, this document has been developed to ensure that consumers have consistent access to credible information regarding qualitative and physicochemical properties of biochar.

The *Guidelines for Specifications of Biochars for Use in Soils* are designed to support an IBI certification program. Separately, the *Guidelines* are also intended for use by various national and regional product standards bodies, and national and regional biochar groups for their own local adaptation and use, and as a reference in regulatory situations, as may be appropriate.

IBI developed the *Guidelines for Specifications of Biochars for Use in Soils* in a transparent process open to public participation, review, and input. Throughout the development process

IBI relied upon the drafting, review, and guidance of experts in the field, ensuring an efficient path from concept to final product, and addressing the needs of a broad range of commercial biochar producers and end users. As the document was developed, public input from the larger international biochar community was continuously sought to provide a wider perspective on the use and functionality of this tool.

The design of the *Guidelines for Specifications of Biochars for Use in Soils* follows current best practices and available science. As biochar science continues to improve, the *Guidelines* will be updated in an iterative process in order to remain current. Therefore these *Guidelines* and this document will be periodically revised through further consultation with the international biochar community.

The *Guidelines for the Specification of Biochars for Use in Soils* document development process is based on the following guiding principles:

- Maintain congruence with best practice guidance for standards development such as International Standards Organization (ISO), American Society for Testing and Materials (ASTM) , and Institute of Electrical and Electronics Engineers (IEEE);
- Strictly adhere to process, ensuring efficient and effective collaboration;
- Engage the knowledgeable and diverse stakeholder groups active in the biochar industry;
- Organize an independent review committee with broad stakeholder representation, (including project developers, environmental non-governmental organizations [ENGOs], researchers, and so on); and,
- Rely on IBI infrastructure and capacity for leadership and administration of the initiative.

The experts charged with initial development of *Guidelines for Specifications of Biochars for Use in Soils* took part in two phases of working group activities. These consisted of Phase 1, an initial review of document formatting and characterization criteria, and Phase 2, an in-depth discussion of characterization criteria and reporting levels selection. At the end of each phase, new draft documents were posted, public comments solicited, reviewed and, as appropriate, incorporated in subsequent revisions of the draft. The working groups for each phase were organized as follows:

Phase 1: Initial review of document formatting and characterization criteria (December 2010 – March 2011)

Working Group #1: North America/South America/Africa

- Jim Amonette, United States
- Jason Aramburu, United States
- Louis de Lange, South Africa
- Mariam Ekebafe, Nigeria

- Johannes Lehmann, United States
- Kim Magrini, United States
- Hugh McLaughlin, Canada
- René Pigeon, Canada
- Joseph Pignatello, United States
- Miguel Rodriguez, Brazil
- Rogerio Traballi, Brazil
- Sunguo Wang, Canada

Working Group #2: Asia/Europe/ Australia/New Zealand

- Marta Camps, New Zealand
- Thomas Harttung, Denmark
- Michael Hayes, Ireland
- Stephen Joseph, Australia
- Rupam Kataki, India
- Guitong Li, China
- Franco Miglietta, Italy
- Amran Salleh, Malaysia
- Yoshiyuki Shinogi, Japan
- Balwant Singh, Australia
- Saran Sohi, United Kingdom
- Lukas Van Zwieten, Australia

Phase 2: Live, in-depth review of characterization criteria and reporting levels selection (July 2011)

- Marta Camps, New Zealand
- Stephen Joseph, Australia
- Johannes Lehmann, United States
- Cordner Peacocke, United Kingdom
- Michael Sesko, United States
- Saran Sohi, United Kingdom
- Edward Someus, Sweden

All working group members from Phases 1 and 2 were invited to review issues highlighted from public comments in December, 2011 to inform this revised document for January, 2012 public review.

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1 Scope

Issued by the International Biochar Initiative (IBI) and based on international consultation, this *Guidelines for Specifications of Biochars for Use in Soils* (hereinafter referred to as *Biochar Guidelines)* document is intended to establish a common definition for biochar, testing and measurement methods for select physical and chemical properties of biochar, and labeling guidelines for biochar materials.

Biochar is a solid material obtained from the thermochemical conversion of biomass in an oxygen-limited environment. Biochar can be used as a product itself or as an ingredient within a blended product, with a range of applications as an agent for soil improvement, improved resource use efficiency, remediation and/or protection against particular environmental pollution, and as an avenue for greenhouse gas (GHG) abatement.

These *Biochar Guidelines* provide a standardized definition of biochar and biochar characteristics related to the use of biochar as a soil amendment. They will serve as the basis for an IBI certification program, and are intended for use and adaptation to local conditions and regulations by any nation or region. These *Biochar Guidelines* support not only baseline safety considerations but also the evolving understanding of the positive functions of biochar in soil. This document does not prescribe appropriate uses for biochar materials, nor provide guidelines on what biochar can or should be used for.

These *Biochar Guidelines* relate to the physical properties of biochar only, and do not prescribe production methods or specific feedstocks, nor do they provide limits or terms for defining the sustainability and/or GHG abatement potential of a biochar material, for a certification scheme or otherwise. Although the biochar production and use parameters, listed above, are critical attributes of biochar production and application, they will be addressed in further IBI documents.

Different feedstock types, and hence differentiated testing requirements of biochar, are defined in this guidance document as means for the identification and classification of a range of biochar materials. This testing scheme is based upon increasing levels of physical and chemical property reporting and not necessarily on increasing levels of biochar performance.

The intended audiences for these *Biochar Guidelines* include commercial biochar producers, users, regulators, researchers and marketers, as well as the many national and regional biochar affiliates of the IBI. However, the commercial biochar producer is the entity most likely to apply the *Biochar Guidelines*, as a label (of differentiation) on its biochar material or product.

2 Terms and Definitions

Note: Terms and definitions have been adapted from the references given. Terms and definitions created specifically for this document are referenced as "IBI".

Ash: The inorganic matter, or mineral residue of total solids, that remains when a sample is combusted in the presence of excess air (US Compost Council and US Department of Agriculture 2001).

Biochar: A solid material obtained from thermochemical conversion of biomass in an oxygen-limited environment (IBI).

Biochar Characteristics: For the purposes of these guidelines, biochar characteristics are those physical or chemical properties of biochar that affect the following uses for biochar: 1) biochar that is added to soils with the intention to improve soil functions; and 2) biochar that is produced in order to reduce emissions from biomass that would otherwise naturally degrade to GHG, by converting a portion of that biomass into a stable carbon fraction that has carbon sequestration value (IBI).

Biological Material: Material derived from, or produced by, living or recently living organisms. This material can be "unprocessed" or "processed". Unprocessed biological material is living material, or recently living material from the plant kingdom (or other non-animal taxa such as fungi or algae) that may have been mechanically resized (such as wood chips), but has not been processed in an animal's body or gone through an anthropogenic chemical modification. Processed biological material is recently living material that has been chemically modified by anthropogenic or biological processes (e.g., paper sludge, manure). All animal products, including bones, offal, food-waste containing animal products, and animal manures are considered to be processed biological material (IBI).

Biomass: The biodegradable fraction of products, waste and residues of biological origin from agriculture (including vegetal and animal substances), forestry, and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste (including municipal solid waste) (European Commission Agriculture and Rural Development, 2010).

Contaminant: An undesirable material in a biochar material or biochar feedstock that compromises the quality or usefulness of the biochar or through its presence or concentration causes an adverse effect on the natural environment or impairs human use of the environment. (Adapted from Canadian Council of Ministers of the Environment 2005). Contaminants include fossil fuels and fossil-fuel-derived chemical compounds, glass, and metal objects (IBI).

Diluent/Dilutant: Inorganic material that is deliberately or inadvertently comingled with biomass feedstock prior to processing. These materials will not carbonize in an equivalent fashion to the biomass. These materials include soils and common constituents of natural soils, such as clays and gravel that may be gathered with biomass or intermixed through prior use of the feedstock biomass. Diluents/dilutants may be found in a diverse range of feedstocks, such as agricultural residues, manures, and municipal solid wastes (IBI).

Feedstock: The material undergoing the thermochemical process to create biochar. Feedstock material for biochar consists of biological material, but may also contain diluents (IBI).

Fossil-Fuel-Derived Chemical Compounds: This category of contaminant includes any compound of a synthetic nature, created from hydrocarbons, including, but not limited to plastics, solvents, paints, resins, and tars. Because of the blending of wastes and use of synthetic materials to bind and label other materials (e.g. plastic flagging tape in forestry residues), fossil-fuel-derived chemical compounds have become commonplace in multiple waste streams, and are often difficult to separate from feedstocks prior to processing. These contaminants can contain highly toxic chemicals like polychlorinated biphenyls (PCBs) that may act as bioaccumulators and affect the resulting quality of biochar (IBI).

Hazardous Materials or Wastes: Potential environmental pollutants that, when concentrated, can be a source of regulatory concern for any use or application that may influence human or environmental health and wellbeing (adapted from US Composting Council and US Department of Agriculture 2001).

Municipal Waste/ Municipal Solid Waste (MSW): solid non-hazardous refuse that originates from residential, industrial, commercial, institutional, demolition, land clearing, or construction sources (Canadian Council of Ministers of the Environment 2005). Municipal solid waste includes durable goods, non-durable goods, containers and packaging, food wastes and yard trimmings, and miscellaneous inorganic wastes (US Environmental Protection Agency 2011).

Organic Carbon: Biologically degradable carbon-containing compounds found in the organic fraction of biochar feedstocks. Biochar feedstocks can contain such compounds as sugars, starches, proteins, fats, cellulose, and lignocellulose, which are thermochemically degradable. Other organic carbon forms can include petroleum and petroleum by-products such as plastics and contaminated oils, which are, for the purposes of this document, included within the definition of contaminants, but may also be thermochemically degraded. The organic carbon fraction does not include inorganic carbonate concretions such as calcium and magnesium carbonates (adapted from US Composting Council and US Department of Agriculture 2001).

Processed Feedstock: Biomass that has gone through chemical processing (for example, paper pulp sludge) or biological processing (for example, digestion, such as manures and sludge from waste effluent treatment) beyond simple mechanical processing to modify physical properties. Because animals may bioaccumulate toxins in their tissues, all animal parts and products are considered to be Processed Feedstocks for purposes of these guidelines (IBI).

Producer and/or Manufacturer: The party or parties who process feedstock materials into biochar, test the biochar properties, and acquire appropriate labeling (IBI).

Residence Time: The time a feedstock is held within a consistent temperature range in a given thermochemical process (IBI).

Soil Functions: Soil functions include: "(i) biomass production, including in agriculture and forestry; (ii) storing, filtering and transforming nutrients, substances and water; (iii) hosting the biodiversity pool, such as habitats, species and genes; (iv) acting as a platform for human activities; (v) source of raw materials; (vi) acting as carbon pool; and (vii) storing geological and archeological heritage." [European Soil Framework Directive COM(2006)232].

Unprocessed Feedstock: Biomass from the plant kingdom (or other non-animal taxa such as fungi and algae) that may have gone through mechanical processing to change its physical properties (e.g. particle size), but has not gone through chemical processing or treatment or biological processing (e.g., digestion)(IBI).

3 Biomass Feedstock Material and Biochar Production

3.1 General Feedstock Material Requirements

The materials used as feedstocks for biochar production have direct impacts on the nature and quality of the resulting biochar. Although the focus of this document is on the biochar material, some restrictions have been applied to feedstock contents and quality. To qualify as biochar feedstock under these guidelines, the feedstock may be any combination of biomass and diluents, and may not contain more than 2% by dry weight of contaminants (following Brinton 2000). Suitable feedstocks include but are not limited to agriculture, food, and forestry residues, which may contain a minimal quantity of contaminants (see above) as part of the feedstock. MSW containing hazardous materials or wastes may not be included as eligible feedstocks under these guidelines. It is the manufacturer's responsibility to ensure that biochar feedstock materials are free of hazardous materials.

Note: Issues of sustainability are to be addressed in other IBI documents not included herein.

3.2 General Biochar Production and Material Handling Recommendations

These *Biochar Guidelines* do not prescribe production and handling parameters for biochar, but do include recommendations for safe production processes. It is the responsibility of the biochar manufacturer to create biochar in a safe manner. The IBI recommends that best industry practices be followed throughout the manufacturing and handling process.

Local requirements and regulations for the operation of biochar production facilities should be followed. Where applicable, biochar production must comply with local and international regulatory requirements and treaties that govern thermal processes, the production of volatile and particulate emissions, and the transport of goods. Relevant to local and international regulatory compliance, biochar producers should follow the two recommendations listed below:

- A biochar producer should provide a relevant material safety data sheet (MSDS) for the final output of its particular biochar production process. Brief outlines of MSDS document creation are available from numerous online sources, including MSDS Search, the Canadian Center for Occupational Health and Safety, and the US Department of Labor Occupational Health and Safety Administration.
- Biochar should be tested to address the potential for self-heating and flammability during storage and transportation. Documentation of the results of this testing should be appended to the MSDS.

While the IBI may not require these practices as part of its definition and certification of biochar since they do not relate directly to product quality, they are important considerations in good business practice and responsible industrial production. The majority of nations provide detailed guidelines, expectations, and regulations governing the manufacturing sector and will have relevant information available to industrial operators.

4 Biochar Material Test Categories and Characteristics

As described in this section, biochar materials shall be characterized according to a defined set of test categories intended to provide increasing levels of physical and chemical property reporting. Feedstocks are differentiated into two types: unprocessed and processed, with different test requirements. An optional test category for advanced analysis and soil enhancement properties is also included. Increasing levels of physical and chemical property testing and reporting do not correspond to increasing levels of biochar performance; rather, the categorization structure is designed to:

- Provide a uniform presentation format by which a biochar user would be able to fairly compare and assess the reported properties of different biochar materials.
- Provide a set of required tests for basic biochar utility and an optional set of additional tests for measuring advanced analysis and soil enhancement properties.
- Require toxin reporting appropriate to the potential risks associated with both unprocessed and processed feedstocks. Additional tests are required to attain quality assurance for processed feedstocks, which carry a higher potential risk of contamination.

Each test category was developed according to an assessment of the relevant parameters for biochar qualities, characteristics, and safety, balanced against cost and accessibility.

These *Biochar Guidelines* identify four categories of tests for biochar materials. All biochars must be tested for Category A and Category B characteristics; only biochars made from processed feedstocks must be tested for Category C characteristics. All tests in Category D are optional. The four categories of tests are:

Test Category A – Basic Utility Properties: Required for all biochars. This set of tests measures the most basic parameters required to assess the utility of a biochar material for use in soil.

Test Category B – Basic Toxin Reporting: Required for all biochars. This series of tests analyzes potential toxins that are not feedstock-dependent that can be produced during the production of biochar, including: Polycyclic Aromatic Hydrocarbons (PAH), dioxin, and furan. Tests for vegetative and invertebrate vigor are also required under Test Category B.

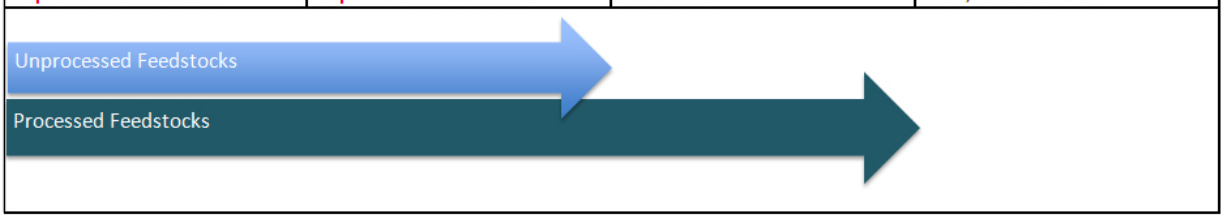
Test Category C – Supplemental Toxin Reporting for Processed Feedstocks: Required for all processed feedstocks. This category tests for additional toxins and elements that may be found in processed feedstocks, including heavy metals, other metals, and polychlorinated biphenyls (PCBs). All processed feedstocks must meet category A, B, and C test requirements.

Test Category D – Advanced Analysis and Soil Enhancement Properties: Optional for all biochars. Biochar may be tested for advanced analysis and enhancement properties in addition to meeting test requirements for Category A, B, and C, depending on the feedstock type. All tests in Test Category D are optional. Producers may report on all, some, or none.

Further details on each of the test categories are provided in the following subsections. An illustration of the interrelationships between the test categories for both unprocessed and processed feedstocks is given in Figure 1, below.

Figure 1. Biochar Test Categories – Requirements based on feedstock type.

A. Basic Utility Properties	B. Basic Toxin Assessment	C. SupplementalToxin Assessment	D. Advanced Analysis and Soil Enhancement Properties
Measures the most basic parameters required to assess the utility of biochars for use in soil.	Analyzes potential toxins that are not feedstock-dependent that can be produced by the thermochemical processes used to make biochar – Polycyclic Aromatic Hydrocarbons (PAH), dioxin and furan. Tests for vegetative and invertebrate vigor are also required.	Tests for additional toxins and elements that may be found in processed feedstocks – heavy metals, other metals and PCB.	Tests for additional biochar characteristics. Biochar advanced analysis characteristics are the electrical conductivity, porosity and surface area of biochars. Biochar soil enhancement properties identify plant nutrients contained in the biochar.
Required for all biochars	Required for all biochars	**Required** for Processed Feedstocks	**Optional**. Producers may report on all, some or none.



4.1 Test Category A – Basic Utility Properties

All biochar must be tested for basic utility properties and meet the criteria specified under Test Category A, as shown in Table 1 below. Basic biochar characteristics include the physical properties of particle size and moisture, as well as the chemical properties of elemental proportions [Hydrogen (H), Carbon (C), and Nitrogen (N)], ash proportion, and pH/liming ability. Organic carbon content (C_{org}) is used to assign the biochar material to a Class that is dependent on the percentage of C_{org} in the material. Carbon stability is indicated by the molar ratio of hydrogen to organic carbon. Lower values of this ratio are correlated with greater carbon stability. See Appendix 5, *The Use of H:C_{org} to Indicate C Stability*, for more information on this analysis.

Table 1: Test Category A Characteristics and Criteria

Test Category A: Basic Biochar Utility Properties - Required for All Biochars			
Requirement	**Criteria**	**Unit**	**Test Method**
Moisture at time of analysis	Declaration	% of total mass	ASTM D1762-84
Organic Carbon	Class 1: ≥30% Class 2: ≥20% and<30% Class 3: ≥10% and <20%	% of total mass	C, H, N analysis by dry combustion (Dumas method). Determine H and then add HCl to assess C_{org}.
$H:C_{org}$	0.7 (Maximum)	Molar ratio	
Total Ash	Declaration	% of total mass	ASTM D1762-84
Total Nitrogen	Declaration	% of total mass	Dry combustion (Dumas method) and gas chromatography, following same procedure as for C, H, N analysis above, without HCl addition.
pH	Declaration	pH units	pH analysis procedures as outlined in section 04.11 of US Composting Council and US Department of Agriculture (2001), following dilution and sample equilibration methods from Rajkovich et al. (2011) See Appendix 3, pH and EC.
Liming (if pH is above 7)	Declaration	% $CaCO_3$	Rayment & Higginson (1992)
Particle size distribution	Declaration	% of total mass in each class	Progressive dry sieving with 200μm, 2,000μm and 20,000μm sieves, as outlined in ASTM D5158-98 - Method for activated carbon.

4.2 Test Categories B and C – Basic and Supplemental Toxin Reporting

In addition to Test Category A thresholds and declarations, all biochar materials must meet the basic soil toxicity assessment thresholds of Test Category B as outlined in Table 2 below. Category B tests are sufficient to assess the toxin risk of biochar made from unprocessed feedstocks. Biochar made from processed feedstocks may carry additional risks from the potential presence of toxins in the feedstock and must meet both Test Category B and Test Category C threshold requirements given in Table 3 below.

Biochar toxicity assessment reporting follows commonly identified soil toxicity and chemical content reporting requirements for soil amendments, composts and fertilizers. The threshold values in Tables 2 and 3 are given as a range of values based on regulatory requirements for soil amendments or fertilizers from a number of countries.[1] The Maximum Allowed Thresholds (MAT) indicate toxin levels above which the material would not be considered acceptable. In order to meet the requirements of these *Biochar Guidelines*, reported toxin levels must be below the MAT, and must specifically be below thresholds established in countries where biochar is produced and/or intended for use. If the country where the biochar will be used has a less stringent threshold or no threshold at all for a particular toxin, the biochar must be below the highest maximum value provided below for each specific toxin. See Appendix 3, *Regulatory Toxin Ranges*, for more information.

Table 2: Test Category B Characteristics and Criteria

Test Category B: Basic Biochar Toxin Reporting - Required for All Feedstocks			
Requirement	**Range of Maximum Allowed Thresholds**		**Test Method**
Earthworm Avoidance Test	Pass/Fail		ISO 17512-1:2008 methodology and OECD methodology (1984a) as described by Van Zwieten et al. (2010), see Appendix 3
Germination Inhibition Assay	Pass/Fail		OECD methodology (1984b) 3 test species, as described by Van Zwieten et al. (2010), see Appendix 3
Polycyclic Aromatic Hydrocarbons (PAH)	6 – 20	mg /kg TM	Method following US Environmental Protection Agency (1996)
Furan	0.5	ng/kg I-TEQ	US Environmental Protection Agency (2007)
Dioxin	0.5	ng/kg I-TEQ	

[1] The following jurisdictions were used to construct the range of values: Australia, Canada, EU, UK, USA. These entities were chosen as standards because they all have a long history of regulations addressing these toxins in soils and other substrates.

Table 3: Test Category C Characteristics and Criteria

Test Category C: Supplemental Biochar Toxin Reporting - Required for Processed Feedstocks			
Requirement	**Range of Maximum Allowed Thresholds**		**Test Method**
Polychorinated Biphenyls (PCB)	0.2 – 0.5	mg/kg I-TEQ	Method following US Environmental Protection Agency (1996)
Arsenic	12 – 100	mg/kg dry wt	US Composting Council and US Department of Agriculture (2001)
Cadmium	1.4 – 39	mg/kg dry wt	US Composting Council and US Department of Agriculture (2001)
Chromium	64 – 100	mg/kg dry wt	US Composting Council and US Department of Agriculture (2001)
Cobalt	100 – 150	mg/kg dry wt	US Composting Council and US Department of Agriculture (2001)
Copper	63 – 1500	mg/kg dry wt	US Composting Council and US Department of Agriculture (2001)
Lead	70 – 500	mg/kg dry wt	US Composting Council and US Department of Agriculture (2001)
Molybdenum	5 – 75	mg/kg dry wt	US Composting Council and US Department of Agriculture (2001)
Mercury	1 – 17	mg/kg dry wt	US Composting Council and US Department of Agriculture (2001)
Nickel	47 – 600	mg/kg dry wt	US Composting Council and US Department of Agriculture (2001)
Selenium	1 – 100	mg/kg dry wt	US Composting Council and US Department of Agriculture (2001)
Zinc	200 – 2800	mg/kg dry wt	US Composting Council and US Department of Agriculture (2001)
Boron	Declaration	mg/kg dry wt	US Composting Council and US Department of Agriculture (2001)
Chlorine	Declaration	mg/kg dry wt	US Composting Council and US Department of Agriculture (2001)
Sodium	Declaration	mg/kg dry wt	US Composting Council and US Department of Agriculture (2001)

4.3 Test Category D - Advanced Analysis and Soil Enhancement Properties

Test Category D is optional for all biochar materials. Producers may report on none, one, some, or all of the properties contained in the Test Category D set of advanced analysis and soil enhancement properties, using the prescribed test methods. Biochar advanced analysis characteristics are electrical conductivity, porosity, and surface area of biochars. Biochar soil enhancement properties identify plant nutrients contained in the biochar.

Biochars tested under Test Category D may report on any or all of the properties presented in Table 4 below:

Table 4: Test Category D Characteristics and Criteria

Test Category D: Biochar Advanced Analysis and Soil Enhancement Properties - Optional for All Biochars			
Requirement	**Criteria**	**Unit**	**Test Method**
Mineral N (ammonium and nitrate)	Declaration	mg/kg	2M KCl extraction, followed by spectrophotometry (Rayment and Higginson 1992)
Total Phosphorus & Potassium (P&K)*	Declaration	% content	Modified dry ashing followed by ICP (Enders and Lehmann 2011)
Available P	Declaration	mg/kg	2% formic acid followed by spectrophotometry (modified from Rajan et al 1992, Nutrient Cycl in Agroecosystems 32:291-302 and AOAC 2005, as used by Wang et al. 2011 Submitted to Plant and Soil)
Electrical Conductivity	Declaration	dS/m	EC analysis procedures as outlined in section 04.10 of US Composting Council and US Department of Agriculture (2001), following dilution and sample equilibration methods from Rajkovich et al. (2011) See Appendix 3.
Porosity	Declaration	cm3/g	ASTM D 6556-10 Standard Test Method for Carbon Black – Total and External Surface Area by Nitrogen Adsorption
Surface Area	Declaration	m2/g	
* Total K is sufficiently equivalent to available K for the purpose of this characterization			

5 Product Labeling Instructions

Product labeling will be an important part of any biochar certification program. In order to qualify for certification, biochar producers and manufacturers must share information about the feedstock and final biochar material. Biochar test results and feedstock origins must be uniformly labeled to communicate information that is important to end consumers and regulators. See Appendix 1 of this document for a sample label.

5.1 Labeling Requirements

To meet the requirements of these *Biochar Guidelines*, a label shall be attached, provided in a web link, or otherwise included with all transactional documents, packaging or other commercial documentation associated with the biochar. The label shall be legible and placed in a fashion that is visible and clear on the biochar packaging or documentation.

5.2 Product Information Requirements

Included with the label, the manufacturer of the biochar shall make available to the purchaser, information pertaining to:

- Feedstock material composition and type, whether Processed or Unprocessed.
- Country of origin for both biochar feedstock and production.
- Country where the biochar will be sold for use.
- All required test results and any optional test results.

5.3 Special Instructions

The manufacturer shall make available to the user instructions for suitable use, storage, and transportation of the biochar in compliance with Hazardous Materials Identification System (HMIS) requirements, or other occupational health and safety requirements, as required by the prevailing jurisdiction. Specifically, this information should include guidance on the safe care, storage, and handling of the biochar material.

6 Conformity and Record Keeping

Adequate documentation and reporting will be required by producers seeking to gain certification. The reporting of biochar feedstock and mandatory and optional test results are all necessary in order to provide assurance of end-product properties. Record keeping will be mandatory in order to establish proof of adequate sampling, testing, and results. Documentation of biochar feedstock (see Appendix 4 for guidelines on identifying feedstocks) and type (unprocessed or processed), production parameters (see footnote 3 below for relevant production parameters), and test results should be kept for seven years.

6.1 Timing and Frequency of Testing

Biochar testing and reporting according to the *Biochar Guidelines* shall be required:

- Annually; or
- After every 600 metric tonnes (dry weight) of consistent feedstock through-put; or,
- After a material change in feedstock;[2] or,
- After a material change in production parameters;[3]

whichever is more frequent.

Testing of biochar materials should occur before final storage or shipment. If the material is intended to be mixed with another material, testing of the biochar material must occur before mixing or blending with any other product.

6.2 Laboratory Standards

Laboratory analysis of biochar shall be conducted by trained and accredited laboratory professionals following the appropriate procedures identified for each test. Testing shall follow strict quality control requirements according to standardized laboratory procedures. Please refer to Appendix 2 for further guidance on sampling procedures and sample processing and handling prior to analysis.

Laboratory professionals are expected to be trained in the relevant field of analytical chemistry and operate in professional laboratories that have received general laboratory accreditation. Such accreditation should be provided by a relevant governing body such as the local jurisdiction's government (e.g. Standards Council of Canada or the US Composting Council) or an international standards body like the ISO. The intent of such laboratory standards is to make certain that contributing laboratories will provide reliable and replicable results that will ensure that an appropriate standard of quality is met.

6.3 Chain of Custody

Chain of custody and product traceability will require an assurance that adequate care and transparency is being exercised to enable trace-back of final end-products from end users across the biochar market to manufacturers and feedstock suppliers. All entities in the biochar production and supply chain will be required to participate in record keeping to maintain quality assurance.

[2] Material changes in feedstock reflect shifts in feedstock type from one source of biomass to a distinctly different source of biomass. See Appendix 4 for more information on how to determine feedstock types that constitute a "material change" in type. In mixed feedstocks, whether processed or unprocessed, a 10% or greater shift in total feedstock composition shall constitute a material change in feedstock.

[3] Material changes in production processes reflect increases or decreases in process temperature (i.e. +/- 50°C), or mean residence time (i.e. greater than 10% change in thermochemical processing time).

7 References

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Appendix 1 – Sample Biochar Label

Figure A1.1 below is an example of adequate product labeling with the necessary product information as specified in these *Biochar Guidelines.*

Producers who wish to report on the properties of biochar contained in a blended product must also report the percentage of biochar as an ingredient in that product and make it clear that the information reported on the biochar label applies to the biochar portion only.

Figure A1.1 Sample Label for a Biochar Product

GOOD GROW BIOCHAR	
MATERIAL TYPE	Biochar made from declared feedstock
COUNTRY OF ORIGIN	Australia
COUNTRY OF USE	Australia
FEEDSTOCK COUNTRY OF ORIGIN	Australia
FEEDSTOCK TYPE	Processed Feedstock
FEEDSTOCK COMPOSITON DECLARATION	poultry manure - 83%, wood chip bedding - 17%
BIOCHAR BASIC UTILITY PROPERTIES:	
Moisture (at time of analysis)	20% - DECLARATION
Organic Carbon	32% - CLASS 1 BIOCHAR
$H:C_{org}$	0.6 - PASS
Total Ash	40% - DECLARATION
Total N	5.4% - DECLARATION
pH	7.5 - DECLARATION
Liming	23% $CaCO_3$
Particle Size Distribution	5% <200µm;
	35% 200-2,000 µm;
	55% 2,000-20,000 µm;
	5% >20,000 µm;
BASIC TOXIN ASSESSMENT:	
Earthworm Avoidance Test	PASS
Germination Inhibition Assay	PASS
Polycyclic Aromatic Hydrocarbons (PAH)	6 mg /kg TM - PASS
Furan	0.5 ng/kg I-TEQ - PASS
Dioxin	0.5 ng/kg I-TEQ - PASS

SUPPLEMENTAL TOXIN ASSESSMENT:	
Polychorinated Biphenyls (PCB)	0.2 mg/kg I-TEQ - PASS
Arsenic	10 mg/kg - PASS
Cadmium	1.2 mg/kg - PASS
Chromium	60 mg/kg - PASS
Cobalt	14 mg/kg - PASS
Copper	143 mg/kg - PASS
Lead	125 mg/kg - PASS
Molybdenum	5 mg/kg - PASS
Mercury	0.5 mg/kg - PASS
Nickel	25 mg/kg - PASS
Selenium	10 mg/kg - PASS
Zinc	320 mg/kg - PASS
Boron	20 mg/kg- DECLARATION
Chlorine	90 mg/kg- DECLARATION
Sodium	140 mg/kg- DECLARATION
BIOCHAR ADVANCED ANALYSIS AND SOIL ENHANCEMENT PROPERTIES:	
Mineral N (ammonium and nitrate)	21 mg/kg - DECLARATION
Total P&K	3.1% P, 4.4%K - DECLARATION
Available P	16 mg/kg - DECLARATION
Electrical Conductivity	7.3 dS/m - DECLARATION
Porosity	.67 cm3/g - DECLARATION
Surface Area	790 m2/g- DECLARATION
Please see attached MSDS documentation for appropriate shipping, handling and storage procedures.	

Appendix 2 – Recommended General Sample Analysis Procedures and Protocols for Specific Tests

Biochar sampling

Strict adherence to standardized biochar sampling procedures is critical to ensure reliable, representative, and replicable test results. Following accepted compost analysis practices, the Test Methods for the Examination of Composting and Composts (TMECC) (US Composting Council and US Department of Agriculture (2001)) has been identified as an effective general sampling procedure to comply with the *Biochar Guidelines*. The TMECC documents provide detailed descriptions of sampling procedures for piles of unsorted, potentially heterogeneous material, which result in homogeneous, representative samples to be used in subsequent chemical analysis (Section 02.01 Field Sampling of Compost Materials in US Composting Council and US Department of Agriculture (2001)). Adhering to TMECC sampling guidance will ensure consistency in analytical approach, since subsequent physicochemical analyses within the *Biochar Guidelines* document recommend the use of TMECC methodologies.

Sample handling and processing

Since sample handling and processing is analysis-methodology-dependent, appropriate procedures should be selected based upon the chemical tests that will be conducted. Sample processing can vary depending upon the physicochemical analyses to be conducted; sample preparation methods followed should be specifically intended for the selected physicochemical tests to be conducted. For example, sample preparation methods can include grinding and sieving or oven-drying for analysis, to provide the dry weight measure indicated in Table 3 of the biochar test categories. General sample preparation procedures can be found in TMECC Section 02.02 Laboratory Sample Preparation in US Composting Council and US Department of Agriculture (2001). Caution should be exercised however, since the methodologies recommended therein are designed for compost, and not for biochar. Comments within the TMECC document (US Composting Council and US Department of Agriculture (2001)) indicate that sample heating can occur while grinding, which can result in a change in sample qualities and characteristics. To avoid this, it is recommended that samples to be ground and sieved to a smaller size range (e.g. 2mm) be hand-ground in a mortar and pestle, to reduce the risk of heating, sparking, or ignition (following sample grinding methods for pH and EC assessment noted in Rajkovich et al 2011).

Combined approach to analyzing pH and EC

Generic pH and EC analysis procedures have been drawn from the TMECC methodologies (US Composting Council and US Department of Agriculture (2001)). These procedures for the use of control and reference pH samples and electrode probes have been adapted for use with biochar, as follows: where the TMECC methodology recommends a 1:5 v:v or w:w[4] solution of compost : deionized water, a 1:20 w:w or v:v solution of biochar : deionized water should be used for biochar pH and EC analysis, following Rajkovich et al (2011). Similarly, additional time should be allotted for solution equilibration after the combination of deionized water and biochar. Following Rajkovich et al (2011), 1.5 hours should be provided for the shaking and equilibration of biochar-deionized-water solutions prior to pH and EC analysis. Upon completion of the shaking and equilibration phase, pH and EC analysis may be conducted on the same samples, rather than making separate replicates for pH and EC. To complete the pH and EC analysis follow methodologies 04.10 and 04.11 of the TMECC methodology (US Composting Council and US Department of Agriculture (2001)).

Earthworm Avoidance and Germination Inhibition Assay

The Earthworm Avoidance and Germination Inhibition Assay analyses follow procedures outlined by Van Zwieten et al 2010. The recommended approach for biochar analysis is to follow Van Zwieten et al's methods, as they are drawn from the initial 1984 OECD and ISO 17512 - 1:2008 methodologies, and to report earthworm behavior as it relates to the avoidance of biochar-soil, and seedling germination as it relates to the failure to germinate in biochar-soil. Lettuce (Lactuca sativa L.) is the most widely recommended species to use in germination assessments, due to its sensitivity. Other species that can be used are found within the OECD (1984b) methodology. The primary approach to the earthworm avoidance test is drawn from ISO 17512 – 1:2008, with instructions on soil matrix blending from the OECD (1984a) methodology. Further augmentations of Van Zwieten et al's approach should follow Li et al (2011) to ensure that adequate wetting of soil and biochar-soil blends is achieved for the duration of the Earthworm Avoidance test. Results should be reported as a "fail" to reflect a statistically significant preference of the worms to avoid biochar-blended soils, or a failure of seedling germination and growth in biochar-blended soils, thus rejecting the null-hypothesis that there is no difference between biochar-soil blends and soil within the test. Results can be reported as a "pass" where there is no difference of worm preference or germination and seedling growth success between biochar-soil blends and soil, or where biochar-soil blends are preferred; both conditions are considered to pass these tests. The purpose of the analyses is to determine whether adding biochar to soil has an effect on worm behaviour and seed

[4] v:v – volume:volume denotes a ratio situation where the annotation is anticipating equivalent units of volume measurement in a dilution or blend (e.g. a 1:5 v:v biochar:water blend could indicate the need to blend 1L of biochar with 5L of water)

w:w – weight:weight denotes a ratio situation where the annotation anticipates equivalent units of weight measurement in a dilution or blend (e.g. a 1:5 w:w biochar:soil blend could indicate the need to blend 1 kg of biochar with 5 kg of soil) germination. It is assumed that a negative effect indicates the presence of undesirable compounds in the biochar material.

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Appendix 3 – Regulatory Toxin Ranges

The following table indicates the maximum allowed toxin thresholds for some international jurisdictions, including the European Union (EU), United Kingdom (UK), Australia, Canada, and the United States (US) that were used to help develop reporting levels for the *Biochar Guidelines*. These entities were chosen as resources for toxin standards due to their history of regulations addressing these toxins in soils and other substrates, and their development of similar soil quality standards (e.g. land-application of biosolids and/or compost). Toxin ranges for reporting to the IBI are **not** indicated within this appendix, and are instead indicated within Table 3, as part of Test Category C. The below table is intended to provide a better understanding of how the IBI developed the maximum threshold range indicated in Table 3 through a survey of international regulations.

Table A3.1 – International toxin regulation resources used for determining IBI range of maximum allowed thresholds.

Toxin	**International Regulatory Maximum Toxin Thresholds**	
Polyaromatic Hydrocarbons (PAH)	6(A), 20(B)	mg EPA PAH*/kg TM
Polychlorinated Dibenzofurans (Furan) (PCDF)	0.5(D)	ng/kg I-TEQ dry wt
Polychlorinated Dibenzodioxins (Dioxin) (PCDD)	0.5(D)	ng/kg I-TEQ
Polychorinated Biphenyls (PCBs)	0.2(A), 0.5(C)	mg/kg I-TEQ
Arsenic	100(B), 12(C), 41(D), 75(E)	mg/kg dry wt
Cadmium	1.4(A), 20(B), 1.4(C), 39(D), 20(E)	mg/kg dry wt
Chromium	93(A), III12%, IV 100(B), 64(C)	mg/kg dry wt
Cobalt	100(B), 150(E)	mg/kg dry wt
Copper	143(A), 1000(B), 63(C), 1500(D)	mg/kg dry wt
Lead	121(A), 300(B), 70(C), 300(D), 500(E)	mg/kg dry wt
Molybdenum	5(C), 75(D), 20(E)	mg/kg dry wt
Mercury	1(A), Methyl mercury 10(B), Inorganic mercury 15(B), 6.6(C), 17(D), 5(E)	mg/kg dry wt
Nickel	47(A), 600(B), 50(C), 420(D), 180(E)	mg/kg dry wt

Selenium	1(C), 100(D), 14(E)	mg/kg dry wt
Zinc	416(A), 200(C), 2800(D), 1850(E)	mg/kg dry wt
*PAHs occur in multiple forms, and while some groups treat them as a whole (Amlinger et al; Australia), others identify individual PAHs to be assessed independently and at different acceptable levels (e.g. Canada) See note (C) below for more detail and url to PAH toxin threshold document. This value represents the PAHs that have been identified within the recommended methodology.		

(A) Amlinger F., Favoino E. and Pollack M., (2004) Heavy metals and organic compounds from wastes used as organic fertilisers. Final Report July 2004 REF. Nr. TEND/AML/2001/07/20 ENV.A.2./ETU/2001/0024 http://www.bvsde.paho.org/bvsacd/cd43/used.pdf. Data has been taken from Table S1. Regulatory data from EU countries (Austria, Belgium, Germany, Denmark, Spain, France, Finland, Greece, Italy, Ireland, Luxembourg, Netherlands, Portugal, Sweden, and United Kingdom) was averaged to produce the reported values. Toxin values are reported as mg/kg of dry mass samples. NB: Individual nations within the EU will have different regulatory expectations than the average values reported herein; appropriate regulatory values should be followed, rather than regional averages.

(B) Australia National Environment Protection NEPC 1999 Assessment of Site Contamination Measure Schedule B(1) Guideline on the Investigation Levels for Soil and Groundwater. www.ephc.gov.au/sites/default/files/ASC_NEPMSch_O1_Investigation_Levels_199912.pdf

(C) Canadian Council of Ministers of the Environment (CCME) 2001; 2006 Soil Quality Guidelines for the Protection of Environmental and Human Health (first published 1999, updated 2001, 2002, 2003, 2004, 2005, 2006 & 2007). http://st-ts.ccme.ca [5]

(D) United States Environmental Protection Agency (US EPA) 1994 A Plain English Guide to the EPA Part 503 Biosolids Rule US EPA 40 CFT Part 503 US EPA, Office of Wastewater Management, Washington DC. EPA/832/R-93/003 http://water.epa.gov/scitech/wastetech/biosolids/503pe_index.cfm

(E) Bureau de Normalisation du Quebec 2005 National Standard of Canada Organic Soil Conditioners – Composts (as a source of threshold levels, Maximum Content for Type B compost was used) http://www-es.criq.qc.ca/pls/owa_es/bnqw_norme.detail_norme?p_lang=en&p_id_norm=8184&p_code_menu=NORME

[5] The CCME document for PAHs is not one single level, but provides individual levels to reflect the varying toxicities of different PAHs, and therefore a single PAH toxin reporting level seems inappropriate. http://ceqg-rcqe.ccme.ca/download/en/320/

Appendix 4 – Determining a "Material Change" in Feedstock

This Appendix addresses the need to identify feedstock types for purposes of determining a "material change" in feedstock types under Section 7.1 - Adequate Sample Testing. Section 7.1 requires that biochar properties and characteristics according to the specification guidelines shall be assessed and reported after every "material change" in feedstock. Table A4.1 is a list of distinct unprocessed feedstock types used to make biochar. Changes between these feedstock types will constitute a "material change" in feedstock. Types are based on biomass composition as listed in the Phyllis Biomass Composition Database (see reference).

Any change in feedstock from one listed type in Table A4.1 to another shall constitute a "material change" in feedstock.

Feedstocks not listed in this table may be used to make biochar if they meet the other feedstock requirements outlined in these guidelines. However, any change between a feedstock listed in Table A4.1 and a feedstock not listed will constitute a "material change" in feedstock and require a new round of testing.

If an unprocessed feedstock not listed in Table A4.1 is changed to another unprocessed feedstock not listed in Table A4.1, then a "material change" in feedstock shall be based on the species of plant material used for the feedstock, so that a change in species constitutes a "material change" in feedstock.

When a mix of unprocessed feedstocks is used, a change of more than 10% in the total feedstock composition shall constitute a "material change" in feedstock.

Table A4.1 – Unprocessed Feedstock Types

Unprocessed Feedstock Types for determining "material change" in feedstock
Rice hulls & straw
Non-maize cereal straws & switchgrass
Maize cobs & stover
Sugar cane bagasse & trash
Softwoods (conifers)
Hardwoods (angiosperms)
Bamboo
Miscanthus

Table A4.2 is a list of feedstocks sourced from processed biomass. Any change from one processed feedstock to another will constitute a "material change" in feedstock, e.g. (1) a change from sheep manure to pig manure, (2) a change from sludge/waste provided by Facility A to that by Facility B, or (3) a significant change in the process parameters (e.g., a change in process chemistry for paper sludge, or a change from dairy manure to pig manure in an anaerobic digester process).

Processed feedstocks not listed in this table may be used to make biochar if they meet the other feedstock requirements outlined in these guidelines.

When a mix of different processed feedstocks is used, or where the processed feedstock consists of a mix of components, a change of more than 10% in the total feedstock composition shall constitute a "material change" in feedstock.

Table A4.2 – Processed Feedstock Types

Processed Feedstock Types for determining "material change" in feedstock
Cattle manure
Pig manure
Chicken manure
Sheep manure
Horse manure
Paper mill sludge
Sewage sludge
Distillers grain
Anaerobic digester sludge
Biomass fraction of MSW
Food industry waste

References

Phyllis, database for biomass and waste, Version: 4.13, Energy Research Centre of the Netherlands (ECN), http://www.ecn.nl/phyllis, (accessed 03 January 2012).

Appendix 5 – The Use of H:C_{org} to Indicate C Stability

The molar H/C_{org} ratio is recommended to distinguish biochar from other carbonaceous organic matter for several reasons: (1) H/C ratios change substantially with thermochemical treatment (Keiluweit et al., 2010); (2) O/C ratios have been shown to correlate well with stability of biochars (Spokas, 2010); (3) H/C and O/C ratios are closely related (for low-ash biochars <50% ash and <80% volatiles (ash-free basis)); (4) H is determined directly in most laboratories, whereas O is calculated by subtraction.

The modification of using the organic C values rather than total C for this ratio is motivated by the large proportion of inorganic carbonates in some high-ash biochars. These inorganic carbonates do not form aromatic groups distinctive of biochar materials.

The upper H/C_{org} limit of 0.7 is used to distinguish biochars from biomass that does not have the fused aromatic structure that is the source of C stability in biochar materials.

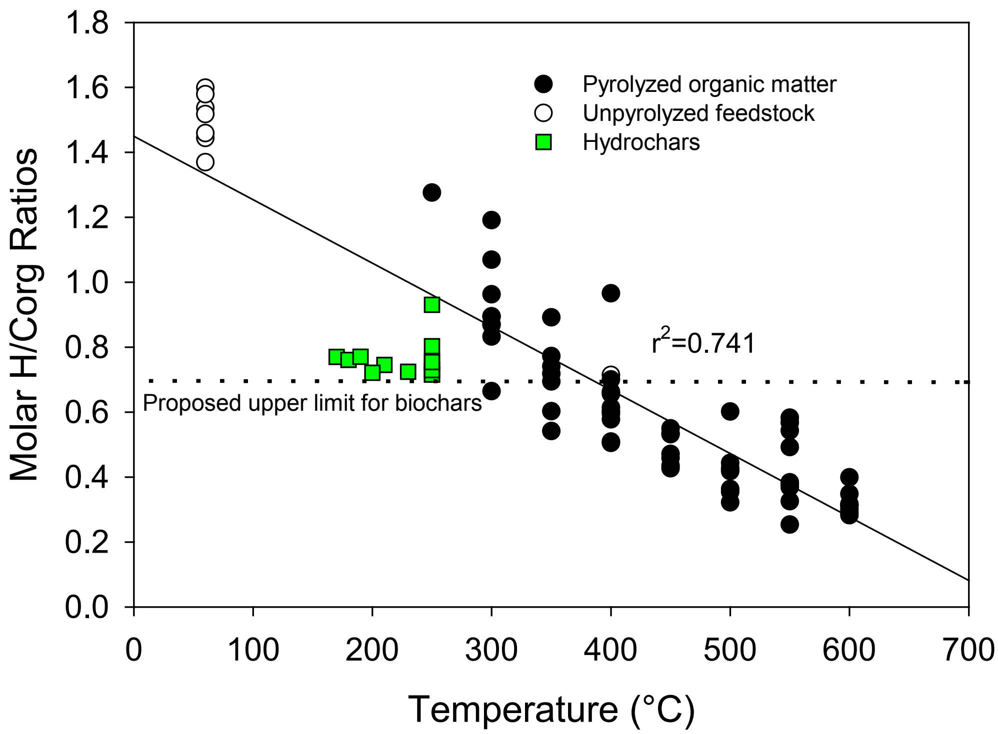

Figure A5.1: Relationship between molar H/C_{org} ratios and temperature of pyrolyzed organic matter in comparison to untreated biomass and hydrochars. Dashed line is the upper limit of 0.7. The correlation coefficient applies to the pyrolyzed organic matter (filled symbols) (data from Sevilla and Fuertes, 2009ab; Camps et al., unpubl.; Enders et al., unpubl).

Definition of Terms Used in Appendix 5

Hydrochar – a carbonaceous material produced by the hydrothermal carbonization process

Pyrolyzed organic matter – a carbonaceous material produced by the pyrolysis process.

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Appendix 6 – Glossary

List of Acronyms and Abbreviations

AOAC – Association of Analytical Communities

ASTM – American Society for Testing and Materials

BNQ – Bureau de Normalisation du Quebec (a member of the National Standards System of Canada, involved in developing product and process standards for Canadians)

C – Carbon

$CaCO_3$ – Calcium Carbonate

C_{org} – Organic Carbon

CCME – Canadian Council of Ministers of the Environment

CSIRO – Commonwealth Scientific and Industrial Research Organisation, Australia

dS – decisiemens

dS/m – decisiemens per meter

dry wt – dry weight

EC – Electrical Conductivity

EPA – Environmental Protection Agency, United States

EU – European Union

g – gram

GHG – Greenhouse Gas

H – Hydrogen

HCl – hydrochloric acid

HMIS – Hazardous Materials Identification System

IBI – International Biochar Initiative

ICP – Inductively Coupled Plasma

IEEE – Institute of Electrical and Electronics Engineers

ISO – International Organization for Standardization

I-TEQ – International Toxicity Equivalent

K – Potassium

KCl – potassium chloride

kg – kilogram

m – meter

mg – milligram

M – molar

MAT – Maximum Allowable Threshold

MSDS – Material Safety Data Sheet

MSW – Municipal Solid Waste

NEPC – National Environment Protection Council, Australia

ng – nanogram

OECD – Organisation for Economic Co-operation and Development

OMS – Office of Mobile Sources, division of US EPA

P – Phosphorus

PAH – Polycyclic Aromatic Hydrocarbons

PCB – Polychlorinated Biphenyls

PCDD – Polychlorinated Dibenzodioxins (Dioxin)

PCDF – Polychlorinated Dibenzofurans (Furan)

S – Siemens

S/m – Siemens per meter

SA – Surface Area

TM – Total Mass

TMECC – Test Methods for the Examining of Composting and Compost, from US Composting Council and USDA

USDA – United States Department of Agriculture

µg – microgram

Definitions

Ash: The inorganic matter, or mineral residue of total solids, that remains when a sample is combusted in the presence of excess air (US Compost Council and US Department of Agriculture 2001).

Biochar: A solid material obtained from thermochemical conversion of biomass in an oxygen-limited environment (IBI).

Biochar Characteristics: For the purposes of these guidelines, biochar characteristics are those physical or chemical properties of biochar that affect the following uses for biochar: 1) biochar that is added to soils with the intention to improve soil functions; and 2) biochar that is produced in order to reduce emissions from biomass that would otherwise naturally degrade to GHG, by converting a portion of that biomass into a stable carbon fraction that has carbon sequestration value (IBI).

Biological Material: Material derived from, or produced by, living or recently living organisms. This material can be "unprocessed" or "processed". Unprocessed biological material is living material, or recently living material from the plant kingdom (or other non-animal taxa such as fungi or algae) that may have been mechanically resized (such as wood chips), but has not been processed in an animal's body or gone through an anthropogenic chemical modification. Processed biological material is recently living material that has been chemically modified by anthropogenic or biological processes (e.g., paper sludge, manure). All animal products, including bones, offal, food-waste containing animal products, and animal manures are considered to be processed biological material (IBI).

Biomass: The biodegradable fraction of products, waste and residues of biological origin from agriculture (including vegetal and animal substances), forestry, and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste (including municipal solid waste) (European Commission Agriculture and Rural Development, 2010).

Contaminant: An undesirable material in a biochar material or biochar feedstock that compromises the quality or usefulness of the biochar or through its presence or concentration causes an adverse effect on the natural environment or impairs human use of the environment. (Adapted from Canadian Council of Ministers of the Environment 2005). Contaminants include fossil fuels and fossil-fuel-derived chemical compounds, glass, and metal objects (IBI).

Diluent/Dilutant: Inorganic material that is deliberately or inadvertently comingled with biomass feedstock prior to processing. These materials will not carbonize in an equivalent fashion to the biomass. These materials include soils and common constituents of natural soils, such as clays and gravel that may be gathered with biomass or intermixed through prior use of the feedstock biomass. Diluents/dilutants may be found in a diverse range of feedstocks, such as agricultural residues, manures, and municipal solid wastes (IBI).

Feedstock: The material undergoing the thermochemical process to create biochar. Feedstock material for biochar consists of biological material, but may also contain diluents (IBI).

Fossil-Fuel-Derived Chemical Compounds: This category of contaminant includes any compound of a synthetic nature, created from hydrocarbons, including, but not limited to plastics, solvents, paints, resins, and tars. Because of the blending of wastes and use of synthetic materials to bind and label other materials (e.g. plastic flagging tape in forestry residues), fossil-fuel-derived chemical compounds have become commonplace in multiple waste streams, and are often difficult to separate from feedstocks prior to processing. These contaminants can contain highly toxic chemicals like polychlorinated biphenyls (PCBs) that may act as bioaccumulators and affect the resulting quality of biochar (IBI).

Hazardous Materials or Wastes: Potential environmental pollutants that, when concentrated, can be a source of regulatory concern for any use or application that may influence human or environmental health and wellbeing (adapted from US Composting Council and US Department of Agriculture 2001).

Municipal Waste/ Municipal Solid Waste (MSW): solid non-hazardous refuse that originates from residential, industrial, commercial, institutional, demolition, land clearing, or construction sources (Canadian Council of Ministers of the Environment 2005). Municipal solid waste includes durable goods, non-durable goods, containers and packaging, food wastes and yard trimmings, and miscellaneous inorganic wastes (US Environmental Protection Agency 2011).

Organic Carbon: Biologically degradable carbon-containing compounds found in the organic fraction of biochar feedstocks. Biochar feedstocks can contain such compounds as sugars, starches, proteins, fats, cellulose, and lignocellulose, which are thermochemically degradable. Other organic carbon forms can include petroleum and petroleum by-products such as plastics and contaminated oils, which are, for the purposes of this document, included within the definition of contaminants, but may also be thermochemically degraded. The organic carbon fraction does not include inorganic carbonate concretions such as calcium and magnesium carbonates (adapted from US Composting Council and US Department of Agriculture 2001).

Processed Feedstock: Biomass that has gone through chemical processing (for example, paper pulp sludge) or biological processing (for example, digestion, such as manures and sludge from waste effluent treatment) beyond simple mechanical processing to modify physical properties. Because animals may bioaccumulate toxins in their tissues, all animal parts and products are considered to be Processed Feedstocks for purposes of these guidelines (IBI).

Producer and/or Manufacturer: The party or parties who process feedstock materials into biochar, test the biochar properties, and acquire appropriate labeling (IBI).

Residence Time: The time a feedstock is held within a consistent temperature range in a given thermochemical process (IBI).

Soil Functions: Soil functions include: “(i) biomass production, including in agriculture and forestry; (ii) storing, filtering and transforming nutrients, substances and water; (iii) hosting the biodiversity pool, such as habitats, species and genes; (iv) acting as a platform for human activities; (v) source of raw materials; (vi) acting as carbon pool; and (vii) storing geological and archeological heritage.” [European Soil Framework Directive COM(2006)232].

Unprocessed Feedstock: Biomass from the plant kingdom (or other non-animal taxa such as fungi and algae) that may have gone through mechanical processing to change its physical properties (e.g. particle size), but has not gone through chemical processing or treatment or biological processing (e.g., digestion)(IBI).