Impacts of elevated CO_2 concentrations on CO_2-adapted and non-adapted environments

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Carbon capture and storage (CCS) into geological formations, like deep saline aquifers or depleted gas and oil reservoirs, is part of global strategies to reduce greenhouse gas emissions and associated climate change. For the commercial application of CCS, environmental implications and hazards of potential CO_2 leakages from deep reservoirs into near-surface environments have to be examined.
This micro- and molecular biological survey is integrated into the EU funded project "RISCS" (Research into Impacts and Safety in CO_2 storage) and focuses on both natural CO_2 vents (adapted sites) and artificial sites (non-adapted). Natural CO_2 vents allow the determination of long-term biogeochemical CO_2 impacts on near-surface ecosystems whereas artificial CO_2-non-adapted sites enable assessing CO_2 effects before, during and after CO_2 exposure.
Therefore, two natural CO_2-adapted sites Laacher See (Germany) and Florina Basin (Greece), and the artificial test site ASGARD (Artificial Soil Gassing and Response Detection, Great Britain) are comparatively investigated. The Laacher See, located in the Eastern Eifel volcanic field west of the river Rhine, discharges about 5 000 t CO_2 per year from multiple gas vents at the bottom of the lake and in its surrounding forests and pastures. The Florina Basin, a tectonic graben in northern Greece, is characterized by CO_2 vents and carbonate springs along rock discontinuities. The ASGARD site, located in the south of Nottingham, comprises differently vegetated plots which are continuously exposed to varying CO_2 concentrations.
The investigation of microbial metabolic activities, the abundance and diversity of selected functional groups of microorganisms, together with biogeochemical parameters showed differences between CO_2-adapted and non-adapted sites. Distinct CO_2-induced alterations in microbial activity, abundance and diversity for both Laacher See and Florina Basin have been observed. In most cases, cell numbers of Bacteria and Archaea at the reference sites exceeded those at the CO_2 vents by up to four orders of magnitude, indicating a negative effect of the CO_2 on the size of the microbial populations. In contrast, with increasing CO_2 concentrations an overall increase of anaerobic methane and CO_2 production rates could be observed. The molecular fingerprinting of the community composition showed CO_2-related differences between high CO_2 and control samples for both the Laacher See and Florina. Our results for these two natural, CO_2-adapted sites illustrate a CO_2-induced shift in microbial activity and community composition caused by the increasingly anaerobic and acidic environmental conditions.
In contrast, no distinct CO_2 impact for the artificial ASGARD site could be determined so far. After two years of continuous CO_2 injection no significant changes in microbial metabolic rates, cell numbers and community composition between CO_2 gassed and reference plots could be observed. Seasonal variations possibly overlie potential CO_2-induced alterations, thus also hindering the detection of potential leaks from deep storage reservoirs.