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Canceling effect leads temperature insensitivity of hydrolytic enzymes in soil

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Extracellular enzymes are important for decomposition of many macromolecules abundant in soil such as cellulose, hemicelluloses and proteins (Allison et al., 2010; Chen et al., 2012). The temperature sensitivity of enzymes responsible for organic matter decomposition is the most crucial parameter for prediction of the effects of global warming on carbon cycle. Temperature responses of biological systems are often expressed as a Q10 functions; The Q10 describes how the rate of a chemical reaction changes with a temperature increase for 10 °C
The aim of this study was to test how the canceling effect will change with variation in temperature interval, during short–term incubation. We additionally investigated, whether canceling effect occurs in a broad range of concentrations (low to high) and whether it is similar for the set of hydrolytic enzymes within broad range of temperatures.
To this end, we performed soil incubation over a temperature range of 0–40°C (with 5°C steps). We determined the activities of three enzymes involved in plant residue decomposition: β-glucosidase and cellobiohydrolase, which are commonly measured as enzymes responsible for degrading cellulose (Chen et al., 2012), and xylanase, which degrades xylooligosaccharides (short xylene chain) in to xylose, thus being responsible for breaking down hemicelluloses (German et al., 2011). Michaelis-Menten kinetics measured at each temperature allowed to calculate Q10 values not only for the whole reaction rates, but specifically for maximal reaction rate (Vmax) and substrate affinity (Km). Subsequently, the canceling effect – simultaneous increase of Vmax and Km with temperature was analyzed within 10 and 5 degree of temperature increase.
Three temperature ranges (below 10, between 15 and 25, and above 30 °C) clearly showed non-linear but stepwise increase of temperature sensitivity of all three enzymes and allowed to conclude for predominance of psychrophilic, mesophilic and thermophilic microorganisms in soil at these temperature ranges. We conclude that the temperature sensitivity (Q10) of enzyme activity declines at higher temperature and lower concentration of substrates in soil. Overall, our results suggest that the fine-scale (five degree) temperature resolution level needs to be considered in global earth system models especially at temperature thresholds for physiological groups of soil microorganisms.

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