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Environmental legacy of an underground gas well blowout: long-term effects of gas and brine leakage on groundwater quality

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In 1965, a catastrophic underground blowout occurred during the drilling of a gas well in the village of Sleen, the Netherlands. The blowout led to the uncontrolled release of large amounts of natural gas and saline groundwater. Now, 50 years later, a number of nearby groundwater monitoring have been sampled to study the long term effects of this event on the groundwater composition of the overlying freshwater aquifers. The findings are used as an analogue for studying the potential adverse effects of hydraulic fracturing on groundwater quality.

In total, 27 samples were taken and analysed for dissolved gas molecular and isotopic composition, major ion chemistry, water isotopes and stable chlorine isotope ratios. The resulting data show that concentrations of dissolved methane are still strongly elevated compared to background samples in a plume downstream of the blowout location. Isotopic data reveals the thermogenic nature of this plume; all samples with methane concentrations greater than 10 mg/l (n=12) had δC-CH4 values greater than -30‰ (VPDB), characteristic of thermogenic methane. The maximum distance at which thermogenic methane is observed is at approximately 500 meter downstream of the centre of the blowout. The progressive enrichment of both δ13C-CH4 and δ2D-CH4, that is observed with distance from the well and decreasing methane concentrations, presents strong evidence for the role of anaerobic methane oxidation (AOM) in limiting the spread of the dissolved methane plume. Low sulphate and increased Fe(II) and Mn(II) concentrations indeed suggest that multiple AOM pathways are involved in the natural attenuation of the dissolved methane plume. Chlorine concentrations were only elevated in a subset of wells in close proximity to the blowout location, indicating that the present-day effects of brine migration are minimal. Nevertheless, elevated Na/Cl ratio's in multiple wells reveal that freshening of the aquifer is still on-going.

In summary, this research sheds new light on the long-term effects of natural gas and brine leakage on groundwater quality, which is considered one of the main environmental hazards related to hydraulic fracturing and unconventional gas production in general. Notably, it shows that the anaerobic oxidation of methane may play a major role in containing the effects of uncontrolled gas migration from reservoirs to shallow aquifers.