Application of organic fertilizers alter the physical and biogeochemical properties of agricultural topsoil and subsoil

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Sustainable agricultural practices aim to ensure the rebuilt of soil organic carbon (SOC) stocks and to sustain soil fertility. One of the levers is the use of carbon and nutrient inputs in the form of organic amendments, such as farmyard manure, slurry and biogas digestate. These organic fertilizers represent a promising alternative to the mineral fertilizers, which are mainly made from non-renewable resources. The use mineral fertilizers is indeed associated with an excessive use of natural resources and a loss of biodiversity. The effect of organic amendments compared with traditional mineral fertilizers on SOC stocks and soil fertility are uncertain in the longer-term. We aimed at investigating the effects of mineral and organic fertilizers (i.e., manure, pig slurry and biogas digestate) on topsoil and subsoil biogeochemistry, after eight years of application. For this purpose, we sampled soil cores down to a depth of one meter in a randomized field experiment in Germany, running since 2011. A full-profile assessment of the carbon and nitrogen distribution, stability and bioavailability was achieved using a combination of classical bulk physico-chemical analyses (e.g., SOC and nitrogen contents, texture, pH, bulk density) and state-of-the-art imaging techniques. Selected samples were analysed for aggregate size distribution, as well as organic carbon and nitrogen contents and allocation within these aggregates. Further, undisturbed core-samples were scanned using a hyperspectral camera in the Vis-NIR range to reveal hotspots of carbon storage at the soil profile scale. Soil carbon distribution was predicted as a function of spectral response, using a variety of machine learning approaches. The application of organic fertilizers (whatever their nature) resulted in higher SOC contents in the first 10 cm, as compared to the control and the mineral fertilizer treatments. The SOC stocks were + 21-33 % higher in the soil treated with organic fertilizers as compared to the control treatment. The application of mineral fertilizer or digestate, as compared to the control, resulted in higher relative amount of microaggregates (versus macroaggregates) (+ 19-40 %) in the soil down to 80 cm. These results will provide essential information to develop management strategies that increase nutrient recycling as well as SOC stocks.