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Detecting gas leakage in the critical zone at fully decommissioned hydrocarbon wells in the Netherlands

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Uncontrolled gas leakage along hydrocarbon wells may pose a risk to groundwater quality and can contribute significantly to greenhouse gas emissions, particularly post-abandonment. In the Netherlands, well decommissioning procedures are relatively strictly regulated. However, no research has thus far been carried out that investigates whether current procedures indeed prevent such leakage. Furthermore, the practice of cutting and burying the top of wells to a depth of about three meter below the surface complicates any follow-up monitoring.
For the present study an elaborate field investigation of 29 decommissioned hydrocarbon well sites was carried out. First, the soil surface was mapped for CH4 concentrations in a circle with a radius of 15 meter around the given coordinates of the well. Then static flux measurements were carried out at the coordinates of the well, a control location and any locations which were found to have deviating CH4 concentrations during the first step. These static flux measurements were then repeated directly after drilling a $\sim$1 meter deep hole into the soil using a hand auger. Methane isotopic composition and $CH4/CO_2$ ratios were established by collecting gas samples from the chamber at the end of selected measurements.
A positive, thermogenic methane flux – clear evidence for leakage along the well from a deep gas reservoir – was encountered at 1 out of 29 sites ($\sim$3%). This is the first scientific observation of a leaky, fully decommissioned hydrocarbon well in the Netherlands. All other samples revealed either no flux or a biogenic flux, and no evidence that such fluxes were related to the underground presence of the decommissioned wellbores. The results obtained from the leaking well site showed that neither the thorough scanning nor the surficial static chamber methods were effective at detecting methane leakage here. This carries important implications for past and future investigations of buried sources of gas leakage, which need to take into account the possible masking effects of dispersion, diffusion and, in particular, oxidation of methane during its passage to the surface. Therefore, a detailed follow-up investigation at this site was carried out with the aim of studying methane migration through the unsaturated zone in more detail, and how to effectively measure leakage fluxes from buried sources. Results from the other sites also indicate that methane fluxes measured at one meter depth were considerably higher than at the surface. Hence, we recommend to monitor for potential gas leakage at a shallow depth in addition to at the surface.