The Evaluation of the Levels of Greenhouse Gases due to Activities Carried Out on a Livestock Farm

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The paper presents the results of tests carried out on a Romanian farm with the purpose of assessing greenhouse gas (GHG) emissions specific to agricultural activities. GHG emissions from the agricultural sector come mainly from the livestock sector, manure management, land cultivation and fertilization. The tests carried out mainly focused on the CO_2, CH_4 and N_2O emissions generated from related manure storage activities as well as the emission level identified in animal shelters. For a correct interpretation of the results obtained, at the same time with the measurement of the GHG concentration, the weather parameters were measured: temperature, humidity and wind direction. The results obtained revealed the presence of these compounds in the air in the animal shelters and in the ambient air (CO_2 and CH_4) in concentrations that are in the range identified in similar studies around the world. The pollutant dispersion in the air leads to a reduction in the pollutant concentration with increasing distance from the observed source as well as the measurement points at 50, 100 and 500 m, that reaches values below the detection limit of the instrument for CH_4 and N_2O, whereas in the case of CO_2 it reaches the level of the usual concentration in the ambient air.

Keywords: dispersion, emissions, farming, greenhouse gas

The climate change is one of the major challenges of our century - a complex phenomenon due to the overlapping effects of anthropogenic activities on the normal climate variability with the change in atmospheric composition. The effects are visible, especially by the increase of the average global temperature by 0.6 +/- 0.2 ºC above the starting point for air quality monitoring (year 1860) and the increased level of greenhouse gases (GHG) such as CO_2, CH_4, N_2O, HFCs, PFCs, and SF6 in the ambient air.

A major source of emissions of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) is the livestock sector with a direct effect on the health and comfort of staff, animals and communities in neighboring areas [1-3]. The methane originates from the anaerobic degradation of organic matter by bacteria in the digestive tract of animals and in manure. Furthermore, the manure is a source of CO_2 and N_2O as a result of incomplete nitrification/denitrification processes in the presence of microorganisms [3]. The level of emissions is determined by a number of factors such as livestock breed, weight, feed used, handling and treatment of manure, and also the micro-climate conditions maintained inside.

The paper presents the results of a case study carried out in a 2200-head pig raising farm with the aim of i) assessing the level of greenhouse gas emissions (CO_2, CH_4, N_2O) inside and outside of the shelters, and ii) the statistical processing of the data obtained through the monitoring in order to establish the possible correlations between the parameters and the pollutant dispersion in the adjacent area. For the assessment of the level of greenhouse gas emissions and the statistical processing of the data, current methods and methodologies were used for air quality inside buildings and the ambient air [4-6].

Experimental part

Location of the measurements

The farm is located in the southern part of Romania, where the temperate climate zone is characterized by an average annual temperature of 10-11.5 °C, annual rainfall below 400 mm, winds predominantly from northwest (in the summer) and southwest (in the winter). The shelters are located at a distance of approximately 2 km from the inhabited area. The specific pig farming activities are carried out in two production halls of 780 m^2 each, identical in constructive terms, with an area of approximately 0.7 allocated to each animal. The production halls are provided with fully perforated floors, basin for under-floor manure collection, and ventilation in the hall, which fulfill the BREF requirements for intensive farming of poultry and pigs [1, 2].

During the period of the tests for the assessment of greenhouse gas emissions in the farm there were 2 batches of pigs: in Hall 2, pigs weighing 45-50 kg, and in Hall 1, pigs weighing 80-90 kg. The animals remain on the farm until they reach the weight of 100-110 kg. The pigs are fed corn, barley, sunflower, soybean meal and a protein-vitamin-mineral complex.

The micro-climate is automatically controlled and 6 outlets of 20.000 m^3/h are installed in the ceiling of each hall for the evacuation of vicious air. On the site, in the vicinity of the farm, no other sources of industrial pollution are identified and the road traffic is carried out at a relatively large distance, without influencing the specific pollution in area [5, 8-14].

Experimental design

Tests were conducted between 19th and 25th of September 2016, a period characterized by atmospheric calm, with no precipitations, with temperatures ranging from 19 to 25°C, 35-55% humidity, wind speed from SV varying between 0.8 and 2.3 m/s, and 1013-1021 mbar atmospheric pressure.

The N_2O and CH_4 concentrations in the air inside and outside of the animal shelters were determined by gas chromatography using a Varian CP 4900 portable chromatograph. The CO_2 concentration was measured using a GrayWolf automated analyzer. For weather

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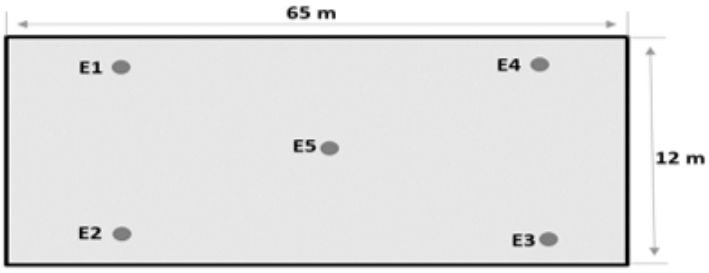


Fig. 1 Sketch of the hall indicating the location of the measuring points (E1 – E5)

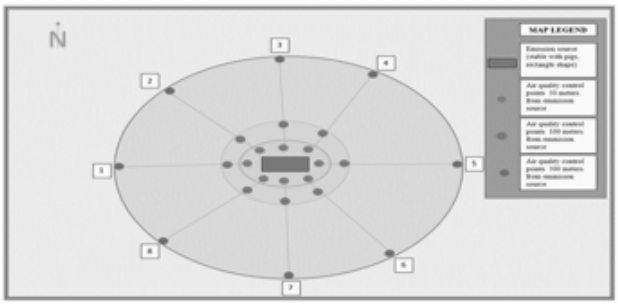


Fig. 2 Location of the measuring points outside the halls (I1 – I8)

parameters, the LSI Lastem Weather Station was used. To ensure the quality of the results, the equipment was calibrated weekly using certified gas cylinders and calibration zero gas.

Since the production halls are constructively identical, the 5 measuring points were spatially distributed in the two halls (fig. 1). Outside, the measurements were made in 24 points arranged concentrically at distances of 50, 100 and 500 m from the production halls, as shown in figure 2. Momentary 10 min-measurements were performed.

Results and discussions

The results of the measurements performed to determine the concentration of CO_2, N_2O and CH_4 in the two production halls and in the ambient air are found in tables 1 and 2, respectively.

The monitoring data revealed that in Hall 1 (pigs of higher weight) the concentrations of pollutants were higher than in Hall 2 (pigs of lower weight). An explanation may be the higher oxygen consumption by larger animals, which leads to higher CO_2 emissions. The amount of food consumed is higher and, consequntly, the amount of manure is higher, hence the increase in emissions of methane and nitrous oxide. No large daily variations are observed for any of the compounds, which can be explained by the constant conditions regarding the animal feeding and hall sanitation.

Regarding the concentrations of the three compounds we find much lower values in the ambient air than in the interior of the halls. In the case of N_2O the measured concentration even at 50 m from the halls is below the detection limit of the chromatographic method (LOD = 0.1 ppm). We also notice a decrease in the concentration of pollutants with increasing distance from the source (fig. 3a and 3b), so that at 500 m, the concentration of CH_4 is below the detection limit (LOD = 1 ppm) and the concentration of CO_2 reaches values specific to the ambient air (about 400 ppm).

Table 1

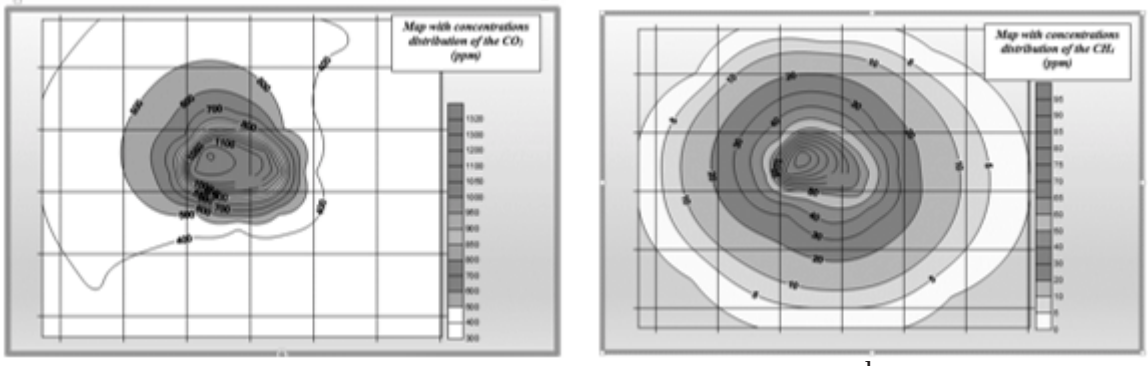
THE AVERAGE CONCENTRATIONS OF CO_2, N_2O AND CH_4 MEASURED IN THE TWO PRODUCTION HALLS (DAILY AVERAGES), 19-25.09.2016

Place	Polutant	Daily average concentration (ppm)							
		Mon	Tue	Wed	Thu	Fri	Sat	Sun	Weekly average
Hall 1	CO_2	2320	2460	2370	2430	2390	2420	2200	**2340**
	CH_4	171	166	198	155	152	194	162	**171**
	N_2O	0.92	0.85	0.93	1.06	0.72	1.01	1.17	**0.95**
Hall 2	CO_2	1620	1860	1970	1730	1890	1920	1750	**1840**
	CH_4	101	99	97	85	79	88	91	**91**
	N_2O	0.42	0.44	0.51	0.48	0.52	0.55	0.50	**0.49**

Table 2

CONCENTRATIONS OF CO_2, N_2O AND CH_4 IN THE AMBIENT AIR, 19-25.09.2016

Distance (m)	Polutant	GHG concentration in points I1-I8, ppm							
		I1	I2	I3	I4	I5	I6	I7	I8
50	CO_2	1200	1320	1136	1050	993	897	915	925
	CH_4	88	95	77	61	58	62	58	55
	N_2O	-	-	-	-	-	-	-	-
100	CO_2	700	708	728	498	428	505	408	502
	CH_4	48	50	48	32	28	36	39	32
	N_2O	-	-	-	-	-	-	-	-
500	CO_2	402	422	418	405	385	378	398	402
	CH_4	-	-	-	-	-	-	-	-
	N_2O	-	-	-	-	-	-	-	-



a b

Fig. 3.Curves of isoconcentration for CO_2 (a) and CH_4 (b) in the ambient air

Table 3

RESULTS OF THE PEARSON CORRELATION STATISTICAL ANALYSIS OF GHG CONCENTRATION IN HALL 1 (A) AND HALL 2 (B)

a

Hall 1	CO_2	CH_4	N_2O
CO2	1.000		
CH4	-.443	1.000	
N2O	-.286	.407	1.000

b

Hall 2	CO_2	CH_4	N_2O
O-CO2	1.000		
O-CH4	-.325	1.000	
O-N2O	-.486	.579	1.000

From the isoconcentration curves (fig. 3) the influence of the meteorological parameters in the process of the pollution dispersion is observed, the highest concentrations being found in the direction of NV, which is the predominant direction of the wind.

The results of the Pearson correlation statistical analysis applied to the data series obtained by monitoring the concentration of the three compounds in the two production halls indicate a weak up to moderate correlation, better in Hall 2 than in Hall 1 (tables 3a and 3b).

The correlation analysis is commonly used in air quality assessment studies inside and outside buildings [4, 6-8] providing useful information in identifying sources of pollution and specific pollutants. In our case, the weak/ moderate correlation identified reveals the possible existence of several types of sources for the three pollutants with different emission factors that does not allow a clear identification of the contribution of each source for each pollutant. However, we can consider as possible sources of CO_2, N_2O and CH_4 pollution, the anaerobic degradation of organic matter by bacteria in the digestive tract of the animals and in the manure, and the incomplete nitrification/ denitrification processes in the presence of micro-organisms.

Conclusions

The tests carried out in the case study revealed the presence of the three greenhouse gases, CO_2, CH_4 and N_2O both in the pig farming halls and outdoors. The pollutant concentration in the farming halls differs according to the animals' growth stage, so that in Hall 1 (animals with a higher weight) the concentrations were higher than in Hall 2 (in which animals of lower weight were raised).

In the interior of the production halls, the maximum CO_2 concentrations were 2340 ppm in Hall 1 and 1840 ppm in Hall 2, and methane levels were 171 ppm in Hall 1 and 91 ppm in Hall 2. With respect to the N_2O concentration, the average daily concentrations of 0.94 ppm in Hall 1 and 0.49 ppm in Hall 2 indicate the existence of much less important emission sources (regarding the emission level) as compared with the other two compounds, CO_2 and CH_4. The specific weather conditions allowed an efficient dispersion of the compounds in the air so that the concentrations measured at a distance of approximately 500 m were below the detection limit for CH_4 and N_2O, whereas the CO_2 concentrations were at the usual level found in the ambient air.

Regarding the sources of pollution with CO_2, N_2O, and CH_4, we consider the anaerobic degradation of organic matter by bacteria in the digestive tract of the animals and in the manure, as well as the incomplete nitrification/ denitrification processes in the presence of microorganisms as the most possible sources of GHG.

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