External drying tunnel for droppings of laying hens: ammonia, GHG and odour emissions

Moscatelli Giuseppe[1], Fabbri Claudio[2], Valli Laura[1], and Mantovi Paolo[2]
[1] Research Centre on Animal Production (CRPA), Reggio Emilia, Italy, g.moscatelli@crpa.it
[2] CRPA Foundation Studies and Researches, Reggio Emilia, Italy

Abstract

The introduction of a drying tunnel to increase the dry matter content of the manure from laying hens and reduce emissions is a recent technique for poultry farms in Italy. The tunnel is equipped with multi-tiered perforated belts and is ventilated with hen-house air. The hen droppings collected under the hen cages are discharged into the tunnel for drying. Measurements were taken over a 1-year period in a commercial unit in order to assess the emissions of ammonia, GHG and odour from the whole emission continuum: hen house, drying tunnel, manure storage and manure application. The results show that with this technique the greatest emissions of ammonia occur inside the tunnel during the drying phase (167 gNH_3 bird^{-1} year^{-1}) and in the hen house (152 g NH_3 bird^{-1} year^{-1}), while emissions over the storage and application stages are very low. The dry matter content of the manure at the end of the drying tunnel is very high, ranging from 55-60% in winter, to over 85% in summer.

Key words: laying hens, drying tunnel, emissions

Introduction

The implementation of the IPPC Directive requires the reduction of pollution in order to achieve a high level of protection for the environment. The environmental impact of the intensive laying hen farms can be reduced if the birds droppings are dried as fast as possible to a dry matter content of more than 60%. A system which is gaining increasing interest among poultry farmers is the external manure drying tunnel. Its use should ensure improved drying of hen droppings associated with low levels of ammonia and odour emissions. The objective of this study has been to check these aspects in a poultry farm of laying hens in the Province of Modena.

Materials and methods

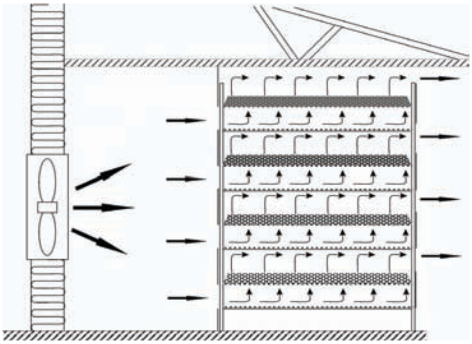
The study was undertaken at a commercial laying hen farm, breeding 44000 layers in two houses. The birds are accommodated in five rows of five-tier cages and manure disposal is by a belt system beneath each tier, with daily removal of the droppings. Ventilation is provided by extraction fans mounted both on the front and side of the building.

The manure is conveyed to a drying tunnel 36 m long placed between the hen houses and ventilated by air coming from the building housing the layers (Figure 1). The droppings are collected under the hen cages and then discharged on the top tier of a multi-tiered perforated belt. The manure is carried along the belt from one end to the other of the tunnel and then in the reverse direction in the lower tiers. At the end of the run on the lowest belt the dried manure is discharged to a covered storage. The whole process takes three days.

Emissions of ammonia, greenhouse gases (GHG) and odours were measured over a prolonged period, coming from the whole chain: hen house, drying tunnel, manure storage and land application. The data were collected continuously in six periods, each lasting approximately one week, distributed over one year, using a photoacoustic detector

(Bruel&Kjaer) to measure NH_3, CH_4 and N_2O, and dynamic olfactometry to measure odours. Ventilation rate, temperature and humidity were continuously recorded. The manure characteristics were also analysed at the various stages – when leaving the henhouse, the drying tunnel and storage.

Figure 1. The drying tunnel



Results and discussion

The ventilation rate of the hen house shows wide variation between the extremes of values recorded in winter (2.7 m^3 h^{-1} hen^{-1}) and in summer (22.5 m^3 h^{-1} hen^{-1}), with an average value of 9.0 m^3 h^{-1} hen^{-1}. Effective environmental control made it possible to significantly reduce extremes in temperature with internal temperatures ranging from 19 to 32 °C as compared with external temperatures of between 7 and 33 °C (Table 1).

Table 1. Environmental parameters recorded during monitoring exercise

	Air flow rate	Temperature		Relative Humidity	
	$[m^3\ h^{-1}\ hen^{-1}]$	Outdoor [°C]	Indoor [°C]	Outdoor [%]	Indoor [%]
Mean	9.0	17.9	23.7	75	55
St. Dev.	6.0	7.9	3.8	20	5
Min-Max	2.7-22.5	7.2-33.0	19.1-31.9	29-100	37-65

The annual average emissions of ammonia and greenhouse gases from the layer house and from the drying tunnel measured during the 1-year monitoring campaign are summarised in Table 2.

Table 2. Average ammonia and GHG emissions of the laying hen house and the drying tunnel

	NH_3 [kg head^{-1} y^{-1}]	N_2O [kg head^{-1} y^{-1}]	CH_4 [kg head^{-1} y^{-1}]	CO_2 [kg head^{-1} y^{-1}]
Layer House				
Mean (year)	0.152	0.002	0.094	65.3
St. Dev.	0.035	0.004	0.056	3.7
Min-Max	0.044-0.290	0.000-0.017	0.000-0.354	58.8-69.6
Drying tunnel				
Mean (year)	0.167	0.001	0.010	3.39
St. Dev.	0.026	0.001	0.005	1.75
Min-Max	0.126-0.210	0.000-0.003	0.003-0.028	1.26-7.59

The average ammonia emission factor from the hen house over the whole period was 0.152 kg NH_3 $head^{-1}$, y^{-1}, a slightly lower value than that obtained in earlier experiments (*Fabbri et al.*, 2007) on a hen house with a ventilated deep pit system (0.162 kg NH_3 $head^{-1}$ y^{-1}), but it was higher than that found in a hen house with ventilated belts (0.063 kg NH_3 $head^{-1}$ y^{-1}). This confirms that the rapid drying of hen droppings, possible to achieve using ventilated belts, has the effect of reducing emissions.

Emissions of methane and nitrous oxide were very low, fairly similar to the results obtained in earlier experiments on the ventilated belt technique and on the deep-pit hen house (0.086 kgCH_4 $head^{-1}$ y^{-1} and 0.025 kgCH_4 $head^{-1}$ y^{-1} respectively, while nitrous oxide emissions were only just detectable).

Figure 2. Ammonia emissions during the 3-day drying process in the drying tunnel

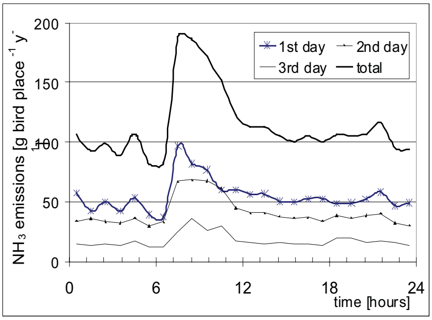
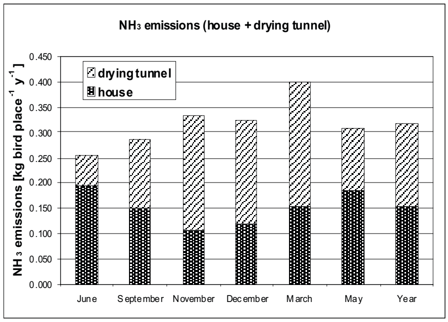


Figure 3. Seasonal trends in ammonia emissions from the hen house and drying tunnel system



The daily ammonia emission rates from the drying tunnel are shown in Figure 2. We measured the emissions of each of the 3 days taken by the manure to complete the run from the inlet to the outlet of the tunnel separately. A sharp increase in the NH_3 emissions can be seen at 8:00 in the morning at the moment when the fresh manure is loaded to the upper belt. The emissions then show a clear decrease as the drying process moves on from the first to the second and third day. This result supports the well substantiated assessment that the drier the manure the lower the ammonia emissions.

Ammonia emissions declined steadily over the first, second and third days, with averages for each day of 103, 49 and 15 g NH_3 $head^{-1}$ y^{-1} respectively, with the overall figure of 167 g NH_3 $head^{-1}$ y^{-1}, little greater than the value for the hen house emissions.

If one considers the seasonal trends of overall emissions of the hen house and drying tunnel system (Figure 3) it can be seen that there is a balancing out of emissions over the different seasons. Thus in the summer, emissions from the hen house are greater than in the winter whereas the drying tunnel, on the contrary, produces greater emissions over the winter. This is due to the drastic reduction in ammonia emissions when the dry matter content of the chicken manure goes over than 60%, occurring in the first part of the tunnel during the summer with a minimal contribution to emissions from the final part. On the opposite, in winter, the chicken manure from the hen house does not dry so much and the greater part of the dehydration occurs in the tunnel, with greater emissions than from the hen house itself.

The measurements on odour concentration were effected on the air extracted from both the hen house and the drying tunnel fans. The values recorded were very low, on average equal to 63 ou_E/m^3 (range = 23-144 ou_E/m^3) in the case of the hen house and 86 ou_E/m^3 in the case of the tunnel (range = 26-195 ou_E/m^3).

The analytical characteristics of the chicken manure entering and leaving the drying tunnel have been illustrated in Table 4.

Table 4. Average analytical characteristics of chicken manure entering and leaving the drying tunnel for each measurement session

Parameters		Jun06	Sep06	Nov06	Dec06	Mar07	May07	mean	St.dev.
Tunnel entrance									
pH	[-]	7.1	7.0	7.1	7.3	7.3	6.9	7.1	0.2
TS	[g/kg]	468.2	391.2	312.0	281.6	276.0	352.8	347.0	73.8
VS	[g/kg]	312.3	283.2	218.1	194.6	195.6	253.2	242.8	48.5
TKN	[mg/kg]	29371	24286	20548	18396	19618	20691	22151	4047
NH_4-N	[mg/kg]	3523	2317	2342	3025	3492	2978	2946	529
Tunnel exit									
pH	[-]	7.9	6.8	7.6	8.8	7.9	7.3	7.7	0.7
TS	[g/kg]	897.3	789.9	546.7	596.4	660.0	892.2	730.4	151.2
VS	[g/kg]	596.4	542.4	380.1	398.7	472.3	630.8	503.4	103.5
TKN	[mg/kg]	47065	37461	28821	30445	36996	41096	36980	6755
NH_4-N	[mg/kg]	1326	1608	3791	2623	2523	1177	2175	997

The dry matter content (TS) in the chicken manure entering the tunnel, (that is, leaving the hen house) varies, according to the season from 26% to over 47%. This results show that the technique of removing the chicken manure onto the belt, even though not ventilated, makes it possible to obtain a product with fairly high dry matter content. The manure leaving the tunnel has very high dry matter content, ranging between 55% in the winter to 90% in summer. The drying efficiency of the tunnel was in any case high, on average amounting to 60% but at times rising to 80% over the summer.

Ammonia emissions during storage and land-spreading of the manure were very low. During storage ammonia losses amounted to 4% of total nitrogen in the heap, while losses during land-spreading amounted to 1.1% of applied TKN (10.4% of TAN). The reduction of ammonia emissions from the land-spreading of dried chicken manure with respect to wet chicken manure was over 90% with respect to total nitrogen and 65% with respect to ammonia nitrogen.

Conclusions

The technique studied here proved to be extremely effective in terms of the drying of the product. Nitrogen emissions in the form of ammonia over the different stages of the production chain, the hen house, treatment, storage and spreading, were lower than those which the reference document for the application of the IPPC Directive considered to be the “reference technique” and they were analogous to those considered to be BAT, such as that using ventilated belts. One aspect of great importance for the farmer clearly emerging from the monitoring exercise is that of the substantial reduction in odour emissions achievable with this technique with respect to systems in which the dry matter content of the chicken manure is not so high. This represents a significant advantage both in terms of the social acceptability of such a unit, not being a source of nuisance for neighbours, and in relation to the possible agronomic use of the product as fertilizer.

References

Fabbri C, Valli L, Guarino M, Costa A., Mazzotta V., (2007). Ammonia, methane, nitrous oxide and particulate matter emissions from two different buildings for laying hens, Biosystem Engineering Vol.97, 441-455.