Annex 2. Dry Matter Determination for Biochar produced under the Global Artisan Standard.

Version 3.0 (01.06.2026)

Chapter 2.2. of Annex 2 specifies the requirements regarding the frequency with which bulk density measurements must be performed and thus takes precedence over the general statement in Chapter 10.2 of Global Artisan C-Sink standard.

Annex 1 expires three months after the Annex 2 enters into force on 15.06.2026.

Introduction

Assessing the dry weight of biochar before its application to a C-sink is a prerequisite for reliable C-sink certification and trade. The Global Artisan C-Sink standard provides three dry weight assessment methodologies, which are 1) The Direct Dry Weight Method 2) The Bulk Density Method, and 3) The Maximum Moisture Method.

1. The Direct Dry Weight Method

If production conditions allow it, the dry weight of freshly produced biochar may be measured directly. This can be done either immediately after production and prior to quenching, or after snuffing, provided the biochar is dry and pure, it was not contaminated with soil or other substances during snuffing. Safe handling of hot biochar must always be ensured.
A deduction of the container tare weight is required, and a margin of at least 5% must be applied to account for minimal moisture contents and char oxidation in both cases (quenching and snuffing). Water-quenched biochar must be quenched immediately after weighing. Snuffed biochar must remain in an airtight container until weighing to prevent moisture absorption.
This method requires prior technical approval by Carbon Standards International.

2. The Bulk Density Method

The bulk density is used as a conversion factor to calculate the dry matter content from volumetric biochar measurements. This method is applicable for all operations that assess biochar production quantity by volume. In these cases, during operation biochar volume must be recorded immediately after production

at the production site by filling it into standardized containers (Artisan C-Sink Standard Chapter 10.2).

Bulk density is a feedstock and technology-specific parameter and must therefore be assessed separately for every registered feedstock and pyrolysis type (e.g., cotton stalk pyrolyzed in a Kon-Tiki kiln). Bulk density must be determined and registered by the C-Sink Manager for each registered feedstock and pyrolysis type following the protocol (see 2.1.2) and updated regularly (see 2.2). C-Sink Managers may commission a qualified local laboratory to perform the analysis using the method described here but remain responsible for correct results, and usage when reporting the dry matter and carbon content of a respective C-sink.

Sending raw biochar samples to laboratories, particularly those located abroad, is not only time-consuming but may alter the physical biochar structure and moisture content during handling and transport, leading to inaccurate results. The method presented here avoids this by sampling an exact volume of freshly produced biochar directly at the production site and implementing further clearly defined steps to ensure an accurate bulk density assessment. It represents a modification of DIN EN ISO 17828 or ASTM D291/D291M-20 for the unground sample to be applicable in field.

In short (detailed steps in 2.1.2), production-fresh biochar from a kiln is used to fill a standardized 30-liter box (Figure 1) exactly to the rim. Subsequently the fresh weight of this exact 30l sample must be recorded and its moisture content is analyzed to obtain the mean bulk density.

The mean bulk density (see 2.3) is then used for conversion of the produced biochar volumes into biochar dry matter.

2.1. Bulk Density Protocol

2.1.1. Required Tools and Equipment

- Mortar and pestle
- 250 ml measuring cup
- Weighing Scale
- Shovel and tarp
- Ziplock bags
- Standardized measuring box (See Figure 1)
- CSI-endorsed thermogravimetric moisture analyzer, or a drying oven capable of reaching and maintaining 105°C combined with a calibrated weighing scale with a precision of at least 1 mg

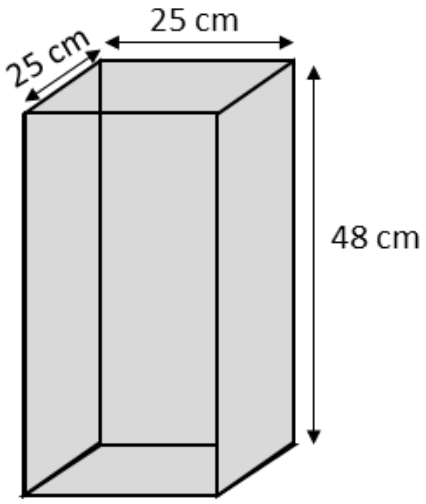

Figure 1. Drawing of a standardized measuring box used to take an exact 30 liter sample. The inner (not outer) dimensions are 25 cm × 25 cm × 48 cm (= 30,000 cm³ = 30 l). Boxes with other dimensions, such as 31.1 cm × 31.1 cm × 31.1 cm (inner dimensions), are also admissible. The measuring box should ideally be made of steel or aluminum, but it can also be made of wood or any other material, provided that the product of the three inner side lengths equals 30 l.

2.1.2. Bulk density sample processing

Step	Description
1	**Filling of the standard box** Immediately after production, the 30 l standard box is filled directly from the freshly produced biochar of the kiln. Fill the box from at least 12 different spots of the biochar pile. Fill exactly to the rim without exceeding it. Do not crush or compact the biochar when filling.
2	**Transferring the content of the box to a bag** The content of the 30 l box is transferred into an empty bag, which is then closed. The bag thus contains a known biochar volume of 30 l and can be used for subsequent analysis.
3	**In-House Analysis (follow steps 4 to 8) or Local Laboratory** The 30 l sample is analyzed "in-house" following the dry matter protocol (see steps 4 to 7) or alternatively, the exact and complete 30 l sample can be sent to an local laboratory for dry matter analysis.
4	**Fresh weight measurement** The fresh weight of the bag (containing the biochar measured with the 30l box) must be recorded immediately before the dry matter analysis (steps 5 and 6). This means it is assessed either after storage and transport to the C-Sink Manager's office, or directly on site if the moisture content analysis is carried out on site. 📷A photo of the scale and bag is taken while weighing.
5	**Homogenization of biochar** After weighing, the bag is opened and the biochar is emptied onto a tarp. The material is then thoroughly homogenized by shoveling it from one pile to another three times.
6	**Sampling** From the homogenized pile, one subsample of 250 ml is taken from random

	locations across the pile. Use at least 10 spots of the pile to collect the subsample. Either proceed directly to the next step or store and label the subsample in a double-layered zip-lock bag.
7	**Sample preparation** The 250 ml sample is milled using a mortar and pestle. 📷A photo of the sample is taken during sample preparation. From the milled sample, an approximately 10 g sub-sample is immediately transferred into the moisture analyzer or if a drying oven is used, weighed on a high precision scale (precision 1 mg) and placed in the pre-heated drying oven (105 °C). Steps 4 to 7 must be carried out in the shade and protected from wind and completed within 30 minutes of the fresh weight measurement to avoid moisture loss. If preparation exceeds this period, the 250 ml subsample must be stored in a double-layered zip-lock bag until analysis.
8	**Drying and measurement** Utilizing the thermogravimetric moisture analyzer the sub-sample is dried at 105 °C, a weight loss of less than 20 mg within 60s is selected as stop-criteria. The resulting moisture content and dry matter values are recorded. For the drying oven, the sample is dried for 24h at 105 °C and weighed on a high precision scale (precision 1 mg) immediately afterwards. 📷 A photo of the analyzers/scale's display is taken.
9	**Data submission** All measurement results for each feedstock must be registered on the same day in the CSI Dry Matter Tool.

Remarks:

The sample material used for bulk density analysis can be used or traded after the determination is completed.

The three photographs shall have a minimum resolution of 300 dpi and are submitted alongside the analytical results.

2.1.3. Bulk density calculations

The dry weight of the 30 l sample is calculated as follows:

$$\text{Dry weight [kg]} = \text{Fresh weight [kg]} \times (1 - \text{Moisture content}) \qquad \text{(i)}$$

where the moisture content of the respective sample is expressed as a fraction (e.g., 0.6 for 60% moisture content).

Bulk Density [kg/m^3] is calculated as

$$\text{Bulk Density [kg/m3]} = \frac{\text{Dry weight [kg]} * 1000}{30\ \text{l}} \qquad \text{(ii)}$$

Remark: In case of drying oven and weighing scale are used the moisture content of approx. 10 g sample is determined as follows:

$$\text{Moisture content} = \frac{\text{Sample weight before drying [mg]} - \text{Sample weight after drying [mg]}}{\text{Sample weight before drying [mg]}} \quad \text{(iii)}$$

2.2. Frequency of Sampling and Measurements

The frequency of sampling and bulk density measurements for C-Sink Networks, Artisan Pro, and C-Sink Villages are as follows:

- **C-Sink Network**
  Every farmer network must register for every feedstock (e.g., corn spindles) and pyrolysis type (e.g., Kon-Tiki) three bulk density measurements following the protocol above (2.1.2). For each measurement, the 30 l sample must be collected from a different production unit (e.g., Kon-Tiki).
  The triplicate sampling and bulk density measurement must be repeated once per year or for every 100 m^3 of biochar produced, whichever comes first. This repetition is compulsory for every feedstock and production technology in each C-Sink Network.

- **Artisan Pro**
  For every Artisan Pro and registered feedstock and pyrolysis type, three 30 l biochar samples are taken from three different production runs. Where three or more kilns are used, each sample must be taken from a different kiln. The triplicate sampling and bulk density measurement must be repeated once per month or every 100 m^3, whichever comes first. This repetition is compulsory for every feedstock and production technology combination at the Artisan Pro site.

- **C-Sink Village**
  For every registered feedstock and pyrolysis type, three 30 l samples are taken once per month. The three samples are taken from the biochar intended for processing or packaging on the sampling date. Each sample must be taken from at least 12 distinct spots. Given the variable logistics of C-Sink Villages, alternative sampling procedures may be approved by Carbon Standards International.

2.3. The Mean Bulk Density

The mean bulk density is calculated as the mean of the three most recent values of the Bulk Density Assessment and issued as a digital certificate by the CSI Dry Matter Tool. Its value is updated when new results from the most recent triplicate sample analysis are available, i.e., following the frequencies stated in 2.2. The mean bulk density must be applied to convert all biochar volumes produced from the same feedstock and pyrolysis type into dry weight (in t dry matter). The mean bulk density value is valid until the next analysis results are available.

3. Maximum Moisture Method

The maximum moisture content (MCmax) is used as a conversion factor to calculate the dry matter of freshly quenched biochar from its measured fresh weight. This method is applicable for Artisan Pro production only.

When biochar is exposed to or immersed in water it absorbs moisture progressively until all accessible pore spaces are filled and no additional water can be retained. This saturation point is referred to as maximum moisture content (MCmax). Any excess water drains freely from the material at this point. MCmax is a directly measurable quantity and serves as the conversion factor for field-based dry matter calculations.

MCmax is a feedstock and technology-specific parameter and must therefore be assessed separately for every registered feedstock and pyrolysis type (e.g., cotton stalk pyrolyzed in a Kon-Tiki kiln). MCmax must be determined and registered by the C-Sink Manager and updated regularly (see 3.2).

In short (detailed steps in 3.1.2), the kiln or vessel containing the biochar is filled with water until the water level clearly exceeds the biochar fill level. The biochar is left to saturate for one hour, after which the water is released. Three samples are taken immediately from the biochar and their exact fresh weight is recorded, samples are immediately processed and analyzed for moisture content to assess the biochar's maximum moisture content (MCmax).

The dry matter content is then determined by applying MCmax as a conversion factor.

3.1. Maximum Moisture (MCmax) protocol

3.1.1. Required Tools and Equipment

- Mortar and pestle
- 250 ml measuring cup
- Shovel and tarp
- Weighing scale (accuracy at least 0.01 kg)
- Ziplock bags
- CSI-endorsed thermogravimetric moisture analyzer, or a drying oven capable of reaching and maintaining 105°C combined with a calibrated weighing scale with a precision of at least 1 mg

3.1.2. Maximum moisture sample processing

Step	Description
1	**Quenching the biochar and filling the kiln or vessel with water** Note the biochar fill level before adding water. The kiln or vessel is then filled with water until the water level clearly exceeds the biochar fill level. Note that the biochar will start to float.

	📷A photo of killn filled with water is taken. It is left to saturate for one hour, after which the water is released and the biochar transferred onto a tarp.
2	**Fresh weight measurement** The produced biochar is homogenized, and three samples of around 15 kg are placed in bags. The exact fresh weight of each of the three bags is recorded immediately. 📷A photo of the scale and bag is taken while weighing.
3	**Homogenization of biochar** Immediately after weighing, the first of the three samples is opened, and the biochar is emptied onto a tarp. The material is then thoroughly homogenized by shoveling it from one pile to another three times.
4	**Sampling** From the homogenized pile, one samples of 250 mL is taken from random locations across the pile. Use at least 10 spots of the pile to collect the sample. Store and label the sample in a zip-lock bag. Steps 2 to 4 must be carried out in the shade and protected from wind and within 15 minutes after fresh weight measurement to avoid any moisture loss.
5	**Sample preparation** The 250 ml sample contained in the zip-lock bag is then milled using a mortar and pestle. 📷A photo of the sample is taken during sample preparation. From the milled sample, an approximately 10 g sub-sample is immediately transferred into the moisture analyzer or if a drying oven is used, weighed on a high precision scale (precision 1 mg) and placed in the pre-heated drying oven (105 °C).
6	**Drying and measurement** Utilizing the thermogravimetric moisture analyzer the sub-sample is dried at 105 °C, a weight loss of less than 20 mg within 60s is selected as stop-criteria. The resulting moisture content and dry matter values are recorded. For the drying oven, the sample is dried for 24h at 105 °C. 📷 A photo of the analyzers/scale's display is taken.
7	**Data submission** All measurement results must be registered on the same day in the CSI Dry Matter Tool.

Remarks:

The sample material used for MCmax analysis can be used or traded with the biochar produced during the batch after the determination is done.

The four photographs shall have a minimum resolution of 300 dpi and are submitted alongside the analytical results.

3.1.3. MCmax calculations

In case drying oven and weighing scale are used the moisture content is determined as follows:

$$\text{Moisture content} = \frac{\text{Sample weight before drying [mg]} - \text{Sample weight after drying [mg]}}{\text{Sample weight before drying [mg]}} \quad \text{(i)}$$

The maximum moisture content analysis calculation is carried out as follows:

$$\text{Mean maximum moisture content}_{n}\ [\%] = \frac{1}{3}\sum_{i=1}^{3} \text{MC}_{n,i} \quad \text{(ii)}$$

where *n* is the number of the biochar bag (1–3) and *MC* is the moisture content of the respective sub-samples *i*, expressed as a fraction (e.g., 0.2 for 20% moisture content).

The standard deviation of the moisture content is added to the average moisture content to provide the default maximum moisture content (MCmax) of the biochar.

$$\text{Default MCmax} = \text{Mean MCmax} + \text{standard deviation MCmax} \quad \text{(iii)}$$

If the highest individual MCmax value of the three assessed values exceeds the lowest by more than 25%, the sampling procedure must be repeated from the start.

The dry biochar mass is then obtained by applying the previously determined default maximum moisture content (MCmax) as follows:

$$\text{Dry weight [kg]} = \text{Fresh weight} \times (1\text{-Default MCmax}) \quad \text{(iv)}$$

For example, if the default MCmax was determined to be 75% and the wet weight of a bag of recently produced biochar is 80 kg, the dry weight is calculated as: 80 × (1 − 0.75) = 20 kg dry matter. During operation, all biochar must be brought to saturation moisture, after which each bag is weighed individually and the weight is recorded. The previously determined maximum moisture content (Default MCmax) is subtracted to directly obtain the dry biochar mass produced.

3.2. Frequency of Sampling and Measurements

The Maximum Moisture Method is currently only available for Artisan Pro production. For every Artisan Pro and every registered feedstock and pyrolysis type, three samples of approximately 15 kg are taken (see 3.1.2).
The triplicate sampling and MCmax assessment must be repeated once per calendar month or after every 100 m³ of biochar produced, whichever comes first. This repetition is compulsory for every feedstock and pyrolysis type combination at the Artisan Pro site.

3.3. The Default MCmax

The Default MCmax is calculated as mean + standard deviation (see 3.1.3 (iii)) of the three most recent MCmax assessments and issued as a digital certificate by the CSI Dry Matter Tool. Its value is updated when new results from the most recent triplicate sample analysis are available, i.e., following the frequencies stated in 3.2. The Default MCmax must be applied to convert all fresh weights of biochar produced from the same feedstock and pyrolysis type into dry weight (in kg dry matter). The Default MCmax value is valid until the next analysis results are available.

4. Notes calibration and equipment sharing

The C-Sink Manager is responsible for proper calibration of the thermogravimetric moisture analyzer or the high precision scale as per the manufacturer’s manual with the supplied test weights. Regardless of the manufacturer's specifications, calibration must be done at least every 365 days or 100 uses, whatever comes first.

Lab instruments, such as the thermogravimetric moisture analyzer or drying oven and high-precision scales can be used by by multiple Artisan Pro within the same C-Sink project. The time between sampling and the measurement must not exceed 96 hours, to ensure smooth operation and timely update of the mean bulk density used as a conversion factor. This indirectly limits the distance and the number of Artisan Pro using the same device.