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DNA-based determination of microbial biomass suitable for frozen and alkaline soil samples

Mikhail Semenov (1,2), Evgeniya Blagodatskaya (3), Boris Kogut (2), and Yakov Kuzyakov (3)

(1) Lomonosov Moscow State University, Department of Soil Science, Moscow, Russian Federation (mikhail.v.semenov@gmail.com), (2) V.V. Dokuchaev Soil Science Institute, Moscow, Russian Federation (kogutb@mail.ru), (3) Göttingen University, Department of Soil Science of Temperate Ecosystems, Göttingen, Germany (janeblag@mail.ru; kuzyakov@gwdg.de)

Microbial biomass is a sensitive indicator of changes due to soil management, long before other basic soil measures such as Corg or Ntot. Improvement of methods for determination of microbial biomass still remains relevant, and these methods should be correctly applicable for the soil samples being in various state. This study was designed to demonstrate the applicability of DNA-based determination of microbial biomass under conditions when the common basic approaches, namely chloroform fumigation-extraction (CFE) and substrate-induced respiration (SIR), are restricted by certain soil properties, experimental designs or research needs, e.g. in frozen, alkaline or carbonaceous soils.

We compared microbial biomass determined by CFE, SIR and by DNA approaches in the range of neutral and slightly alkaline Chernozem and alkaline Calcisol of semi-arid climate. 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.

Extraction and subsequent quantification of dsDNA revealed a strong agreement with SIR and CFE when analyzing the microbial biomass content in soils with pH below 8. The conversion factors (FDNA) from dsDNA to SIR-Cmic (5.10) and CFE-Cmic (4.41) were obtained by testing a range of the soil samples down to 1.5 m depth and indicated a good reproducibility of DNA-based estimations. In alkaline soils (pH > 8), CO_2 retention due to alkaline pH and exchange with carbonates resulted in a strong underestimation of soil microbial biomass by SIR or even in the absence of any CO_2 emission, especially at low absolute values of microbial biomass in subsoil. Correction of CO_2 efflux by theoretical retention pH-dependent factors caused overestimation of SIR-biomass. In alkaline conditions, DNA extraction proved to be a reliable alternative for microbial biomass determination. Moreover, the DNA-based approach can serve as an excellent alternative enabling correct estimation of microbial biomass in geographically widespread soils after their freezing.

The DNA-based approach can also be applied to calculate eco-physiological indexes, e.g. Cmic:Corg ratio. The DNA-Cmic revealed that although the absolute values of microbial biomass in Chernozem were expectedly higher than in Calcisol, the Cmic:Corg ratio was greater in Calcisol versus Chernozem. Therefore, Chernozems can be characterized by a low proportion of microbiologically active C in total Corg. DNA-based determination of Cmic and Cmic:Corg ratios revealed that agrogenic impact does not always lead to negative consequences for soil status and cannot be considered as a solely negative phenomenon.