## Supplementary information

Table S1 Criteria for certify the biochar under IBI Biochar Certification Program, United State (IBI, 2015)

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| **Production criteria** |  |
| Pyrolysis Temperature | ranging from 550oC – 900oC |
| Composition of the pyrolysis biomass | 100% Southern Yellow Pine species (including long leaf, loblolly, short leaf & pond pine) |
| **Product Criteria- Category A** |  |
| Ash | Low Ash Close to Neutral pH Moisture Stabilized High Porosity |
| Moisture | Declaration |
| Organic Carbon (Corg) | 10% Minimum Class 1: ≥60%, Class 2: ≥30% Class 3: ≥10% and <30% |
| H:Corg | 0.7 Maximum |
| Total Ash | Declaration |
| Total Nitrogen | Declaration |
| pH | Declaration |
| Electrical Conductivity | Declaration |
| Particle size distribution | Declaration |
| **Product Criteria- Category B (Toxicant Assessment)** | **Range of Maximum Allowed Thresholds** |
| Germination Inhibition Assay | Pass/Fail |
| Polycyclic Aromatic Hydrocarbons (PAHs), total (sum of 16 US EPA PAHs) | 6 – 300 mg/kg dry wt |
| Dioxins/Furans (PCDD/Fs) | 17 ng/kg WHOTEQ dry wt |
| Polychlorinated Biphenyls (PCBs) | 0.2 – 1 mg/kg dry wt |
| Arsenic | 13 – 100 mg/kg dry wt |
| Cadmium | 1.4 – 39 mg/kg dry wt |
| Chromium | 93 – 1200 mg/kg dry wt |
| Cobalt | 34 – 100 mg/kg dry wt |
| Copper | 143 – 6000 mg/kg dry wt |
| Lead | 121 – 300 mg/kg dry wt |
| Mercury | 1 – 17 mg/kg dry wt |
| Molybdenum | 5 – 75 mg/kg dry wt |
| Nickel | 47 – 420 mg/kg dry wt |
| Selenium | 2 – 200 mg/kg dry wt |
| Zinc | 416 – 7400 mg/kg dry wt |
| Boron | Declaration mg/kg dry wt |
| Chlorine | Declaration mg/kg dry wt |
| Sodium | Declaration mg/kg dry wt |
| **Product Criteria- Category C (Advanced Analysis and Soil Enhancement Properties)** |  |
| Mineral (available) Nitrogen (ammonium and nitrate) | Declaration mg/kg |
| Total Phosphorus & Potassium\* | Declaration mg/kg |
| Available Phosphorous | Declaration mg/kg |
| Total Calcium, Magnesium and Sulfur | Declaration mg/kg |
| Available Calcium, Magnesium and Sulfate-S | Declaration mg/kg |
| Volatile Matter | Declaration % of total mass, dry basis |
| Total Surface Area | Declaration m2 /g |
| External Surface Area | Declaration m2 /g |

Table S2 Characteristics of activated charcoal (FAO/WHO, 2010)

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| --- | --- |
| **Definition** | |
| A solid, porous, carbonaceous material prepared by carbonizing and activating organic substances. The raw materials, which include sawdust, peat, lignite, coal, cellulose residues, coconut shells, petroleum coke, etc., may be carbonized and activated at high temperature with or without the addition of inorganic salts in a stream of activating gases such as steam or carbon dioxide. Alternatively, carbonaceous matter may be treated with a chemical activating agent such as phosphoric acid or zinc chloride and the mixture carbonized at an elevated temperature, followed by removal of the chemical activating agent by water washing. | |
| **Identification** | |
| Solubility | Adsorbent, decolourizing agent |
| Adsorption | The colour of the carbon treated iodine solution shall be lighter in colour than that of the reference solution, indicating the adsorptivity of the sample. |
| Adsorption power | Not less than 90% and not more than 110% of the value stated on label. |
| Loss on drying (Vol. 4) | Not more than 15% (120º, 4 h) |
| Sulfide compounds | To 1.0 g of the sample in a conical flask add 5 ml of 1 N hydrochloric acid and 20 ml of water. Heat to boiling. The fumes released do not turn lead acetate paper brown. (Lead acetate paper is prepared by saturating filter paper with lead acetate TS and drying the paper at 100º). |
| Acid soluble substances | Not more than 3% |
| Sulfated ash | Not more than 5% |
| Water extractable substances | Not more than 4% |
| Alcohol soluble substances | Not more than 0.5% |
| Alkali soluble coloured substances | To 0.25 g of sample add 10 ml of 2 N sodium hydroxide and boil for 1 min. Cool, filter and dilute the filtrate to 10 ml with water. The colour of sample solution shall not be more intense than that of the reference solution. |
| Cyanogen compounds | Mix 5 g of sample with 50 ml of water and 2 g of tartaric acid. Distil the mixture, collecting 25 ml of distillate below the surface of a mixture of 2 ml of sodium hydroxide TS and 10 ml of water contained in a small flask placed in an ice bath. Dilute the distillate to 50 ml with water, and mix. Add 12 drops of ferrous sulfate TS to 25 ml of the diluted distillate, heat almost to boiling, cool, and add 1 ml of hydrochloric acid. No blue colour is produced. |
| Higher aromatic hydrocarbons | Extract 5 g of the sample with about 45 ml of cyclohexane in a continuous extraction apparatus for 2 h. Collect the extract and dilute to 50 ml with cyclohexane. Examine under ultraviolet light at 365 nm. The colour or fluorescence of the solution is not more intense than that of a 83 ng/ml solution of quinine prepared in 0.01N sulfuric acid, examined under the same conditions. |
| Arsenic | Not more than 3 mg/kg |
| Lead | Not more than 5 mg/kg |
| Zinc | Not more than 25 mg/kg |

Table S3 Positive list of biomasses feedstock approved for use in producing biochar (EBF, 2012)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Origin** | **biomass feedstock** | **Special requirements for basic grade biochar** | **Special requirements for premium grade biochar** | **Biomass for woodchar** |
| Local waste collection services with waste separation | Biodegradable waste with/without kitchen waste, and/or leftovers |  |  |  |
| Garden waste | Leaves, Flowers, Vegetables | Not street cleaning waste Only waste not / no longer usable as animal feed |  | Yes |
| Roots | Attached soil is deemed an additive and must not account for more than 10% of DM |  | Yes |
| Prunings from trees, vines and bushes, Clippings from nature conservation measures |  |  |  |
| Hay, grass | Only waste not / no longer usable as animal feed |  |  |
| Agriculture and forestry | Harvest leftovers, Straw, used straw, husks and grain dust, grain, feedstuffs, fruit | Attention: health & safety precautions where dust is involved; Only waste not / no longer usable for human consumption or as animal feed |  |  |
| Grain, feedstuffs, prunings from biomass plantations grown for energy or biomass use (renewable resources). |  | Biomasses must have been produced in a sustainable manner. |  |
| Seeds and plants |  |  |  |
| Bark and chippings, wood, Sawdust, wood shavings, wood wool, prunings from trees, vines and bushes | Only from untreated wood |  | Yes |
| Kitchens and canteens | Kitchen, canteen and restaurant leftovers | check chlorine content, dioxin analysis |  |  |
| Vegetable production | Material from washing, cleaning, peeling, centrifuging and separation processes; Pulp, pips, peelings, shreds or pomace (e.g., from oil mills, spent grain) |  |  |  |
| Waterway maintenance (vegetable material) | Raked off material, flotsam, fishing residues, harvested material, water plants |  |  |  |
| Animal by-products | Hides and skins, bristles, feathers, hair, bones, manure | Subject to national hygiene regulations and check chlorine content - dioxine analysis |  |  |
| Textiles | Cellulose, cotton and vegetable fibres Hemp, sisal and other fibres wool leftovers and wool dust | only from untreated Textile fibres |  |  |
| Plant-based packaging material Origin | Cotton and wood fibres | not chemically modified of solely natural origin, untreated |  |  |
| Paper production | Paper fiber sludge | only from wood fibres not treated chemically (a contamination analysis of the paper fibre sludge must be presented) |  |  |
| Biogas plants | Fermentation residues |  | biomasses for biogas plants must be produced sustainably |  |