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Coupled cadmium and climatic stress increase agricultural greenhouse gas emissions

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Agricultural soils contribute up to 5% to total anthropogenic greenhouse gas (GHG) emissions. The heavy metal cadmium has been accumulating in agricultural soils, due to atmospheric depositions and modern agricultural processes using impure, metal-bearing phosphate fertilizers [Grant et al. 2012]. Cadmium has no metabolic function and is considered toxic to microorganisms that produce most of the GHG emitted from agricultural soils. A change in Earth´s climate alters microbial activity [Bardgett et al. 2008] and may also shift cadmium bioavailability due to, for example, altered binding characteristics within the soil matrix. Thus, it is important to understand how climate impacts GHG emissions from cadmium-bearing agricultural soils. We hypothesize that future climate and increasing soil cadmium combined, will reduce GHG emissions from agricultural topsoils compared to when cadmium contaminated soils are exposed to today´s climate.

In climatically controlled incubation chambers, vertical soil mesocosms filled with agricultural soils bearing three different cadmium concentrations (0.24, 0.78, 4.42 µg cadmium kg^{-1} dry soil) were exposed to different climatic conditions for 7 weeks in a multifactorial design. Increasing atmospheric CO_2 concentration to 800 ppm_v and atmospheric temperature by 4°C (a likely scenario 2100 according to IPCC 2017) relative to today's climatic conditions were simulated. Soils of low cadmium contamination emitted more N_2O and CO_2 under today's climatic conditions, compared to soils with background cadmium concentrations. Under future climatic conditions, soil cadmium did not affect CO_2 emissions yet increased N_2O emissions compared to soils with background cadmium concentrations. As N_2O has a 265 times higher warming potency than CO_2, the global warming potential of GHGs emitted from low cadmium contaminated soils exposed to future climatic conditions was almost two times higher compared to soils with background cadmium and exposed to today's climatic conditions. To reason our surprising findings that contradict our hypothesis, we will present a combination of geochemical and microbial ecology data to explain differences in cadmium binding to the soil matrix and nitrogen cycling in the different incubation set-ups.

Our results indicate that low topsoil cadmium concentrations can affect soil-induced GHG emissions under a simulated future climate, warranting further investigation on a field scale.