METHANOGENIC DEGRADATION AND MICROBIAL METABOLISM OF TRACE GASES

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The objectives of the Conrad lab in the past years have been to learn which groups of soil microorganisms are responsible for particular biogeochemical processes and to understand the reason why. For this purpose we investigated biogeochemical processes involved in the exchange of climatically relevant trace gases (CH_4, H_2) between soil and atmosphere. A particular focus was on processes in flooded rice fields, which we have used during the last thirty years as a model system for studying biogeochemistry and ecology of soil microbes.

After my retirement in 2017, I continued publishing experimental work that had been done in the previous years but had not been completely evaluated and written up. This process is still on-going. In 2021 to 2023 we published for example experimental work on stable carbon Isotope fractionation during the methanogenic and sulfidogenic degradation of acetate and propionate, which are important Intermediates of the anaerobic breakdown of organic matter in anoxic paddy soils and lake sediments. We found isotopic enrichment factors for acetate degradation in the range of -26‰ to -17‰ under both methanogenic and sulfidogenic conditions. Methane and CO_2 both became depleted in 13C relative to acetate (Conrad *et al.* 2021). The isotopic enrichment factors of propionate degradation were only -8‰ to -3‰ (Conrad & Claus, 2023). Propionate degradation proceeded by the Smithella-type and the Syntrophobacter-type pathway under methanogenic and sulfidogenic conditions, respectively. The Smithella-type pathway starts with disproportionation of propionate to acetate and butyrate, the butyrate becoming depleted in ^{13}C (Figure). In the Syntrophobacter-type pathway propionate is oxidized with sulfate to acetate and CO_2, with CO_2 becoming depleted in ^{13}C (Figure 1).

Publications

Conrad, R., Liu, P., & Claus, P. (2021). Fractionation of stable carbon isotopes during acetate consumption by methanogenic and sulfidogenic microbial communities in rice paddy soils and lake sediments. ***Biogeosciences***, 18: 6533-6546. doi:10.5194/bg-18-6533-2021.

Ji, Y., Xu, Y., Zhao, M., Zhang, G., Conrad, R., Liu, P., Feng, Z., Ma, J., & Xu, H. (2022). Winter drainage and film mulching cultivation mitigated CH_4 emission by regulating

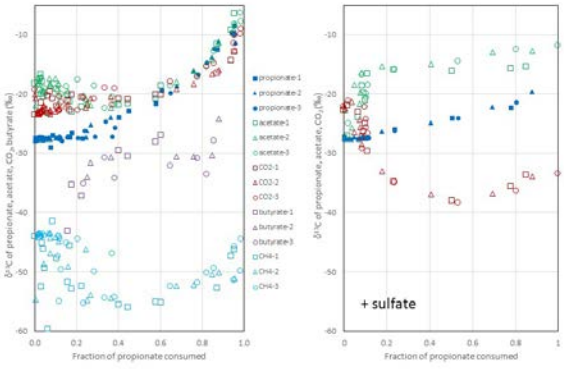

Figure 1 | Change of $\delta^{13}C$ of propionate, acetate, butyrate, CO_2 and CH_4 relative to the fraction of propionate consumed under methanogenic and sulfidogenic conditions in paddy soil from Vercelli (Italy). The different symbols indicate three different replicates (adapted from Conrad & Claus, 2023)

the function and structure of methanogenic archaeal and fermenting bacterial cummunities in paddy soil. ***Journal of Environmental Management,*** 323: 116194. doi:10.1016/j.jenvman.2022.116194.

Conrad, R. (2023). Complexity of temperature dependence in methanogenic microbial environments [review]. ***Frontiers in Microbiology,*** 14:1232946. doi:10.3389/fmicb.2023.1232946.

Conrad, R. & Claus, P. (2023). Fractionation of stable carbon isotopes during microbial propionate consumption in anoxic rice paddy soils. ***Biogeosciences,*** 20: 3625-3635. doi:10.5194/bg-20-3625-2023.

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