Using low-cost gas sensors in agriculture: a case study

ABSTRACT

The main goal of the POREM (LIFE17 ENV/IT/000333) project consisted in demonstrating the applicability of the treated poultry manure for the soil restoration or bioremediation. To perform the research activities planned for the project, a considerable amount of poultry manure was stored in a large depot located in a rural, remote, and unattended area. The use of the manure implied the emissions of odours and gases that required a continuous and real-time monitoring. This task could not be accomplished by placing expensive instrumentation in such remote and unattended location, therefore, we have investigated the use of low-cost gas sensors for monitoring such poultry manure emissions. A portable monitoring unit mainly based on chemoresistive gas sensors was used to provide indications about the concentrations of NH3, CH4, H2S, and CO2. This experiment proved the feasibility of the use of the low-cost devices in such particular environments, and data gathered seem to indicate that, if properly stored, gases and odours emitted by poultry manure have a limited impact on the air quality of the surrounding environment.

MATERIALS AND METHODS

The SentinAir system aims to provide a flexible tool for managing a wide range of sensors and instruments for research purposes in uncomfortable environments, far from the laboratory facilities. It was built to replace expensive chemical analyzers due to budget issues. Considering the comparative and indicative nature of the investigation to carry out, the use of low-cost sensors to install on the SentinAir system resulted to be a reasonable option compared with the use of professional and expensive instruments. The SentinAir hardware and software architecture are detailed in [1,2], while its assembly procedure has been exposed in [2]. Two copies of the SentinAir device (see figure 3) were used for evaluating the impact of the emissions coming from the poultry manure stored in a depot. The storage site was a closed space which dimensions are 20m x 15m x 5m. A set of windows placed just below the depot ceil provided the openings to the external environment. No forced ventilation system was used for the air exchange between the internal and the external space, therefore the airflow was ensured by leaving the windows opened. In this way, the area available for natural ventilation was about 2.7 m^2. The first SentinAir device was placed outside the depot (see figure 1), in a place 3m high from the ground, while the second one was located very close to the manure heaps (see figure 2). As concerns the set of sensors mounted inside the monitors, they are summarized in table 1. The device placed in the depot was also equipped with a temperature probe to monitor the temperature trends inside the poultry manure heaps. The probe was built in the laboratory by using the TC1047A sensor and a steel pipe.

Table 1. Sensors used in the SentinAir monitors

Sensor	Parameter	Type	Manufacturer
IRC-A1	CO_2	NDIR	Alphasense
TGS 825	H_2S	chemoresistive	Figaro
TGS 826	NH_3	chemoresistive	Figaro
TGS 2611	CH_4	chemoresistive	Figaro
HIH 5031	RH	capacitive	Honeywell
TC 1047 A[1]	T	termoresistive	Microchip

[1]*this sensor was mounted inside the monitors to measure ambient temperature, and also in the probe.*

Figure 1. The second monitoring unit outside the depot.

Figure 2. The monitoring unit placed inside the depot and the poultry manure heaps.

Figure 3. The SentinAir device

RESULTS

The measurements carried out every five minutes were used by the two monitoring units to calculate the hourly averages of each monitored variable. They were useful to understand the fermentation process trend of the manure heaps and impact of the poultry manure emissions outside the storage depot. The dataset obtained in this way is summarized in the plots of the time series concerning each measured parameter (see figures 4-9).

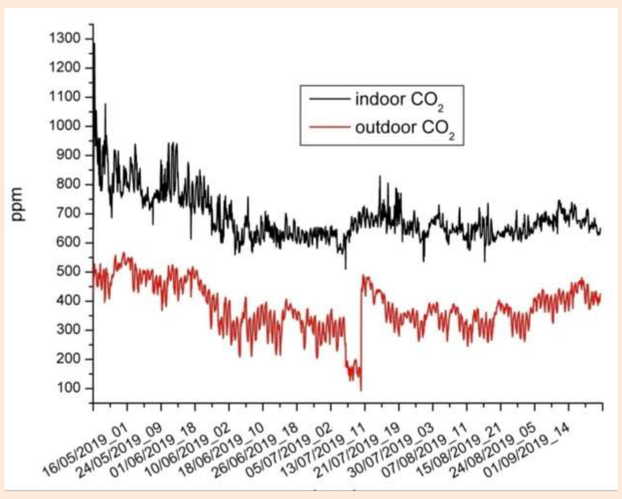

Figure 4. Trends of the CO_2 concentration measured inside and outside the depot.

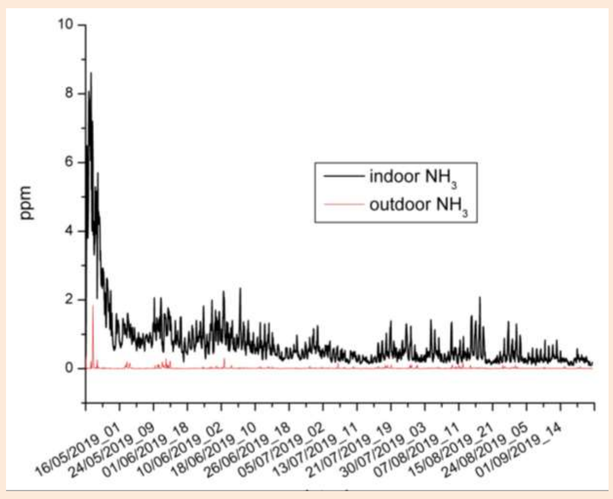

Figure 5. Trends of the NH_3 concentration measured inside and outside the depot.

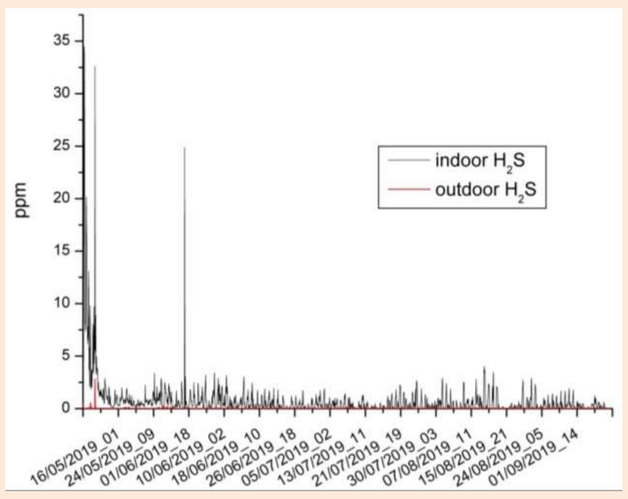

Figure 6. Trends of the H_2S concentration measured inside and outside the depot.

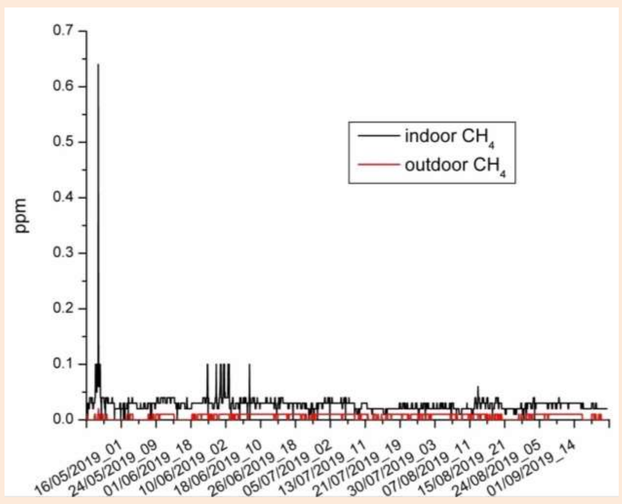

Figure 7. Trends of the CH_4 concentration measured inside and outside the depot.

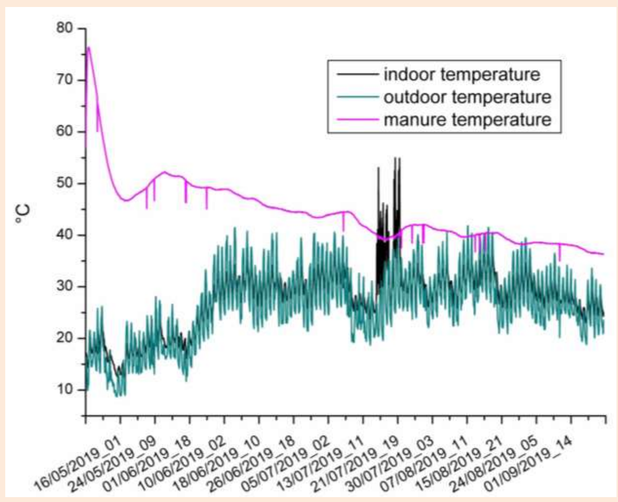

Figure 8. Trends of the temperature measured inside the manure heaps and inside and outside the depot.

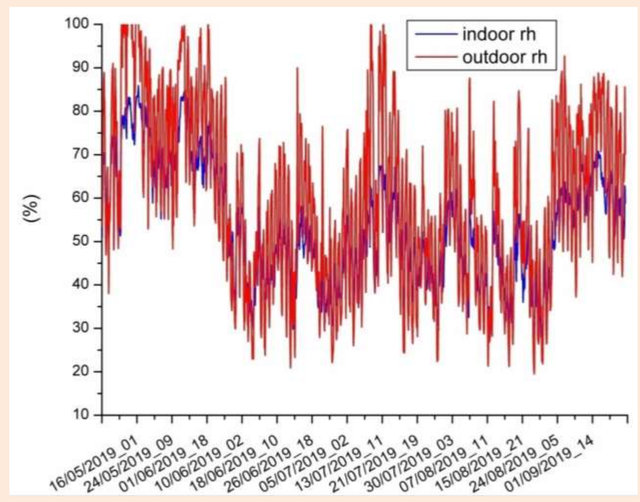

Figure 9. Trends of the relative humidity measured inside and outside the depot.

CONCLUSIONS

We have shown that in circumstances where expensive chemical analyzers must be left in remote, uncomfortable, and unattended places, the SentinAir device and the chemoresistive gas sensors could be a valid option. Its effectiveness has been proved in a particular case study related to agriculture activities. More specifically, the results arising from this experience seem to indicate that the gaseous emissions of the poultry manure are mainly concentrated in the first ten days; therefore, if properly stored before its use, its emission impact on the air quality of the surrounding environment is significantly limited. This factor is of remarkable importance in situations where farming activities are a concern for communities dwelling in their close vicinities.

REFERENCES

1. Suriano D., SentinAir system software: A flexible tool for data acquisition from heterogeneous sensors and devices, *SoftwareX*, **2020,** 12, https://doi.org/10.1016/j.softx.2020.100589
2. Suriano D., A portable air quality monitoring unit and a modular, flexible tool for on-field evaluation and calibration of low-cost gas sensors, *HardwareX*, **2021**, vol. 9, https://doi.org/10.1016/j.ohx.2021.e00198