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Methane trapping and release in restored and unrestored peatlands

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Unique biochemical and environmental conditions prevailing in natural peat deposits make peatlands one of the largest natural emitters of methane (CH_4) to the atmosphere. Methane can be released through ebullition, diffusion and plant tissues. Under anaerobic conditions in the subsurface, a portion of CH_4 undergoes oxidation by methanotrophs. Considerable amounts of CH_4 become trapped under the peat surface in dissolved or gaseous phase. Biogenic free-phase gas (FPG) in peatlands accounts for up to 1/5 of the total peat volume and contains up to 50% of CH_4.

Horticulture peat extraction targets peat of certain type (e.g., low-decomposed *Sphagnum* peat) leaving behind a part of the peat deposit that is less profitable for the industry. These severely disturbed ecosystems are stripped of vegetation and dried through installed ditched, while the extracted peat is compacted by heavy machinery. During extraction, FPG escapes to the atmosphere, but how much FPG is released and how much remains within the peat matrix during and post-extraction is unknown. Does the subsurface CH_4 pool recover by itself, which would indicate returning of the ecosystem to the natural carbon balance, or is restoration necessary to promote this process by returning peatland vegetation and hydrological conditions?

Ideally, to answer these questions, the amount of FPG should be assessed before peat extraction to establish an individual baseline for each site. In practice, these data are very difficult to obtain. However, our site is located at a horticulture peatland complex where currently extracted, unrestored, natural, and restored sites of different age of restoration are located right next to each other. We can therefore assume that differences in CH_4 dynamics across these sites represent changes over the extraction and restoration process. We used a relatively non-invasive method of ground-penetrating radar with a 100 and 200 MHz antenna to assess the FPG content, CS616 probes to measure changes in volumetric water content that indicate gas volume over time and potentially its movement and release, and Los Gatos Research portable gas analyzer with a chamber to measure diffusive fluxes and monitor ebullition events. Environmental conditions and meteorological data were also recorded to investigate factors that may influence FPG dynamics. All the data were collected in the growing seasons of 2013, 2016, and 2017 capturing very dry to extremely wet periods.

Monthly GPR surveys at each site show changes in FPG on a short time scale. We observed ebullition and large diffusive fluxes at flooded parts of the restored sites, and lower CH_4 fluxes at unrestored and natural site. Zones of potentially continued CH_4 production and/or trapping during peat extraction have been detected at the unrestored sites. The presence of FPG at a newly restored site may be a result of gas trapping under peat layers of increased post-extraction density.

Obtained results can be applicable in improving greenhouse gas emission inventories and future decision-making in peatland management. Simplified methods could be utilized by the industry for monitoring extracted and restored sites.