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Effects of changing redox conditions on the dynamics of dissolved organic matter and CO_2 in paddy soils

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The current knowledge about dissolved organic matter (DOM) dynamics in soils and its dependence on different C pools based mainly on observations and experiments in aerobic environments. We have only a limited understanding about the effects of changing redox conditions on production and composition of DOM although this fraction of soil organic matter is important for greenhouse gas emission and carbon storage in soils. In many ecosystems temporal and spatial changes of oxic and anoxic conditions are evident and might even increase in future. It is assumed that changing redox conditions are the key drivers of DOM dynamics in such ecosystems.

More detailed we tested the following hypotheses:

1. Anoxic conditions result in relative DOM accumulation due to less mineralization of already produced DOM
2. Close relationship between DOM production and CO_2 emission
3. ^{14}C signature of CO_2 enables the identification of different C pools degraded at oxic and anoxic conditions

We chose paddy soils as a model ecosystem because these soils are anoxic during the rice growing period and oxic during harvest and growth of other crops. Furthermore, paddy soils have oxic and anoxic horizons. Soils of a unique chronosequence of paddy soil evolution (50 to 2000 years, China) were studied in direct comparison to non-paddy soils of the same age. In these soils, exposed to different redox conditions over defined periods of times, the dynamics of DOM, CO_2, ^{14}C of the CO_2 and other redox sensitive elements were followed in laboratory experiments. In the latter redox conditions were changed every 3 weeks from oxic to anoxic and vice versa. Besides analysis of the composition of the soil solution and the gas phase we determined differences in C pools being respired at oxic and anoxic conditions by ^{14}C AMS of the CO_2.

The measured redox potentials of -50 mV to 250mV at anoxic conditions and 350 mV to 550 mV at oxic conditions were in the expected range and proofed the appropriate setting of the chosen incubation method. PH values varied between 5.5 and 7.5, where anoxic samples had higher values than oxic ones. We further observed only small DOC contents of less than 1mg per g C. Under anoxic conditions as well as among the non-paddy soils DOC production was slightly higher than their respective counterparts. However, we could not find large effects of the time of rice cultivation. Nevertheless, the 2000 year old paddy soil showed highest DOC and CO_2 production. The increase of DOC and CO_2 production was strongest when the oxic period disrupted the anoxic conditions.

^{14}C data revealed that CO_2 respired from the 700 year old paddy soil was much older than from the 2000 year old paddy soil independently from redox condition. Furthermore, C mineralized at anoxic conditions was older than at oxic ones. During the incubation experiment the C consumption shifted from older pools to younger ones.

We conclude that DOM accumulated at anoxic conditions will be quickly mineralized at oxic conditions. The influence of soil development on the C dynamics was less important than expected, thus fresh organic matter seems to play a more decisive role. The unexpected large decomposition of old organic matter at anoxic conditions hints to changes in the microbial community involved.