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Sometimes size matters – new insights into the physical disintegration of biochar

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It is often assumed that the physical disintegration of biochar determines its persistence and mobility in soil. Freeze-thawing can cause physical stress on biochar, breaking it down into smaller and presumably more reactive particles. We here investigated the physical decay and subsequent mobilisation of five different biochars under "realistic worst-case scenarios" in a laboratory sand column setup, in shaking as well as in sonication experiments. Mobilisation of carbon from biochar particles (0.25 - 1 mm) was studied in a sand column (pH 6.3, with and without 80 freeze-thaw cycles). Small biochar particles did not disintegrate much after the freeze-thawing, possibly due to freezing point depression in biochar micropores. Freeze-thaw-induced physical decay of biochar is a process that is more pronounced in large biochar particles with substantial meso- and macropores, based on our results compared to literature data. Biochar with larger ash fractions disintegrated more, presumably due to the formation of unstable voids within the biochar associated with ash pockets. The physical stability of biochars produced from the same feedstock at different pyrolysis temperatures decreased with increasing aromaticity, which could be related to higher stiffness of the more aromatic structures. Soil moisture content increased carbon mobilisation from biochar more than physical stresses such as freeze-thawing. The physical disintegration of biochar and subsequent mobilisation of micro- and nanoscale carbon should therefore be considered less important and in many cases is not expected to be a decisive factor for the stability of biochar in soil.