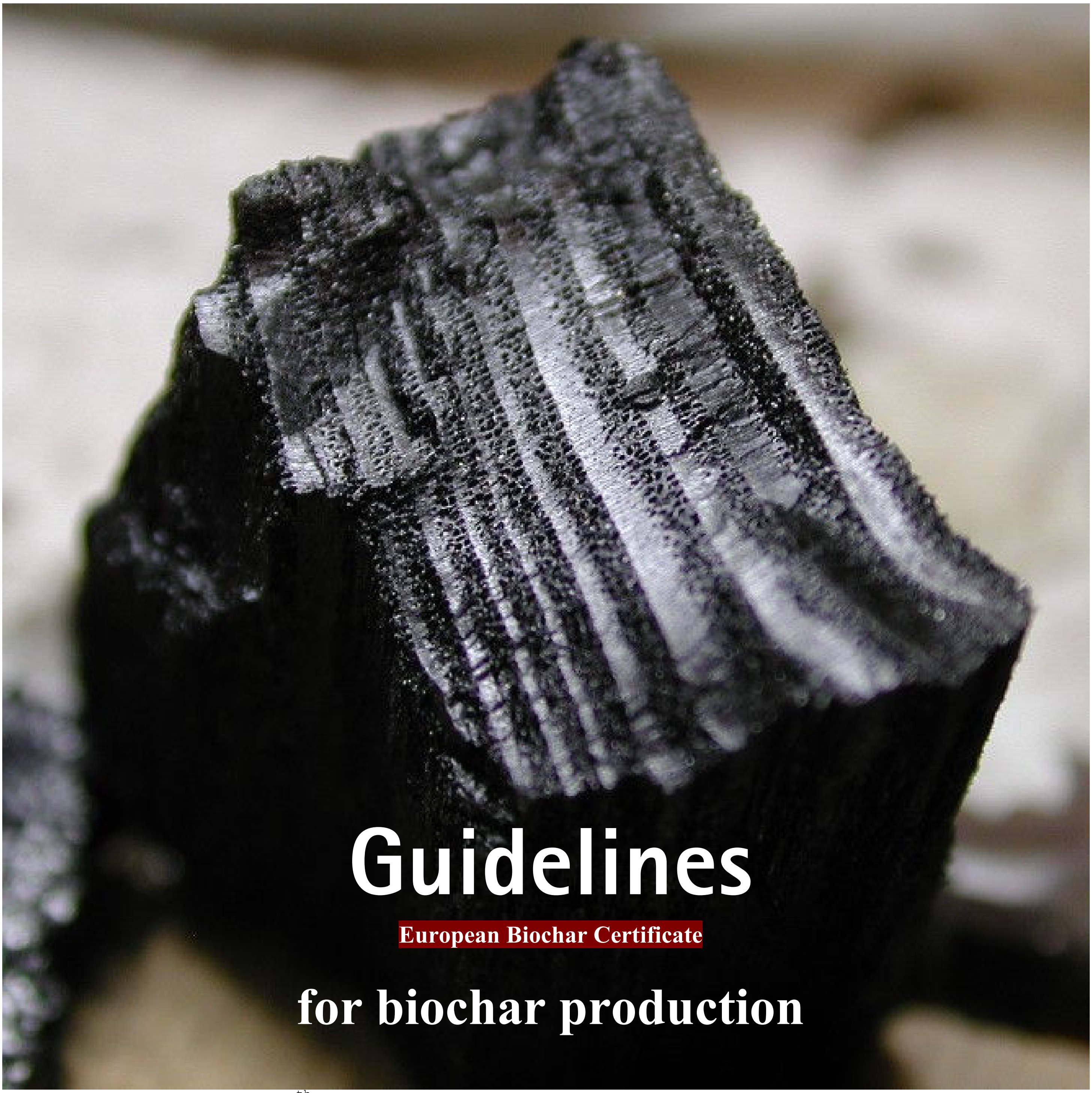

Guidelines

European Biochar Certificate

for biochar production

Version 4.3 of 10th September 2012

Impressum

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

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Guidelines on the production of biochar

Europäisches Pflanzenkohle Zertifikat / European Biochar Certificate

Publisher: Biochar Science Network

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 is 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 only now being rediscovered.

Thanks to wide-ranging multidisciplinary research and field trials, the understanding of the biological and chemo-physical processes involved in the 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.

Traditional kiln production of charcoal and biochar was unsatisfactory with regard to its carbon efficiency and especially its environmental footprint. Accordingly, it is unsuitable for producing larger biochar amounts to be used in future agriculture. Modern pyrolysis plants are now ready to produce biochar from a large variety of different feedstocks in energy efficient way and without harming the environment. As both, biochar properties and the environmental footprint of its production are very much dependent on the technical control of pyrolysis and the type of feedstocks, a secure control system for its production and analysis needs to be introduced.

The intention of the Biochar Science Network in issuing these guidelines on how to gain biochar certification is first to introduce a control mechanism based on the latest research and practices. Second, the biochar certificate aims to enable and guarantee sustainable biochar production. It is introduced to give customers a reliable quality basis, while (third) giving producers the opportunity of proving that their product meets well-defined quality standards. Fourth, it aims at providing a firm state-of-the-art knowledge transfer as a sound basis for future legislation. Finally, it is introduced to prevent and hinder misuse or dangers from the start, as long as no ”special interests” are calling for exceptions (e.g. such as cutting down native forests to produce biochar).

Biochar production technology is currently developing very fast, with more than 500 research projects worldwide looking into biochar properties and interactions. 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 are steadily and rapidly growing. This biochar certificate is closely linked to this research and technical momentum and will accordingly be revised annually 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 the guidelines is to ensure 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 a 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.

2. Definition of biochar

Biochar is here defined as char produced by pyrolysis for use in agriculture (and other non-thermal applications) in an environmentally sustainable manner.

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 (<2%) thermal 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. For products produced using other carbonisation processes, specific certificates may be compiled once wider-ranging and better-secured knowledge is available on their quality and effects in soils and in other non-thermal applications.

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

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 have to be met.

3. Feedstock

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

3.2 It must be ensured that all non-organic waste such as plastic, rubber, electronic scrap has been removed.

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

3.4 When using primary agricultural products, it must be guaranteed that these were grown in a sustainable manner.

3.5 Biochar may only be produced from wood from forests or short rotation forestry plantations if their sustainable management, for example through appropriate PEFC or FSC certification, can be proven.

3.6 Feedstocks used for the production of biochar must not be transported over distances greater than 80 km. An exception is made for pyrolysis additives or special biomasses for use in production tests. [Since the current network of pyrolysis facilities is not yet extensive an exemption to this transport distance requirement can be granted as long as such exemption is only a temporary measure.]

3.7 Complete records of feedstocks must be kept.

4. General requirements for biochar production records

Each biochar batch must be clearly labelled and be given a unique identification number for reconstructing the circumstances of production and guaranteeing the quality of the biomasses used. For each biochar batch, separate production records are to be kept. Each batch must be tested to ensure compliance with the required threshold values.

A uniform biochar batch is deemed to exist when the following criteria are met:

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 resumption of production.
2. The composition of the pyrolysed biomasses does not fluctuate more than 15%
3. The production period of the batch does not exceed 120 days of production within a maximum of 240 days.
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 batch for which new production records have to be kept.

5. Biochar properties

Current knowledge and the analytical methods are such that it is at present very difficult and expensive to attain a detailed physical-chemical characterisation of biochar. This means that no complete scientific characterisation of the certified biochar can be required. The focus is therefore on guaranteeing compliance with all environmental threshold values and declaring all product properties of relevance for the agricultural use of biochar.

5.1 The biochar's carbon content must be higher than 50% of the dry mass (DM)
The organic carbon content of pyrolysed chars fluctuates between 10% 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%.
When using mineral-rich feedstocks such as sewage sludge or animal manure, the pyrolysed products tend to have a high ash content. Pyrolysed chars with carbon contents below 50% are therefore not classified as biochar but as "pyrolysis ash containing biochar".
When pyrolysis ashes meet all other threshold criteria of this biochar certificate, they may be marketed as *pyrolysis ash*. Pyrolysis ashes have a high nutrient content, therefore representing a valuable fertiliser additive. This does however mean that they belong to a different product category.

In the sense of using resources as efficiently and sustainably as possible, it is preferable to compost or ferment mineral-rich biomasses, or for them to be concentrated into fertiliser. In doing so, the nutrients they contain can be recycled more efficiently than by pyrolysis.

The specification of carbon content is of particular relevance when working with CO_2 certificates
Permitted test methods: DIN 51732
(Specify for each batch)

5.2 The black-carbon content must represent 10 - 40% of overall carbon
Biochar carbon is made up of easily degradable organic carbon compounds and very stable, aromatic carbon structures (black carbon). Black carbon content is an important criterion for characterising biochar and also reflects the biochar's stability in the soil. The latter aspect is of particular relevance with regard to carbon sequestration.
According to Schimmelpfennig und Glaser [2012], the black carbon content of biochars should represent 10 - 40% of the overall carbon. Chars where the black carbon content is under 10% of the overall carbon cannot be considered as biochar.
There is no standardised methodology yet available for analysing black carbon content. Consequently, no mandatory control of black carbon content as part of the certification process can yet be required. Nevertheless it is recommended to (optionally) include the value and details of the methodology used to determine the content in the production records.

5.3 The molar H/C ratio must be less than 0.6

The molar H/C ration is an indicator of the degree of carbonisation and therefore of the biochar's stability. The ratio is one of the most important characterising features of biochar. Values fluctuate dependent on the biomass and process used. Values exceeding 0.6 are an indication of inferior chars and pyrolysis deficiencies (Schimmelpfennig & Glaser [2012]).

Permitted test methods: DIN 51732
(Specify for each batch)

5.4. The molar O/C ratio must be less than 0.4

In addition to the H/C ratio, the O/C ratio is also relevant for characterising biochar and differentiating it from other carbonisation products (Schimmelpfennig & Glaser [2012]). Compared to the H/C ratio, measuring the O/C ratio is relatively expensive. As the molar H/C ratio in association with the other data recorded in biochar certification permits the clear classification of the certified char as a pyrolytically produced biochar, mandatory control of the O/C ratio is not required. It is however recommended to (optionally) obtain this value for the production records.

5.5 The biochar nutrient contents with regard to nitrogen, phosphorus, potassium, magnesium and calcium must be available and listed on the delivery slip.

The nutrient contents of different biochars are subject to major fluctuations. For a carbon content exceeding 50%, they can range from 1% to 45%. Please note that, due to biochar's high adsorption capacity, these nutrients may only partly be available to plants. They may take decades to enter 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%.

Permitted test methods: DIN EN ISO 17294 – 2 (E29)
(Specify for each batch)

5.6 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 (*Schweizerische Chemikalien-Risikoreduktions-Verordnung or ChemRRV*), 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
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 in composting, practically the whole amount of heavy metals contained in the originally feedstock will remain in the final product. Here the heavy metals will naturally be more concentrated than in the starting material (educt). However biochar is able to very effectively bind a number of heavy metals, thereby immobilising them for a long period of time. How long has not however as yet been determined. As the amounts of biochar used in agriculture are relatively low compared to those of compost and manure, toxic accumulation of heavy metals can practically be ruled out, even when thresholds are higher. Nevertheless this is no reason to disregard the heavy metal thresholds stipulated in Germany's Soil Protection Act or Switzerland's Chemical Risk Reduction Act, or any other European legislation.

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. An exemption can be granted for biochars with a nickel contamination below 100 g/t DM. Such biochars shall only to be used for composting purposes since the valid thresholds are complied with in the finished compost.

Permitted test methods

Heavy metals: DIN EN ISO17294-2 (E29)

Mercury: DIN EN1483 (E12)

(Specify for each batch)

5.7 The delivery slip must specify the biochar's pH value, bulk density, water content and, for the *premium* quality level, its specific surface area and water holding capacity.

The biochar's pH value is an important criterion with regard to its specific use both in substrates and in binding nutrients in animal husbandry. When a biochar has a pH value exceeding 10, the delivery slip must feature appropriate handling information (regarding health and safety dangers). Please also note that only the application of larger amounts of biochar will lead to changes in a soil's pH value.

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 characteristics, and a control value for the pyrolysis method used. It should preferably be higher than 150 m^2/g DM. The water holding capacity either pure or in mixture with a sandy soil is a valuable indication on the effectiveness of biochar in increasing a soil's water holding capacity.

Permitted test methods:

pH: analogous to DIN 10 390

Water content: DIN 51718; TGA 701 D4C

Specific surface area: BET measurement ISO 9277

(Specify for each batch)

5.8 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. Their amount is dependent in particular on production conditions. 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, with activated biochar being used as an air filter for removing PAHs from exhaust gases and for immobilising PAHs in contaminated soils. 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.

Though some PAHs bound in biochar are available to plants, this takes place at an even lower level than with compost or manure due to biochars' adsorptive capacity. Moreover, whereas up to 40 tonnes of compost or manure may be applied per hectare over a 3-year period, current guidelines for biochar stipulate max. 40 tonnes over a 100-year period. 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 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, only 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 Agroscope ART (Hilber et al. [2012]), a longer-term Toluol extraction is needed before any suitably representative test value can be determined. However as this is not yet a standard method used in European test labs, the current standard test method (DIN EN 15527) remains in effect. The measured values should however be interpreted with caution. Additional tests using the method developed by Hilber et al. is therefore recommended.
The current standard method fulfils its purpose with regard to this certificate, since it is able to determine with sufficient exactitude higher PAH contamination levels deemed to be a problem (Schimmelpfennig & Glaser[2012]).
As biochar PAH values are dependent on the pyrolysis method and seemingly less dependent on the feedstock used, an analysis once every six months is sufficient.
Permitted test methods: DIN EN 15527 (with caution); recommended: Hilber et al, 2012
Analysis once every 6 months

5.9 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, meaning that annual control can be considered sufficient. Thresholds are based on the soil protection regulations applicable in Germany and Switzerland (BBodschV, VBBo, ChemRRV).
Permitted test methods: AIR DF 100, HRMS

6. Pyrolysis

6.1 Biomass pyrolysis must take place in an energy-autonomous process.
The energy used for operating the reactor (electricity for power drive systems, ventilation and automatic control systems, fuel for preheating, etc.) must not exceed 8% (*basic* grade) or 4% (*premium* grade) of the calorific value of the biomass pyrolysed in the same period. With the exception of preheating, no fossil fuels are permitted for reactor heating. Industrial waste heat (e.g. from cement or biogas production) or renewable energy sources like solar heat may be used for reactor heating in order to use the syngases for energy production or for motor fuel.

6.2 The synthesis gases (syngases) produced during pyrolysis must be trapped. They are not allowed to escape into the atmosphere.

6.3 The heat produced by the reactor must be recycled.
Approximately one-third of the energy contained in the biomass feedstock can be found in the syngas at the end of pyrolysis. Its combustion can in turn be used for heating the biomass, whereby additional waste heat is produced. At least 70% of this must be used for drying biomass, for heating, for generating electricity or for similar sustainable purposes.
Syngas can also be stored and used later for subsequent energy purposes.

6.4 Syngas combustion must comply with national emission thresholds for such furnaces.
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. Sale and application of biochar

7.1 Fire and dust protection regulations are to be complied with throughout the production, transport and end-user chain.

7.2 During transport and bulk transfers attention must be paid to the biochar being sufficiently moist to prevent dust generation or dust explosions. The moisture content of the delivered biochar has to be given to ensure that the customer knows how much dry biochar he/she obtained.

7.3 Production workers must be equipped with suitable protective clothing and breathing apparatus.

7.4 Delivery slips must contain well-visible usage instructions and health and safety warnings.

7.5 When applying biochar on fields or in animal stables and housings, biochar must be kept slightly moist to prevent dust formation. In this respect, producers must provide appropriate information on the delivery slip or on packaging.

8. Quality assurance and certification

Biochar producers' compliance with European Biochar Certificate requirements is coordinated throughout Europe by the independent quality assurance agency q.inspecta, with inspections of production plants in individual countries carried out by independent national inspection agencies. Inspections take place once a year. Producers confirm that they will keep up-to-date production records.

Producers may submit applications to q.inspecta to take part in the certification programme once their production starts. They are recommended to contact q.inspecta beforehand, enabling them to integrate the necessary recording into their production process.

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9. 9. References

Deutsche Bundes-Bodenschutz- und Altlastenverordnung (BBodSchV), 1999, latest amendment 31.7.2009

Hilber, I, Bucheli, TD, Blum, F, Leifeld, J, Schmidt, HP Quantitative determination of PAHs in biochar – a prerequisite to assure its quality and safe application. J. Agric. Food Chem. 2012

Schimmelpfennig, S.; Glaser, B. One step forward toward characterization: Some important material properties to distinguish biochars. J. Environ. Qual. 2012, 41, 13.

Schweizerische Verordnung über Belastungen des Bodens (VBBo, SR 814.12), 1998

Schweizerische Chemikalien-Risikoreduktions-Verordnung (ChemRRV, SR 814.81), 2005

Vierte Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes (4.BImSchV), 1997