Biochar Product Definition and Standard DRAFT VERSION

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Leading Carbon Ltd.

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Disclaimer

This document has been prepared with the intent of providing the public with a standardized method for classifying Biochars with relevant, reliable and measurable characteristics. In no way shall the IBI or its associates be responsible for the use or misuse of information and guidance provided in this document.

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

The IBI Biochar Product Definition and Standard is intended to be a living document. This document is subject to continuous updates and modification as the science and body of knowledge surrounding biochars continues to evolve. Please ensure that you are using the most up-to-date version.

Foreword

This Biochar Product Definition and Standard has been developed through the International Biochar Initiative with the collaboration of a wide variety of industry experts on an international level.

This Biochar Product Definition and Standard was created with the intent to encourage further development of the biochar industry. This shall be accomplished through achieving more consistent levels of product quality and providing standardized information regarding the use, characterisation, and benefits of biochar. Along with this product definition and quality standard, this document has been developed to ensure consumers have more consistent access to information regarding the quality and physical properties of biochar.

The Biochar Product Standard project approach is designed to support an IBI certification program. The standard can also then be leveraged into the various national and regional product standards bodies, as may be appropriate. By starting with an internal IBI process, the discussion can be focused among experts in the field, ensuring an efficient path from concept to final product, and addressing the needs of a broad range of biochar producers and users.

The proposed standard, and living document development process relies on the following principles:

- Build from congruence in best practice guidance for standards development (ISO, ASTM, IEEE);
- Strict adherence to process required to ensure that the collaborative effort yields appropriate results efficiently.
- Engage the knowledgeable and diverse stakeholder group active in the biochar industry;

- Organize an independent review committee with broad stakeholder representation (project developers, ENGOs, Researchers, etc.).
- Rely on existing infrastructure and capacity within IBI for leadership and administration of initiative;
- Provide oversight to standards development process.
- Formalize and validate standard development and review process.

The participants charged with the development of the standardization of Biochar have been divided into two working groups.

The working groups have been organized as follows:

Phase 1: Initial review of document formatting and characterisation criteria

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Table of Contents

1 Scope

This standard establishes testing, measurement, and reporting methods, and markings for the product characteristics of concern for Biochar as an agent for soil improvement, remediation of soil pollution or protection against soil pollution and as an avenue for carbon sequestration. This standard does not prescribe appropriate uses for biochar products, nor provide limitations on what biochar can or should be used for.

Different feedstocks and hence differentiated testing requirements of biochar are defined in this standard as means for subjugation and classification of biochar products.

This standard does not provide limits or terms for defining the sustainability, or carbon sequestration ability of a biochar product on a life cycle analysis basis, be it for a certification scheme or otherwise.

2 Effective Date

The effective date of this standard is targeted to be *[October 1 2011].* The trail and comment period is tentatively scheduled for late summer 2011.

3 References

- [identify here all reference documents or standards identified as part of or support to this document]
- AA or ICP total K??
- ASTM 1510-09 Iodine Method; Compares the relative surface area of biochar (Mianowski et al., 2007)
- ASTM D1762
- ASTM D4096-91 (2009) Standard Test Method for total suspended particulate matter in atmosphere (high volume sample methodology)
- ASTM D7439-08 Determining elements in particulate matter ICP-Mass Spectrometer
- AOAC Official Methods for assessing Fertiliser NPK
- Butane Adsorption Activity Test
- Dioxin and Furan TEQ OMS tests (chlorine surrogate for Dioxin)
- Dumas combustion, after removal of carbonate C
- EU Fertiliser Regulations (2007)
- McShields Method
- Method R&H 3A1 (Rayment and Higginson 1992) Indicates soluble cations and anions
- Method 19A1 (Rayment and Higginson 1992) testing carbonate equivalent -Expressed as a percentage of CaCO3
- NSW EPA230800d (EPA Compost Guidelines Public Consultation (2009) for Grade A & B
- OECD Germination inhibition is tested against three test species using OECD standard soil (OECD 2004). Method description in Van Zwieten et al., 2009.

- OECD Toxicity testing conducted using the Organisation for Economic Co-operation and Development (OECD) earthworm avoidance method (OECD, 1984) as described in Van Zwieten et al., 2004. Biochar is applied into OECD standard soil at a rate of 1% w/w, with 10 replicates.
- An Update of Ontario's Compost Guideline and Regulatory Framework (EBR Registry Number 010-6658).
- Rayment & Higginson 1992, Australian Laboratory Handbook of soil and water chemical methods. Inkata Press.
- Spanish Compost Guidelines Grades A & B
- NPK Analysis
- Proximate Analysis
- Progressive Sieving
- Sample weight loss through drying (oven-drying moisture content sampling).
- Saturation paste extract method
- Thermogravimetric Analysis
- USEPA Methodology 23
- USEPA Methodology 8290
- CCME SQG Soil Quality Guidelines
- TCLP Toxicity Characteristic Leaching Procedure

4 Terms and Definitions

[identify here all technical terms that may not be clear or may have subjective definitions]

Anthropogenic Carbon – Carbon which has not participated in the current or recent biosphere, (e.g. fossilized carbon (petroleum, natural gas, etc.)) and is currently being used in anthropogenic activities (e.g. production of energy, creation of plastics, etc.). When released to the atmosphere, anthropogenic carbon has an associated CO_2 equivalence which can be assigned based on the molecular form in which the carbon is released (e.g. CO_2, CH_4, etc.).

Ash – The solid mineral fraction of biomass or organic material that is not combustible. Ash may remain as a fixed solid after combustion of an organic substance, or it may be entrained as solid particulate matter in the exhaust gases from combustion.

Biochar – A solid carbonaceous material obtained from thermally degrading organic material following carbonisation. Biochar may be added to soils with the intention to improve soil functions and to reduce emissions from organic material that would otherwise naturally degrade to greenhouse gases. Biochar has appreciable carbon sequestration value. These properties are measureable and verifiable in a characterisation scheme, or in a carbon emission offset protocol.

Biogenic Carbon – Carbon that participates in the current biosphere. Biogenic carbon has a CO_2 equivalence of zero, because it originates from biomass sources as living, recently living or by-products of living organisms. Biogenic carbon results from the activity, or life processes of living

organisms. Examples of biogenic carbon include constituents or secretions of plants and animals, such as woody material, fermentation by-products, and manure; among others.

Biomass –Biological material produced by living or recently living organisms. Biomass does not include petroleum related resources from ancient or fossilized biological material. Biomass carbon is thus considered biogenic as opposed to anthropogenic carbon.

Carbonisation – The process of converting biomass or organic material into biochar and/or charcoal through thermal degradation. The process involves a combination of time, heat and pressure exposure factors that can vary between processors, equipment and feedstocks.

Char – any solid product of pyrolysis or combustion, including that from natural fires, gasifier operations, coal burning facilities, etc.

Contaminant – An undesirable material in a biochar or biochar feedstock that degrades the quality or usefulness of the final Biochar product. Contaminants may or may not be toxic.

Diluent / Dilutant – A material derived from either anthropogenic carbon sources (e.g., plastics) or inorganic sources (e.g. clays, metals, etc.) that are mixed with the organic material prior to pyrolysis processing. These materials will not carbonise in an equivalent fashion to the organic materials, when submitted to pyrolysis.

Fast Pyrolysis -

Feedstock material – the material undergoing the pyrolysis or carbonisation process to create biochar. Typically for biochar, the feedstock material consists of organic material, but may also contain diluents.

Flash Pyrolysis—a type of slow-pyrolysis process conducted at 10 atmospheres pressure that is complete in about 30 minutes (developed by Dr. Michael Antal at the University of Hawaii)

Gasification -

***Good Carbonisation Practices – ensure that the biochar production process is optimised to meet local emission and OHS standards,while minimising GHG emissions and energy consumption.

Highest Treatment Temperature (HTT) – The maximum temperature to which the feedstock and biochar are subject during the pyrolysis or carbonisation process.

Holding Time – The time a feedstock is held within the pyrolitic temperature range during its pyrolysis. This time is a characteristic parameter of pyrolysis process.

Heating Rate – The rate at which a feedstock is heated to the pyrolitic temperature range when it is undergoing pyrolysis. This rate is a characterisitic parameter of the pyrolysis process.

Hydrothermal Conversion —a process in which wet biomass is heated for several hours between about 180°C and250°C and autogenous pressure.

Labile Carbon – the portion of carbon in biochar after pyrolysis, which is likely to be released to the environment in less than 1 year. It is likely that once the labile carbon is released to the environment, it will partake in chemical or biological reactions in the environment to be ultimately converted to carbon dioxide or methane in the atmosphere.

Manufacturer – The party or parties who take responsibility for processing the feedstock materials into biochar, acquiring appropriate labelling, and testing of the biochar properties.

Municipal Solid Waste (MSW) – Domestic or small commercial non-hazardous wastes. MSW includes food wastes, yard wastes, containers and product packaging, and other miscellaneous inorganic wastes from residential, commercial, institutional and industrial sources. Municipal solid waste may contain biodegradable components (e.g. food scraps, coffee grounds, etc.), recyclable material (paper, glass, certain plastics, etc.), inert waste (e.g. construction and demolition waste, metal scrap, wall board, empty containers, etc.), composite wastes (toys, fabrics, etc.), domestic hazardous waste (medication, e-waste, paints, lightbulbs, batteries etc.) sludge (e.g. from waste treatment plants, water supply treatment plants, or air pollution control facilities (e.g., scrubber sludge)). Other discarded material, including solid, semi-solid, liquid, or contained gaseous material resulting from community activities can also be found in MSW. This standard is only concerned with non-hazardous fractions of MSW. It is the manufacturer's responsibility to ensure that biochar feedstock materials are free of hazardous materials.

Organic Material – Biological material derived from, or produced by living, or recently living organisms. This material can be 'unprocessed' or 'processed'. 'Unprocessed material' is living material, or recently living material, (biomass) that has not gone through an anthropic chemical modification (e.g., wood chips). 'Processed material' is recently living material that has been chemically modified by anthropic processes (e.g., paper sludge, manure). This document recognizes that other definitions of "organic" exist such as those of organic chemistry. The IBI Biochar Product Definition and Standard has opted to define organic only as it pertains to biogenically-sourced materials, and not with a wider chemical definition.

Pyrolysis –A thermochemical decomposition of organic material at elevated temperatures in the absence of oxygen.

Pyrolitic Gasification -

Recalcitrant Carbon – the portion of carbon which will likely remain in the biochar for more than 100 years after incorporation into soil or a final storage. This carbon is not likely to be converted to carbon dioxide in the atmosphere.

Slow Pyrolysis -

Soil Functions – Soil functions are defined by the proposal for a European Soil Framework Directive COM(2006)232, as follows: "(i) biomass production, including in agriculture and forestry; (ii) storing, filtering and transforming nutrients, substances and water; (iii) biodiversity pool, such as habitats, species and genes; (iv) physical and cultural environment for humans and human activities; (v) source of raw materials; (vi) acting as carbon pool; and (vii) archive of geological and archeological heritage.". In this product definition and standard document, we will focus on environmental and production functions of biochar in soils.

Torrefaction—a process whereby dry biomass is heated to temperatures in the range of 200-325°C to release any remaining moisture, to increase its density and to increase its energy density.

[DRAFT NOTES TO WGs: PLEASE FEEL FREE TO PROVIDE MORE TERMS AND THEIR DEFINITIONS OR REVISE THE EXSITING DEFINTIONS PROVIDED]

5 Feedstock Material and Biochar Production

5.1 General feedstock material requirements

The materials used as feedstocks to biochar processes have direct impacts on the nature and quality of the resulting biochar and shall have the following properties:

- **1** Be of a biomass origin with little chemical or physical changes imposed, such that the original identity of the material is still visibly understood.

  Examples include but are not limited to: wood chips, corn stover, rice and peanut hulls, tree bark, and forestry residues.

- **1** OR be a waste material or by-product of other value generation processes and not resulting from the direct destruction of biomass systems or conversion of land use type specifically for the generation of Biochar feedstock material.

  Examples include but are not limited to paper mill sludge, animal manure, natural rubbers, organic fractions of municipal and agricultural wastes. Non-biotic fractions of waste (i.e. plastics) are considered diluents to a Biochar.

- **2** Be of suitable physical and chemical characteristics for the pyrolysis process through which it is intended to undergo.

  Examples include but are not limited to particle or grain size, moisture content, flammability, sulphur content

- **3** Be free of any potentially harmful levels of contaminant

  Examples include but are not limited to wood preservatives or leaded paint on waste wood

- **4** Have no more than *[20%]* diluents

Examples include but are not limited to petroleum products, rubber, PVC, etc.

5.2 Feedstock material reporting

The feedstock material(s) used to generate a biochar shall be declared by the manufacturer as discussed in Section 7.2.

**Classification for feedstock materials required for product classification

5.3 General Biochar process requirements

The processes used to generate a biochar from the feedstock material shall:

- Provide a means to control the rate and extent to which the carbonisation process proceeds and therefore the residence time of feedstock in the process.
- Provide for a means of escape *[and destruction]* for air pollutants, particulates, volatile gases and derivatives from the feedstock / biochar material in a safe, effective and reliable fashion during the pyrolysis process. The syngas or off-gas should be captured and at the minimum flared but optimally used as a source of energy to offset fossil fuels. The plant itself should comply with local emission and OHS standards.
- Provide a mechanism to safely and effectively arrest the pyrolysis process. The method to safely arrest the process must be an active form of suppression, such that it is capable of stopping pyrolysis of feedstock already undergoing thermal conversion. Discontinuing the supply of feedstock is not considered an active method for stopping the pyrolysis process.
- Maintain a desired level of consistency of the biochar production to the extent possible by limiting variations in the process conditions relative to variations in the operating environment and feedstock variability and report significant variations in consistency as described in Section 8.

Further (optional) recommendations include:

- Biochar production shall follow all applicable laws of the country in which it occurs, and shall endeavour to follow all international treaties relevant to thermal processes to which the relevant country is a party.
- Biochar production shall comply with local regulatory requirements that govern utilisation of the source material and production of volatile and particulate emissions.
- Biochar production and utilisation shall contribute to climate change mitigation by reducing GHG emissions (compared to fossil fuels) and converting labile carbon into more stable forms of carbon, including emission reductions along the complete supply chain.
- Biochar production shall avoid negative impacts on ecosystems, and areas human health.
- Biochar production shall optimize surface and groundwater resource use, including minimizing contamination or depletion of these resources, and shall not violate existing formal and customary water rights.
- Biochar production shall not violate land rights.

6 Biochar Product Classification

As per the descriptions given in this section, biochar products shall be classified and labelled such that the relevant parameters can be made known to users of biochar.

The classification scheme does not provide any insight towards the applications of any biochar product, as the onus is on the user to determine if a biochar is suitable given the soil conditions, climate, etc. to which he/she intends to apply the biochar. The classification scheme works to:

- Provide a uniform information presentation scheme in which a biochar user would be able to fairly compare and assess the properties of different Biochars and determine if any particular Biochar is suitable for their intended application.
- Incrementally heighten the requirements of general quality, so that a higher class provides more comprehensive understanding of the contents included in the product as well as a lower probability of adverse effects on soil functions when used properly.

Higher class ratings do not imply that any one product is more suitable than others for any particular application.

The proposed definitions of the classes are given in the following subsections. Class requirements are cumulative meaning Class I has the least requirements, and each subsequent class has incremental requirements in addition to the previous requirements. **Error! Reference source not found.** shows the relationship of requirements for each class.

Each product shall be tested once yearly for each feedstock and process combination, after initial proof of consistent product quality is obtained. When a new feedstock material is added to a process, the classification testing for a Biochar shall need to be repeated. When a new process is implemented on a feedstock, the classification testing for a Biochar shall be repeated.

Requirement Definitions:

Advanced Soil Enhancement Properties: sorption activity, cation exchange capacity

Advanced Soil Toxicity Requirements: potentially toxic or harmful elements, and more stringent maximum allowable thresholds

Basic Biochar Characterisation: carbon stability, total ash and moisture content, electrical conductivity and particle size.

Basic Soil Enhancement Properties: liming value, and macro nutrient (NPK) content

Basic Soil Toxicity Requirements: potentially toxic or harmful elements, with maximum-allowable content thresholds

Heterogenous feedstock: A biochar feedstock from potentially multiple, or unknown sources. These may include biomass, municipal solid waste, manure, pulp & paper mill waste, etc.

Improved Toxicity Requirements: more stringent measures of micronutrients, heavy metals and other potentially toxic element concentrations (e.g. PCBs)

Improved Soil Enhancement Properties: cation exchange capacity, available moisture/ moisture holding capacity

Persistence in Soil: rate of oxidation

Physical Property Reporting: particle size distribution, moisture content, total carbon, bulk density, electrical conductivity,

Specific Properties for Soil and Water Remediation:

Vegetative & Invertebrate Vigour: germination inhibition and earthworm avoidance tests

Virgin Feedstock: A biochar feedstock from a single, known, and accounted-for biomass origin (e.g. corn stover, wood chips) Must be proven.

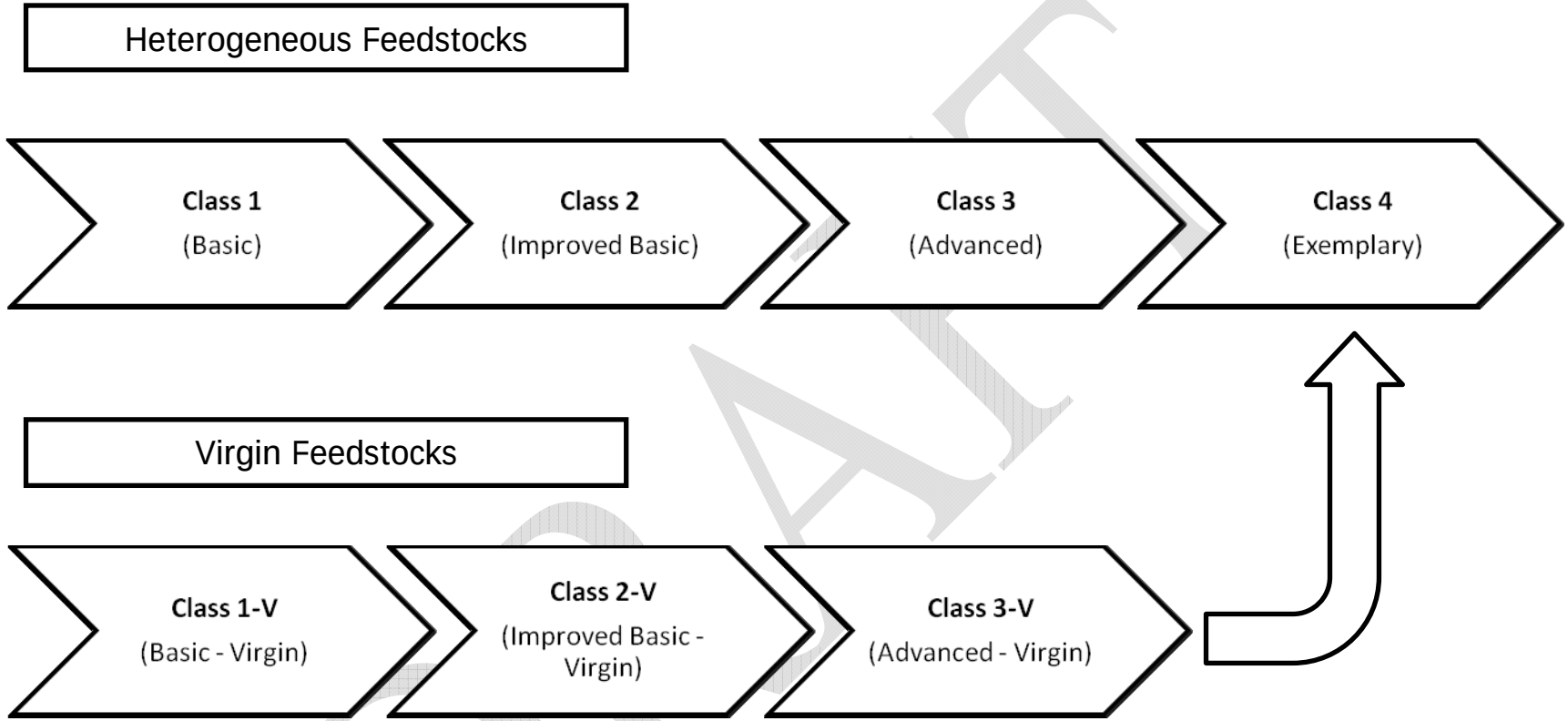

Figure 1: Class Requirements Flow Chart

6.1 Class 1 (Basic)

Class 1 biochars must meet local jurisdiction regulations, vegetative and invertebrate vigour tests, and declare basic biochar characteristics to meet the requirements of a Class 1 quality standard.

Class 1 Biochars shall conform to the requirements presented in the table below.

Requirement	Limit*	Unit	Test Method
Local Jurisdiction Regulations	**Pass/Fail**	**Variable**	**Variable Assay Methodologies: Dependent upon local laws**
Vegetative and Invertebrate Vigour	**Pass/Fail**		**Assay Pass/Fail**
Earthworm Avoidance Test	Pass/Fail		OECD methodology (1984) as described by Van Zwieten et al. (2009)
Germination Inhibition Assay	Pass/Fail		OECD methodology (2004) 3 test species, as described by Van Zwieten et al. (2009)
Basic Biochar Characterisation	**Thresholds/ Declarations**	**Variable**	**Characteristic-dependent**
C- Stability	Declaration	% fossilized Carbon	ASTM D1762
Total Ash	Declaration	% of total mass	ASTM D1762
Liming	Declaration	% CaCO3	Method?
Moisture Content	Declaration	% of total mass	ASTM D1762
Electrical Conductivity	Declaration	dS/m	Method 3.A1 Rayment and Higginson 1992) EC of 1:5 soil/water content
Particle size distribution	Declare	Diameter (cm)	Progressive sieving
Dust	Lower limit 0.4	g/Nm^3	ASTM D4096-91 (2009)

* Limits are expressed as 'less than' unless specified otherwise

6.2 Class 2 (Improved-Basic)

Class 2 biochars must meet basic soil toxicity assessment guidelines, report basic soil enhancement properties, and meet all Class 1 requirements to meet the requirements of a Class 2 quality standard.

Class 2 Biochars shall conform to the requirements presented in the table below:

Requirement	**Limit***	**Unit**	**Test**
Basic Soil Toxicity	**Threshold**		***Variable methodologies depending on property assessed***
Polychorinated Biphenyls	0.2	mg/kg TM or TEQ	*[Compost Ordinance?] or [feedstock precursor?]*
Arsenic	20	mg/kg	NSW EPA230800d (EPA Compost Guidelines Public Consultation (2009) for Grade B); EU Fertiliser Regulations (2007);
Boron	????	mg/kg	FIND METHODOLOGY 1.8ppm max
Cadmium	5 or 2 or 1**	mg/kg	NSW EPA230800d (EPA Compost Guidelines Public Consultation (2009) for Grade B; or New Spanish Compost Guidelines Grade B; or EU Fertilizer Regulations (2007)
Chromium (total)	250 or 250 or 300	mg/kg	NSW EPA230800d (EPA Compost Guidelines Public Consultation (2009) for Grade B; and/or New Spanish Guidelines for Compost, grade B; or EU Fertiliser Regulations (2007)
Cobalt	150	mg/kg	An Update of Ontario's Compost Guideline and Regulatory Framework (EBR Registry Number 010-6658).
Copper	375 or 300 or 300	mg/kg	NSW EPA230800d (EPA Compost Guidelines Public Consultation (2009) for Grade B; or Spanish Compost Guidelines Grade B; or EU Fertiliser Regulations (2007)
Cyanide	0.10	mg/L	FIND METHODOLOGY
Lead	150 or 150 or 125	mg/kg	NSW EPA230800d (EPA Compost Guidelines Public Consultation (2009) for Grade B; or Spanish Compost Guidelines Grade B; or EU Fertiliser (2007)
Manganese	1.0	mg/L	FIND METHODOLOGY
Molybdenum	20	mg/kg	An Update of Ontario's Compost Guideline and Regulatory Framework (EBR Registry Number 010-6658).
Mercury	4 or 1.5 or 0.5	mg/kg	NSW EPA230800d (EPA Compost Guidelines Public Consultation (2009) for Grade B; or Spanish Compost Guidelines Grade B; or EU Fertilizer Regulations (2007)
Nickel	125 or 90 or 40	mg/kg	N NSW EPA230800d (EPA Compost Guidelines Public Consultation (2009) for Grade B; or Spanish Compost Guidelines Grade B; or EU Fertilizer Regulations (2007)
Selenium	8	mg/kg	NSW EPA230800d (EPA Compost Guidelines Public Consultation (2009) for Grade B
Sodium	????	mg/kg	FIND METHODOLOGY

Requirement	Limit*	Unit	Test
Tin	1.0	mg/L	FIND METHODOLOGY
Zinc	700 or 500	mg/kg	NSW EPA230800d (EPA Compost Guidelines Public Consultation (2009) for Grade B; or Spanish Compost Guidelines Grade B
Basic Soil Enhancement Properties			**Variable depending on property**
Liming	Declaration	% CaCo3 eq.	19A1 Rayment and Higginson (1992) Carbonate equivalence
Total NPK	Declaration	% content	Standard Fertiliser Analysis (AOAC Official Methods)
Available NPK	Declaration	% content	Standard Fertiliser Analysis (AOAC Official Methods)
Suspended solids	100	mg/L	TLCP and Standard Methodology

* Limits are expressed as 'less than' unless specified otherwise

** where multiple tests are included, they are listed in order of appearance, and correspond to limit values reported in the same order of appearance (e.g. Cadmium: 5 = NSW EPA 230800d; 2 = New Spanish Guidelines; 1 = EU Fertiliser Regulations)

In addition, Class II Biochars must meet all requirements of Class I Biochars.

6.3 Class 3 (Advanced)

Class 3 biochars must meet advanced soil toxicity assessment guidelines, report advanced soil enhancement properties, and meet all Class 1 and 2 requirements to meet the requirements of a Class 3 quality standard.

Class 3 Biochars shall conform to the requirements presented in the table below

Requirement	Limit*	Unit	Test
Advanced Soil Toxicity	**Variable**		**Variable depending on property assessed**
Cadmium	3 or 0.7	mg/kg	NSW EPA230800d (EPA Compost Guidelines Public Consultation (2009) for Grade A; or Spanish Guidelines, Grade A
Chromium (total)	100 or 70	mg/kg	NSW EPA230800d (EPA Compost Guidelines Public Consultation (2009) for Grade A; or Spanish Grade A
Copper	100 or 70	mg/kg	NSW EPA230800d (EPA Compost Guidelines Public Consultation (2009) for Grade A; or Spanish Grade A
Mercury	1 or 0.5	mg/kg	NSW EPA230800d (EPA Compost Guidelines Public Consultation (2009) for Grade A; or Spanish Grade A
Nickel	60 or 25	mg/kg	NSW EPA230800d (EPA Compost Guidelines Public Consultation (2009) for Grade A; or Spanish Grade A
Selenium	5	mg/kg	NSW EPA230800d (EPA Compost Guidelines Public Consultation (2009) for Grade A
Zinc	200	mg/kg	NSW EPA230800d (EPA Compost Guidelines Public Consultation (2009) for Grade A; and Spanish Grade A
Polycyclic aromatic hydrocarbons (PAH)	16	mg EPA PAH/kg TM	FIND METHODOLOGY
Furan	0.5	ng/kg I TEQ OMS	*Surrogate Test?*
Dioxin	0.5	ng/kg I TEQ OMS	*Chlorine Surrogate Test?*
Advanced Soil Enhancement Properties	**Declaration**		**Variable depending on property**
Cation Exchange Capacity	Declaration		Conducted after elimination of soluble salts
Available/ Unavailable Water	%		Water content at -0.3 and -15 BAR (pressure plate)
Crystalline Silica			Based on local standards or best practices (?)

* Limits are expressed as 'less than' unless specified otherwise

In addition, Class III Biochars must meet all requirements of Class II Biochars.

6.4 Class 4 (Exemplary)

Class 4 biochars must meet specific properties for soil and water remediation, and meet all Class 3, 2 and 1 requirements to meet the requirements of a Class 4 quality standard.

Class 4 Biochars shall conform to the requirements presented in the tables below:

Requirement	Limit*	Unit	Test
Specific Properties for Soil and Water Remediation	**Declarations**		**Variable**
Sorption Activity			Butane Test??
Porosity			ASTM 1510-09 Iodine Method to compare lreative surface area of biochar (Mianowski et al. 2007)
Surface Area			FIND METHODOLOGY
CEC			3A1 (Rayment & Higginson)
Moisture Retention			FIND METHODOLOGY
Total Nitrogen		% volume	Dry/ Dumas Combustion
Total K		% volume	Dry combustion, dissolution in acid, & measured with AA or ICP
Total C		% volume	Dry/ Dumas Combustion
Liming Value	Declare	$CaCO_3$ eq.	Method 19A1 (Rayment and Higginson 1992) testing carbonate equivalent -Expressed as a percentage of CaCO3
O:C ratio		No units	Dry/ Dumas Combustion, to assess stability
H:C ratio			??? FIND METHODOLOGY

* Limits are expressed as 'less than' unless specified otherwise

In addition, Class IV Biochars must meet all requirements of Class III Biochars. OR, if from Virgin Feedstocks, Class IV Biochars must meet all req uirements of Class 3-V Biochars.

6.5 Class 1-V (Basic – Virgin Feedstocks)

Class 1-V biochars must meet local jurisdiction regulations, vegetative and invertebrate vigour tests, and declare basic biochar characteristics to meet the requirements of a Class 1-Virgin quality standard.

Class 1-V Biochars shall conform to the requirements presented in the tables below:

Requirement	Limit	Unit	Test
Local Jurisdiction Regulations	**Pass/Fail**	**Variable**	**Variable Assay Methodologies: Dependent upon local laws**
Basic Biochar Characterisation	**Thresholds / Declarations**	**Variable**	**Characteristic-dependent**
C- Stability	Declaration	% fossilized Carbon	ASTM D1762; Fixed Carbon assessment
Total Ash	Declaration	% of total mass	ASTM D1762
Liming	Declaration	% CaCO3	Method?
Moisture Content	Declaration	% of total mass	ASTM D1762
Electrical Conductivity	Declaration	dS/m	Method 3.A1 Rayment and Higginson 1992) EC of 1:5 soil/water content
Particle size distribution	Declare	Diameter (cm)	Progressive sieving
Dust	0.4	g/Nm^3	ASTM D4096-91 (2009)
Vegetative and Invertebrate Vigour	**Pass/Fail**		**Assay Pass/Fail**
Earthworm Avoidance Test	Pass/Fail		OECD methodology (1984) as described by Van Zwieten et al. (2009)
Germination Inhibition Assay	Pass/Fail		OECD methodology (2004) 3 test species, as described by Van Zwieten et al. (2009)

* Limits are expressed as 'less than' unless specified otherwise

6.6 Class 2-V (Basic – Virgin Feedstocks)

Class 2-V biochars must declare basic soil enhancement properties, and meet all requirements of Class 1-V quality standards in order to meet the requirements of Class 2-Virgin biochars.

Class 2-V Biochars shall conform to the requirements presented in the tables below:

Requirement	Limit		Test
Basic Soil Enhancement Properties			**Variable depending on property**
Liming	Declaration	% CaCo3 eq.	19A1 Rayment and Higginson (1992) Carbonate equivalence
Total NPK	Declaration		Standard Fertiliser Analysis (AOAC Official Methods)
Available NPK			???
Suspended solids	100	mg/L	TLCP and Standard Methodology

* Limits are expressed as 'less than' unless specified otherwise

In addition, Class 2-V Biochars must meet all requirements of Class 1-V Biochars.

6.7 Class 3-V (Basic – Virgin Feedstocks)

Class 3-V biochars must declare basic soil enhancement properties, and meet all requirements of Class 1-V and 2-V quality standards in order to meet the requirements of Class 3-Virgin biochars.

Class 3-V Biochars shall conform to the requirements presented in the tables below:

Requirement	Limit		Test
Advanced Soil Enhancement Properties	**Declaration**		**Variable depending on property**
Cation Exchange Capacity	Declaration		Conducted after elimination of soluble salts
Available/ Unavailable Water	%		Water content at -0.3 and -15 BAR (pressure plate)

* Limits are expressed as 'less than' unless specified otherwise

In addition, Class 3-V Biochars must meet all requirements of Class 2-V Biochars.

7 Product Marking and Instructions

7.1 IBI Marking General Requirements

The IBI label shall be attached or included in transactional documents, packaging, advertisement or other commercial documentation associated with a Biochar product if and only if all the requirements of this standard are adhered to in their entirety.

The IBI label shall be not be larger than *[3%]* of the surface on which it is included and shall not give the impression that the product has direct providence from the IBI or any of its associates. The label shall be placed in a fashion that is visible and clear, however not mistaken as the entity responsible for the production, sale or use of the Biochar product.

An example of the IBI product standard label is included in Appendix 1

7.2 Product information requirements

Included with the IBI label, the manufacturer shall make available to the user, information pertaining to:

- The feedstock material(s)
- The relevant information required by class
- Other relevant safety concerns regarding transportation and application methods or constraints
- Other materials combined or otherwise mixed with the biochar (soils, fertilizers, etc.)
- Percentage of material within the mixture that is biochar
- Content (by weight or volume) of diluents within the biochar fraction.

7.3 Special instruction

The manufacturer shall make available to the user, instructions for suitable storage and transportation methods with respect to maintaining:

- The safety of the users and foreseeable non-users whose presence is anticipatable in the intended or normal use of the product.
- The quality of the product in terms of soil safety, carbon stability, soil fertilization properties and other general properties as described in this standard (see Section 5)

8 Conformity and Record Keeping

Documentation and reporting are required by producers seeking to gain the IBI's confidence in product standardization. Being a product of potentially variable feedstock, the reporting of Biochar feedstock contents, pyrolysis process and end-product quality are all necessary to

provide adequate assurance in end-product uniformity. As such, record keeping will be mandatory, not only for the purpose of proof-of-adequate sample testing, but also for proof of product authorization though time.

Chain of custody and product traceability will require an assurance that adequate care and transparency is being exercised to enable trace-back of end products to producers and feedstock suppliers from end-users across the Biochar market. All levels in the Biochar production and supply chain will be required to participate in record keeping in order to maintain quality assurance. For the sake of feedstock supplier and pyrolysis producer, files may be amalgamated on site if this enables more accurate and longer-term full-circle accounting. Producers and vendors will be required to maintain records in order to enable backtracking between finished product on the shelf and the pyrolysis project operators.

Appendix 1 – Marking and Labeling Examples

An example IBI product marking is given below with the necessary product information as described in this standard:

IBI CERTIFIED BIOCHAR PRODUCT		
International Biochar Initiative www.biochar-international.com	PRODUCT TYPE:	CLASS 2
	FEEDSTOCK TYPE:	WOODY RESIDUES, SAW DUST, BARK
	DENSITY:	700KG /M3
	CARBON SEQ. VALUE	30% BY MASS
	PARTICLE SIZE:	5mm
	APPLICATION METHOD:	DIRECT
	INGREDIENTS:	50% - BIOCHAR 45% - COMPOSTED SOIL MIXTURE 5% - WATER
	APPROVAL DATE:	NOV 2010
	APPROVAL INDEX:	123456789

An additional option for labelling could appear like this (below), with Class labelling at the bottom, along with IBI website information. This will more easily fit the 3% rule.