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Assessment of CO₂ health risk in indoor air following a leakage reaching unsaturated zone: results from the first representative scale experiment

Loschetter A¹., de Lary L¹., Grandia F²., Powaga E.³ Collignan B³., Marcoux M⁴., Davarzani¹ H., Bouc O¹., Deparis J¹.

Author Affiliation:

¹ BRGM, 3 avenue Claude Guillemin, 45100 Orléans

² AMPHOS 21

³ CSTB, 24 Rue Joseph Fourier, 38400 Saint-Martin d'Hères, France

⁴ IMFT, allée Prof. Camille Soula, 31400 Toulouse

Abstract (595words)

Leakage of CO₂ from geological reservoirs is one of the most fearsome unexpected scenarios for CO₂ storage activities. If a leakage reaches the ground level, exposure to high CO₂ concentrations is more likely to occur in low ventilated spaces (pit dug in the ground, basement, building) where CO₂ could accumulate to high concentrations. Significant literature and models about indoor exposure resulting from intrusion of soils gases in building are available in several domains (e.g., contaminated soils, radon, etc.). However, there is no guarantee that those approaches are appropriate for the assessment of consequences of CO₂ leakage due the specificity of CO₂ and due to the singularities of the source in case of leakage from anthropic reservoirs. Furthermore, another singularity compared to conventional approaches is that the risk due to CO₂ exposure should be evaluated considering acute concentrations rather than long term exposure to low concentrations. Thus, a specific approach is needed to enable a quantitative assessment of the risk for health and living in indoor environment in case of leakage from a reservoir reaching the unsaturated zone below the buildings.

We present the results of the IMPACT-CO₂ project that aims at understanding the possible migration of CO₂ to indoor environment and to develop an approach to evaluate the risks. The approach is based on modelling and experiments at laboratory scale and at field representative scale. The aim of the experiment is to capture the main phenomena that control the migration of CO₂ through unsaturated zone, and its intrusion and accumulation in buildings. The experimental results will also enable numerical confrontation with tools used for risk assessment. Experiments at representative scale (Figure 1) are performed on the PISCO₂ platform (Ponferrada, Spain) specifically instrumented and designed for understanding the impacts of CO₂ migration towards the soil surface. The experiment is composed of a 2.2 m deep basin filled with sand upon which a specifically designed cylindrical device representing the indoor condition of a building (with controlled depressurization and ventilation) is set up. The device includes a calibrated interface that represents a cracked slab of a building. The injection of CO₂ is performed at the bottom of the basin with a flow rate in the range of hundreds of g/d/m².

The first results show that the presence of a building influences significantly the transport of CO₂ in the surrounding soil leading to two competing phenomena: 1) seepage in the atmosphere mainly controlled by diffusion gradient and 2) advective/diffusive flux entering the building due to the depressurization. Models have been established to quantitatively assess the proportion of CO₂

entering the building and the resulting indoor concentrations. Important variations of indoor CO₂ concentrations have been evidenced during the monitoring of the experiment. As the health effects are mainly related to the maximum of exposure, it appeared necessary to be able to capture and evaluate these extreme values. Thus a significant part of the study is dedicated to the analysis of the influence of environmental parameters (including atmospheric pressure, depressurization in buildings, soil water saturation and temperature) and their respective contribution to the resulting exposure. The experimental results show episodes of massive release of CO₂ and high exposure in building followed by periods of accumulation in soil, potentially correlated to variations of atmospheric conditions.

Experimental results obtained at laboratory scale and at representative scale have been used to elaborate and calibrate models and to determine conservative configurations that should be considered in risk analysis. Models have then been used to assess a range of possible scenarios of exposure for several configurations that are representative of inhabited areas at CO₂ storage sites.

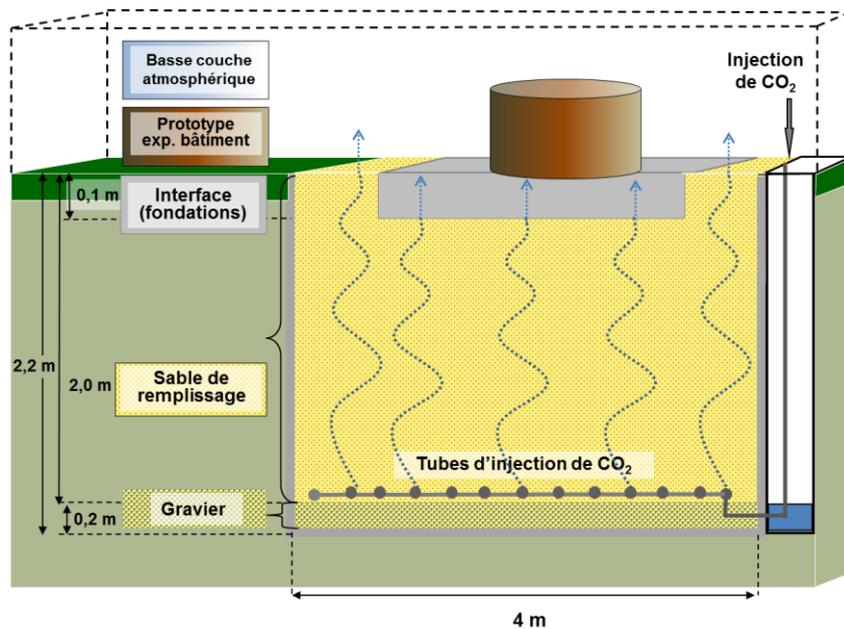


Figure 1: Representative –scale experiment to study intrusion of CO₂ in indoor air.