EGU2020-892
https://doi.org/10.5194/egusphere-egu2020-892
EGU General Assembly 2020

Preferential flow induced nutrient gradients create microbial hotspots and shape bacterial community structure

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In this study we used oxygen sensitive optodes, or optical sensor devices, to observe oxygen depletion by soil microbes. Depletion served as a reference for microbial activity along three artificially constructed preferential flow paths consisting of coarse sand in the center surrounded fine sand. Following a flow event with glucose addition, images showed that oxygen depletion is greatest along the boundary between preferential flow paths (coarse sand) and the bulk matrix (fine sand). Oxygen gradients as well as nutrient gradients are commonly attributed to shaping soil bacterial communities, however, these mechanisms have not been studied in the specific soil architecture of preferential flow paths. A separate experiment was performed in which the fine sand matrix was replaced with a sandy soil containing its native microbial community. An addition of glucose and DOM was flowed through the columns containing real soil. Oxygen depletion was again monitored using oxygen sensor foils. To assess changes in the microbial community in time 16S rRNA analysis was performed on soil samples taken from different locations within the chambers. By monitoring the levels of oxygen depletion in time, we are able to gain an understanding of how this dynamic process alters microbial community structure. Additionally, zymography was performed to elucidate the locations where enzyme activity was greatest. By studying the microbial community in time along with oxygen depletion and enzyme activity, we are able to gain insight into structure-function relationships that take place within preferential flow paths. Furthering our understanding of processes taking place within preferential flow paths will allow for better estimation of how these entities function biogeochemically.