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AMMONIA TRAP FOR DECREASING AMMONIA LEVEL IN BROILER HOUSE – A PATENTED SYSTEM DESIGN

Ali COSKAN[1], Atilgan ATILGAN[2]

[1]Süleyman Demirel University, Faculty of Agriculture, Soil Science & Plant Nutrition Department, 32260 Isparta, Turkey
[2]Süleyman Demirel University, Faculty of Agriculture, Agricultural Structure and Irrigation Department, 32260 Isparta, Turkey

Corresponding author email: atilganatilgan@sdu.edu.tr

Abstract

The urea existing in broiler manure is converted into ammonia gas by urease enzyme and consequently the concentration of ammonia rising in the poultry house which results decline on broiler productivity. To reduce in-barn ammonia level a patented ammonia trap system is developed. System is looking like a miniature cooling tower. This so-called cooling tower is filled by the polyethylene balls to increase surface area and balls are wetted continuously by 5 M of phosphoric acid solution. In-barn air forced to pass through within the balls, ambient ammonia reacts by phosphoric acid and ammonium phosphate obtained as a by-product which can be used as a mineral fertilizer. Initial results revealed that the system is effective on ammonia reduction in barn and it was patented by Turkish Patent Institute with the patent Nr: TR 2012 13292 Y. System is under development stage; however, meanwhile we did not maintain patent protection. Thus, we would like to encourage farmers to use this system to reduce ammonia levels in their facilities to improve their benefit as well as reduce atmospheric pollution.

***Key words**: Ammonia trap, broiler house, In-barn gases, poultry.*

INTRODUCTION

In order to provide better living conditions for animals, animal barns should be designed by considering not only the thermal conditions but also a wide range of environmental factors. These environmental conditions cover many issues such as providing adequate living space, growing factors, lighting, feed and water requirements as well as manure management. These conditions closely related by the purpose of facility, animal type and geographical conditions. At the present time, intensive production techniques are being followed; therefore, animals are staying in the poultry house throughout their lifetimes. Thus, environmental conditions of barns are as important as growing material and feed for broiler productivity, health and feed utilization rates. Indoor environmental condition term refers adequate temperature, humidity and sanitation conditions in the poultry house, avoiding harmful gases, regulation of enlightenment and animal density in the poultry house (Atilgan, 2000). Common air pollutants in the poultry houses are CO_2, ammonia and CO. These gases can create an uncomfortable environment for both labourer and animals (Alchalabi, 2006).

The most common air pollutant in poultries is ammonia gas (Akbay, 1986). Emission rates should be assessed very well in countries, because the ammonia emission values vary widely according to breeding type and season. These differences in ammonia emission values are sometimes not explained by physical or chemical processes (Groot Koerkamp et al., 1998).

The ammonia concentration in the poultry house is affected by a number of factors. These factors include ventilation, bedding age and type, animal age, inner temperature of poultry house, relative humidity, fan status and water lines (Fairchild, 2006). Ammonia gas is formed as a result of decaying manure which has been accumulating on bedding throughout the growing period (Okuroglu, 1987; Yahav, 2004). Ammonia is a gas which is colourless, pungent-scented, lighter than atmosphere and soluble in water. Ammonia concentration shows fluctuation depending on the poultry house conditions. In the poultry which ventilation capacity is 1.1 m^3 h^{-1}, the concentration of ammonia at 24°C varies between 15 to 90 ppm. If the ventilation rate is almost doubled to 2.3 m^3 h^{-1}, the concentration of ammonia will increase to a maximum of 50 ppm (Valentine, 1964; Anderson et al., 1964, Hellickson and Walker, 1983).

In poultry houses where ventilation was not well performed, the problems were observed when the ammonia concentration was 50 ppm (Sainsbury, 1981). Ammonia can be easily recognised due to the pungent malodorous where even at 5 ppm human nose can feel the odour. Over 20 ppm it causes tears (Wathes et al., 1997). Between 100 to 200 ppm ammonia causes sneezing, irritation of the respiratory system and reducing appetency.

When it is reached to 1500 ppm, cough and foaming in the mouth appear; it is fatal over 5000 ppm. Ammonia levels in the poultry exceed 25 ppm in winter even in normal ventilation conditions.

The 25 ppm ammonia concentration is considered the limit value for poultries (Carlile, 1984, Gurdil, 1998, Erensayin, 2000, Gurdil et al., 2001, Gurdil, 2003). Ventilation is one of the important parameters to ensure environmental control in poultry houses.

A well-planned ventilation system is essential for adequate ventilation. Ammonia gas level increases in the winter time even if barn equipped with effective ventilation system because the outside temperature in winter is quite low; therefore, low ventilation rates preferred for conserving in-barn heat (Alchalabi, 2006). Thus In the winter months, determined ammonia value in the barn was found to be well above the critical limit of 25 ppm. The most practical way to reduce ammonia is ventilation; but the environmental concern and increasing energy cost are the obstructions of effective ventilation. In this study, it was aimed to design a system that help to reduce ammonia level in poultry without increasing costs.

MATERIALS AND METHODS

The system constructed by polyethylene materials to prevent corrosion. The barrel was used as a main body of the system which capacity is approximately 0.07 m^3 (Figure 1). The volume of the system is not critical, it can be selected any size, but the bigger capacities results the better reducing effects of ammonia.

Figure 1. Designed ammonia trap system

This barrel is filled up by polyethylene balls to increase surface area (Figure 2). Smaller ball size provides higher surface area in same volume; however, salt occurrence may prevent uniform solution and air flow throughout the balls. Thus, the smaller diameter less than 3 cm is not recommended. In the designed system the 80 ball which diameter was 8.5 cm each were placed to barrel and 1.82 m^2 of surface area was achieved.

The solution in the bottom reservoir is transferred to top of the system via pomp and the balls inner the barrel is wetted. For the uniform distribution to be able to wet entire balls, ½” polipropilen water pipe is rounded, bottom face drilled to have evenly spaced 60 hole by 2 mm bit (Figure 3).

As an inlet ports, 18 holes of 3.3 cm in diameter were opened 14 cm above the bottom of the barrel. Eight cm long plastic pipes with an outside diameter of 3.3 cm and an inside diameter of 2.1 cm placed to these holes. On the upper side of the system, a single hole with a diameter of 11.5 cm is opened and a fan with 190 m^3 h^{-1} capacity is placed here (Figure 4).

Figure 2. The balls used in the barrel

Figure 3. Solution distributor

In the preliminary experiment 5 M of phosphoric acid solution was used. Expected reaction in the barrel is presented was:

$$NH_4OH + H_3PO_4 \rightarrow NH_4H_2PO_4 + H_2O$$

Figure 4. Complete system with fan

Although ant type of acid solution even water can be used in the system. In the room temperature more than 500 litre of ammonia gas can be solved in the water; however, acid solutions are more effective and by product can be used in agricultural system as fertilizer.
Briefly system works in following steps:

1. The solution pumping from bottom reservoir to top sprayer/distributor unit.
2. While solution is wetting balls, the barrel air sucking by fan that located the top centre of the barrel.
3. Sucked air forced the barn atmosphere enter the system via inlet ports.
4. While barn atmosphere passed within balls, ammonia is trapped by acid solution. Thus, ammonia concentration in outlet reduced compared the inlet.
5. Ammonium phosphate fertilizer occurs in the solution. Some of them have been precipitated on the surfaces.

RESULTS AND DISCUSSIONS

This system tested in the poultry and bulk of data recorded. The ammonia measurement results will be summarized at prospective manuscript; however the aim of this paper is presenting entire system and potential improvement possibilities. First of all this system is promising options to reduce ammonia level in poultry; but it needs extra labour; therefore, system should be developed for automatization. These developments will also eliminate the disadvantages we meet, which will be explained below. Those disadvantages are:

(1) The acid solution somehow reaches the metal equipment of the barns that stimulate corrosion. Moreover concentrated acid solution is not safe for the workers and any accident would treat animal welfare. Thus lower acid concentration should be used but in this case ammonia fixing capacity is reduced.

(2) Depending on the in-barn ammonia concentration, the neutralization interval is not predictable. Besides the ammonia trap efficiency is related the H^+ ions of the solution which decreased by the time. As a result, acid solution should be continuously controlled which lead to extra workload.

(3) System powered by mains voltage and acid solution is rather conductive. In case of electrical leakage employees may be injured. Although the fan can be replaced by 12 volt brushless version, the 12 volt pomp is not providing adequate circulation of the solution.

(4) The reservoir of the system increases the system weight. When the system located at the floor, around 1 square meter of the area occupied for each. Alternatively, system may be hanged to the roof construction, but in this case extra weight should be considered.

To overcome the above mentioned problems a cascade system is designed (Figure 4).

Cascade system design allows weaker acid solution usage while effective ammonia trapping. The pH of the solution can be easily controlled by on-line pH probe which control the one dosage pomp to keep the pH constant. In this design, high voltage required only for outside located facility which is less risky. Due to the no solution will be located under the each system; it will be lightweight compared to the original design. Moreover, with this cascade design, system may adapt every poultries without considering size and the shape of barn as well as labour requirement.

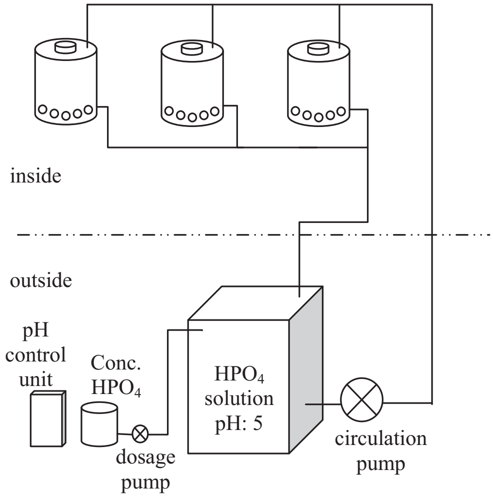

Figure 4. The cascade system design trap systems (the number of the unit can be easily increased as required)

Obtained ammonium phosphate solution can be directly used as a fertilizer or can be dried out via solar drying systems. In our experiment the ammonium ($NH^+{}_4$) concentration of solution in the ammonia trap reached up to 1.2% whereas the acquired salt after drying process was contained 10.4% ammonium.

CONCLUSIONS

Based on the overall observations and measurements it is concluded that developed system is decreasing in-barn NH_3 level evidently without treating livestock production system. This system although needs some improvement to increase its efficiency as well as usability, presented version is good start point to mitigate NH_3 emissions. As well-known, ammonia is one of the gas that treat in-barn and surrounding communities.

The system that presented here is considerably promising approach to reduce this huge anthropogenic emission without causing any side effects. On one hand, decreasing in-barn NH_3 concentrations lead welfare improvement for both animals and the workers in livestock facilities. On the other hand each system acts as a so-called nitrogenous fertilizer production plant.

Expected by-product of the system is ammonium phosphate which is one the most commonly used fertilizer in greenhouse vegetable production in Turkey; therefore, marketing this by-product would provide additional income.

Although organic farming system totally refused mineral fertilization with minor exceptions, limited usage of this by-product may be considered one of the fertilizer sources considering its production techniques which both environmentally safe and human-friendly.

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REFERENCES

Akbay R. 1986. Environmental conditions that productivity of poultries. Turkish IV. Poultry congress. 19-20 June, Turkey (in Turkish)

Alchalabi D., 2006. Solving carbon dioxide and ammonia problems. www.wpsa.info/docs/ ammonia_and_CO2_control.pdf

Anderson D.P., Cherms F.L., Hanson R.P., 1964. Studies on Measuring The Environment of Turkeys Raised in Confinement. Poultry Science, 43(2), 305-318.

Atilgan A., 2000. A research to determine environmental condition of curtain system broiler house in Adana/Turkey. PhD Thesis, Cukurova University, Adana (in Turkish)

Carlile F. S. 1984. Ammonia in poultry houses: A literature review. World's Poult. Sci. J. 40:99-113.

Erol H., Coskan A., Dogan K., Gok M., 2010. The Effects of Organic and Conventional Production Systems on Soil on Mineral Nitrogen Content and Biological Activity at the Oily Rose farms (*Rosa damascena*) in Isparta. 5th National Plant Nutrition and Fertilizer Congress. 15-17 September, Ege University Agricultural Faculty Journal, Special Issue, 1, 593-598, İzmir (*in Turkish*)

Fairchild B., 2006. Ammonia Emissions From Poultry Houses:The US view. Poultry İnternational, 45(3), 8-12.

FAO, 2006. Livestock's role in climate change and air pollution. http://www.fao.org/tempref/docrep/fao /010/ A0701E/A0701E03.pdf Accessed in April 2018.

Groot Koerkamp P.W.G., Metz J.H.M., Uenk G.H., Philips V.R., Holden M.R., Sneath R.W., Short J.L., White R.P., Hartung J., Seedorf J., Schröder M., Linkert K.H., Pedersen S., Takai H., Johnsen J.O., Wathes C.M., 1998. Concentrations and Emissions of Ammonia in Livestock Buildings in Northern Europe. Journal of Agricultural Engineering Research, 70, 79-95

Gurdil G.A.K., 1998. Confined Space Hazards: Air Contaminants in Livestock House. In: Sborník referátu z mezinárodního vědeckého semináře. Nové poznatky v technologických zařízeních v zemědělských a potravinářských provozech (International Scientific Seminars: New Knowledge in Technological Equipment and in Agricultural Operations) TF ČZU. Praha, 2-3 September, 13-15

Gurdil G.A.K., 2003. Ventilation and Climatization in Poultry Houses Ing. Czech University of Agriculture in Prague.

Gurdil G.A.K., Kic P., Yıldız Y., Öner I., 2001. The Effect of Hot Climate on Concentrations of NH_3 in Broiler and Laying-Hen Houses. In: International Conference on Weather Extremes as a Limiting Factor of Biometeorological Processes. September 10-12, 2001. Račková dolina- Slovak Republic ISBN 80-7137-910-7

Hellickson M.A., Walker J.N., 1983. Ventilation of Agricultural Structures. Effects of The Thermal And Gasses Environment of Livestock, Michigan, 121-165.

Okuroglu M. 1987. Hazardous gases, dust and their effects in animal barns. Journal of Meet and Fish Industry, 8(49), 19-24.

Sainsbury D.W.B., 1981. Health Problems in Intensive Animal Production. Environmental Aspects of Housing for Animal Production, England, 439-454.

Valantine H., 1964. A Study of Effect of Different Ventilation Rates on The Ammonia concentration in The Atmosphere of Broiler Houses. British Poultry Science, 5(2), 149-159.

Wathes C.M., Holden M.R., Sneath R.W., White R.P., Philips V.R., 1997. Concentration and Emission Rates of Aerial Ammonia, Nitrous Oxide, Methane, Carbon Dioxide, Dust and Endotoxin in UK broiler and Layer Houses. British Poultry Science, 38, 14-28.

Yahav S. 2004. Ammonia affects performance and thermoregulation of male broiler chickens. Anim. Res., 53, 289–293.