Guidelines

European Biochar Certificate

for a sustainable production of biochar

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These guidelines are effective as of 1 January 2012 and constitute the basis for biochar certification through the independent, governmental accredited inspection agency q.inspecta.

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Table of contents

1. Objective of the biochar guidelines
2. Definition of biochar
3. Biomass feedstock
4. General requirements for keeping production records
5. Biochar sampling
6. Biochar properties
7. Pyrolysis
8. Health and safety regulations
9. EBC-Feed: Biochar for animal feeding
10. Processing of EBC-certified biochar
11. Labelling requirements, EBC-logos, sale
12. Control and certification
13. Analytical methods
14. Analytical methods for EBC-Feed
15. Additional analytical parameters
16. References

APPENDIX
17. Positive list of biomasses
18. Company declaration
19. Biochar production records
Guidelines for the production, processing and sale of biochar

European Biochar Certificate (EBC)

Publisher: Ithaka Institute for Carbon Strategies, Switzerland

1. Objective of the guidelines and certification

For thousands of years, charcoal has been one of civilisation's basic materials. By far the most common use of charcoal was for cooking, for heating and for smouldering when producing metal tools. However, for centuries charcoal and biochar have also been used for conditioning soils, or as litter (bedding) materials, as medicine and also as a feed additive. In the course of the last century most of this traditional knowledge has been lost and is being rediscovered since 2010.

Thanks to wide-ranging multidisciplinary research and field trials, the understanding of the biological and chemo-physical processes involved in the production and use of biochar has made great progress. Thus a major increase in the agricultural use of biochar is to be expected for the next years. Usage ranges from soil conditioning, compost additives and carrier for fertilizers, manure treatment and litter (bedding) materials to silage additives, feed-additives, medical applications and others. Moreover, an increasing use of biochar in construction and composite materials, in the textile and electronic industries, for waste water treatment and soil remediation is expected.

Traditional kiln production of charcoal and biochar without the combustion of pyrolysis gases was unsatisfactory with regard to its carbon efficiency and especially its environmental footprint. Accordingly, those kilns are unsuitable for the production of larger amounts of biochar to be used in agriculture. Modern pyrolysis plants and also some types of farmer scale kilns like flame curtain pyrolysis systems are now ready to produce biochar from a large variety of different feedstocks in an energy efficient way and without harming the environment. As both, biochar properties and the environmental footprint of its production are largely dependent on the control of pyrolysis parameters and the type of feedstocks to be used, a secure control system for its production and analysis needs to be introduced.

In issuing these guidelines for the certification of sustainable biochar production, processing and sale, the Ithaka Institute intents to introduce a control mechanism based on the latest research and practices. The European biochar certificate (EBC) aims to enable and guarantee sustainable biochar production, processing and sale. It is introduced to provide customers a reliable quality basis, while giving producers the opportunity to proof
that their product meets well-defined and recognized quality standards. It further aims at providing a firm state-of-the-art knowledge transfer as a sound basis for future legislation. Finally, it is introduced to prevent misuse and to avoid from the start the risk of “special interests” that would call for exceptions (e.g. such as using industrial wastes or cutting down native forests to produce biochar).

Biochar production technology is currently developing very fast, with well over 1000 research projects worldwide looking into biochar properties, interactions, and applications. Every month new test results and numerous scientific studies appear on the subject. Every year sees new manufacturers of pyrolysis equipment entering the market and the areas in which biochar and biochar products are used grow steadily and rapidly. The European biochar certificate is closely linked to this research and technical momentum and will accordingly be revised regularly to take into account the latest findings and developments. Thresholds and test methods will be adapted to reflect the latest findings and, if necessary, re-introduced.

The goal of these guidelines is to ensure the control of biochar production and quality based on well-researched, legally backed-up, economically viable and practically applicable processes. Users of biochar and biochar-based products will benefit from transparent and verifiable monitoring and quality assurance. It is our as well as every biochar user’s duty to make sure that a good idea will not be carried into misuse. The certificate was designed to serve this goal.

The European Biochar Certificate is a voluntary industry standard in Europe. In Switzerland it is obligatory for the use of biochar in agriculture.
2. Definition of biochar

Biochar is a heterogeneous substance rich in aromatic carbon and minerals. It is produced by pyrolysis of sustainably obtained biomass under controlled conditions with clean technology and is used for any purpose that does not involve its rapid mineralisation to CO$_2$ and may eventually become a soil amendment.

Biochar is produced by biomass pyrolysis, a process whereby organic substances are broken down at temperatures ranging from 350°C to 1000 °C in a low-oxygen process. Torrefaction, hydrothermal carbonisation and coke production are further carbonisation processes whose end products cannot however be called biochar under the above definition. Biochars are therefore specific pyrolysis chars characterised by their additional environmentally sustainable production, quality and usage features. Gasification is understood as being part of the pyrolysis technology spectrum and can, if optimized for biochar production, be equally certified under the EBC.

In accordance with the certificate to which these guidelines apply, a differentiation is made between three different biochar grades, each with its own threshold values and ecological requirements: "basic", "premium", and “Feed”

Moreover, the present standard sets the regulations for the certification of biochar based products.

For gaining the European biochar certificate, the following criteria regarding the biomass feedstock, the production method, the properties of the biochar and the way it is applied and labelled have to be met.
3. Feedstock

3.1 Only organic substances listed in the positive list (Appendix 1) may be used for the production of biochar.

3.2 It must be ensured that non-organic waste such as plastic, rubber, or electronic scrap is adequately removed.

3.3 Feedstocks must be free of paint, solvents and other organic or non-organic contaminants.

3.4 When using primary agricultural products (e.g. Miscanthus or short rotation forestry), it must be guaranteed that these were grown in a sustainable manner.

3.5 Biochar may only be produced from forestry wood if appropriate standards, laws or certificates (e.g. PEFC or FSC) can proof sustainable forest management.

3.6 Only biomass that was grown in Europe is allowed as feedstocks for the production of biochar.

3.7 Complete records of feedstocks must be kept.
4. General requirements for biochar production records

Each biochar series must be clearly labelled and be given a unique identification number. The traceability of the biomass feedstock and of the conditions of production must be ensured. For each biochar series, separate production records are to be kept. Each series must be analysed in an EBC accredited laboratory to ensure compliance with the required threshold values.

A biochar series is defined as follows:

1. The pyrolysis temperature in °C do not fluctuate more than 20%. Interruption of the production is allowed as far as the production parameters keep the same after the restart of the production. For small-scale production with a yearly production below 50 t of biochar continuous recording of production temperatures are not requested.
2. The composition of the pyrolysed biomasses does not fluctuate more than 15% based on the type of feedstock listed in the feedstock positive list.
3. The production period of the series does not exceed one year including any interruption of the production.
4. Complete production records must be kept, providing detailed descriptions and dates of any production problems or halts.

Once any one of these four criteria is not met, the biochar subsequently produced belongs to a new series for which new production records and analyses are required.

Sending biochar samples to the accredited laboratory:

4.1 The biochar samples have to be sent to the accredited laboratory within the first three days after the start of a new series. As long as it can be guarantied that the same biomass feedstock and the same process parameters are used, the biochar sample can be sent up to three weeks before the start of a batch.
4.2 When sending the biochar sample to the EBC accredited laboratory, the series number of the sample has to be transmitted to the lab.
4.3 The accredited laboratory has to be informed that the sent sample should be considered as a sample to obtain the EBC certification.
4.4 The accredited lab will then send a copy of the analytical results to the accredited controlling organism as well as to the EBC.
4.5 The EBC has the right to use the analytical results anonymised for statistical assessments.
5. Biochar sampling

The biochar samples have to be taken following the procedure described here. The accredited controlling inspector is entitled to take samples and send them to the accredited laboratory or as reserve sample to the EBC.

To obtain a biochar sample as representative as possible (in terms of accuracy and precision) of a total lot (batch), it must be taken in a proper way. For this, the following general guidelines have to be followed:

5.1 A biochar lot (batch) subject to sampling must consist of at least the amount of one day of production.

5.2 Before sampling, the whole lot has to be thoroughly mixed 3 times by turning and piling it upside-down by means of physical replacement with a front loader or comparable technical device.

5.3 15 subsamples of 1.5 litre each have than to be arbitrarily gathered from different spots of the homogenized biochar lot (ISO (2006) or Bunge & Bunge (1999)). For small scale production of less than 200 litres per day the subsample size may be reduced to 0.5 litres.

5.4 The 15 subsamples have to be united and milled or crushed if the particle size is above 3 mm.

5.5 The new subsample has than to be homogenized thoroughly by turning and piling it 3 times upside-down.

5.6 A further 15 sub-subsamples of 150 mL each have to be arbitrarily taken from different spots of the gathered subsample lot.

5.7 The 15 sub-subsamples (totalling 2.25 L) have to be united and well mixed.

5.8 The sample of 2.25 L has to be sent to an accredited laboratory for the EBC analyses.

As illustrated in Bucheli et al. (2014), such a sampling procedure may still not be sufficient to obtain truly representative samples, but assures a degree of accuracy (bias) and reproducibility (variance) to compare analytical results with guide values set in this certificate.

5.9 Alternatively, an automated incremental cross-stream sample of 100 g could be taken every 30 min for at least 24 hours. Such an automated incremental cross-stream sample could replace the above-described sampling method.
5.2 Random Sampling

At each control visit, the controller takes a random sample of the biomass feedstock and the resulting biochar, seals both sample bags and let the producer send them to the EBC.

5.10 Retention Sample

In addition to the EBC-analysis sample and random sample, the producers are obliged to take daily an incremental cross-stream sample of at minimum 100g. The time of the daily sample has to be marked in the production protocol. The daily cross-stream samples have to be collected in a monthly sample bag or case. After one month the sample bag has to be sealed and dated. The next 30 cross-stream samples will be collected in a new monthly bag or case. The incremental cross-stream sampling guaranties a most representative sampling of the product.

The monthly sample bags (3 kg) have to be stored for at least three years at a protected and dry location.
6. Biochar properties

It is not the task and purpose of the EBC certificate to provide a complete physico-chemical characterization of biochar. The costs of analyses for such a characterization would go beyond economically reasonable limits. Rather, it is crucial for the EBC certificate to guarantee compliance with all environmentally relevant limit values and to declare all product characteristics relevant to agricultural practice. The permissible test methods as well as the analytical methods for the individual parameters are detailed in Chapter 13.

6.1 The biochar's carbon content must be higher than 50% of the dry mass (DM).

Pyrolysed organic matter with a carbon content lower than 50% are classified as Pyrogenic Carbonaceous Material (PCM). The organic carbon content of pyrolysed biomass fluctuates between 5% and 95% of the dry mass, dependent on the feedstock and process temperature used. For instance the carbon content of pyrolysed poultry manure is around 25%, while that of beech wood is around 85% and that of bone is less than 10%.

When using mineral-rich feedstocks such as animal manure, the pyrolysed products may contain more ash than carbon. Such pyrolysed matter with carbon contents below 50% are therefore not classified as biochar but as Pyrogenic Carbonaceous Material (PCM). When PCM meet all other threshold criteria of this biochar certificate, they may be marketed as EBC certified Pyrogenic Carbonaceous Material (PCM).

6.2 The molar H/C\textsubscript{org} ratio must be less than 0.7

The molar H/C\textsubscript{org} ratio is an indicator of the degree of carbonisation and therefore of the biochar stability. The ratio is one of the most important characterising features of biochar. Values fluctuate depending on the biomass and process used. Values exceeding 0.7 are an indication of non pyrolytic chars or pyrolysis deficiencies (Schimmelpfennig and Glaser, 2012).

6.3 The molar O/C\textsubscript{org} ratio must be less than 0.4

In addition to the H/C\textsubscript{org} ratio, the O/C\textsubscript{org} ratio is also relevant for characterising biochar and differentiating it from other carbonisation products (Schimmelpfennig and Glaser, 2012). Compared to the H/C\textsubscript{org} ratio, direct measuring of the O content is expensive and not standardized. Therefore the calculation of the O content from C, H, N, S and ash content is accepted.

6.4 Volatile Organic Compounds (VOC)

During the pyrolysis process aromatic carbon, carbonates and a multitude of divers volatile organic compounds are formed. The later constitute a large part of the pyrolysis gas that partly condensates on biochar surfaces and pores. These condensed pyrolysis gas compounds are substantial constituents of biochar materials (Spokas et al., 2011; Yang et al., 2013), are essential for certain biochar functions and thus necessary for the
characterisation of biochar and PCM. Moreover, the VOC-content is an important indicator for the evaluation of the pyrolysis process.
Permitted test methods: Thermal-Gravimetric-Analysis (TGA)
Principle: The TGA determines the loss of weight of the volatile matter according to the temperature without oxygen.
(Not obligatory for producers of less than 50 t biochar or PCM per year)

6.5 The biochar nutrient contents with regard to nitrogen, phosphorus, potassium, magnesium and calcium must be provided.
The nutrient contents of different biochars are subject to major fluctuations. It has to be considered that these nutrients may only partly be available to plants. They may take decades before entering the biological life cycle. The nutrient availability of the phosphorus found in biochar is for instance only 15% in the first year, that of nitrogen a mere 1%, while that of potassium can reach 50% (Camps-Arbestain et al., 2015).
Permitted test methods: DIN EN ISO 17294 – 2 (E29), DIN EN ISO 11885
(Specify for each batch)

6.6 The following thresholds for heavy metals must be kept
The following maximum values for heavy metals correspond - for the basic quality grade - to Germany’s Federal Soil Protection Act (Bundes-Bodenschutzverordnung or BBodSchV), and - for the premium quality grade - to Switzerland’s Chemical Risk Reduction Act, Appendix 2.6 on recycling fertilisers. The respective thresholds refer to the biochar’s total dry mass (DM):

basic: Pb < 150 g/t DM; Cd < 1,5 g/t DM; Cu < 100 g/t DM; Ni < 50 g/t DM; Hg < 1 g/t DM; Zn < 400 g/t DM; Cr < 90 g/t DM; As < 13 g t\(^{-1}\) TM 
premium: Pb < 120 g/t DM; Cd < 1 g/t DM; Cu < 100 g/t DM; Ni < 30 g/t DM; Hg < 1 g/t DM; Zn < 400 g/t DM; Cr < 80 g/t DM; As < 13 g t\(^{-1}\) TM

Beside some few heavy metals that are volatile at pyrolysis temperatures, the amount of heavy metals contained in the originally feedstock will remain in the final product. Therefore, most heavy metals are more concentrated in the biochar than in the original biomass. However biochar is able to very effectively bind a number of heavy metals, thereby immobilising them for a considerable long time. As the quantities of biochar used in agriculture are relatively low compared to those of compost and manure, toxic accumulation of heavy metals could practically be ruled out.

Abrasion in connection with the use of chromium-nickel steels in the construction of pyrolysis reactors may lead, especially in the first weeks of production, to an increased nickel contamination of biochar. For biochar with a nickel load of up to 100 g / t TM, a one-off exemption may be applied for, according to which these biochars may be used for non agronomic uses or for composting, provided that the applicable limit values of the finished compost are complied with.
6.7 pH, bulk density, water content, water holding capacity, and specific surface area.
The biochar's pH value is an important criterion with regard to its specific use in substrates, soil amendments, or for binding nutrients in animal husbandry. Details on bulk density and water content are necessary for the production of homogeneous substrate mixtures or filter ingredients requiring constant carbon contents. The specific surface area is a measure of a biochar's quality, and a control value for the pyrolysis method used. The water holding capacity of a given biochar is a valuable indication on it's effectiveness in increasing a soil's water holding capacity and for humidity buffering when e.g. applied to the root zone. However, its analysis is not mandatory. The BET specific surface area is an important characterization and comparison criterion for the physical structure of biochar. However, the specific surface area of biochar is only a relative and no absolute value. The reason for this is that all analytical methods to measure the specific surface area effect the pore size distribution and pore accessibility and thus the measured surfaces due to the necessary steps of drying and degassing of the samples. Therefore, it is particularly important to rigorously follow the EBC accredited analysis method for the measurement of the BET specific surface area, in particular in regard to the applied temperature (150 °C) and duration (2h) of drying and degassing.

6.8 The biochar's PAH content (sum of the EPA's 16 priority pollutants) must be under 12 mg/kg DM for basic grade and under 4 mg/kg DM for premium grade biochar. As in any combustion, pyrolysis also causes polycyclic aromatic hydrocarbons (PAHs) to be released (Fagernäs et al., 2012). Their amount is dependent in particular on production conditions (Bucheli et al., 2015). Modern pyrolysis methods allow a significant reduction of the PAH pollution. High PAH levels are an indication of unsatisfactory or unsuitable production conditions. On the other hand, biochar is able to very effectively bind PAHs and is, therefore, used as air filter for removing PAHs from exhaust gases or for immobilising PAHs in contaminated soils (Li et al., 2014). The risk of PAH contamination, when using biochar in agriculture, is hence considered to be low, even if higher thresholds would be taken into account. Although some PAHs bound in biochar may become available to plants, this takes place at an even lower level than with compost, digestate or manure due to biochars' adsorptive capacity (Gomez-Eyles et al., 2013). Nevertheless current approval practice indicates that the PAH threshold defined in the Swiss Chemical Risk Reduction Act (ChemRRV) will also apply to biochar and that an exemption on the grounds of biochar's sorption properties is hardly feasible. Therefore, the threshold for premium grade biochar corresponds to the PAH threshold defined in the Swiss Chemical Risk Reduction Act (ChemRRV), also used as a guideline in the Compost Act (Kompostverordnung). No PAH thresholds are specified yet in the European soil protection regulations for soil conditioners and organic fertilisers. The threshold for basic grade biochar is therefore based on a value which, taking the latest research into account, implies a minimum risk for soils and users.
Please note that, due to biochar's high adsorption properties, most standard methods for testing PAHs are unsuitable for biochar. According to researches carried out by Hilber et al. (2012), an extended Toluol extraction is needed before any suitably representative test value can be determined. DIN EN 15527: 2008-09 and DIN EN 16181:2019-08 (with toluol extraction) proved to be close to the method of Hilber et al. (2012) and are admitted too (see chapter 13).

6.9 PCB content must be below 0.2 mg/kg DM; levels of dioxins and furans must be below 20 ng/kg (I-TEQ OMS).
Modern pyrolysis facilities produce only very low levels of PCB, dioxins and furans, we therefore consider one control per production unit as sufficient. Dioxin content is mostly dependent on the chlorine content of the feedstock. All authorized feedstock of the feedstock positive list have low chlorine content and are expected to produce during pyrolysis only dioxin contents that are lower than the threshold by several orders of magnitude. If the controlling organism or the EBC considers the risk of chlorine contamination of a given feedstock as relevant, they can require supplemental dioxin analyses. Thresholds are based on the soil protection regulations applicable in Germany and Switzerland (BBodschV, VBBo, ChemRRV). (Specify for each production unit for producers of more than 50 t biochar or PCM per year)
7. Pyrolysis

7.1 Biomass pyrolysis must be operated in an energy efficient manner.

With the exception of the preheating of the pyrolysis reactor, the use of fossil fuels for heating the pyrolysis reactor is prohibited. The use of waste heat from other industrial processes, such as bio-digesters or cement production or the use of solar thermal energy is permitted. If the pyrolysis reactor is electrically heated, the use of renewable energy sources or the use of surplus electricity must be proven.

7.2 The pyrolysis gases produced during pyrolysis must be recovered or burned. They are not allowed to escape into the atmosphere.

Most of the global charcoal and biochar production is still done using obsolete technology (Brown et al., 2015) where most of the original feedstock carbon is released as toxic emissions to the atmosphere. Although the material quality of biochar produced in such kilns may meet EBC requirements, the environmental impact of such production techniques is highly negative. However, if pyrolysis gases are trapped and are cleanly burned or used as bio-oil for the chemical industry, the environmental impact is neutral and even improved compared to biomass burning or natural decomposing. The EBC certificate guarantees that only biochar production technology is used that does not release unburned pyrolysis gases to the atmosphere.

7.3 Syngas combustion must comply with national emission thresholds.

With emission thresholds and regulations differing from one European country to the next, any further definition of emission thresholds for pyrolysis facilities would exceed the purpose and proportionality of these guidelines. Therefore manufacturers must provide a guarantee that their facilities comply with national emission regulations.

7.4 The heat produced by the pyrolysis process must be used.

35 to 60 % of the energy contained in the biomass feedstock is eventually contained in the pyrolysis gas. Part of the energy released during the combustion of these gases is usually used to heat the biomass for pyrolysis. However, high amounts of waste heat remain. At least 70% of this waste heat must be used, e.g. for drying biomass, for distant heating, for generating electricity or for similar sustainable purposes. Bio-oil and pyrolysis gases can also be stored for later material and/or energetic uses. Small-scale biochar production units with an annual output of less than 50 tons are exempt of the heat recovery requirement, although it is highly recommended.
8. Work safety and health

8.1 Fire and dust protection regulations are to be complied with throughout the entire production, transport and user chain.

8.2 All workers must be informed in writing about possible risks and dangers of and around the production facility and sign the document. In particular, this concerns the self-ignitability of char dust, respiratory protection, contact with bio-oil and tars and possible gas leakage.

8.3 During transport and bulk transfers attention must be paid to the biochar being sufficiently moist to prevent dust generation or dust explosions.

8.4 Workers must be equipped with suitable protective clothing and breathing masks where necessary.
9. Biochar for use as a feed additive (EBC FEED grade)

Biochar is a traditional feed additive that was often used to treat digestive problems of livestock. Since 2010, biochar is increasingly used as an additive to daily feed mixtures. The use of biochar (i.e. vegetal carbon) as a feed additive is authorized by the EU-Feed Regulation [1]. According to EU-Regulation 2002/32/EC of 7 Mai 2002 on undesirable substances in animal feed [2] and EU-Regulation 396/2005 of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin [2], analytical parameters, methods, and thresholds for biochar used as feed are different than those used in soil. Parameters and analytical methods for the EBC-certification of biochar as animal feed additive (EBC FEED) are outlined below.

The permissible test methods as well as the analytical methods for the individual parameters are detailed in Chapter 14.

9.1 Precondition for EBC FEED grade certification
Biochar can only be certified under EBC FEED when all conditions for EBC premium quality are met and the production was accordingly certified.

9.2 Biomass – only biochar made from natural and untreated wood is permissible
Although a large number of scientific studies have shown positive effects of biochar feed on animal health [3,4], there are few studies on the specific effects of different types and qualities of biochar on digestive activities and animal welfare in general. There are many years of experience in the use of wood-biochar (i.e. charcoal) and activated carbon, but not of biochar from other biomass such as straw, pomace or green waste with higher ash contents. Therefore, it can currently not be ruled out with certainty that biochars from more ashy non-woody biomass precursors could have adverse effects on animal health when used as a feed additive on a long-term basis. Based on the precautionary principle, only biochar from natural, untreated trunk wood is currently permitted for use as animal feed. The EBC follows closely the scientific literature on biochar feed and will include other biomass feedstock as soon as safe and reliable data can be presented.

9.3 Carbon content > 80% of dry matter (DM)
The Carbon content of biochar for use as animal feed must contain at least 80% carbon (dry matter).

9.4 Heavy metals
According to feed regulations, the contents of the heavy metals including arsenic, lead, cadmium and mercury must be stated. Their limits differ from those for EBC premium quality. The use of biochar as feed is based on the following thresholds to be calculated on
88% of the dry matter content: arsenic: 2 mg kg\(^{-1}\); lead: 10 mg kg\(^{-1}\); cadmium 1 mg kg\(^{-1}\) and mercury: 0.1 mg kg\(^{-1}\).

9.5 Benzo-a-pyren < 25 µg/kg
In addition, the PAH-thresholds for EBC premium quality (4 mg PAH16 kg\(^{-1}\)), biochar for animal feed is subject to the specific reference limit for carcinogenic PAHs of 25 µg kg\(^{-1}\) benzo-a-pyrene.

9.6 Dioxine, furane, dioxin-like PCB (WHO-PCB) und non-dioxin-like PCB (DIN-PCB).
The EU feed regulations prescribe strict limits for polychlorinated dioxins, furans and PCBs, which are well below the limits of the soil protection ordinance. Therefore, (1) each batch of feed biochars must be analyzed for these substances, and (2) the accredited test method must have a lower detection limit. Consequently, special test methods and limit values for feed grade biochar apply here.
For PCDD / PCDF, a trigger value of 0.5 ng TE kg\(^{-1}\) at 88% DM and a limit of 0.75 ng TE kg\(^{-1}\) at 88% DM apply. For dl-PCB, a trigger value of 0.35 ng TE kg\(^{-1}\) at 88% DM applies. For PCDD / PCDF + dl-PCB the threshold is 1.25 ng TE kg\(^{-1}\) at 88% TS. For the sum 6 of DIN PCB, a limit value of 10 µg TE kg\(^{-1}\) at 88% DM applies.

9.7 Fluor < 150 mg kg\(^{-1}\) (88% TS)
Fluorine salts are usually volatile in pyrolysis conditions and will hardly occur in biochars in significant concentrations. However, according to the feed ordinance, the analysis is required by default.

9.8 Dry matter, crude ash, ash insoluble in hydrochloric acid
The specification of dry matter, crude ash content and HCl-insoluble ash are prescribed standard values of the EU feed regulations and must be stated on the product label. The content of the ashes must be determined by combustion at 550 ° C and given on a 88% dry matter basis.

9.9 Crude protein, crude fibre, crude fat
The indication of crude protein, crude fiber and crude fat contents are prescribed standard values of the EU feed regulations. Crude protein, crude fiber and crude fat are completely decomposed in the course of complete pyrolysis and are therefore no longer present in biochar. A biochar is considered to be completely pyrolyzed if the H / Corg ratio is <0.7. If the H / Corg ratio according to EBC premium quality is less than 0.7, the analysis of crude protein, crude fiber and crude fat is not required and set by definition as 0 g kg\(^{-1}\). The information is mandatory and must be stated on the product label.
10. Certification of biochar-based products and biochar processing companies

In agriculture and animal husbandry, biochar is rarely used in pure form. Most often it is part of a processed product such as a soil substrate, compost, fertilizer, bedding material, feed, or as AD and silage additive. In addition to the producers specialized in biochar manufacturing, a growing industry has developed, acquiring and processing biochar as a raw material for the production of biochar-based products.

In order to guarantee and properly label products made with EBC certified biochar, the entire supply chain including production, processing, packaging and labeling of the products needs to be controlled and certified.

Products containing biochar are only allowed to use the EBC logo and the inscription "Manufactured with EBC certified biochar" if the biochar processing company and their biochar-based products have been certified according to the following guidelines.

10.1 Exclusive use of EBC certified biochar

The risks associated with the use of non-certified biochar in agriculture, livestock farming and in products ultimately destined for agricultural use, such as compost or biogas slurry, are considered to be very high, since in this case pollutants such as PAHs, dioxins and heavy metals may enter the human food chain and accumulate permanently in soils and the environment.

Therefore, products made with biochar can only become EBC certified if the processing company uses exclusively EBC certified biochar for their biochar-based products. The certified company may not use, store or trade any biochar for agronomic purposes that is not EBC certified. Non-EBC certified biochar may be used by means of a written EBC exemption permit for industrial purposes such as in building materials and plastics or as charcoal for barbecue, provided that the spatial separation of certified biochar and the user protection are ensured. Without EBC exemption, no non-EBC certified biochar may be used, stored and traded by the certified company.

10.2. Incoming goods inspection

All incoming biochar or biochar-based products must have the corresponding EBC certificate (EBC premium, EBC basic or EBC feed) marked on the delivery documentation and labels. The incoming goods inspection must be documented. Unmarked biochar and biochar-based products should not be processed.

10.3 Storage

Biochar and biochar-based products must be stored in such a way that no contamination can occur. Particular attention should be paid to gaseous pollutants (for example engine exhaust gases) as these can be absorbed by the biochar. Biochar processors must ensured that neither different EBC grades (EBC premium, EBC basic, EBC feed) nor different batches from different or the same manufacturers are mixed without documentation. The
quality and origin of stored biochar as well as a traceable identification number and product name must be marked clearly visible.

10.4 Processing journal
Each processing step of biochar and biochar-based products must be documented in a processing protocol. The quantity and quality of all processed biochar and the amount of biochar contained in the final products have to be documented. If the biochar or biochar-based products are merely repackaged or relabeled, the quantity and quality of the original and final products must still be listed in the processing journal. The control of the flow of goods (balance between incoming biochar and biochar products, specific processing, and the outgoing biochar and biochar products) must be tracked and documented at all times.
11. Labeling and Advertising with EBC Certification

11.1 Advertising with EBC certification

Only EBC certified companies are entitled to advertise their EBC certification and to mark their products accordingly using the signs listed below under points 11.1.1 and 11.1.2. The listed signs (logos) can be requested and downloaded via the website www.european-biochar.org or the control body «q.inspecta».

11.1.1 Reference to certification by q.inspecta

If reference is made to the use of EBC certified biochar on the label, delivery note or any other document related to the EBC certified product (e.g., website), one of the following must be noted on the label:

![q.inspecta logo]

11.1.2 Use of the term "EBC"

The characters
(1) "EBC" and
(2) EBC logo:

![EBC logo]

were notified as Union trademarks by the Foundation Ithaka Institute on 24 May 2019 for the following list:

Class 01: Chemical substances, chemical materials and chemical preparations and natural elements, in particular biochar, activated carbon activated adsorbents, activated carbon filters for the purification of gases, and activated carbon filters for the purification of liquids; Growth and fertilizers and chemicals used in agriculture, forestry and horticulture, in particular fertilizers (in part) consisting of biochar
(biochar); Putties, fillers and glues for industrial purposes, in particular coal for filters for removing organic contaminants from water; Filter materials [chemical, mineral, vegetable and other raw materials], in particular activated carbon.

Class 04: Fuels, in particular of biochar (charcoal, charcoal).
Class 05: Biochemical feed additives made from biochar.
Class 19: Building materials and components, not of metal, (partially) consisting of biochar.
Class 31: Foodstuffs and animal feed (in part) consisting of biochar (biochar); Litter and bedding materials for animals (partially) consisting of biochar (biochar).
Class 40: Production of coal by biomass pyrolysis; Processing of biochar (biochar) as a raw material for the production of various products.

The Foundation Ithaka Institute grants EBC certified companies the right to use these trademarks under the following conditions:

a) The EBC logo may only be used as registered.
b) The word mark “EBC” may only be used in isolation or in combination with the words "certified" or "certified".

If the user of the warranty marks culpably violates the statutes of these trademarks, he is liable to pay a fine of 500, - EUR to 10,000, - EUR to the Foundation Ithaka Institute. The amount of the fine to be paid shall be determined by the Foundation Ithaka Institute at its reasonable discretion and, in the event of dispute, reviewed by a court of law as to its appropriateness. Accordingly, the Foundation deprives Ithaka Institute of the right to use the warranty marks.

11.2 Information on biochar
The shipping label for unprocessed EBC biochar must indicate the following information about the biochar:

- Quality grade (basic / premium / Feed)
- Carbon content
- H / Corg – ratio
- Nutrient content (N, P, K, Ca, Mg)
- The highest temperature reached in the pyrolysis process
- pH
- Specific surface area
- Water content
- Raw density

Furthermore, an internet link or QR code must be printed on the label and the shipping label, via which the EBC-certified analysis of the corresponding batch can be viewed and downloaded.
11.3 Information about biochar containing products

The shipping label and the biochar product packaging label shall include the following information:

- Quality grade of the contained Biochar (basic / premium / Feed)
- Carbon content of the biochar used in the product
- Biochar content

If different EBC grades are used in a product, the end product may only bear the EBC quality grade corresponding to the lowest certified biochar in the product. EBC basic is the lowest, EBC premium the medium quality designation and EBC feed the highest quality. Only biochar certified with EBC feed certification may be used for feed. If several EBC certified biochars are mixed in the product, a corresponding averaged carbon content must be reported. The biochar content should be expressed either in weight or in volume.

Furthermore, an internet link or QR code must be printed on the label and the shipping note, via which the analytical values of the biochar contained in the product can be consulted. It does not necessarily have to be the copy of the official EBC analysis of the biochar producer. The inspector checks the conformity of the biochar analysis on the website and the supplier’s EBC Eurofins analysis.

Certified resellers of biochar or biochar products do not need to name and identify the original company or production site.
12. Control and certification

Biochar producers’ compliance with European Biochar Certificate requirements is coordinated throughout Europe by the independent, governmental accredited quality assurance agency q.inspecta. On-site inspections take place once a year. Producers confirm that they always keep up-to-date production records.

If a biochar producer desires to become EBC certified, their entire biochar production site must be controlled and certified, regardless of whether only one batch, several or all batches qualify for one of the EBC certificates. Biochar from non-EBC certified batches may not be sold for agriculture or livestock uses.

In order to be reasonably proportional to the risk assessment and to the environmental protection goals, small-scale producers with an annual production capacity below 50 t of biochar are exempt from on-site inspection of production. Compliance for small-scale producers is controlled by the accredited quality assurance agency via self-declaration and a detailed description of the complete production process. The requirements for biochar batch analyses, thresholds, feedstock sustainability and handling of biochar is the same as for industrial producers. Manufactures producing more than 50 t biochar per year are not considered small-scale producers even if they intend to certify less than 50 t only. If for example, a manufacturer produces 200 t of biochar per year and only wants to certify a single batch of e.g. 40 t, the yearly on-site inspection by the accredited controlling body is still obligatory.

For small biochar-processing companies, a small-scale producer regulation may also apply. If less than 10 tons of biochar are processed into biochar-based products per year, these establishments are exempt from the annual on-site inspection. Compliance with the production and quality guidelines is evaluated by the government accredited inspection body using self-declaration and processing protocols.

The trade in unpackaged, loose goods (for example containers) or underpackaging and repackaging as well as relabelling are subject to the control and certification obligation of processing companies.

The pure trade of ready packed and EBC certified biochar is subject to no further control and certification if correctly labeled by the certified manufacturer according to EBC regulations. Thus, if a non-certified company or individual markets EBC-certified biochar or biochar-based products, both the certified producer and the biochar batch must be clearly traceable. The certified manufacturer must therefore be named on the label or delivery note. If the original manufacturer is not mentioned on the packaging or on the delivery note, the company placing the goods on the market must inevitably be EBC-certified, otherwise he may not label the goods as EBC-certified.
To register for certification, please contact directly the controlling body q.inspecta. It is recommended to contact q.inspecta before commencing production to enable integration of the necessary recording steps into the production processes.

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13. Analytical Methods

Basic Package

Sample preparation (DIN 51701-3):
After homogenization, the sample is divided representatively into portions. This subsampling is done by quartering (quarter method) of the homogenized sample. Approximately 100 g of the original sample are used for the determination of the conductivity, the salt content and pH.
A portion of the sample is dried at 40 °C and is divided into some subsamples after drying and homogenization. Approximately 250 g of the 40 °C dried and uncrushed sample is used to determine the true density and the BET surface of the material. Approximately 50 g of the 40 °C dried sample is finely ground in a vibratory mill. After homogenization the fine material is subsampled for further analysis (PAK, TGA, ash, CHN, S, trace and major elements). Unless otherwise specified, the particle size of the analytical samples are specified by the respective methods and standards.

Bulk density (analogue VDLUFA-Method A 13.2.1):
The sample (at least 300 ml) is filled into a graduated cylinder and the mass is determined by weighting. The volume of the sample is read after 10 times compression by means of falling. The density in kg / m³ is calculated from the mass and the volume of the sample.

Electrical conductivity (salt content) - Method of the BGK (Federal quality community compost), volume 1, method III. C2 – in analogy to DIN ISO 11265:
Adding 20 g of the sample to 200 ml desalinated water and shaking it for 1 hour, followed by filtration of the solution. The conductivity is measured then in the filtrated water. The correction of temperature is automatically done in the measuring device. The electrical conductivity is given for a solution at 25°C. The salt content is calculated using the factor 52,8 [mg KCl/l]/[10⁻⁴/cm] and is given in mg KCl/l. This is based on the conductivity (14,12 * 10⁻⁴ S/cm) of a 0,01 molar KCl solution.

pH-value DIN ISO 10390 (CaCl₂):
Minimum 5 ml of the air-dried sample is placed in a glass vessel. Five times the volume (25 ml) of a 0.01 M CaCl₂ solution is added. The suspension is overhead rotated for 1 h. The suspension obtained is directly measured with a pH meter.

Water content according to DIN 51718:
Method A / two-step method (Reference method for coal)
raw moisture
The sample (100 to 1000 g) is spread evenly in a drying bowl crucible, weighed with 0.1 g accuracy and dried in an oven at (40 ± 2) °C until the mass is constant. If necessary, the sample is divided and dried in more than one crucible.
Analysis: raw moisture (FG) in %

\[
FG = \frac{m_E - m_R}{m_E} \times 100
\]

- \( m_E \) = raw moisture in %
- \( m_E \) = mass of the sample before drying in g
- \( m_R \) = mass of the sample after drying in g

hygroscopic moisture
A subsample of the air-dried and crushed (grain size < 1 mm) sample is weighed immediately after the subsampling into a TGA crucible and is dried in a nitrogen atmosphere at (106 ± 2) °C to constant mass.
Evaluation: hygroscopic moisture (FH) in %

\[
FH = \frac{m_E - m_R}{m_E} \times 100
\]

- \( FH \) = hygroscopic moisture in %
- \( m_E \) = mass of the sample before drying in g
- \( m_R \) = mass of the sample after drying in g

water content
Evaluation: water content (Wt) in %

\[
W_t = FG + FH \times \frac{100 - FG}{100}
\]

- \( W_t \) = water content in %
- \( FG \) = raw moisture in %
- \( FH \) = hygroscopic moisture in %

Ash content (550 °C) analogue DIN 51719:
To determine the ash content two programs of the TGA (30 or 60 min) could be used. The weight determination of the crucible is carried out automatically. Enter the sample number for corresponding crucible position. Add 1.0 g of the sample in the ceramic crucible and spread the substance evenly in the crucible. The weighing is done automatically relative to the crucible position.
The oven runs the following heating program:
- heating with a rate of 5 K / min to 106 °C under a nitrogen atmosphere to constant mass (\( m < 0.05\% \)).
- temperature increase with 5 K / min to 550 °C under oxygen atmosphere,
- hold this temperature for 30 or 60 min to constant mass (\( m < 0.05\% \)).
The ash content is automatically determined and calculated for the used sample.
Thermogravimetry:
The TGA curve is determined, like the ash content, with the TGA. For this purpose, 1.0 g of pre-dried and ground sample is weighed in the TGA crucible. During the temperature rise from 30 °C to 950 °C with 10 K / min, the crucible is weighed at frequent intervals in the TGA furnace. The result is shown graphically.

Carbonate CO₂ analogue DIN 51726:
1 g of pre-dried and ground sample is weighed to 0.2 mg and placed in the decomposition flask. The device consists of an absorption tower, which frees the air of carbon dioxide, the decomposition flask with an attachment to add the decomposition acid and three connected washing bottles. The carbon dioxide freed air is sucked through the system. After the system purged and the washing bottles were filled with an absorbing solution of BaCl₂ and NaOH solution, 30 ml decomposition acid (hydrochloric acid with HgCl₂ as a catalyst and a wetting agent) are added to the decomposition flask. The content of the decomposition flask is boiled for about 10 minutes. The inert gas flow transports the carbon dioxide produced through the acidic solution in the first wash bottle in the other two wash bottles. In the second wash bottle, the carbon dioxide dissolves under consumption of base and is precipitated as barium carbonate. If something precipitates in the third wash bottle, the measurement must be repeated with a lower initial mass. The consumption of base in the second wash bottle is determined by a pH-titration using hydrochloric acid. The carbonate content of the sample is calculated from the base consumption and is calculated as CO₂.

CHN according to DIN 51732:
A TruSpec CHN is used. The sample (80-100 mg of the pre-dried and crushed sample) is weighed directly (relative precision 0,1%) into a tin capsule. After that the capsule is closed and is put in the machine for measurement. The TruSpec CHN determines the carbon content, the hydrogen content and the nitrogen content in mass percent.

Sulfur according to DIN 51724-3:
The pre-dried and crushed sample is weighed in a ceramic crucible. With the aid of a catalyst layer of V₂O₅ and at high temperatures (> 1300 °C) the sulfur is oxidized in an oxygen stream. The resulting SO₂ is detected in an IR cell and is calculated with the sample mass as total sulfur content.

Oxygen (calculation) according to DIN 51733:
The oxygen content is a calculated parameter. It is assumed that the sample consists essentially of ash, carbon, hydrogen, nitrogen, sulfur and oxygen. If one subtracts the ash, carbon, hydrogen, nitrogen and sulfur content in percent from 100 %, the result will be the oxygen content in percent.
C\textsubscript{org}, H/C und O/C (calculation):

Other quantities and ratios can be calculated from the determined data.

C\textsubscript{org} is derived from the total carbon content minus the inorganic carbon content (CO\textsubscript{2}) in the sample.

PAH analogue to DIN EN 15527: 2008-9 (extraktion with Toluol); DIN ISO 13877: 1995-06 – Principle B with GC-MS; DIN EN 16181: 2019-08 with extraction method 2

2.5 g of the pre-dried and crushed sample is weighed into a extraction thimble and is extracted with 50 ml of toluene at reflux for two hours. The extract is concentrated to 10 ml. An aliquot of the extract is transferred to an injection vial and the PAH are analyzed by gas chromatography.

Gas chromatograph: Network GC System 7890N and 5975C MSD and inertXL

AS 7693 Fa: Agilent Techn

Capillary column: HP 5MS (30 mx 0.25 mm x 0.25 microns)

Temperature program: 90 ° C (0.5 min), 20 ° C / min to 250 ° C, 5 ° C / min to 275 ° C, 20 ° C / min to 320 ° C for 5 min

Transfer line: 280 ° C

MSD temperature: 150 ° C

Injection volume: 1 µl

Injector temperature: 250 ° C

Carrier gas: helium (1,5 ml / min)

Trace metals after microwave-assisted digestion according to DIN 22022-2, DIN 22022-7, DIN EN ISO 17294-2 / DIN EN 1483:

(Pb, Cd, Cu, Ni, Hg, Zn, Cr, B, Mn, As)

The pre-dried and crushed sample is weighed into the reaction vessel of the microwave. 6 ml of nitric acid, 2,0 ml of hydrogen peroxide and 0,4 ml of hydrofluoric acid are added.

The reaction vessel is sealed and is placed in the microwave.

Program flow of the microwave pressure digestion:

heating (room temperature to 190 ° C) in 15 min

holding time at 190 ° C for 20 minutes

free cooling

additional only for ICP-OES:

Program flow of the fluoride masking (Boric acid, adding 5 ml of saturated solution):

heating (room temperature to 160 ° C) in 8 minutes

holding time at 160 ° C for 7 minutes

free cooling

After complete cooling, the reaction vessels are opened and the digestion solution is transferred to in a 50 mL plastic volumetric flask and filled with deionized water.

The diluted solution is measured by ICP-MS (DIN EN ISO 17294-2).

To determine the levels of mercury a cold vapor AAS (DIN EN 1483) is used.
Main elements after melting digestion DIN 51729, DIN EN ISO 11885 / DIN EN ISO 17294-2: (P, Mg, Ca, K, Na, Fe, Si, S)

The melting process is performed on the ashes of the biochar. 200 mg of the fine ash are weighed into a platinum crucible and thoroughly mixed with 2 g of lithium metaborate. The platinum crucible is placed in a digestion oven. The digestion remains at least 15 minutes at 1050 °C in the oven. The melt is dissolved in hydrochloric acid and filled to 500 ml.

The samples are measured with ICP-OES (DIN EN ISO 11885) or ICP-MS (DIN EN ISO 17294-2).
14. Analytical Parameter for EBC-Feed

14.1 Tracemetals following VDLUFA III oder DIN EN ISO17294-2
As, Pb, Cd: VDLUFA VII 2.2.1 (digestion); VDLUFA III 17.2.2; DIN EN ISO17294-2 (E29);
DIN EN ISO 11885(E22) (direct measuring)
Hg: VDLUFA VII 2.2.1 (digestion); VDLUFA III 17.4.3; DIN EN 13506; EN 12338 (direct measuring)
0,1 g bis 1 g des getrockneten, gemahlenen und homogenisierten Materials werden
in einen Kunststoffbecher (PTFE, PFA) oder Quarzbecher für die Mikrowelle
eingewogen. Nach Zugabe von 65%iger Salpetersäure im Verhältnis 1+5
(Einwaage+Säure) und nach Zugabe von 30%igem Wasserstoffperoxid im Verhältnis
1+2,5 bis 1+10 (Einwaage+Wasserstoffperoxid) wird bei der für das System
maximal zulässigen Temperatur aufgeschlossen (in der Regel 190°C). Aufheizphase:
15 min; Haltezeit: 30 min.
Nach dem Abkühlen wird quantitativ in ein Polypropylengefäss mit
Volumenmarkierung überführt und mit 0,1 M Salpetersäure bis zur Marke aufgefüllt.
Die Messung erfolgt mit ICP-MS oder ICP-OES. Beim Quecksilber werden
Kaltdampf-AAS oder Atomfluoreszenzspektrometrie eingesetzt.

14.2 Benzo-A-Pyren für EBC-Futter
DIN ISO 13877 oder VDLUFA VII 3.3.3.2 (with Toluol extraction)
Das Material wird zerkleinert (<1 mm) und bei maximal 35°C getrocknet. 10 g
Probe werden mittels Soxhletextraktion 6 h mit Toluol unter Zugabe von
geeigneten internen Standards extrahiert. Alternativ kann eine ASE Extraktion
verwendet werden. Der Extrakt wird aufkonzentriert und entsprechend DIN ISO
13877 oder VDLUFA VII 3.3.3.2 mit Säulenchromatographie gereinigt. Die Messung
und Quantifizierung des gereinigten Extraktes kann mit HPLC-FLD oder
GC+Massenspektrometrie erfolgen. Geeignet sind MSD, MS/MS-, HRMS- oder
TOF-Geräte.

14.3 PCB
nach VDLUFA VII 3.3.2.2 (DIN-PCB; Heißextraktion, GC-MS)
Das Material wird zu Pulver (<1 mm) zerkleinert und bei maximal 35°C im
Trockenschrank getrocknet. Alternativ kann chemisch oder durch Gefriertrocknung
getrocknet werden. 5-10 g Probe werden mittels Soxhletextraktion 6 h mit Toluol
unter Zugabe von geeigneten internen Standards extrahiert. Alternativ kann eine
ASE Extraktion verwendet werden. Der Extrakt wird aufkonzentriert und
entsprechend VDLUFA VII 3.3.2.2 mit Kieselgel-Säulenchromatographie gereinigt.
Die Messung und Quantifizierung des gereinigten Extraktes erfolgt mit GC-MS oder
GC-ECD.
14.4 PCDD/PCDF/coplanare PCB
VDLUFA VII 3.3.2.4 (PCDD+PCDF+ coplanar PCB; GC-HRMS),
Das Material wird zu Pulver (<1 mm) zerkleinert und bei maximal 35°C im
Trockenschrank getrocknet. Alternativ kann gefriergetrocknet werden. 2 g
Probenmaterial werden nach Zugabe isotopenmarkierter Standards 20 h mit Toluen
im Soxhlet extrahiert. Alternativ können spezielle Heissextraktoren wie die ASE
ingesetzt werden. Nach Aufkonzentrierung wird der Extraktnach VDLUFA
Methode VII 3.3.2.4 durch mehrfache Säulenchromatographie gereinigt und kann in
verschiedene Fraktionen unterteilt werden. An dieser Stelle ist auch eine
Gewinnung der DIN-PCB Fraktion möglich. Zuletzt erfolgt die Messung der
Komponenten mit GC-HRMS.

14.5 Fluor
Permitted test methods: VDLUFA VII 2.2.1
Das getrocknete und gemahlene Material wird verascht und mit Natriumhydroxid
aufgeschlossen. Der erkalte Aufschluss wird in Salzsäure unter Zugabe eines
Komplexbildners (TISAB) gelöst. Anschließend wird ein pH-Wert von 5,5 eingestellt
und der Fluoridgehalt mittels einer ionensensitiven Elektrode ermittelt.

14.6 Carbon
Permitted test methods: DIN 51732
A TruSpec CHN (Manufacturer: Leco) is used.
The sample (80-100 mg of the pre-dried and crushed sample) is weighed directly (relative
precision 0,1%) into a tin capsule. After that the capsule is closed and is put in the machine
for measurement. The TruSpec CHN determines the carbon content, the hydrogen content
and the nitrogen content in mass percent.

14.7 Dry matter
Permitted test methods: dry matter: DIN 51718; VDLUFA III 3.1;
Mindestens 50 g der Probe werden entnommen und soweit erforderlich, unter
Vermeidung von Feuchtigkeitsänderungen zerkleinert. 5 g Kohle werden auf 1 mg
genau eingewogen und bei 103°C 4 h getrocknet. Nach dem Beladen des Ofens
beginnt die Trocknungszeit erst nach genauem Erreichen der 103°C. Nach dem
Abkühlen im Exsiccator wird auf 1 mg genau zurückgewogen.

14.8 Crude ash
Permitted test methods: analog to DIN 51719, VDLUFA III 8.1; HCl-insoluble ash:
VDLUFA III 8.2
Etwa 5 g Probe werden auf 1 mg genau in eine geglühte und tarierte
Veraschungsschale eingewogen. Die Schale wird in einen Muffelofen gebracht und
15. Additional Parameters

**Gross calorific value / net calorific value according to DIN 51900:**
For the determination of the calorific values a bomb calorimeter which fulfills the requirements of the stated standard is used. 0,3 to 0,8 g of pre-dried and ground sample is weighed into a combustion bag, capsule or crucible. The sample is mounted in the combustion bomb with an ignition wire and 10-20 ml of eluent in bottom part of the bomb. The bomb is placed into the calorimeter. The oxygen filling, the ignition and the measurement are done automatically. After the combustion the bomb must be checked for signs of incomplete combustion. The gross calorific value is calculated using the calibration and measurement data. With further corrections, the net calorific value is calculated.

**Ash content (815 °C) DIN 51719:**
The ash content (815 °C) is determined after the ash content (550 °C) by rising the temperature from 550 °C with 5 K / min to 815 °C and holding until constant weight (mass difference ± 0,05%) is reached.

**Volatile matter according to DIN 51720:**
1,0 g of the pre-dried and ground sample is weighed into a crucible (with lid). The sample must form a uniformly thick layer on the bottom of the crucible. The crucible is placed in the oven preheated at 900 ± 5 °C. After 7 minutes (± 5 sec), the crucible is removed from the oven and reweighed after cooling to room temperature. The volatile matter content is calculated from the mass loss of the sample.

**Water holding capacity (WHC) according to DIN ISO 14238-2011**
Water-holding capacity. This can be measured using the method according to German Standard E DIN ISO 14238-2011; appendix A (draft).
The test consists of soaking the 2mm fraction of the material in water for a period of 24 hours. After this, the material has to be placed on a dry sand bed for 2 hours for removing free water. The saturated material has to be weighed and then dried at 40°C in a compartment dryer. After drying the material has to be weighed again for estimate the water holding capacity.
16. References


