新型低コストガス検出装置を用いた土壌ガス中の N_2O モニタリング
Application of the New Low-Cost Gas Detecting Device for N_2O Gas Monitoring in the Soil Atmosphere

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1. Introduction

The higher crop production rate tremendously demands synthetic fertilizers. Mainly, nitrogen (N) requirement is provided from synthetic fertilizers with owning a higher contribution to the N_2O emissions. Due to its inherited characteristics, N_2O is 298 times more powerfully contributes to global warming than CO_2 [1]. Therefore, controlling nitrogen-based fertilizer is a timely need by monitoring N_2O emission levels. For the instrumentation, costly high-precision gas-monitoring instruments have been introduced and consistent with some negative aspects such as less portability, difficulties in maintenance and running in harsh environments [2]. Therefore, we have developed and tested a new low cost (2780 US Dollar) easy to assemble device with the features of measurement range 1–2000 ppm, portable (weight- 1.2 kg), easily maintainable and low power (9 V, 670 mA DC) consumption [3]. Using the new device, this study aimed to monitor the N_2O gas concentration in the soil atmosphere, which was kept under periodically ventilating headspace of the enclosed chamber that provides the condition of the conventional method of gas-monitoring known as the chamber method.

2. Materials and methods

The new device consisted of a lens tube (60 cm length, 2.5 cm diameter), which edges were covered with micro-electromechanical systems based infrared emitter and pyroelectric detector. As optical components, one convex lens and two optical windows have been connected. The soil chamber was filled with ammonium sulfate mixed with 4 kg of soil (rate-1 g / 1 Kg). A silicone tube was placed in the middle of the soil region for diffusing N_2O gas from the soil into the silicone tube. For detecting the gas in the soil atmosphere, the new device was connected with a silicone tube (length 53.5 cm) via the air pump and dryer (figure 01). The upper air chamber was connected with the air pump and three-way solenoid valve for providing ventilation under conditions of the chamber method. The gas in the upper chamber was sent out for one hour (ventilation period) and circulated within the system for a thirty-minute period (measuring interval) by the solenoid valve. The N_2O gas level in the silicone tube was recorded by the new device at each 30-minute interval. The soil saturated by the connected water container for two days and the drainage period was kept as two days. The soil moisture condition was recorded by the moisture sensor. All data recording process was conducted for six consecutive saturation and drainage cycles. The recorded N_2O gas concentration levels by the new device and soil moisture data were graphically extrapolated for understanding the temporal variation of N_2O gas in the soil region.

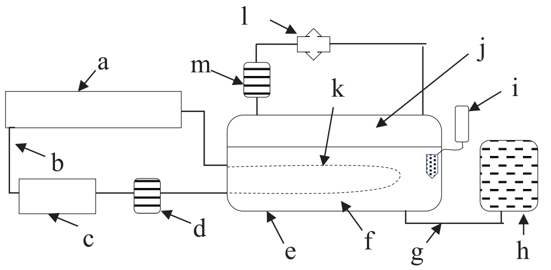

Figure 01. Experimental setup of the soil gas monitoring test. (*a*) new gas detecting device, (*b*) gas circulation tube, (*c*) membrane dryer(*d*) air pump, (*e*) soil containing chamber (*f*) soil, (*g*) water supplying tube, (*h*) water container, (*i*) data logger and soil moisture probe, (*j*) air in headspace (*k*) diffusion cell (silicone tube), (*l*) solenoid valve(*m*) air pump.

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3. Results and discussion

Figure 02 shows recorded N_2O gas concentration levels at a 30-minute interval during six soil moisture saturation and drainage cycles. During the first cycle of saturation, a higher concentration was recorded as it was the immediate period of ammonium sulfate was added to the soil. Starting from the second saturation cycle, it gradually shows an increase in the gas concentration up to the fourth cycle and turns out to reduce when the sixth cycle has been completed. When starting the drainage in all cycles, it shows a rapid increase and drop of gas level since drainage changes direction of airflow temporarily. Considering all six cycles, the changes in gas concentrations show a similar pattern within each other. This fact proves the N_2O gas-monitoring ability in the soil environment for the long-term using low-cost device together with silicon diffusion cell. The recorded gas concentrations have fluctuated approximately from 88 −820 ppm during the saturation events and 80 - 120 ppm range during the drainage periods. Compared to the chamber method, the recorded gas concentration levels in the soil environment are at a considerably higher level, and low-cost low precision devices are possible to use for estimating the soil N_2O gas emission by monitoring the gas in the soil atmosphere.

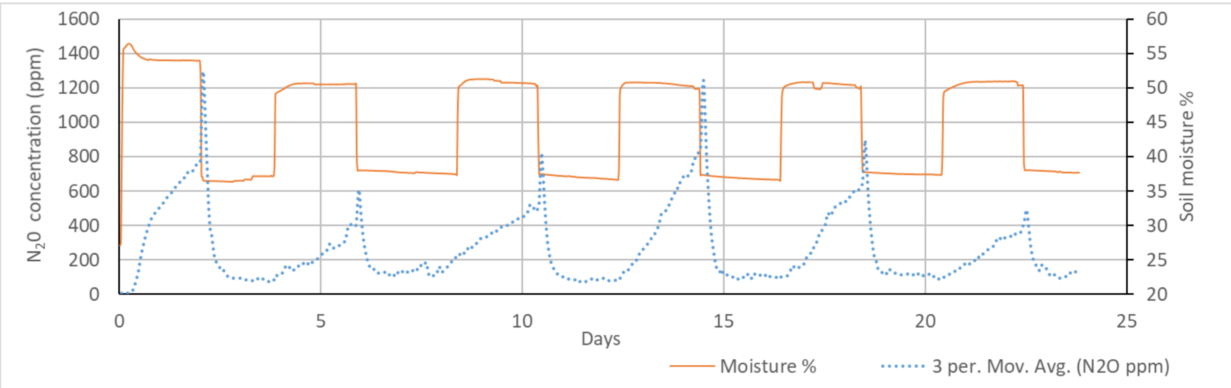

Figure 02. Recorded N_2O gas concentrations by the new device.

4. Key References

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