Analele Universităţii din Oradea, Fascicula: Ecotoxicologie, Zootehnie si Tehnologii de Industrie Alimentara, Vol. XV/B Anul15, 2016

ATMOSPHERIC SPREADING MODEL FOR AMMONIA RELEASED FROM THE POULTRY HOUSE

Tamás János *, Edit Gorliczay*, János Borbély#

*University of Debrecen, Faculty of Agricultural and Food Sciences and Environmental Management, Hungary, 4032 Debrecen, Böszörményi út 138., e-mail: tamas@agr.unideb.hu
#BBS Biochemicals, Hungary, 4225 Debrecen

Abstract

In this report a model calculation is presented for demonstrates the atmospheric dispersion of ammonia generated in a poultry house. Broiler breeding facilities work with high density of population as estimated 17 birds per square meter, thus the exhausted air contains significant amount of pollutants. Released dusts are minimal in the earl stage of the 42 days long breeding process, however, their amount increase exponentially, particularly in the last two weeks period. The major pollutant that must be release are as follows: fine particular matter, carbon dioxide generated by animal breath, and by older type of heating equipments, ammonia that is generated due to decomposition of manure, and in lower amount hydrogen sulphide and methane. The poultry houses are considered as point rather than diffuse sources. Concentration of pollutants is kept at a low level, which is required for the animal health, thus conditions are met with correct settings of the ventilation system (Kovács, 2000). The Bátortrade Ltd. (Nyírbátor, HU) installed heat exchanger equipments for saving energy related to ventilation. Thus, to avoid the return of air pollutant once had been released. ALOHA software has been used for spreading model calculations.

Keywords: poultry house, ammonia emission, atmospheric dispersion, modeling, ALOHA software

INTRODUCTION

The ammonia in poultry houses is produced by degradation of the stool/excrement (Lin et al., 2016). However, high ammonia concentrations increase the risk of respiratory system of birds and infectious diseases, in addition adversely affects the daily weight gain of animals, the quality of the feed conversion and meat (Aviagen, 2009). In accordance with the recommendations for the air quality of the broiler houses the ammonia concentrations must be kept in the range between 10 ppm and 25 ppm (Blake and Hess, 2001, NCC, 2014).

It is well known that ammonia plays an essential role in the nitrogen cycle of atmosphere (Aneja et al., 2006). The ammonia is derived from a variety of sources, but livestock production is the major contributor of emissions into the atmosphere (FAO, 2006).

Environmental and safety considerations have become essential to air quality or human health hazard modeling of the spreading of gases into the atmosphere. For this purpose the ALOHA simulation is a very suitable software. The results obtained by ALOHA calculation are useful for risk assessment (Tseng et al., 2012). ALOHA chemical-case evaluation was launched in the (EPA) initiative called CAMEO program. The CAMEO (Computer Aided Management of Emergency Operations) framework program developed by the US Environmental Protection Agency (EPA) is called ALOHA (Areal Locations of Hazardous Atmospheres) chemical-case evaluation program. The ALOHA program is applicable and runs on personal computers as PC's and Macintosh systems, as well as. The program gives useful information for prediction of toxic area of the vapor cloud, and help to eliminate the effects of accidents that might occur in the presence of chemical substances provides planning and practical assistance (ref. 11).

The aim of the research was to determine the concentration of ammonia in the environment of the poultry houses and generate a model for the ammonia spreading by using ALOHA software 5.4.7. version.

MATERIALS AND METHODS

The ALOHA program calculates the spread of various gases enter into the atmosphere. It takes into account the physical and toxicological properties of a substance, the characteristics of the area concerned conditions of the micro-meteorological conditions and the conditions of access to the outside. The software uses a graphical interface that allows introducing various data, which are essential for the prediction of the atmospheric transport of hazardous substances.

During application of program the following information should be entered: meteorological conditions which modify the propagation conditions, and to generate the propagation model: wind direction, wind speed, temperature, vertical stability of air, humidity, weather conditions - (sunny, cloudy), the environment density and roughness - (forest, urban, flat and hilly).

When each dialog boxes are filled in the program, error checking is performed. The raw data included are summarized in Table 1. The detailed results of the calculations are shown in graphical forms in Figure 1 and are shown in a text form in Table 2.

The study area was in Nyírbátor (Hungary), in the poultry farm including composting facilities and poultry houses of Bátortrade Ltd. The composting facilities use a mechanical mixing periodically, that results accumulation of ammonia at high concentration in the bulk. Thus, in consequence the agitation suddenly large amount of ammonia escapes. This fact must be taken in consideration in order to avoid any accident.

The chickens discharged the nitrogen form of urine and feces, and the nitrogen uric acid, ammonia and urea in the form of leaves (Goldstein and Skadhauge, 2000). Ammonia is generated in poultry houses; however, its concentration is reduced by time-regulated continuous ventilation. In order to save energy the ventilation system is equipped with heat exchangers that utilize the heat content of the extracted ammonia polluted air released out from the poultry house by ventilation. Prediction of the ammonia plume is important to avoid the return of the polluted air through the heat exchangers back into the poultry houses.

Table 1

Raw data to create the spread model and results of the calculation

Site data	Location: NYIRBATOR (HU), HUNGARY Building Air Exchanges Per Hour: 0.21 for site A (Composting facilities) and 10 for site B (Poultry Houses). Time: April 27, 2016 10:23 hours ST (user specified)
Chemical data	Chemical name: ammonia (NH3) CAS Number: 7664-41-7 Molecular Weight: 17.03 g/mol AEGL-1 (60 min): 30 ppm AEGL-2 (60 min): 160 ppm AEGL-3 (60 min): 1100 ppm IDLH: 300 ppm LEL: 150000 ppm UEL: 280000 ppm Ambient Boiling Point: -33.5° C Vapor Pressure at Ambient Temperature: greater than 1 atm Ambient Saturation Concentration: 1,000,000 ppm or 100.0%
Atmospheric data	Wind: % m/sec at site A; and due to the ventilation 20 m/sec at the site B; outside temperature 25°, at 2 meters Ground Roughness: open country Cloud Cover: 10 tenths Air Temperature: 20 ° C Stability Class: D Relative Humidity: 45% No Inversion Height

The software, which calculates a Gaussian profile, is a local-scale model. It is used when the diffusion of pollutants in the direction of transport is negligible. AEGL (Acute Exposure Guideline Levels) values were divided in tree groups as shown in the Table 1.

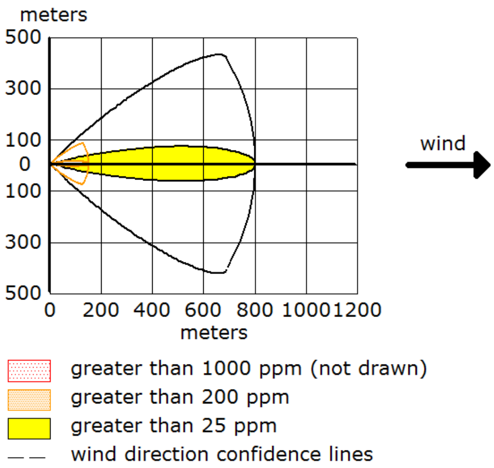
RESULTS AND DISCUSSION

Spreading profiles have been calculated for Composting facilities (site A) and for the poultry house (site B), respectively. For site A it is taken in consideration, that ammonia generated in bulk is not released continuously, however, due to non-periodic mixing it can escape in a very short time. Thus, it concentration might be very high for a short time, that fact must be important for the safety of the workplace. The threat zones have been plotted as is shown in Figure 1 (site A) and their distance values in Table 2.

In the poultry houses the flat litter thickness is maximum 10 cm, and there is a time controlled continuous ventilation, in consequence the ammonia concentration is limited as 10-20 ppm. In fact, that is required to protect the health of birds. The meaning of calculation is to avoid the return of polluted air back to the poultry house through the heat exchangers. There is no threat zone, the yellow trace has been plotted as is shown in Figure 1 (site B) and its distance value in Table 2.

MARPLOT presentation of Poultry facilities

A) The threat zone surrounding composting area



B) The threat zone surrounding poultry house area

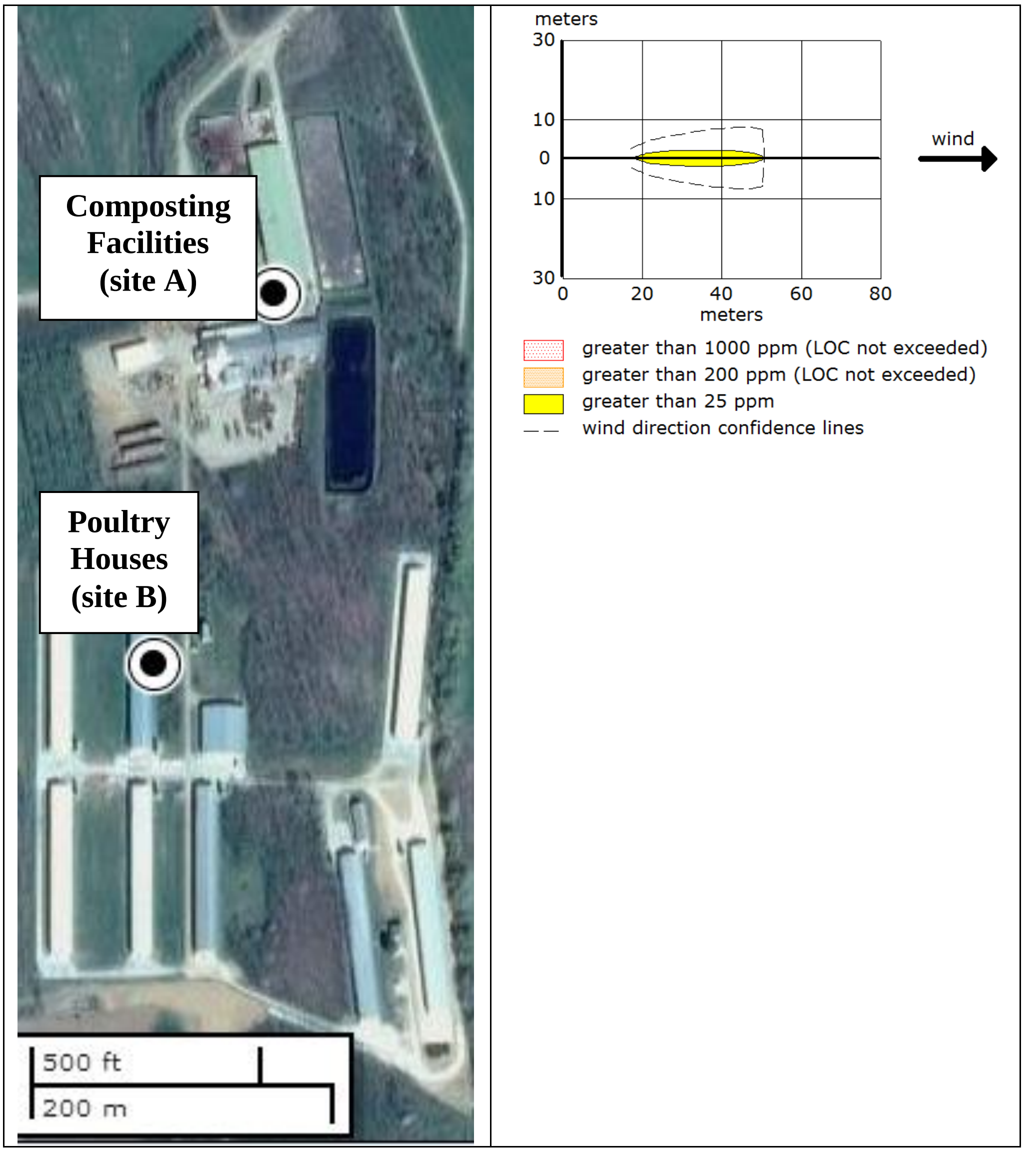


Figure 1 The MARPLOT map of poultry facilities and the threat zone spreading profiles of the Composting facilities and around the Poultry houses (details are summarized in Table 1)

Table 2

Detailed results of the calculations are shown in a text form

	(A) Composting Area	(B) Poultry House
Threat zones (Gaussian selected)	Red : 28 meters --- (1000 ppm) Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances. Orange: 152 meters --- (200 ppm) Yellow: 808 meters --- (25 ppm)	Red : LOC is not exceeded --- (1000 ppm) Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC. Orange: LOC is not exceeded --- (200 ppm) Note: Threat zone was not drawn because the ground level concentrations never exceed the LOC. Yellow: 51 meters --- (25 ppm)

CONCLUSIONS

The animal husbandry is one of the largest sources of ammonia emission, due to degradation of nitrogen containing components of manure. In case of birds the main source of ammonia is hippuric acid, that is decomposed due to microorganisms are present in manure. The acceptable ammonia concentration changes between 10 and 50 ppm, although it depends on the species of animal and on the exposure time (Koerkamp, 1998). Many researchers pointed out that in the poultry houses and their environment ammonia concentrations exceeded the acceptable limit.

In our experiments based on the field measurements it was observed that the ventilation capacity in the poultry houses is regulated depending on the level of ammonia, which keeps the ammonia concentration below harmful level. However, during the post treatment of manure, e.g., compotation may generate very high ammonia concentration, which has to be managed in order to secure safety at the workplace.

ACKNOWLEDGMENTS

This research was supported by the Norwegian Government and the State of Hungary in the framework of Implementation of Green Innovation in Food Industry, HU09-0015-A1-2013

REFERENCES

1. Aviagen, 2009. Effective Management Practices to Reduce the Incidence of Ascites in Broilers http://www.aviagen.com.
2. Food and Agriculture Organization of the United Nations (FAO): 2006. Livestock's Long Shadow: Environmental Issues and Options Chapter 3: Livestock's Role in Climate Change and Air Pollutions, pp. 95–99.
3. Goldstein, D.L. and Skadhauge E.: 2000 Renal and Extrarenal Regulation of Body fluid composition. In G.C Whittow (ed.) Sturkies avian physiology. 265-297, Academic press San Diego, California.
4. J.P. Blake, J.B. Hess: 2001. Sodium Bisulfate as a Litter Treatment, ANR-1208 Alabama Cooperative Extension System.
5. J.M. Tseng, T.S. Su, C.Y. Kuo: 2012. Consequence evaluation of toxic chemical releases by ALOHA. Procedia Engineering 45 (2012) 384 – 389.
6. NCC (National Chicken Council): 2014. Animal Welfare Guidelines and Audit Checklist www.nationalchickencouncil.org.
7. P. W. G. Groot Koerkamp; J. H. M. Metz; G. H. Uenk; V. R. Phillips; M. R. Holden; R. W. Sneath; J. L. Short;
8. R. P. White; J. Hartung; J. Seedorf; M. Schröder; K. H. Linkert; S. Pedersen; H. Takai; J. O. Johnsen; C. M. Wathes: 1998. Concentrations and Emissions of Ammonia in Livestock Buildings in Northern Europe. J. agric. Engng Res. (1998) 70, 79—95.
9. R.A. Smith: 1998. Impact of disease on feedlot performance. A review Journal of Animal Science, 76, pp. 272–274.
10. V.P. Aneja, W.H. Schlesinger, D. Niyogi, G. Jennings, W. Gilliam, R.E. Knighton, C.S. Duke, J. Blunden, S. Krishnan: 2006. Emerging national research needs for agricultural air quality. Transactions American Geophysical Union, 87 (3), pp. 25–29.
11. http://response.restoration.noaa.gov/sites/default/files/ALOHA_Tech_Doc.pdf (I1)