Emissions of ammonia in vertical and conventional systems of eggs production by hens

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Abstract

The production of eggs for human consumption is increasing. In 2003 it was around 1,022 trillion units, reaching 2011 with 1,220 trillion, providing a jump of 19.41%. This fact can be attributed to vertical creations systems, and can accommodate hundreds of thousands of laying hens in just a single installation. With increased production, simultaneously there is an increase of concerns for animal welfare and environmental issues. We compare the emission of ammonia from the vertical aviary, where the manure is often removed with conventional systems where the manure remain stored for a long period. It was observed that the vertical systems show lower ammonia concentrations (mean 3 ppm) compared to conventional (average of 12 ppm). By removing the manure often they are observed lower potential generation and emission of ammonia. Unlike when they are stored. Vertical systems have better health for animals and workers.

Keywords: Egg production; greenhouse gas emissions; natural fertilizer

1. Introduction

The production of hen's eggs in the global context, for human consumption, is increasing. In 2003 it was around 1.022 trillion units, arriving, in 2011, around to 1.220 trillion, resulting in a growth of 19.41% in the period. In 2015 the production was estimated at 71.5 million tons. Noting average annual industry growth of 1.5% per year (last 14 years). This improved production is attributed to the creation of vertical systems, where it is possible to lodge hundreds of thousands of laying hens in only single facility. With increased production, occurs concomitantly raised concerns with animal welfare and environmental issues. For this work, we compare emissions of ammonia (NH_3) into the atmosphere from the laying hens' manure with vertical system, where it is often removed, with conventional systems where the manure remain stored for a long period before being forwarded to its proper treatment and/or disposal.

2. Materials and Methods

The concentration of NH_3 in avian issued every three hours from six o'clock over a period of 24 hours. The values were measured on the emission of ammonia for five minutes at each collection point simultaneously to obtain the average value per point. In vertical aviary (capacity of 120.000 laying hens housing), the collection points were distributed forming a line perpendicular to shed length, and was placed a sensor at each passage hall for employees, totaling five points of data collection (five hall pass) (Figure 1). It was also measured the concentration of ammonia near the electrical panel to drive the collector mats of manure, where an employee stays during the cleaning operation of the installation, still, the point where there is greater movement of waste.

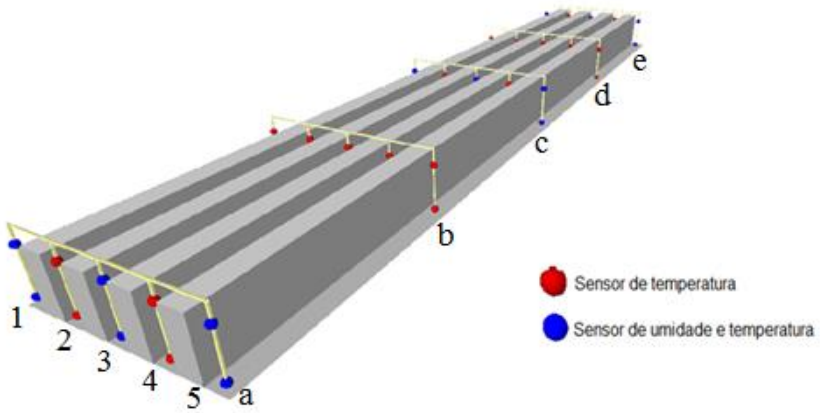

Figure 1: Vertical cages

The lanes are numbered from 1 to 5 and assigning letters "a" to "e" to the lines of temperature and humidity sensors, as is shown in Figure 1. The sensors for collecting ammonia were distributed along the line "c", which is situated at half the length of the shed forming the points c1, c2, c3, c4 and c5 which ammonia emitted was measured.I

n vertical farming systems, measurements were performed on days corresponding to the first day after the removal of waste of laying hens shed, and on the day the mats would be triggered for new cleaning.

Figure 2: Vertical System

Figure 3: Manure belt

The manure was removed mechanically by means of mats positioned below each floor cages carting them towards the point "a" to point "and" where they are directed to another conveyor, which transports all waste out of installation for subsequent adequate treatment. As the ends of the aviary are closed and the movement of waste when they pass a treadmill to another, provides a release of gas, it was decided to measure the NH3 concentration also in the waste transition area located at the end of the shed in point 3e, which is located near the electrical panel responsible for triggering the mats.

Already in the corresponding avian conventional production system (accommodation capacity of 7.000 birds), the measurement was performed in the three corridors for access to the cages at a height equal to 1.10m (midpoint height between the two levels cages).

For this purpose, we used ammonia sensors inside the facility by measuring the concentration of NH_3 gas at the level of the animals. At the vertical system opted for the average height of battery cages (1.7 m), whereas in conventional system chosen height was the first row of cages (0.7 m).

Figure 4: Convention System

Figure 5: Manure stored

3. Results and Discussion

In the vertical system, it was realized that the next day cleaning the shed, hall pass 1, 2, 4, and 5 showed no ammonia concentrations perceptible to the sensor while running three showed a relatively low concentration throughout the day (2 ppm), with

higher values at the end of the measurement period (3 ppm), possibly due to the time elapsed after cleaning and waste accumulation. The presence of NH_3 in hall 3 and the lack of detection of this gas in the other hall on the day after cleaning can be explained, perhaps, by the fact that the runners one, two, four and five are close to the side of the shed is therefore more benefit from natural ventilation.

In the shed cleaning day, it was not detected ammonia concentrations in the corridors 1 and 5, as in the hall 2 and 4 average concentration was 3 ppm and in the hallway 3 this was 6 ppm. This difference was attributed to the natural circulation of air which is more restricted, as we approach the center of the installation

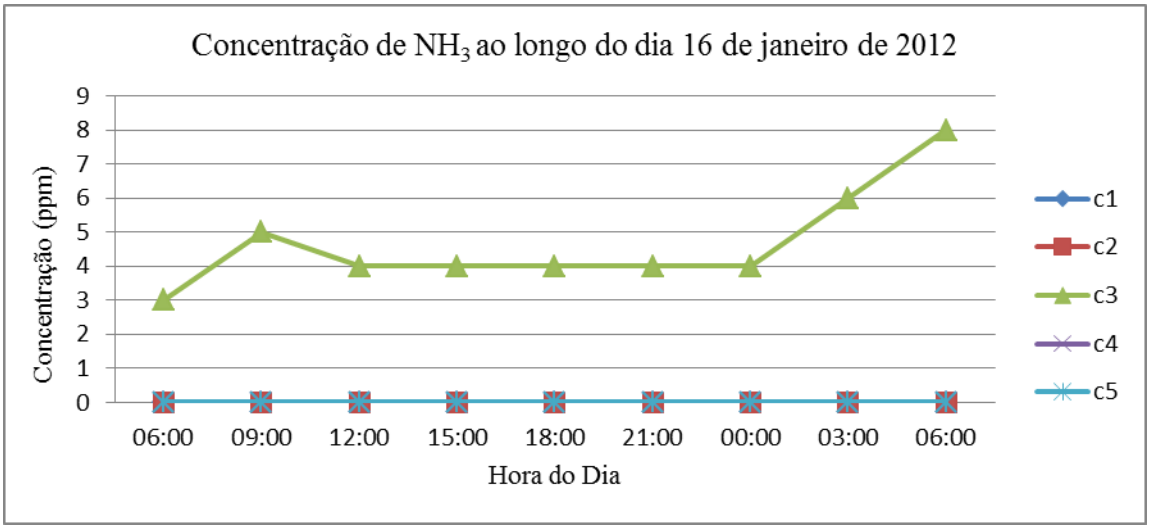

Figure 6: ammonia concentration at the vertical system

At the time of cleaning was still observed, one corresponding NH_3 concentration to 32 ppm (greater than recommended for workers, established by Brazilian law – 20ppm) close to the wiper drive panel. Remember that this point is where there is greater movement of stools, which are passed mats in the cages for the treadmill that will remove them from the shed. After cleaning the waste, the concentration of ammonia within the facility tends naturally to reduce significantly.

When observing the result of the analysis of the average NH_3 concentration in the three halls of conventional aviary, you can realize that this was 12ppm. This value relatively higher than the concentrations found in vertical farming system. This was attributed to the storage of waste in the cages throughout the production cycle.

It was observed that the vertical facility have lower concentrations of NH_3 inside (average of 3 ppm), when compared to conventional (average of 14 ppm).

4. Conclusions

It can be concluded that the concentration of ammonia in the aviary that has the vertical system of rearing laying hens, is lower compared to the aviary that have conventional system. Even one having an accommodation capacity 17 times higher than this. This fact can be attributed to the frequent withdrawal of installation inside the waste.

It was concluded that, where the manure is often removed (Vertical system), have a lower potential for generation and emission of ammonia, when compared with the facilities where the manure remain stored for long periods (Conventional system). Thus they have better condition of health for the animals and workers. Besides the manure from this system have two times more nitrogen than the stored, which improves the potential for use as a natural fertilizer.

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References

ABPA. Produção de ovos do Brasil cresce 6,1% e chega a 39,5 bilhões de unidades. Disponível em: http://abpa-br.com.br/noticia/producao-de-ovos-do-brasil-cresce-61-e-chega-a-395-bilhoes-de-unidades-1550. 28/01/2016. Acesso em: 05 de abril de 2016.

AUGUSTO, K. V. Z. **Caracterização quantitativa e qualitativa dos resíduos em sistemas de produção de ovos: compostagem e biodigestão anaeróbia**. 2007. Dissertação (Mestrado em Zootecnia)–Universidade Estadual Paulista, Jaboticabal, 131p

BRASIL. Norma Regulamentadora nº 15, Atividades e operações insalubres, de 06 de julho de 1978. **Diário Oficial da União. Brasília**, DF, 1978.

COELHO, DIOGO J. DE R., et, al., Mapeamento do ambiente térmico de aviários de postura abertos em sistema vertical de criação. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v.19, p.996 - 1004, 2015.

DEMMERS, T. et al. First experiences with methods to measure ammonia emissions from naturally ventilated cattle buildings in the UK. **Atmospheric environment,** v. 32, n. 3, p. 285-293, 1998

HARTUNG, J. Influence of housing and livestock on ammonia release from buildings. **Odour and Ammonia Emissions from Livestock Farming**, p. 22-29, 1990.

MAHIMAIRAJA, S. et al. Losses and transformation of nitrogen during composting of poultry manure with different amendments: an incubation experiment. **Bioresource Technology,** v. 47, n. 3, p. 265-273, 1994.