Poultry Housing and Manure Management Systems : Recent Developments in Italy as Regards Ammonia Emissions

Bâtiments avicoles et systèmes de gestion des déjections : développements récents en Italie, en lien avec les émissions d'ammoniac.

F. da Borso, R. Chiumenti
University of Udine, Department of Crop Sciences and Agricultural Technologies, Section of Agricultural Engineering, Via delle Scienze, 208 - 33100 Udine, Italy
E-mail : Francesco.daborso@dputa.uniud.it

Abstract

Laying hen and broiler keeping systems strongly developed during the last years, aiming to the reduction of environmental impacts (especially of emissions in atmosphere) and to make easier poultry manure management. As concerns broiler structures, no advances technologies are applied, but simple management systems can significantly reduce ammonia and odour emissions ; to give an example, the adoption of an adequate height of litter layer and the use drop-collecting drinking nipples allowed a reduction of ammonia level to 6 ppm, in respect to about 20 ppm of the « traditional » system tested. As concerns the laying hen compartment, several studies on the vertical batteries with manure drying on belts were carried out, showing a sufficiently improved management of poultry manure. Therefore, the possibility of reaching higher levels in dry matter of manure must be closely examined.

Keywords : poultry manure, ammonia and odour emission, drying, composting.

Résumé

De nombreux systèmes ont été développés récemment dans le but de réduire l'impact environnement (notamment les émissions atmosphériques) et de faciliter la gestion des déjections avicoles (fumiers de volailles et pondeuses). En ce qui concerne les bâtiments volailles de chair, de simples mesures permettent de réduire les émissions d'ammoniac telles que l'épaisseur de la litière et l'amélioration des systèmes d'abreuvement.
En ce qui concerne les bâtiments de pondeuses, plusieurs études sur le séchage ont montré leur efficacité. Cependant ces systèmes ne permettent pas d'obtenir un taux de matière sèche du produit au delà de 50% ; ce séchage incomplet s'accompagnant de nuisances olfactives et d'émissions d'ammoniac au cours du stockage et de l'épandage.

Mots-clés : fumier volailles, ammoniac et odeurs, séchage, compostage.

1. Introduction

Modern poultry breeding techniques have been developed with the purpose of improving farm productivity, automation and environmental impacts, both indooors (i.e. animal health and welfare, workers' safety) and outdoors (i.e. preservation of soil, water and air quality and their related ecosystems). Several studies which dealt with housing and manure management systems have been carried out by our Department in order to have an insight into these aspects.

The aim of the present work is to review different housing and manure handling systems which are adopted in broiler and laying hen sectors, as far as ammonia emission are concerned.

2. Materials and methods

During a period of 3 years and taking several technical, environmental, energy and economic parameters into account, the following full scale poultry barns were monitored at a full scale :

I. broiler litter bed floor houses,
II. laying hen houses with different types of batteries and manure drying systems,
III. alternative-to-cage systems for laying hens (litter bed and perches),
IV. laying hen houses with manure drying and storage in deep pit.

When the housing systems were characterized by natural ventilation (systems I and III) ammonia concentration were measured with a photo-acoustic infrared instrument, the Bruel & Kjaer 1320 with 1303 Multiplexer; air samples were taken in several points inside the barn in order to calculate the mean indoor ammonia concentration. Ammonia emissions were calculated basing on airflow rate estimate by means of the carbon dioxide balance method; the carbon dioxide produced by animals was estimated at 41 ml CO_2 per kJ of the total heat produced by one bird (Albright, 1990).

Under artificial ventilation conditions (systems II and IV), ammonia concentrations were measured with the above mentioned instrument; however, air samples were taken in the airflow at the fan oulets. Ammonia emissions were calculated basing on airflow rate measurements by means of hot-wire and magnetic transducer anemometers.

Further details on sampling points and frequencies will be given in the specific paragraphs.

3. Broiler houses

Most of the broiler produced in Italy are bred on litter bed in floor barns. Several experimental tests were carried out by our Department with the purpose of improving litter management in these housing systems, i.e. litter material, height of the layer, number of birds per m^2, drinking and eating equipments, litter discharge and storage methods, etc.; aim of the present review is to quantify the effects of different drinkers on ammonia emissions. With regard to this aspect, tests were carried out in 2 barns which were identical in reference to the number of animals (12,800 birds each), the size (12 m x 99 m each) and the litter material (wood sawdust). Hence, it was possible to compare ammonia levels in the air from barn equipped with nipple drinkers with those from the barn equipped with nipple drinkers plus bowls, used for preventing water dropping.

Indoor air was hourly sampled during a period of 9 days in summer; ammonia concentrations were significantly lower in the barn with nipple drinkers + bowls, apparently because of a lower moistening of litter below drinkers. The mean airflow rate was estimate to be 2.4 $m^3\ h^{-1}\ bird^{-1}$; this estimate showed ammonia emissions of 0.657 and 0.404 g $day^{-1}\ bird^{-1}$, for the nipple and nipple + bowl drinkers respectively (Table 1).

Drinker type	*Birds / drinker, number*	*Estimated ventilation rate, $m^3\ h^{-1}\ bird^{-1}$*	*Ammonia concentration, mg m^{-3}*	*Ammonia emission, g $day^{-1}\ bird^{-1}$*
Nipples	6.5	2.4	11.4	0.657
Nipples + bowls	12.4	2.4	7.01	0.404

Table 1
Results of ammonia determination in broiler barns

4. Laying hen batteries with manure drying

In Italy, a large number of laying hens are kept in new types of batteries which allow a partial drying of manure on the conveyer belts. Since 1991, the following manure drying systems were studied by our Department :

- air moved by a system of paddles over the belts (Salmet Ô);
- air blowed by fans through holed air-ducts over the belts (i.e. Valli Ô);
- air sucked by fans into tunnels over the batteries where manure belts flow (Farmer Ô).

During a period of 1 year, several parameters (i.e. manure characteristics, energy consumption, environmental aspects, etc.) were monitored in full scale barns characterized by different manure drying systems. With regard to ammonia emissions, results are shown in Table 2.

Manure drying system	*Ammonia emission in winter, g day^{-1} bird^{-1}*	*Ammonia emission in summer, g day^{-1} bird^{-1}*
Paddle system	0.031	0.172
Air blowed in holed ducts	0.027	0.157
Air sucked in tunnels	0.027	0.134

Table 2
Results of ammonia determinations in laying hen barns characterized by different manure drying systems

Ammonia emissions from barns equipped with fan drying system batteries were lower than those from barns characterized by paddle drying system batteries, both in winter and in summer. However, it must be noticed that ammonia emissions from all the 3 manure drying systems were considerably lower than those usually shown by batteries without any drying system. In fact, previous studies concerning barns which adopted stair-step cage batteries with gutters and scrapers for manure removal showed that ammonia emissions were about 0.18 g day^{-1} bird^{-1} in winter and up to 0.70 g day^{-1} bird^{-1} in summer.

5. Alternative-to-cage systems for laying hens

Housing systems where laying hens are not confined in cages are present in several European Countries. Until today, these systems have assumed a relatively little importance in Italy, but the interest in them is growing especially in relation to the animal welfare requirements as well as to the egg marketing advantages.

Because of this increasing importance, an experimental research was carried out fucusing on the environmental requirements which these alternative systems have to meet.

During 3 weeks in spring, two alternative poultry barns were monitored; they were identical in relation to the ventilation system (natural ventilation), the relative surface of the bed floor and the perches to the total surface (the litter bed floor was 1/3 of the total surface), the animal density (7 birds m^{-2}), but they differed from each other in the age of breeding animals; one barn kept pullets, the other laying hens.

The mean indoor ammonia concentration was higher in laying hen barn than that one in pullet barn; the estimated ammonia emission was 0.262 and 0.192 g day^{-1} bird^{-1}, for laying hens and pullets respectively (Table 3).

Type of birds	Ammonia *Concentration, mg m^{-3}*	*Estimated ventilation rate, m^3 h^{-1} bird^{-1}*	*Estimated ammonia emission, g day^{-1} bird^{-1}*
Pullets	5.4	1.48	0.192
Laying hens	7.0	1.56	0.262

Table 3
Results of ammonia determination in alternative-to-cage housing systems for laying hens

6. Laying hen housing systems with deep pit storage

The housing system with deep pit storage is characterized by a subdivision of the barn into two levels: laying hens are kept in stair-step cages at the raised-floor, while poultry manure is stored at the ground floor during the whole hen production cycle (over 12 months). A mechanical ventilation system allows both the air changing at raised-floor and a partial drying of poultry manure at the ground floor. The inlets of fresh air are located under the eaves, while the suction fans are placed at the ground floor on the side walls. Hence, the air coming from the upper level can pass through the mesh floor and/or through the batteries and it can flow on the manure piles at the ground floor.

An outstanding research which is presently being conducted by our Department deals both with ammonia emissions from this kind of housing system and manure characteristics during and after the storage period. Tests are being carried out in two barns which are characterized by identical size but different types of floor on the service passages between the batteries; in one poultry barn there is a wire-mesh floor and hence the air can pass both the mesh floor and the cages, while in the other there is a solid floor which allows the air to pass only through the cages.

Preliminary results have shown that the ammonia emissions from laying hen housing systems with deep pit storage are higher than those from the other housing systems (0.870 – 0.626 g day^{-1} bird^{-1}, for wire-mesh floor and solid floor respectively, Table 4).

Floor type in the corridors	*Ammonia emission g day^{-1} bird^{-1}*
Wire mesh floor	0.870
Solid floor	0.626

Table 4
Results of ammonia determinations in laying hen houses with deep pit storage

7. Discussion and Conclusions

Several experimental studies have been carried out by our Department with the purpose of quantifying the effects of different housing and manure management systems on air quality, and in particular on ammonia emissions.

Ammonia emissions from poultry barns were important especially in summer. If we consider that the initial nitrogen concentration in laying hen manure is 45 g total N kg^{-1} dry matter, the calculated nitrogen losses as ammonia emissions ranged from about 6.1 to 39.6% of the total initial manure nitrogen.

Regarding the final nitrogen content in broiler litter as 35 g total N kg^{-1} dry matter, the ammonia emissions caused losses which ranged from 22,8 to 32,7% of total final litter nitrogen.

Drinking equipments for broilers influenced litter bed moisture and consequently ammonia production from the barns. Ammonia emission from broiler barns where drinkers for water loss prevention (i.e. nipples + collecting bowls) were adopted, presented a 38.5% reduction, in comparison with those from broiler barns characterized by simple nipple drinkers.

Ammonia emissions were reduced down to 80% by timely poultry manure drying inside the barns, in comparison with ammonia emissions from stair step batteries without any manure drying systems and a twice-a-month manure removal by scrapers.

Ammonia esmissions from the “alternative-to-cage” systems were higher than those from the above mentioned cage systems, but in the same time they were lower than those from the litter bed housing systems for broilers.

Ammonia emission from the housing systems where poultry manure is stored in deep pit were the highest, ranging from 0.62 to 0.87 g day^{-1} $bird^{-1}$, certainly due to the long term indoor storage (13 months); moreover, sensible seasonal effects on ammonia emission could be expected.

Lastly, it must be considered that the storage of poultry manure inside the barns played an important role on emissions, as regards some of the systems above described. For this reason, further studies should be necessary in order to determine the “global” ammonia emissions from the different housing and manure management systems. For example, considering the poultry manure produced in broiler and laying hen cage barns, it should be necessary to quantify the ammonia losses which can occur during manure storage outside the barns.

8. References

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