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Organic matter content controls the N and P degradation process on biogeochemical interfaces: A micro-ecosystem scale study based on SoilChips-XPS-Zymography integrated technique in paddy soils

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The biogeochemical interfaces are hotspots for organic matter (OM) transformation. However, direct and continuouxiacis tracing of OM transformations and N and P degradation processes are lacking due to the heterogeneous and opaque nature of soil microenvironment. To investigate these processes, a new soil microarray technology (SoilChips) was developed and used. Homogeneous 2-mm-diameter SoilChips were constructed by depositing a dispersed paddy soils with high and low soil organic carbon (SOC) content. A horizon suspension on a patterned glass. Dissolved organic matter from the original soil was added on the SoilChips to mimic biogeochemical processes on interfaces. The chemical composition of biogeochemical interfaces were evaluated via X-ray photoelectron spectroscopy (XPS) and the two-dimensional distribution of enzyme activities in SoilChips were evaluated by zymography. Over 30 days, soil with high SOC content increases microbial nutrition (N and P) requirements than soil with low SOC evidenced by higher hotspots of β-1,4-N-acetaminophen glucosidase, and acid phosphomonoesterases and higher 16S rRNA gene copies. The degree of humification in dissolved organic matter (DOM) was higher and the bioavailability of DOM was poorer in soil with high SOC than soil with low SOC. The poorest bioavailability of DOM was detected at the end of incubation in soil with high SOC. Molecular modeling of OM composition showed that low SOC mainly facilitated the microbial production of glucans but high SOC mainly facilitated the microbial production of proteins. We demonstrated that SOC content or DOM availability for microorganisms modifies the specific OM molecular processing and N and P degradation processes, thereby providing a direct insight into biogeochemical transformation of OM at micro-scale.