Effect of redox-active and conductive biochar particles on methane emission and Fe(III) reduction in anoxic paddy soil

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Biochar, made by biomass pyrolysis, can function as redox-active electron shuttle stimulating microbial Fe(III) mineral reduction. Conductive biochar particles have been shown to link interspecies metabolisms through electron transfer, and create syntrophic interactions among microorganismsm. In anoxic paddy soil environments, methanogenesis competes with microbial Fe(III) reduction for (in)organic electron donors. The influences of different concentrations and particle sizes of redox-active biochar on the competition between methane formation and microbial Fe(III) reduction in anoxic paddy soils are still unclear. Therefore, the aims of this study are i) to investigate the competition between methanogenesis and microbial Fe(III) mineral reduction in the presence of different wood-derived Swiss-biochar:ferrihydrite (Fh) ratios in anoxic microscosm experiments and ii) to follow the shifts in microbial community after biochar addition.

We found that microbial Fh reduction and methane formation were stimulated simultaneously by biochar amendments. Methane production only decreased after the addition of a methanogenic inhibitor, bromethanesulfonate. In particular small-particle-sized biochar and/or biochar amendment at high concentrations lead to high rates of Fe(II) formation and CH_4 production. These observations allow to speculate that direct electron transfer (DET) from redox-active conductive biochar particles, that are reduced by the Fe(III)-reducers, to methanogens occurred in our microcosms, and thus could be an important process in biochar-amended anoxic paddy soils. These findings suggest that in such environments, the network of microbial electron transfer processes can establish syntrophic associations between microbes, by connecting interspecies metabolisms through the use of conductive, redox-active particles.