

EGU24-2682, updated on 08 Dec 2024

<https://doi.org/10.5194/egusphere-egu24-2682>

EGU General Assembly 2024

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Modelling and Measurement of Radon and CO₂ Release from Thawing Permafrost Caused by Climate Change

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Thawing of permafrost due to climate change is known to release gases such as the climate drivers carbon dioxide and methane, as well as the carcinogen radon. Radon is a natural radioactive gas responsible for about 10% of lung cancer deaths globally, and substantially greater rates in sub-Arctic communities. Gas transport is significantly reduced in permafrost, but now that permafrost is thawing due to climate change, the effect on the release of CO₂ and CH₄, and on domestic radon exposure is unknown.

Measurement: Few experimental measurements have shown the gas permeability of permafrost to be very small (order of 10⁻¹⁶ m²). Here we present the initial measurements of the changes in porosity and gas permeability during the thawing of synthetic permafrost using a pyknopermeameter that we are developing. The results show increases in gas permeability by many orders of magnitude, that remain during freeze-thaw cycles providing the thawed water does not drain from the sample. Draining the thawed water leads to compaction which decreases the effects of subsequent thawing on the matrix gas permeability, but can cause fracturing which provide high permeability pathways for gas flow.

Modelling: Results from radon transport modelling through soil, permafrost, and model buildings either with basements or built on piles show that permafrost acts as an effective radon barrier, reducing radiation exposure to a tenth of the background level in dwellings while producing a ten-fold increase in the radon activity below the permafrost. When we model thawing of the permafrost barrier, we find no increase in radon to the background level for buildings on piles. However, for buildings with basements, the level of radioactivity due to the radon increases to over one hundred times its initial value and can remain above the 200 Bq/m³ threshold for up to 7 years depending on the depth of the permafrost and the speed of thawing. When thawing speed is taken into account, radiations remain higher than the threshold for all scenarios where 40% thawing occurs within 15 years. This new information suggests that the sub-Arctic population could be exposed to dangerous radon levels as a result of climate change.