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Effect of air turbulence on gas transport in soil; comparison of approaches

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Greenhouse gases are playing the key role in global warming. Soil is a source of greenhouse gases such as methane (CH4). Radon (Rn) which is a radioactive gas can emit form subsurface into the atmosphere and leads to health concerns in urban areas. Temperature, humidity, air pressure and vegetation of soil can affect gas emissions inside soil (Oertel et al., 2016). It's shown in many cases that wind induced fluctuations is an important factor in transport of gas through soil and other porous media. An example is: landfill gas emissions (Poulsen et al., 2001).
We applied an experimental equipment for measuring controlled air turbulence on gas transport in soil in relation to the depth of sample. Two approaches for measurement of effect of wind turbulence on gas transport were applied and compared. Experiments were carried out with diffusion of CO_2 and air as tracer gases with average vertical wind speeds of 0 to 0.83 m s-1. In approach A, Six different sample thicknesses from 5 to 30 cm were selected and total of 4 different wind conditions with different speed and fluctuations were applied. In approach B, a sample with constant depth was used. Five oxygen sensors were places inside sample at different depths. Total of 111 experiments were carried out.
Gas transport is described by advection-dispersion equation. Gas transport is quantified as a dispersion coefficient. Oxygen breakthrough curves as a function of distance to the surface of the sample exposed to wind were derived numerically with an explicit forward time, central space finite-difference based model to evaluate gas transport.
We showed that wind turbulence-induced fluctuations is an important factor in gas transport that can increase gas transport with average of 45 times more than molecular diffusion under zero wind condition. Comparison of two strategies for experiments, indicated that, constant deep samples (Approach B) are more reliable for measurement of gas transport under influence of wind turbulence. They are more similar to natural conditions and also the lower layers of soil are affecting the diffusion and dispersion coefficients of soil in the upper layers. Power spectrum density is calculated for all the all wind conditions to determine strength vibration of all the wind speeds and its relation to gas transport. Differential pressure for different wind conditions are measured at two sides of samples.

References

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