The contributions of biotic and abiotic processes in a nitrate-dependent Fe(II) oxidation system

CHEN DANDAN, LI XIAOMIN, LIU TONGXU*, LI FANGBAI* AND LUO XIAOBO

Guangdong Institute of Eco-Environmental and Soil Sciences, Guangzhou 510650, China, cefbli@soil.gd.cn; txliu@soil.gd.cn

The redox reaction between iron and nitrogen drives the global biogeochemical cycles of iron and nitrogen, and concomitantly changes the mineralogy and the fate of nutrients. Despite the microbial nitrate-dependent Fe(II) oxidation has been reported to play a key role on the Fe/N interactions under neutral-anoxic conditions, the detailed mechanisms underpinning remain poorly understood. The microbial nitrate-dependent Fe(II) oxidation was known as a biotic process before, but recent studies showed this process could be mediated by both biotic and abiotic mechanisms. To examine the simultaneous Fe(II) oxidation and nitrate reduction under neutral-anoxic conditions, anaerobic experiments was set up with a lithoautotrophic nitrate-dependent Fe(II) oxidation bacterium, *Pseudogulbenkiania* sp. strain 2002 in this study. The reaction kinetics of Fe(II) oxidation and nitrate reduction clearly showed that Fe(II) oxidation was greatly enhanced when the presence of nitrate and the intermediate of nitrate reduction (nitrite) could also chemically oxidize Fe(II). Furthermore, the isotope fractionation of N_2O showed that the biotic process, abiotic process, and the coupling processes were largely separated, implying that the overall nitrate reduction and iron oxidation could be mediated by both the biotic and abiotic processes. Mineral phases analysis indicated goethite was formed after Fe(II) oxidation in the abiotic control, however, the dominant mineral was identified as lepidocrocite (>70%) in the nitrate-dependent Fe(II) oxidation system. Thus, the elementary reaction mechanism was proposed based on the aforementioned results, and a brief kinetic model was also established. According to the best-fitting to the experimental kinetic data, the optimal rate constants of biotic process, abiotic process, and the coupling processes were obtained, so the relative contributions of each processes were evaluated. This study will not only estimate the contributions of chemical and microbial reactions but also provide new insights into their interactions.

This work was funded by the National Natural Science Foundations of China (41522105 and 41571130052).