METEC Research Alert
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For Leaks in Rain, Snow and Ice Conditions, Experiments Show Faster Gas Migration, Higher Gas Concentrations, and Continued Gas Migration Days after Leak was Stopped

Purpose:

Recent experiments at Colorado State University's (CSU) Methane Emission Technology Evaluation Center (METEC) indicate that belowground natural gas movement during and after rainy, snowy and icy conditions is further and faster than previously thought or anticipated by the research team. Service providers and operators should consider the effect of varying surface conditions due to weather events in leak detection, repair and monitoring practices.

Summary:

Controlled release experiments simulating a wide range of belowground NG leaks demonstrate that an underground natural gas (NG) leak generally considered non-hazardous during dry summer conditions can quickly become more hazardous in the presence of rain, snow and ice on the ground surface. For the scenarios tested, rainy and snow/ice surface conditions resulted in gas spreading 4 times farther than dry grass covered conditions in similar time frames. In addition, the gas continued to spread away from the leak point at concentrations exceeding LEL[1], after the leak was terminated and at much high speeds than under dry summer conditions.

Experimental Data:

The research team conducted three contrasting controlled release experiments simulating 10-12 slpm (21-26 scfh) belowground releases of distribution grade NG (~90% CH_4 by volume). The experimental testbed, as seen in Figure 1, was designed to simulate an urban/suburban environment using structures simulating houses, asphalt paved roads and sidewalks, open grassy areas and underground utilities and piping. For this set of experiments, releases were performed using a belowground methane release point located at 0.9 m (3 ft) below ground surface (BGS). An underground network of methane concentration sensors[2] deployed at 0.3, 0.6, 0.9 m BGS along the vertical

[1] LEL - Lower Explosive Limit of 50,000 ppm
[2] SGX Integrated Infrared 100% Methane – SGX ME 100% sensor

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sections located 1.3, 3.2, 4.6, and 5.5 m away from the release point measure the variation of subsurface CH_4 concentration (ppm) continuously at 5 second time intervals.

Experiments were conducted to specifically target the variation of surface conditions to include (a) grass, (b) heavy rain and (c) snow/ice on the gas behavior belowground (Figure 1 a-c). Experiment 1 occurred during dry summer-like conditions consisting of a grass/pavement surface condition, experiment 2 occurred during spring heavy rainy conditions representing saturated grass and a wet pavement surface, while the third experiment occurred during winter conditions consisting of a frozen topsoil layer and snow cover of ~10 cm (4 inches).

During dry conditions (Figure 1, left column), subsurface gas concentrations and lateral migration remained within ~2m of the release location. Spreading of the gas was limited to the gas release period. In other words, when the gas release was terminated (i.e., the leak stopped), CH_4 concentrations returned to background concentrations within one day.

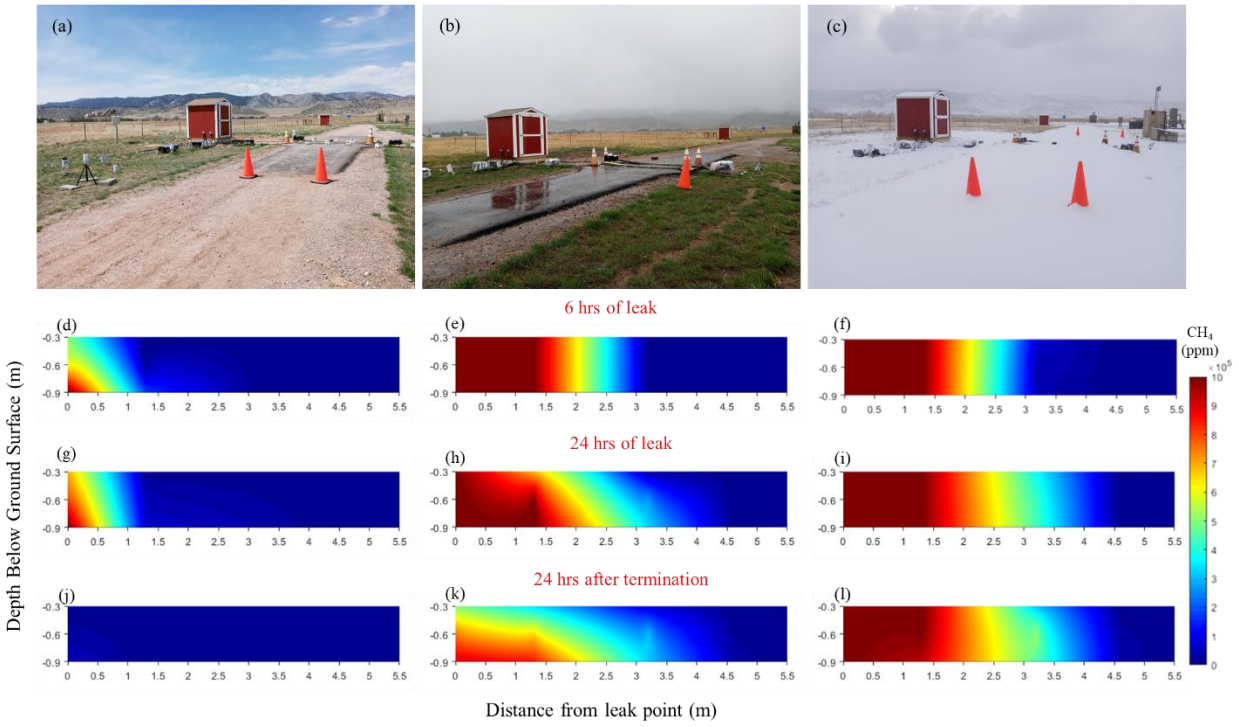

Figure 1: View of METEC urban testbed during (a)summer, (b)heavy rainfall, and (c)winter experiments. d-l show the belowground CH_4 profiles for each experiment, demonstrating the change with time. d-f and g-h profiles are 6 and 24 hrs, respectively, after the start of the leak. j-k demonstrate the CH_4 profiles 24hrs after termination of leak.

During heavy rainfall experiments where the soil surface was close to full saturation (Figure 1 e, h, k) , the soil within 1.5m of the leak point reached saturation within 6 hours. Gas migrated more than 4 times farther within the same time period than during dry summer conditions. Additionally, gas continued to migrate away from the leak point at concentrations exceeding LEL for several days after the gas release stopped (note that only 24hrs after termination is shown in figure). LEL levels 4.6 m (15 feet) from the leak location persisted more than 5 days. Although not shown here, light rain conditions which nominally increased the soil moisture in the top soil profile (e.g. increase from 30 to 40% saturation) resulted in similar gas concentration profiles over time.

As previously reported in a METEC Research Alert (April 2022), during a similar release conducted with a frozen top-soil layer and a snow cover (Figure 1 f, i, l), similar to rainfall conditions gas quickly saturated the soil at the leak location and migrated laterally over 4 times farther than summer conditions for the same gas release duration (1 day). Additionally, gas continued to migrate for several days after the gas release stopped at concentrations exceeding LEL. LEL levels 4.6 m (15 feet) from the leak location persisted more than 5 days.

Implications:

The slow belowground clearing of gas from the leak, coupled with continued movement of relatively high gas concentrations for several days after the release was terminated, exceeded prior expectations of the research team. While preliminary, these results indicate that additional caution may be required when responding to leaks during rain and snow/ice conditions. It is the research team's understanding that operators in cold regions often increase leak surveys during extended periods of freezing weather although procedures vary between operators.

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