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ABSTRACT

Anthropogenic emission of carbon dioxide is constantly growing, accounting for the development of effective carbon sequestration strategies. A lot of attention is paid to soil carbon pool, among which pyrogenic carbon is considered as a particularly stable. One of the contemporary forms of pyrogenic carbon applied into the soil is biochar. It is produced by thermal conversion of biomass under oxygen-limited conditions (pyrolysis), has a high carbon content (> 50%) and is considered an effective tool for CO_2 sequestration. Stability of biochar in soil depends on its properties, but also on a number of abiotic and biotic factors that can contribute to the violation of biochars structure. When considering the use of biochar as a soil amendment with high carbon sequestration potential, factors determining its stability in soil should be investigated. One of the common approaches to estimate biochar stability is evaluation of its chemical properties, including C:O and H:C molar ratios. However, this assessment does not take into account the impact of external factors. Therefore, in the presented dissertation, more complex approach is proposed, that combines new analytical tools and analysis of labile carbon pool, which is chemically and biologically active and undergoes processes similar to soil organic matter.

The main aim of this dissertation was to evaluate susceptibility of various biochars for decomposition process, in order to assess their usefulness in carbon sequestration. The research was conducted based on the 12-month incubation experiment. Three groups of variables potentially important for biochar decomposition processes were considered: (1) different feedstocks for pyrolysis process, (2) soil type with emphasis on the variability of the texture and chemical properties, (3) presence of exogenous organic matter in soil. In order to assess the stability of biochar, standard analytical methods were used as well as a range of up-to date analyses dedicated to characterize biochar response to potential abiotic and biotic factors. Obtained results verified the hypotheses that each evaluated variable has influence on the interaction of biochar with the environment and, consequently, its suitability for carbon sequestration.

It was noted that feedstock type strongly determined properties of charred biomass. The elemental composition, content of labile carbon fractions, expected stability in the environment and, consequently, the effect on respiration and enzymatic activity after introduction into the soil differed between studied biochars. Poorly carbonized biochars derived from kitchen waste and coffee grounds, the most abundant in dissolved organic carbon and water-soluble forms of carbohydrates, proved to be the most susceptible to decomposition processes, as indicated by an increase in CO_2 emissions and the activity of extracellular enzymes. The addition of

exogenous organic matter modified the effect of biochar in the soil, stimulating enzyme activity and increasing carbon losses during the initial stage of incubation. Varied properties of the soils were reflected in the intensity of respiration and enzyme activity - greater carbon loss with CO_2 occurred in sandy soil, but microbial activity was higher on the silt loam. Considering high diversity of biochars properties and their interaction with soil, in the assessment of the stability of pyrolyzates it is necessary to evaluate not only their carbonization level, but also the content of labile carbon, which can provide a source of energy for soil microorganisms and accelerate decomposition processes.

Based on the conducted research it can be concluded that to ensure effective carbon sequestration, it is recommended to avoid poorly carbonized pyrolysis products of food waste, such as kitchen residues and coffee grounds, which have been shown to be particularly susceptible to decomposition. It is also important to consider the possibility of elevated carbon losses from light-textured soils due to CO_2 emissions. Co-application of biochars with other exogenous organic amendments should be avoided, as it provides an additional source of nutrients for soil microorganisms and can lead to an increased decomposition rate of biochars.

Keywords: biochar, sequestration, organic matter, dissolved organic carbon, soil respiration