Technological Regulation of biochar production from Miscanthus waste

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Abstract

To ensure a complete Miscanthus value chain relevant to the circular economy, the Miscanthus waste was utilized by pyrolysis to biochar as a valuable source of nutrients used at the fields again. In addition to the type of plant itself, the pyrolysis temperature, the heating rate as well as the residence time in the reaction zone also contribute to the resulting biochar quality. With increasing pyrolysis temperature, the yield of biochar decreases. The pyrolysis temperature also affects the decomposition and content of volatile organic compounds formed by the pyrolysis process and the organic substances present in the biomass. The chemical properties of biochar, especially pH and nutrient content, but also the physical properties of biochar, such as pore size, pore volume and specific surface area, play a key role in determining biochar quality. The use of biochar in the soil leads to changes in the physicochemical properties of the soil and stimulates the activity of soil microorganisms, which affect both soil properties and plant quality.

From Miscanthus waste to biochar

At the IET (Institute of Environmental Technology, VŠB-TUO), pyrolysis of miscanthus was performed. A scheme of the work process is shown in Figure 1.

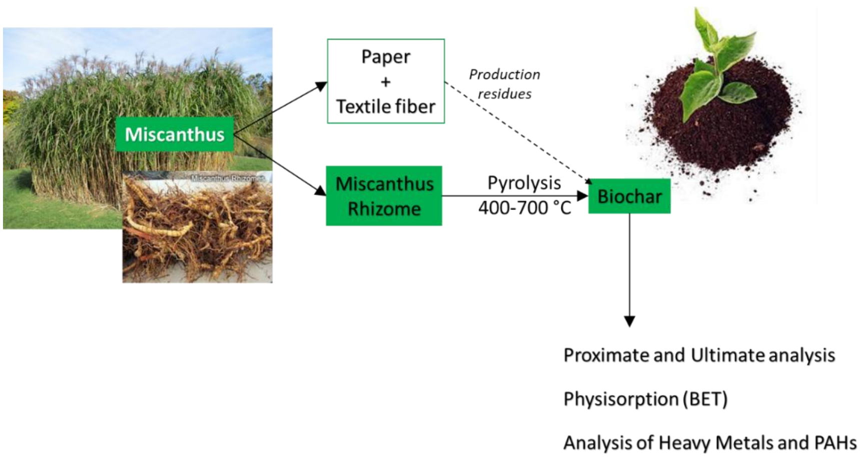

Figure 1 Scheme of the work process

Due to the selection of the most suitable conditions ((400, 500, 600, 700 – final temperature (°C); 0.25, 1, 2 – residence time (hour)) for the biochar preparation, a series of experiments were performed. Carbon content, specific surface area as well as PAH content were taken into consideration. An available sample of miscanthus rhizomes from S WHG Ltd. [1] in Valašské Meziříčí was chosen for initial testing. After these optimal conditions (600 °C, 2 h residence time) were determined, different parts of Miscanthus (Miscanthus rhizomes, mixture, leaves, contaminated rhizomes and fiberboards) were processed.

Pyrolysis experiments were performed in a laboratory unit. The retort with length of 30 cm and inner diameter of 5.5 cm was gas tightly closed, positioned into the furnace and connected to other components of the apparatus. A gasometer was placed at the end of the apparatus. The whole system was inertized using nitrogen before starting the experiment. All pyrolysis products were collected and subjected to further analyses (please see Figure 2).

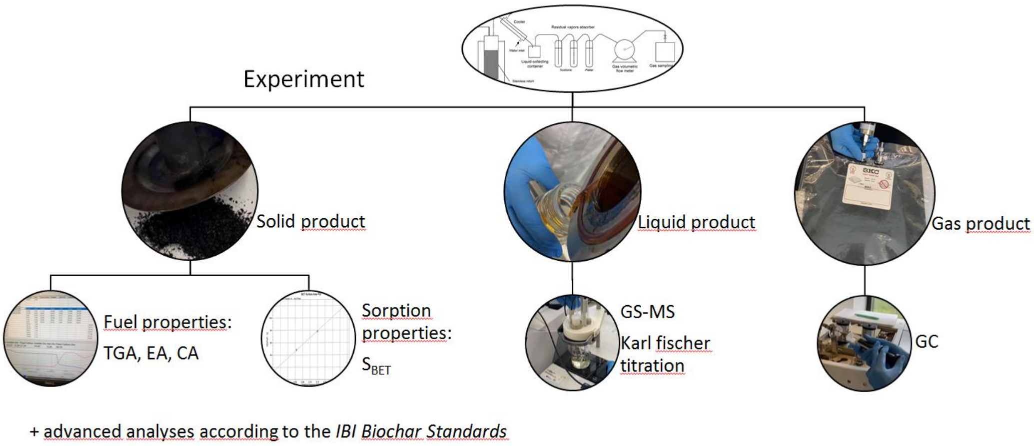

Figure 2 Scheme of evaluation of final products

The quality of biochar, which is used as a soil additive, is monitored by many national and transnational institutions. In the Czech Republic, biochar is registered by the Central Institute for Supervising and Testing in Agriculture. There are also organizations which provide certification. These certificates tend to be more difficult due to monitoring more areas than national legislation. These are the "European Biochar Certificate" (EBC) and the "International Biochar Initiative" (IBI). The goal of both initiatives is to ensure a safe product for the environment and to create a unified list of features as a sign of reliability and quality for consumers. The EBC is a European initiative that introduces a control mechanism based on the latest research and practice. For the determination of chemical and physical properties of biochar, the already valid ISO and DIN standards are used. The IBI provides a platform for new collaborations between stakeholder's entities, develop quality industrial technologies and set environmental and ethical benchmarks so that safe and sustainable biochar could be created. IBI is an organization set up in the USA and therefore internationally known ASTM standards are recommended. The quality of biochar produced from miscanthus waste was checked according to the "IBI Biochar Standard". Testing of biochar materials should occur after complete thermochemical processing and before application to soils.

IBI Biochar Standards [2] identify three categories of tests for biochar materials:

- Test Category A – Basic Utility Properties: Required for all biochars. This set of tests measures the most basic properties required to assess the utility of a biochar material for use in soil.
- Test Category B – Toxicant Assessment: Required for all biochars. Biochars made from processed feedstocks must be tested more frequently than biochars made from unprocessed feedstocks.
- Test Category C – Advanced Analysis and Soil Enhancement Properties: Optional for all biochars. Biochar may be tested for advanced analysis and enhancement properties in addition to meeting test requirements for Test Categories A and B. All tests in Test Category C are optional.

Biochar meets all the criteria (basic properties, toxicity assessment, advanced analysis) according to IBI, and therefore can be both a source of nutrients and, thanks to its properties, can be used for soil aeration or pH adjustment (pH of biochar aqueous leachate is 10.3). Its main component is chemically stable carbon (81 wt.%) and the value of the specific surface is measured to be 217 $m^2.g^{-1}$.

[1] Energetické plodiny [online]. © 2021 S WHG s.r.o. [cit.2021/05/31]. Available from: https://www.energetickeplodiny.cz/index.php

[2] I. B. Initiative, "Standardized Product Definition and Product Testing Guidelines for Biochar That Is Used in Soil," Int. Biochar Initiat., no. January 2011, pp. 1–47, 2012.