Use of dynamic systems to propose a maximum value of ammonia emitted from manure by laying hens

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Abstract

It is estimated that the world production of eggs by laying hens, in 2015, was 71.5 million tons. We observed an average annual growth of the sector in the last 14 years, from 1.5% a year. Will be expected, for 2030, a produce around 86.8 million tons. This rise in production is attributed to vertical systems for industrial rearing of laying hens. The facilities have batteries of overlapping cages. These batteries may have several floors of cages and, between each stage there is a manure belt, to facilitate removal thereof from within the production facilities. Being fully automated, the vertical aviaries offer considerable increase productivity when compared with conventional production systems. This results from the increased efficiency in the housing laying hens / m². In this scenario it is possible the accommodation of 50.000 to 400.000 hens in one aviary. It is observed in this model creation, a higher concentration of birds in confined spaces, which generates result, higher manure concentrations. Emerging concerns about pollution caused by improper disposal of manure, or even, its management on the environment. The formation of some types of inorganic aerosols in the atmosphere, it is associated with ammonia (NH_3) emitted by laying hens creations. These molecules present in the atmosphere, leverage the greenhouse effect, being directly related to climate changes. This work aimed to create diagrams that inter-related the physical, chemical and biological factors, with the production and emission of NH_3 from the laying hen manure. Besides that, it was using the system dynamics to propose a maximum potential to emission of NH3. A causal diagram has been created listing the steps of NH_3 generation. These data were analyzed computationally by Vensim program. It is possible to determine a maximum emission potential for this gas, equal to 64.5% of the total nitrogen excreted by the laying hens.

Keywords: System dynamics; vertical aviaries; egg production

1. Introduction

In 2015, Brazil's capacity to host the production of eggs flock was 91.2 million laying hens. As a leading producer, São Paulo, Minas Gerais, Espirito Santo and Mato Grosso (ABPA, 2016).

According to Coelho et. al., (2015) in Brazil most of the facilities for the creation of laying hens are open and vertical systems. Getting to house 120,000 birds in a single installation. It is observed in this model creation, a higher density of birds per unit area. Accordingly, expected that a higher number of birds per square meter, produces larger volumes of manure per area.

The main environmental problems associated with waste, from poultry, are related to the generation and emission of ammonia. Baek and Aneja (2004), in their studies associate the formation of some types of inorganic aerosols in the atmosphere with the release of ammonia. Pilewskie (2007) points out that these molecules present in the atmosphere potentiate the greenhouse effect is directly related to climate change.

Environmental factors such as temperature and relative humidity, and management, as the levels of crude protein and energy feed, can influence the uric acid excretion rate of laying hens (Hsu et. al., 1998).

From the foregoing, it is clear that the system dynamics (SD) can be an important tool in analyzing and addressing the interrelations process of excretion of uric acid by the hens.

2. Materials and Methods

System Dynamics (System Dynamics) is above all, a language allowing to express, more properly, existing chains of events in nature. Through the use of diagrams can be displayed graphically a system.

VenSim® the computer program was used to generate the desired diagrams. The database that will feed the Vensim consisted of a literature review of pre-existing studies, which we will mention below.

We can cite the work of HSU et al. (1998), where the authors realize that there is a significant influence of nitrogen excretion rate (in the form of uric acid) in birds compared to the ambient temperature. The pH of waste is another factor that has significant influence to determine the loss of nitrogen from waste to the atmosphere as ammonia (Gay &

Knowlton, 2009). The pH range between 9 and 10 enhances the formation of NH_3 from the above two processes. The variation of moisture content of laying hens waste on the degradation of uric acid was studied by Koerkamp (1994).

3. Results and Discussion

The data gathered from literature reviews were entered in the causal diagram constructed in Vensim. Then we generate a new diagram, flow-stock depicted in Figure 1.

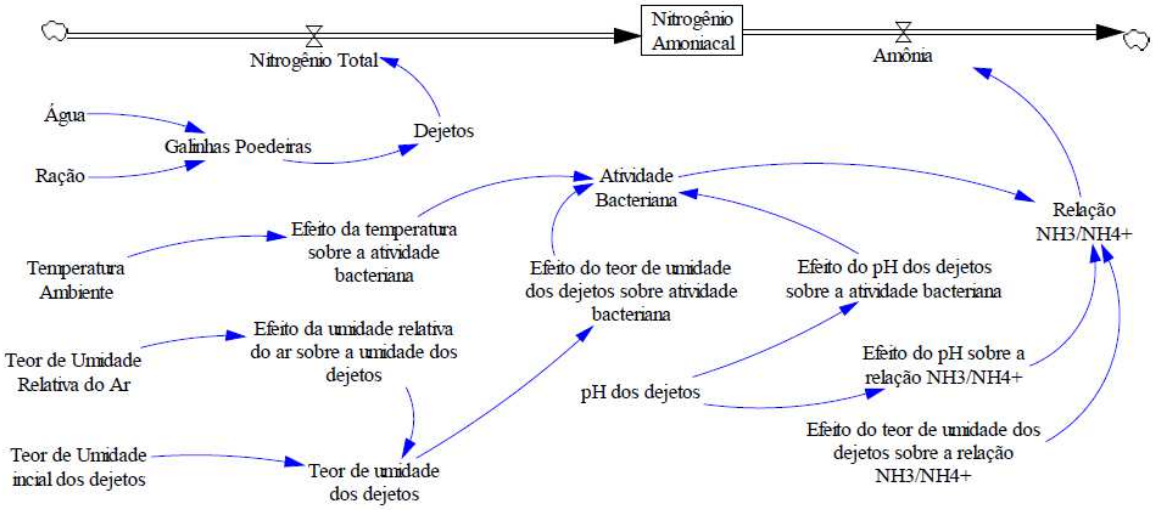

Figure 1: Diagram generated by VenSim

After insertion of data in the software, where a simulation predicted that the maximum percentage of 64% of total nitrogen found in the manure of hens was carried out, has the potential to be converted to ammonia (Figure 2). Recalling that this condition is hypothetical and provide the maximum potential emission (according to the literature review and presented previously). The data used to make this simulation are shown in Table 1.

Each case can be evaluated individually, feeding the diagram generated by Vensim. For the simulation performed generated the graph shown in Figure 2 as result.

The percentage of 64% of the total nitrogen present in the conversion of laying hens in ammonia waste was obtained by the analysis conducted by Vensim to the parameters in the interrelations provided to the program.

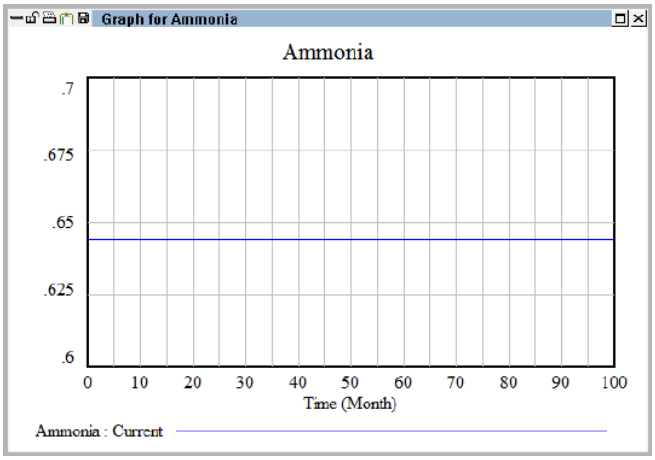

Figure 2: Maximum ammonia emission potential found for the conditions tested

4. Conclusions

The system dynamics is presented as a promising tool to analyze the generation and emission of ammonia from the manure of laying hens. Additional studies to adjust the displayed flow model and inventories are being conducted. We realize that by using this tool, we can predict how much will be the maximum emission of ammonia to the right location using the local environmental conditions.

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