Japan Biochar Association Standard JBAS 0002

Biochar for Soil Carbon Storage

- Measurement Method - 002 (2025)

August 4, 2025

Translated and Published by the Japan Biochar Association

Foreword

This translation has been made based on the original Japanese version of Japan Biochar Association Standard revised and issued on 4 August, 2025.

Version 001 : Issued on 7 November, 2019
Version 002 : Revised and issued on 4 August, 2025

Table of contents

Japan Biochar Association Standard JBAS 0002

Biochar for Soil Carbon Storage
- Measurement Method -

002 (2025)

Introduction

This standard is intended to systematically provide measurement methods for evaluating biochar for soil carbon storage.

1. Scope

This standard specifies the biochar measurement methods systematically for practical soil carbon storage.

2. Terms and Definitions

Some terms used in this standard are defined as follows.

a) Biochar

Biochar refers to pyrolyzed materials derived from biological resources, in which the ratio of volatile matter content relative to refractory carbon content, as determined by this standard, is less than 0.6. Note that the biochar defined here is estimated to be pyrolyzed at a temperature of 350°C or higher.

b) Bulk density

Bulk density is defined as the value obtained by dividing the mass of sample material by container volume they occupied.

c) Refractory carbon

It refers to carbon and carbon compounds which poorly decompose under natural conditions. Quantitative values of this refractory carbon shall be measured by quantitatively described by this standard.

d) Refractory carbon content

It is a mass percentage of refractory carbon.

e) Refractory carbon analysis

It means to obtain moisture content, ash content, volatile matter content and refractory carbon content of sample

f) Mass conversion factor for refractory carbon

It is a factor used to determine the mass of refractory carbon contained in a given volume of biochar materials from the volume value.

g) Wet weight basis

It shows weight percent based on weight of biochar samples without air-drying

pretreatment. This biochar samples contain moisture added during manufacturing process and/or absorbed from atmosphere.

h) Air-dried basis

It shows weight percent based on weight of biochar samples after air-drying pretreatment. This biochar samples contain moisture absorbed from atmosphere after air-drying pretreatment.

i) Lot

A group of biochar products produced from the same raw materials using the same manufacturing method during the same period (shorter than one (1) year) and stored in the same place is identified as one (1) lot (one (1) set).

Mixture of different lots, which are produced from different materials, during different periods and/or using different manufacturing methods, is possible to constitute a single lot if they are uniformly mixed and stored in the same place. The manufacturing method of the combined lots is described as “mixture of multiple lots” . Its manufacturing date is the day when the multiple lots are mixed.

3. Terms to be measured

Terms to be measured shall include as below;

a) Bulk density

b) Refractory carbon analysis (mass fractions of moisture content, ash content, volatile matter content and refractory carbon content)

c) Mass conversion factor for refractory carbon

4. Sampling

4.1 Overview

The method of collecting samples representing subject biochar lots is provided.

4.2 Equipment

The following equipment will be used.

a) Measuring cup

Stainless steel or plastic cup with a capacity of 1 L.

b) Sample packaging container

Non-hygroscopic and sealable container with an internal volume of 5 to 6 L. When plastic bags are used as a container, they shall have a thickness of 0.08 mm or more.

4.3 Sampling method

Collect samples with a volume of 1 L from each of 5 different points or 5 different containers from the same lot. Samples should be taken not from near-surface areas but from the area as close to the center as possible.

4.4 Sample mixing

Put all collected samples into a container or sample packaging container and mix them.

4.5 Sample packaging

Put all mixed samples into a sample packaging container and sealed. If a plastic bag is used as packaging container, seal the opening by thermocompression bonding or tightly close the bag by binding it with a string or rubber band.

4.6 Sample labeling

Label the sample container distinctly by itself. The label or package should contain the following information;

(1) Biochar production location
(2) Biochar manufacturer
(3) Biochar manufacturing date
(4) Types of raw materials for biochar
(5) Manufacturing method of biochar
(6) Lot number
(7) Sampling place and date
(8) Name of sampling operator
(9) Weather on the sampling day
(10) Other related information

5. Preparation of measurement sample

5.1 Measurement sample type

a) Samples for bulk density measurement
b) Samples for refractory carbon analysis

5.2 Sample for bulk density measurement

Untreated samples should be used for bulk density measurement.

Samples after bulk density measurement can serve as **a** sample for storage and/or as raw material for refractory carbon analysis.

5.3 Sample for refractory carbon analysis

5.3.1 General

The purpose of preparing samples for refractory carbon analysis is to prepare measurement samples passed through a sieve with mesh size of 212 μm.

The samples used for bulk density measurement can serve as raw materials for preparing samples for refractory carbon analysis. If a large amount of biochar is collected for the measurements, however, samples other than those used for bulk density measurement may be used for this measurement.

Samples are prepared through preliminary drying, air-drying and grinding processes. As weight loss obtained by subtracting the weight of the air-dried sample from the weight just before the preliminary drying represents the amount of moisture and is

required for calculation of refractory carbon analysis, it is necessary to measure the weights at these two occasions.

Samples for refractory carbon analysis and samples under preparation for tests should not be mixed with untreated samples. If necessary, the prepared and semi-prepared samples are packaged in separate containers.

5.3.2 Preliminary drying

Preliminary drying is conducted as follows.

a) Adjust a drier with drying temperature maintained at 107°C ± 5°C.

b) Place samples in a stainless steel, aluminum or brass tray with a known weight, and weigh them to 0.01 g units. This weight is defined as mass of the sample before preliminary drying (m_w). In general, 100 g of samples is adequate for measurement.

c) Insert the tray containing the sample into the dryer.

d) Dry the sample until the sample achieves a constant weight.

Note: Wet biochar achieves constant weight after 12 hours of drying. The drying duration is roughly 12 to 24 hours.

5.3.3 Air-drying operation

The samples after preliminary drying are exposed to room temperature to prepare air-dried sample that is largely saturated with atmospheric moisture. The air-drying procedure is described below.

a) Expose the tray containing the preliminarily dried sample to room temperature in the laboratory.

Note: Two hours are sufficient for exposure time. However, if moisture absorption may have not achieved saturation level, weigh the sample every hour and continue exposure until the weight variability is less than 0.5%.

b) Weigh air-dried sample to 0.01 g units. The weight is defined as mass of the sample after air-drying (m_{ad}).

5.3.4 Grinding

The air-dried sample is crushed using a crusher or manually using a pestle and mortar into ground samples completely passed through a sieve with mesh size of 212 μm.

The ground samples are sealed and stored for refractory carbon analysis.

Note: The moisture content of sample for refractory carbon analysis will not change over about one week if it is stored in a tightly plugged package.

6. Bulk density measurement

6.1 Principle

Divide mass of sample material by container volume they occupied.

6.2 Equipment

The following equipment will be used.

a) Measuring container: A cylindrical container (with a volume of 2 L) is desirable.

b) Balance: It should be able to measure to 1 g unit.

6.3 Operation

The measurement operations are described below.

a) Fill the measuring container with water at a temperature of 20°C ± 10°C, weigh the weight to 1 g unit and convert it to a volume (Assuming 1 gram of the sample has a volume of 1 cm^3).

b) Weigh the container to 1 g unit.

c) Put the sample into the measuring container until it overflows.

d) Allow the measuring container to fall from the height of about 5 cm onto the concrete floor surface three times.

e) Repeat steps c) to d) until the sample levels with the container edge.

f) Flatten the sample surface.

g) Weigh the combined weight of the measuring container and sample to 1 g units.

6.4 Measurement results

6.4.1 Calculation of bulk density

Calculate the bulk density to three decimal places by the following formula and round it off to two decimal places.

$$D = \frac{m_b - m_a}{V}$$

where

D : bulk density (g/cm^3)

m_a : mass of the measuring container (g)

m_b : mass of the measuring container and the sample (g)

V : volume of the measuring container (cm^3)

6.4.2 Times of measurement

Measurement shall be repeated three times.

6.4.3 Representation of the results

Calculate the mean values of the three measured bulk density values to three decimal places and round it off to two decimal places.

6.5 Report of the measurements

Report of the measurements shall contain the following elements.

(1) Biochar manufacturer

(2) Biochar manufacturing date

(3) Types of raw materials for biochar

(4) Lot number

(5) Number of samples tested

(6) Shape and volume of the measuring container used for measurement

(7) Measurement data and calculation result(s)
(8) Measurement date
(9) Other related information

7. Refractory carbon analysis

7.1 Principle

Calculate the mass fractions of moisture content, ash content, volatile matter content and refractory carbon content consisting of the biochar based on the mass fractions of moisture content, ash content, volatile matter content, refractory carbon content, and pre-preliminary drying weight and air-dried weight of the ground samples prepared for refractory carbon analysis (hereafter, called the measurement sample).

7.2 Moisture content determination method

7.2.1 Overview

Moisture content (air-dry basis) represents the mass percentage (%) of the weight loss relative to the weight of the measurement sample when it is dried at 107°C ± 2°C. Calculate the moisture content (mass percentage) of biochar sample (wet weight basis) from the moisture content of the measurement sample (air-dry basis), mass of the sample before preliminary drying and mass of the sample after air-drying.

7.2.2 Equipment

The following equipment will be used.

a) Balance: The Balance should be able to measure to 0.01 g units.

b) Dryer: The dryer should provide the following capabilities.

1) Sufficient ventilation in the chamber.

Note: Electrical thermostat with automatic temperature controller is desirable. Preferably, the unit should be able to adjust and maintain the chamber temperature at 107°C ± 2°C.

2) Keeping the temperature measured at the bottom of the inserted sample container at the specified heating temperature.

3) Restoring its original temperature within 10 minutes after sample insertion.

c) Drying container: A dried flat weighing bottle with a size of 40 dia. × 20 height (mm) in nominal, and a container compatible with the bottle.

7.2.3 Amount of weighed sample

Weigh approximately 1 g of sample to 0.01 g units.

7.2.4 Operation

Measurement operations are described below.

a) Adjust the dryer so that the drying temperature is 107°C ± 2°C.

b) Weigh the sample in a drying container with a known weight and flatten and cover the sample surface.

c) Remove the lid of the Drying container and insert it into the drying chamber together

with the lid.

d) Heat the sample over 1 hour after sample insertion.

e) Cover the Drying container with the lid and remove it from the dryer. Transfer it to a desiccator and cool it down naturally.

f) Weigh to 0.01 g units immediately after cooling.

Note: Preferably, cooling time is within 20 minutes.

7.2.5 Calculating measured values

a) Moisture content of the measurement sample (air-dry basis)

The moisture content of the measurement sample (air-dry basis) is calculated to two decimal places using the following formula and rounded off to one decimal place.

$$M_{ad} = \frac{m_1 - m_2}{m_0} \times 100$$

where

M_{ad} : moisture content of the measurement sample (air-dry basis) (%)

m_1 : mass of the container and the sample before drying (g)

m_2 : mass of the container and the sample after drying (g)

m_0 : mass of the weighed sample (g)

b) Moisture content of biochar (wet weight basis)

The moisture content of biochar (wet weight basis) is calculated to two decimal places using the following formula and rounded it off to one decimal place.

$$M_w = \left(M_{ad} \times \frac{m_{ad}}{m_w} \right) + \left(\frac{m_w - m_{ad}}{m_w} \times 100 \right)$$

where,

M_w : moisture content of biochar (wet weight basis) (%)

M_{ad} : moisture content of the measurement sample (air-dry basis) (%)

m_w : mass of the sample before preliminary drying (g)

m_{ad} : mass of the sample after air-drying (g)

7.2.6 Times of measurement

Measurement is repeated twice in the same laboratory. If the difference in measured sample moisture content of the measurement sample between duplicated measurements exceeds the tolerance, repeat the measurement again once more.

7.2.7 Tolerances

The tolerances of moisture content in the measurement sample are provided in the table below.

Moisture content of the measurement sample	Tolerances (measured values)
5.0 or lower	2
5.1～10.0	3
10.1～16.0	4
16.1 or higher	5

Unit (%)

7.2.8 Value to be reported

If the difference between the two measured moisture contents is within the tolerance, calculate the mean value of the two measured moisture content values by rounding it to one decimal place to determine the value to be reported.

7.3 Ash content determination method

7.3.1 Overview

Ash content of the measurement sample represents the mass percentage (%) in the total of the measurement sample for which the residual ash generated by heating and incineration at 815°C under atmosphere.

The ash content (mass percentage) of biochar sample (wet weight basis) is calculated from the ash content of the measurement sample (air-dry basis), mass of the sample before preliminary drying and mass of the sample after air-drying.

7.3.2 Equipment

The following equipment will be used.

a) Balance: The Balance should be able to measure to 0.01 g units.

b) Electric kiln: The kiln should provide the following capabilities.

1) Sufficient ventilation in the kiln.

2) Wide soaking zone.

3) Raising temperature at a rate specified in Section 7.3.4.

4) Maintaining the temperature measured at the bottom of the inserted sample container at 815°C ± 10°C.

c) Ashing container: A shallow glazed porcelain, quartz, or platinum dish with an inner bottom area of 10 cm^2 or more.

Note: When new ashing containers are used for the first time, they should be heated without any content for 1 hour at 815°C using the electric kiln.

7.3.3 Amount of weighed sample

Weigh approximately 1 g of sample to 0.01 g units.

7.3.4 Operation

Measurement operation are described below.

a) Weigh the sample in an ashing container and spread it thinly.

b) Insert the ashing container in the soaking zone of the electric kiln.

c) Turn the electric kiln on, raise the temperature to 500°C within approximately 60

minutes, then raise it to 815°C within another 30 to 60 minutes and maintain the temperature at 815°C ± 10°C until constant weight is achieved.
Typically, the duration during which a temperature of 815°C ± 10°C should be maintained is one hour, but the duration may be prolonged to 2 or 3 hours for the sample that is unlikely to be ashed over one hour.
d) Once ashing is completed, take out the container. Cool the container initially with a cold metal plate for 10 minutes, then within a desiccator over 15 to 20 minutes.
e) Weigh the container to 0.01 g units immediately after cooling.

7.3.5 Calculating measured values

a) Ash content of the measurement sample (air-dry basis)
Ash content of the measurement sample (air-dry basis) is calculated to two decimal places using the following formula and round it off to one decimal place.

$$A_{ad} = \frac{m_1 - m_2}{m_0} \times 100$$

where,

A_{ad} : ash content of the measurement sample (air-dry basis) (%)
m_1 : mass of the container and the sample after ashing (g)
m_2 : mass of the container (g)
m_0 : mass of the weighed sample (g)

b) Ash content of biochar (wet weight basis)
The ash content of biochar (wet weight basis) is calculated to two decimal places using the following formula and rounded it off to one decimal place.

$$A_w = A_{ad} \times \frac{m_{ad}}{m_w}$$

where,

A_w : ash content of biochar (wet weight basis) (%)
A_{ad} : ash content of the measurement sample (air-dry basis) (%)
m_w : mass of the sample before preliminary drying (g)
m_{ad} : mass of the sample after air-drying (g)

7.3.6 Times of measurement

Measurement is repeated twice in the same analytical laboratory. If the difference in measured ash content of the measurement sample between duplicated measurements exceeds the tolerance, repeat the measurement once more.

7.3.7 Tolerances

The tolerances of ash content in the measurement sample are provided in the table below.

Ash content of the measurement sample	Tolerances (measured values)
10.0 or less	2
10.1～20.0	3
20.1 or more	4

Unit (%)

7.3.8 Value to be reported

Use the two consecutive measured ash contents whose difference is within the tolerance If the difference between the two measured ash content is within the tolerance, calculate the mean value of the two measured ash content values by rounding it to one decimal place to determine the value to be reported.

7.4 Volatile matter content determination method

7.4.1 Overview

The measurement sample is placed in a crucible with a lid and heated at 900°C for 7 minutes as avoiding the contact with the air. Determine the mass percentage (%) of the weight loss by heating of the measurement sample, then the volatile matter content of the measurement sample by subtracting the moisture content of the measurement sample which is determined at the same time.

The volatile matter content (mass percentage) of biochar sample (wet weight basis) is calculated from the volatile matter content of the measurement sample (air-dry basis), mass of the sample before preliminary drying and mass of the sample after air-drying.

7.4.2 Equipment

The following equipment will be used.

a) Balance: The Balance should be able to measure to 0.01 g units.

b) Electric kiln: The kiln should provide the following capabilities.

1) Maintaining the temperature of 900°C ± 5°C.

2) Providing sufficient heat capacity to achieve an initial temperature of 900°C and restores the temperature within 4 minutes after inserting a cold stand and the crucible.

3) Providing at least 160 × 100 mm of heating zone with a uniform temperature inside the kiln to accommodate multiple samples.

4) The crucible stand should be set up in the soaking zone, and the position should be always used to measurement.

5) The temperature of 900°C should be kept as strictly as possible. The tolerance of ± 5°C is considered as to allow temperature measurement error and non-uniformity of temperature distribution.

c) Measuring container for volatile matter content

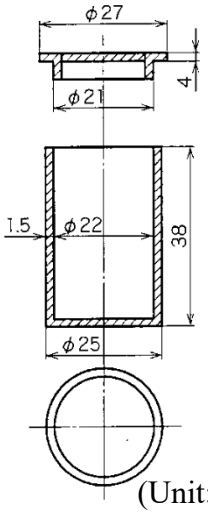
A cylindrical quartz crucible with a lid. It has a weight of 10 to 14 g (see Fig. 1). Alternatively, a porcelain crucible for measuring volatile matter contents is also acceptable. The fitness of the crucible with the lid is important for quantification. A lid should fit the crucible so closely that the horizontal clearance between the crucible and

the lid does not exceed 0.5 mm. Once a well-fitting lid is chosen, rub the opening edge of the crucible with the lid to make their surfaces smooth, and attach common identification symbols.

d) Stand (see Fig. 2)

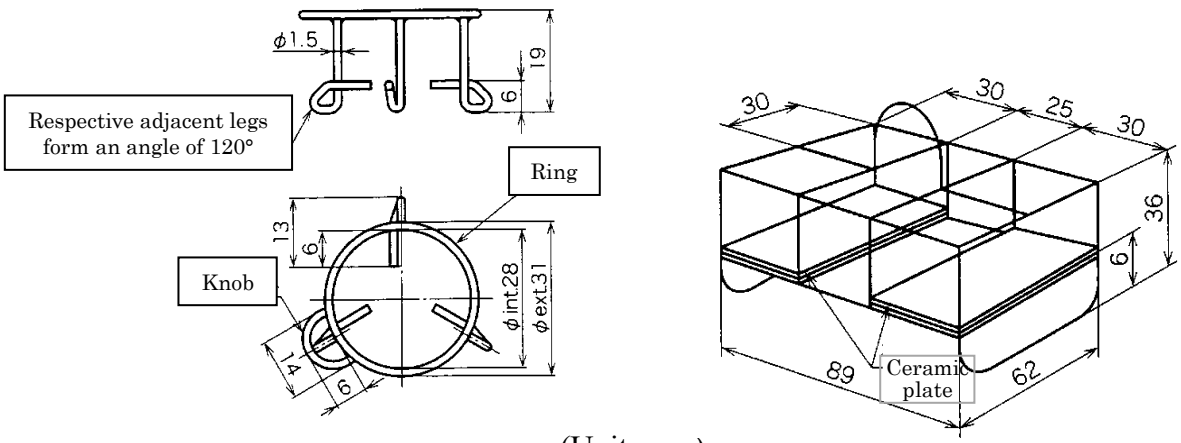
The stand should be able to reach an appropriate heating rate to support a crucible in the kiln. Possible stands include the following.

1) For quantifying one sample, an annular heat- persistent steel wire as shown in Fig. 2a may be used. Place a porcelain disc with a diameter of 25 mm and a thickness of 2 mm on the inner protrusion of the leg.



(Unit: mm)

Fig. 1 Quartz crucible and lid



(Unit: mm)

a) Stand for single sample measurement

b) Stands for multiple sample measurement

Fig. 2 Crucible stand (example)

(Fig.1 and 2 are reprinted from Japan Industrial Standard “Coal and coke − Methods for proximate analysis” (JIS M 8812:2004).

2) For simultaneously quantifying multiple samples, a heat-persistent steel wire basket with appropriate dimensions as shown in Fig. 2b may be used. The basket is equipped with a 2 mm thick porcelain plate supporting the crucible.

7.4.3 Amount of weighed sample

Weigh approximately 1 g of sample to 0.01 g units.

7.4.4 Operation

Measurement operation is described below.

a) Adjust the electric kiln to attain 900°C ± 5°C at the soaking zone.

b) Insert a stand with one or required numbers of empty crucible(s) and lid(s) on it (them) into the kiln. Maintain the inner temperature at 900°C ± 5°C for 7 minutes.

c) Take out the crucible(s) and cool it (them) down to room temperature on a thick metal plate.

d) As soon as it (they) cool(s) down, weigh the empty crucible(s) and lid(s). Weigh 1.0 ± 0.1 g of sample to 0.01 g units and put the sample in each crucible.

e) Put lid(s) on the crucible(s) and tap them gently three to four times on a clean and hard surface until the sample has uniform thickness in the crucible bottoms.

f) Mount the crucible(s) containing sample in a cooled stand, put them into the kiln and close the door.

g) Keep them inside the kiln exactly for 7 minutes ± 5 seconds. Then take it out and allow it to cool down and weigh the crucible(s) to 0.01 g units in the same way as when the empty crucibles are weighed.

Note: When multiple crucibles are simultaneously weighed, empty crucibles shall be placed on available spaces of the stand.

7.4.5 Calculating measured values

a) Volatile matter content of the measurement sample

The volatile matter content of the measurement sample (air-dry basis) is calculated to two decimal places using the following formula and rounded it off to one decimal place.

$$VM_{ad} = \frac{m_1 - m_2}{m_0} \times 100 - M_{ad}$$

where,

VM_{ad} : volatile matter content of the sample (air-dry basis) (%)

m_1 : mass of the container and the sample before heating (g)

m_2 : mass of the container and the sample after heating(g)

m_0 : mass of the weighed sample (g)

M_{ad} : moisture content of the measurement sample (air-dry basis) (%)

b) Volatile matter content of biochar (wet weight basis)

The volatile matter content biochar (wet weight basis) is calculated to the two decimal places using the following formula and rounded it off to one decimal place.

$$VM_w = VM_{ad} \times \frac{m_{ad}}{m_w}$$

where,

VM_w : volatile matter content of biochar (wet weight basis) (%)

VM_{ad} : volatile matter content of the measurement sample (air-dry basis) (%)

m_w : mass of the sample before preliminary drying (g)

m_{ad} : mass of the sample after air-drying (g)

7.4.6 Times of measurements

Measurement is repeated twice in the same analytical laboratory. If the difference in measured volatile matter content of the measurement sample between duplicated measurements exceeds the tolerance, repeat the measurement once more.

7.4.7 Tolerances

The tolerances of volatile matter content of the measurement sample are provided in the table below.

Volatile matter content of the measurement sample	Tolerances (measured values)
50.0 or less ~~more~~	4
50.1 or more ~~less~~	6

Unit (%)

7.4.8 Value to be reported

If the difference between the two measured volatile matter content is within the tolerance, calculate the mean value of the two measured values by rounding it off one decimal place to determine the value to be reported.

7.5 Calculation method of refractory carbon content

a) Refractory carbon content of the measurement sample (air-dry basis)

$$RC_{ad} = 100 - (M_{ad} + A_{ad} + VM_{ad})$$

where,

RC_{ad} : refractory carbon content of the measurement sample (air-dry basis) (%)

M_{ad} : moisture content of the measurement sample (air-dry basis) (%)

A_{ad} : ash content of the measurement sample (air-dry basis) (%)

VM_{ad} : volatile matter content of the measurement sample (air-dry basis) (%)

b) Refractory carbon content of biochar (wet weight basis)

The refractory carbon content of biochar (wet weight basis) is calculated using the following formula to two decimal places and rounded to one decimal place.

$$RC_w = RC_{ad} \times \frac{m_{ad}}{m_w}$$

where,

RC_w : refractory carbon content of biochar (wet weight basis) (%)

RC_{ad} : refractory carbon content of the measurement sample (air-dry basis) (%)

m_w : mass of the sample before preliminary drying (g)

m_{ad} : mass of the sample after air-drying (g)

7.6 Report of the measurements

Report of the measurements shall contain the following information.

(1) Biochar manufacturer

(2) Biochar manufacturing date

(3) Types of raw materials for biochar

(4) Lot number

(5) Number of samples tested

(6) Measurement results

Measurement sample
moisture content, ash content, volatile matter content, refractory carbon content （air-dry basis）(%)
Mass of the sample before preliminary drying (g)
Mass of the sample after air-drying (g)
Biochar
moisture content, ash content, volatile matter content, refractory carbon content （wet weight basis）(%)

(7) Measurement date

(8) Other related information

8. Mass conversion factor for refractory carbon

8.1 Principle

The bulk density of the sample is multiplied by refractory carbon content of biochar (wet weight basis) and further increased 10-fold to determine the mass conversion factor for refractory carbon.

8.2 Calculating mass conversion factor for refractory carbon

Mass conversion factor for refractory carbon is calculated to one decimal place using the following formula and rounded off to a figure before a decimal point.

$$\alpha = D \times \frac{RC_w}{100} \times 1000$$

where,

α : mass conversion factor for refractory carbon (kg/m^3)

D : bulk density (g/cm^3)

RC_w : refractory carbon content of biochar (wet weight basis) (%)

8.3 Report of the measurements

Report of the measurements shall contain the following information.

(1) Biochar manufacturer

(2) Biochar manufacturing date

(3) Types of raw materials for biochar

(4) Lot number

(5) Measurement results

(6) Measurement date

(7) Other related information

9. References

JIS M 8810:1994 Coal and coke -- General rules for sampling, analysis and testing

JIS M 8811:2000 Coal and coke -- Sampling and sample preparation

JIS M 8812:2004 Coal and coke -- Methods for proximate analysis

JIS Z 7302-9:2002 Densified refuse derived fuel -- Part 9: Test method for apparent bulk density