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Short-term incubation studies on degradation of biochar in soil

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Biochar is considered a stable, recalcitrant substance, which holds potential to store carbon in soils for prolonged time and therefore would provide a long-term carbon sink. Furthermore, biochar is discussed to enhance soil fertility and plant productivity, and may improve water and nutrient holding capacity. However, mineralisation to CO_2 may occur, as for any soil organic carbon pool, depending on char composition, soil properties and environmental conditions. Therefore, it is important to gain insight into the stability of its carbon structure and the dynamics of decay processes in soil. The evaluation of biochar stability in soil is complicated by the impact of external factors thus as soil moisture and temperature, soil nutrient status and moreover by extended decay timescales. To overcome these difficulties, we performed dynamic incubation experiments under laboratory conditions, using a multi-channel, automated infra-red gas analysis system at 20°C for up to 10 days to detect CO_2 emission over time. Our aim was to compare the decay dynamics of different biochar preparations added to soil, i.e. HTC-char and pyrochar from maize silage with and without biological post-processing (anaerobic digestion), as compared to unmodified maize straw. Digestate from a maize silage-fed anaerobic biogas reactor was also tested.

As a result, the addition of charred or digested materials to soil resulted in much lower CO_2 emission rates as compared to the unmodified maize straw, proving stability of biochar carbon compounds. Pyrochar showed to be the most stable of all substrates added, as the CO_2 emission was hardly distinguishable from that of the control soil. Soil enriched with HTC-char emitted significantly more CO_2 compared to soil enriched with pyrochar, but the post-processing was effective in reducing the emissions. Furthermore, HTC-char showed a two-step decay kinetics, which cannot apparently be explained with a simple double-pool model.

In conclusion, the short-term incubation approach was effective to highlight differences in decomposition dynamics between the considered substrates in soil, and confirmed the effectiveness of the charring process to increase the stability of organic substrates in soil. More investigations are necessary to reveal the impact of readily available substrates and nutrients on degradation of biochar in soil, and to clarify the mechanisms responsible for the observed kinetics in order to derive a suitable process model.