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Total soil DNA quantification as an alternative microbial biomass determination approach

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Many studies on geographically widespread soils from arctic permafrost to arid and tropical soils, as well as those studies on extreme events, such as freezing-thawing and drying-rewetting of soils, require immediate freezing of soil after sampling. The two common basic approaches, such as chloroform fumigation-extraction (CFE) and substrate-induced respiration (SIR), however, are not applicable in frozen or dry soil samples due to a partial destruction of microbial cells during freezing-thawing and drying-rewetting. This calls for approaches enabling correct estimation of microbial biomass in frozen or dried soil samples.

This study was aimed to compare commonly used SIR and CFE techniques with total soil DNA quantification and demonstrate the applicability of DNA-based determination of microbial biomass in carbonate-containing, slightly (Chernozem) and strongly alkaline (Calcisol) soils of semi-arid climates. The samples of natural and agricultural ecosystems were taken throughout the soil profile from long-term static field experiments in the European part of Russia.

The linear regression between SIR-Cmic and total soil dsDNA for the Chernozem showed very strong correlation. From the regression equation, the conversion factor of 5.10 with R2 = 0.96 was obtained. The effect of CO_2 retention at alkaline pH (>8) and low microbial biomass-C resulted in an inability to obtain any SIR-CO_2 release at deeper horizons of Calcisol, i.e. the CO_2 retention potential was higher that the CO_2 evolution. As a consequence, the values of SIR-Cmic of Calcisol at the horizons with pH > 8.0 were strongly underestimated (by a factor of 2-3). This smoothed the differences in Cmic between soil horizons. Nevertheless, reliable dsDNA values obtained for these soils demonstrated well-pronounced changes in microbial biomass within soil profile.

The CFE and DNA-based approaches showed a good correspondence, with R2 = 0.96 for both soil types. The CFE-Cmic to DNA-Cmic factor of 0.87 indicated slight (about 13%) underestimation of microbial biomass-C obtained by the CFE approach.

Thus, quantification of microbial dsDNA is an alternative option to determine soil microbial biomass under extreme conditions, e.g., in frozen and alkaline soils. In contrast to approaches based on indirect characteristics (respiration, etc.), the DNA-based approach enables evaluating microbial biomass using the immediate content of basic cell compounds universal to all living organisms.

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