Ammonia Emission in Poultry Facilities

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Brazil is the largest broiler meat exporter in the world. This important economic activity generates income in different branches of the production chain. However, the decomposition of residues incorporated in the poultry litter generates several gases, among them ammonia. When emitted from the litter to the air, ammonia can cause several damages to animals and man, in addition to being able to convert into a greenhouse gas.

Keywords: air quality ; livestock production ; poultry housing ; waste management

1. Overview

Brazil is the largest broiler meat exporter in the world. This important economic activity generates income in different branches of the production chain. However, the decomposition of residues incorporated in the poultry litter generates several gases, among them ammonia. When emitted from the litter to the air, ammonia can cause several damages to animals and man, in addition to being able to convert into a greenhouse gas. The main chemical processes for generating ammonia in poultry litter have been introduced and some practices that can contribute to the reduction of ammonia emissions have been provided. The PMU, Portable Monitoring Unit, and the SMDAE, Saraz Method for Determination of Ammonia Emissions, with the required adaptations, are methodologies that can be used to quantify the ammonia emissions in hybrid facilities with a natural and artificial ventilation system. An ammonia emission inventory can contribute to the control and monitoring of pollutant emissions and is an important step towards adopting emission reductions. However, quantifying the uncertainties about ammonia emission inventories is still a challenge to be overcome.

2. Ammonia Emissions in Brazil

It is estimated that the world population will reach 9.3 billion people in 2050 [1]. With the increase in population, an increase in food production is demanded. To meet this demand, the modern livestock industry has been showing a tendency to produce animals in feedlots. In confinements, fully closed, air-conditioned, and fully open installations with naturally ventilated can be used, as well as hybrid installations that work open or closed using artificial thermal conditioning systems, depending on local climatic conditions. The production of broilers stands out among other meat production systems for presenting low cost and short production cycles [2][3]. The USA is today the largest producer of chicken meat in the world, followed by China and Brazil [4].

In 2020, Brazilian chicken meat production grew around 4% compared to 2019. With 4.23 million tons exported, Brazil once again established itself as the world's largest chicken meat exporter, a position it has occupied since 2004. The annual consumption of this animal protein in Brazil reached 45.27 kg per capita in 2020 [5]. In recent years, there have been significant technological advances in this sector, influenced by commercial and productive demands. These advances provided the supply of low-cost animal protein and the generation of jobs and income in the different branches of the national production chain [6][7].

In countries with a tropical climate, such as Brazil, poultry facilities are predominantly open or hybrid, that is, they can operate in an open or closed manner according to the thermal conditioning needs of the birds and the local climatic conditions. This typological trend is due to the advantages of the tropical climate, which allows the use of natural ventilation in aviaries reducing production costs [3][8]. In broiler production systems, poultry litter is used on the floor of the facility with the main function of incorporating the waste generated. However, the decomposition of waste in the litter generates several gases, the main one being ammonia (NH_3), because it is present in greater proportions than the other gases such as carbon monoxide (CO) and carbon dioxide (CO_2) [4]. In South America, most ammonia emissions come from agriculture, mainly from animal production due to the intensive production standards and density of animal housing adopted [9].

Ammonia can generate global effects when present in the atmosphere, and can contribute to the formation of nitrogen oxides, which are greenhouse gases [10]. In addition, ammonia in the atmosphere can contribute to the formation of acid rain, which can cause acidification and eutrophication of the soil and rivers [9][11][12].

Continuous exposure to high concentrations of ammonia is harmful to humans and animals. In humans, continuous exposure to ammonia causes respiratory problems [13], and eye irritation [14], which can lead to blindness [15]. In broilers, damages from continuous exposure are reported in the reduction of weight gain [16], problems related to irritation in the eyes, and the possibility of a higher incidence of diseases [17], which can even lead to death [11].

On the other hand, in the literature, studies are also reported showing that in vitro ammonia can even be beneficial to birds and that fish can be tolerant to ammonia and can even metabolize the ammonia present in water [18][19][20]. These studies confirm the fact that the exposure of embryonic cells to ammonia affects the expression of myostatin, which is a protein that is related to the production of muscle mass. Studies conducted with fish cells indicate that exposure to high concentrations of ammonia does not affect the myogenic response, which indicates that fish have ways of mediating ammonia toxicity [18]. In vitro studies with embryos from developing chickens suggest that the increase in serum ammonia concentration leads to a reduction in myostatin expression. Therefore, it is concluded that exposure to higher concentrations of ammonia in the embryonic stage can lead to improvements in muscle growth and meat production in poultry [19][20]. Given the biology of birds, it may be possible that broilers and layers will also show an adaptive response to facility environments with high ammonia content. However, the relatively short period of exposure and life span of broilers, which are slaughtered around 45 days of age, must also be considered in this development of the adaptive response to high concentrations of ammonia. Therefore, at least until then, awaiting further studies, it is important to consider most of the negative effects of high concentrations of ammonia in the facilities, caused in the first weeks of life, during the initial phase of chick growth.

However, given the environmental problems caused by the emission of gases in animal production, the countries of the European Union, with the objective of reducing ammonia emissions, have established policies that are currently used to monitor and control the maximum emissions of their states. The European Parliament and the Council of the European Union established Directive 2010/75/EU [21], which deals with aspects related to atmospheric emissions, including animal production facilities, with the aim of preventing, reducing, and even eliminating pollution.

In the Netherlands, the government encourages producers to reduce greenhouse gas emissions through, for example, the creation of a green seal that rewards producers who generate less greenhouse gases [22]. In countries such as the United Kingdom [23], Denmark [24], France [25], England [23], and the USA [26], inventories of annual ammonia emissions from animal production facilities are conducted. These inventories contribute to the monitoring and control of emissions of this gas in all productive sectors.

However, worldwide, there are still no methods to efficiently measure ammonia emission in open areas [22][27]. Despite the huge number of methods for measuring ammonia concentration, most are still expensive and have limitations in terms of measurement efficiency [28][29]. Another major challenge in determining emissions, especially in installations in tropical climate areas, which are predominantly open, is related to the difficulty in correctly measuring the ventilation rate, due to the complexity of the wind flow [8][22][27][30][31].

In Brazil, there are still no inventories of ammonia emissions. Information on actual annual emissions is still scarce. There are no standards that deal with the standardized methods that must be adopted in inspections. We are still restricted to labor standards related to the limits of workers' exposure to ammonia and to animal strain management manuals. There is a regulatory standard NR-15 [32] that determines the maximum concentration of ammonia to which the worker can be exposed during working hours. NR-15 sets a maximum exposure concentration of up to 20 ppm ammonia for 48 working hours per week. In the case of animal health and performance, specifically for poultry facilities, Brazilian producers only follow breeding manuals that present air quality guidelines and determine the minimum ventilation rate for air renewal inside the facility, in addition to the maximum concentration levels of gases. In the management manual for broilers of the Cobb line [33], among the air quality guidelines, a maximum limit of 10 ppm of ammonia in poultry facilities is established.

Thus, at the national level, in Brazil, there is still no environmental legislation that regulates the exposure of animals or people to ammonia concentrations or that imposes a limit on emissions into the atmosphere [34]. In addition, there is still no established standard method to measure ammonia emission rates in animal production facilities that have the constructive typology of tropical climate areas, so the studies on the methods that are used in the world and their application in facilities predominantly opens are so important.

3. Conclusions

Strategies such as the use of additives and the use of diets with lower levels of crude protein are some examples of measures that can contribute to reduce ammonia emissions in broiler production facilities. The SMDAE and PMU methods can be adapted to measure the ammonia emission in poultry facilities with the constructive typology of countries with hot climates, such as Brazil. In several countries around the world, there are already initiatives that make it possible to conduct inventories of ammonia emissions from poultry farming. The quantification of uncertainties about ammonia emission inventories and emission factors is a challenge to be overcome. In view of the lack of real ammonia emission data, further studies are required to fill these gaps.

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