Fluctuations of CO2 concentration inside a mofette long-term, high-frequency monitoring and a simple model.

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Our study investigates experimentally and theoretically the fluctuation of carbon dioxide (CO2) concentration and emission in a mofette located in Covasna city (Romania), On the experimental side, data over a period of 7 months were collected, measuring CO2 concentration at different depths, pressure, and temperature inside the mofette with a time resolution of 1 second. For the measurement of the CO2 concentration and temperature, we used 20 vertically placed STC31 sensors with a 5cm spacing. The atmospheric pressure was monitored at one point located at a depth of 1.2m from the bottom of the mofette using a BMP280 sensor. The data is publicly available and the measured values can be consulted in real-time at the web-site dedicated to this study [http://comodi.phys.ubbcluj.ro:8087/].

Using the collected concentration data and the classical convection-diffusion equation, we estimated the CO2 flow yield. The power-spectra of the fluctuation for this flow yield shows clearly distinguishable scaling regimes. We also found correlations between the flow yield and various environmental parameters (pressure and temperature), aspects that motivated a simple theoretical model. Our model consists of a grid of chambers connected by tubes, each chamber supplied with a constant CO2 flow yield. The flow between the chambers is assumed to be proportional to their pressure difference, while the resistance between the chambers depends on the temperature. One of the chambers is connected to the atmosphere through a tube, therefore it is directly influenced by the external pressure. Using such a connected chamber ensemble, we predicted the flow yield numerically by a 4th order Runge-Kutta method. The model is characterized by some unknown physical parameters. In order to determine their optimal values, we minimized the average of the squared differences between the measured and predicted flow yields. To account also for a possible change in the system parameters over time, we divided our dataset into 14 equal parts and optimized the model parameters for each interval separately. Using the best fit parameters, the model predicts accurately the measured flow yield both in time, generating a statistically correct power-spectra in the low frequency limit.

Overall, our study provides experimental and theoretical insight into the CO2 emission in a mofette and proves the existence of correlations between the flow yield and environmental parameters. Potential applications are diverse ranging from environmental science to earth- and medical sciences. As an immediate example we recall that mofettes are widely used in medical treatment in some circulatory disease. Understanding the dynamics and predictability of CO2 emission is crucial for ensuring patient safety. Sudden jumps in CO2 flow yield can pose a significant risk to patients, therefore the ability to anticipate and respond to large fluctuations in emission levels should be critical in the medical use of mofettes. Our original experimental apparatus can provide solution for such demands as well.

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