Ammonia emissions after manure belt cleaning operations in a laying hen house

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Introduction

Ammonia (NH_3) is one of the main pollutant gases associated with poultry operations, with effects on both animal welfare and the environment.
Indoor NH_3 levels are greatly influenced by housing and management factors, such as housing type, bird age and density, manure handling and ventilation rates.
NH_3 from various European livestock production facilities, including poultry houses, have been widely investigated [1,2,3,4,5], but most of the published studies on laying hen units have been carried out in Central and North European countries. However, few studies are available at different climate conditions such as those in Southern Europe. These would be the first published results from a commercial laying hen adapted to welfare directive in Spain.
As a facility regulated by Directive 2010/75/EU on industrial emissions, laying hen farms need to adopt a best available technique or strategy that can prevent or limit emissions and at the same time, is sustainable. One strategy that can be easily adjusted to farmer's management is the frequency of manure removal. Previous studies have shown an influence of manure removal on NH_3 emissions [1,6,7,8] with discrepancies reported to be related to manure quality, dietary CP content, thermal conditions, ventilation rate, etc
The purpose of this study was to quantify gaseous NH_3 emissions from a laying hen house and to determine the effect of the belt cleaning frequency on such emissions.

Material and Methods

Approximately 52,000 Lohmann-Brown hens were housed in a commercial laying hen unit in a vertical tiered cage system adapted to Directive 1999/74/EC. The selection of the farm was based on its management practices being representative of the current egg production facilities in the Basque Country. The house was 17 m wide and 66 m long and enriched cages were arranged in 6 rows of 9 tier cages. The house was tunnel ventilated with 18 exhaust fans (Munters, EM50n). The hens were fed *ad libitum* with a commercial diet containing 16.7% crude protein. Samples of the rations were taken fortnightly for determination of nutrient content. Inlet and outlet air temperature and relative humidity were monitored and recorded every 15 min using data loggers (HOBO, U12-013) with a precision of ±0.35ºC and 2.5% RH. In accordance with commercial practices, inside temperature was set at 23ºC.
To guarantee the reliability of these results, gas concentrations and ventilation rates have been continuously measured from June to December 2012 to cover diurnal and seasonal effects.
Ventilation rate was measured under the usual rearing conditions of the farm [9]. The average percentage of operation of each fan was obtained every 5 minutes. An electronic data logger system converted every second the electric signal from each fan into digital data on fan status. Each fan was individually calibrated for airflow rate at different levels of pressure drop associated to each ventilation programme (2-31 Pa). The air was ducted 30 cm upstream from each fan and the air velocity was measured at 25 different locations in the section using a hot wire anemometer (Testo 425).
Ammonia concentrations were measured continuously by a photoacoustic infra red gas analyser (INNOVA 1412). Exhaust air samples were taken at 8 fans, whereas air inlet samples were taken at 4 outdoor points. Ammonia emission was determined by multiplying the housing ventilation rate by the difference between exhaust and outdoor concentrations.
Air from outside the building was blown from one end of the building to the other end, where fans were located, at a higher speed in summer due to a higher number of operating fans.

Manure was collected on belts under the cages and removed every 1 to 4 days. All operations were recorded by the company's staff and also the amount of manure removed from the building was weighed at the farm on each occasion. Manure from the belt was sampled fortnightly and analysed for DM, total N, ammoniacal N, OM and pH.
The number of hens was calculated by subtracting from the total initial amount of hens the hens that died and were taken out of the cages by the staff.
Emissions per hen (hens present in the hen house on the measurement day) were expressed in mg h^{-1}.

Results
Mean NH_3 emission during the period of study was 1.03 g h^{-1} 500kg^{-1}[lw]. Fabbri et al., 2007, reported a similar emission,, with 1.64 g h^{-1} 500kg^{-1}[lw],on the contrary Nicholson et al., 2004, found a higher emission (3.3g h^{-1}500kg^{-1}[lw]) due the weekly frequency of belt cleaning [1,10].

Table 1. Temperature (T) and relative humidity (RH) inside and outside the hen house, ventilation rate, concentrations of ammonia (NH_3) outside and inside the hen house, emissions of NH3.

		Mean	SD	Min	Max
T (ºC)	Outside	16.69	4.77	3.17	29.79
	Inside	23.63	1.38	19.65	32.59
RH (%)	Outside	78.85	11.83	27.96	98.11
	Inside	64.60	7.53	32.06	82.65
Ventilation rate (m^3 h^{-1} hen^{-1})		3.41	2.32	0.51	13.01
NH_3 conc (mg/m3)	Outside	0.53	0.24	0.15	3.95
	Inside	1.95	1.32	0.29	10.35
NH_3 emission (mg hen^{-1} h^{-1})		4.01	3.32	0.15	27.02

Inside the farm, temperature ranged around the set point temperature of 23ºC. Table 2 shows results of manure analysis from 1 to 4 days after belt cleaning. Manure pH averaged 7.57, DM ranged from 18.84 % to 39.49%. As Carr et al.,1990, reported, NH_3 decreases when the moisture falls below 30%. Therefore, manure DM content of the current experiment would not limit the NH_3 emission [11].

Table 2. Composition of manure

Composition of the manure	Mean	SD	Min	Max
DM (%)	24.75	3.89	18.84	39.49
pH	7.57	0.60	6.44	8.76
Total N (% DM)	5.60	0.98	3.60	8.39
Amoniacal N (% DM)	2.13	1.09	0.86	5.07
OM (%)	71.74	4.56	55.52	79.84

Ammonia emissions decreased after belt cleaning for 5 hours as reported by Fabbri et al., 2007. At this time the minimum values (1.8 mg hen^{-1} h^{-1}) were recorded which were used as time zero [10]. The increasing amount of manure on the belt together with the longer accumulation time explained the potential regression model (Figure. 1)

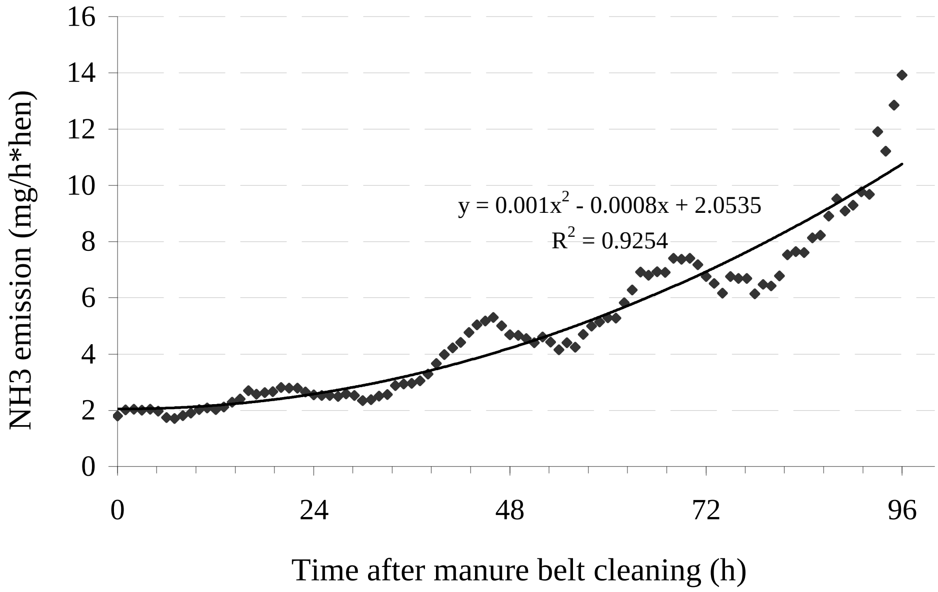

Figure.1 Ammonia emissions after manure belt cleanings (hourly data averaged over all the measuring periods)

A simulation was also conducted in which total NH_3 emission related to different removal frequencies was calculated after 12 days. According to these data, Table 3 shows the reduction (%) in NH_3 emission due the increasing removal frequencies. Results demonstrated that increasing the extraction frequency by one day could reduce NH_3 losses by around 25%. Reducing from 4 to 2 days and from 3 to 1 day reduced NH_3 emissions by over 40%.

Table 3. Reduction of NH_3 emission (%), increasing the frequency of belt cleaning (simulated frequency) with respect to management manure in a reference scenario.

		Simulated Frequency			
		Every 4 days	Every 3 days	Every 2 days	Every 1 days
Reference scenario	Every 4 days	-	26,0	44,6	55,9
	Every 3 days		-	25,2	40,4
	Every 2 days			-	20,3
	Every 1 days				-

Conclusion and perspectives

The NH_3 emission is highly dependent upon belt cleaning frequency. Thus, increasing cleaning frequency could be a realistic best available technique to reduce NH_3 emissions in laying hen houses.

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