EMISSION OF AMMONIA IN PIGSTIES

Oliver Sada, Boris Reppo
Estonian University of Life Sciences
oliver.sada@emu.ee, boris.reppo@emu.ee

Abstract. Building of large pigsties with deep litter and without litter which use liquid manure removal systems, has become a wide practice nowadays. The indoor climate parameters of the working environment have an impact on the human capacity for work and productivity of animals. Enlargement of pigsties is accompanied with problems regarding the achievement of the required indoor climate of the working environment. For the purpose of studying of the pigsties with different animal-keeping technologies of the simultaneous effect of temperature and relative humidity on the emission ammonia content in the air of pigsty, were measured in summer and in winter pigsties in above pig-pen at the height of 1.5 meters from the floor were measured daily. Data logger equipment, relevant sensors and the content of ammonia in the air measured by using Gas Monitor Pac III equipment were used for the study. The measurement results were statistically processed by using computer programmes AMR Win Control, Pac III Software3.nn, SAS and MS Excel.

Keywords: pigsty, deep-litter, liquid manure, system, pens, tending passages, working environment, air temperature, relative humidity, ammonium hydrate, ammonia contend correlation, tending activities, data logger.

Introduction

A pig farm represents a biotechnical system „man-machine-animal", which together with the indoor climate of buildings or premises constitutes a work environment for producing animal products. Indoor climate parameters of working environment have impact on the human capacity for work [1-3] and the productivity of animals [3-5]. Humidity and ammonia have more harmful effect on premises [6], whereas the indoor climate depends on various factors such as applicable tending technology, number of animals, systems for providing animals with forage and water, removal of manure, use of litter, and season or outdoor climate [3-8]. The indoor air temperature and relative humidity of a pigsty have been researched more thoroughly [3; 7; 8]. The working environment air gas composition, its variations on a daily basis and its dependence on applicable technologies and animal keeping methods have been studied to a lesser extent.

The aim of the present research was to find out the impact of different methods for animal keeping and tending works on the indoor working environment during summertime. The daily developments of air velocity and contents of oxygen, carbon dioxide and ammonia were measured at the height of 1.5 m above the floor of the pigsty in the central part. The study results provide further information concerning the indoor climate in pigsties and also allow selecting the method for keeping of animals with the least harmful tending environment.

Materials and methods

The indoor climate was studied in pigsties for 1600 fattening pigs, and 800 young pigs, which are hereinafter referred to as Pigsty A, and B (Table 1). The pigsties were made of silicate bricks and reinforced concrete. Fattening pigs and young pigs were fed with dry fodder delivered by an automatic conveyor from automatic feeders. The automatic conveyor Big Dutchman was used in Pigsty A and Roxcell device was used in Pigsty B. In Pigsty A fattening pigs were kept on straw litter (60 pigs per pen), manure was removed with a shovel-loader after replacing the fattening pigs in the pigsty. In Pigsty B liquid manure system was used, where manure was drained from the pen with 30 young pigs into a channel below grated floor, leading to the pump-room, where it was pumped to the manure storage. Nipple drinkers were used as drinking device in all pigsties. Ventilation was regulated by automatic forced ventilation controlled by temperature.

The methods of the study were based on the Health Protection Act of the Republic of Estonia [9] and Finnish standards [10], American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc. (ASHARAE) [4] according to which the numerical values of the indoor climate parameters of the work environment can be defined for animals at the height of 1.0 m and for human workplace at the height of 1.5 m. In order to study the daily changes in the indoor climate of pigsties depending on the outdoor climate, methods for animal keeping, performing technological processes, activities of the tender and animal behaviour, indoor air temperature, relative humidity and ammonia were measured on a daily basis at the interval of 60 seconds in the central part of the pigsties at the height of 1.5 m above the floor of the pigsty in summer. ALMEMO Data Logger 8990-8 equipment with relevant sensors was used for studying the indoor climate.

Table 1

Data on pigsties

Item	Pigsty A	Pigsty B
Number on pigs	1600 fatlings (25-100 kg)	800 young pigs (15-50 kg)
Way of keeping	Deep-litter	Liquid manure system
Ventilation	Compulsion ventilation	Compulsion ventilation
Air flow control	Automatic	Automatic
Additional heating	Missing	Water-heated floor
Fodder delivery	Automatic system Big Dutchman	Automatic system Roxcell
Manure disposal	With tractor	Liquid manure, with flow to the pumping-station
Drinking device	Nipple drinker	Nipple drinker
Litter used	Straw	Missing

The air temperature and relative humidity were measured with the AMR-manufactured sensor FH646-1 with measurement area -20…+80 ºC (measuring accuracy 0.01 ºC) and 5-98 % (measuring accuracy 0.1 %), respectively. The ammonia content was measured with the Gas Monitor Pac III equipment manufactured by Dräger Safety AG & Co, its measurement area was 0-250 ppm and the measuring accuracy 1 ppm. The measurement results were analysed by using computer programmes AMR WinControl, Pac III Software 3.nn and statistically processed by using programme MS Excel and SAS [12; 13].

Results and discussion

The indoor air temperature, relative humidity and ammonia concentration are the main indoor climate parameters of the pigsty [12; 13]. The recommendatory temperatures for pigs depending on their age and live weight are considered as follows: the lowest admissible temperature 5 ºC, the highest 32-34 ºC and optimum 16-21 ºC [4; 6; 13; 14]. Relative humidity of the indoor air is recommended 60-75 %, not over 85 %, because then also other microclimatic parameters deteriorate [7; 14; 15]. Surplus humidity causes drippings, mould and mildew on the building border area and reduces heat resistance of the building and pigs as well. Insufficient air humidity less than 55 % can cause mucous membrane desiccation because of dust in the room [7; 15].

The study results revealed that with deep litter in Pigsty A (Fig. 1) and also liquid manure in Pigsty B (Fig. 3) the indoor air temperature was (accordingly 11.4-21.4 ºC and 14.93-25.7 ºC) practically within the limits.

The measured relative humidity was Pigsty A 63.3-88.7 % and Pigsty B 73.9-96.7 %, exceeding the limits.

Ammonia is originated in the decomposition process with the presence of excrements and urine. Ammonia is extremely toxic for organisms, causing liver troubles and constant nervousness, irritating respiratory organs, inflicting chemical burns. The capacity of ammonia diffusing through the cell walls increases ammonia riskiness for mammals [7]. The utmost permissible concentration of ammonia in the work zone air is 25 ppm (for 5minute workday). For pigs the concentration limit is 20 ppm [6; 17].

The indoor climate investigation showed that the ammonia concentration in Pigsty A air was 5-38 ppm and pigsty B was 2-25 ppm (Fig. 2 and 3).

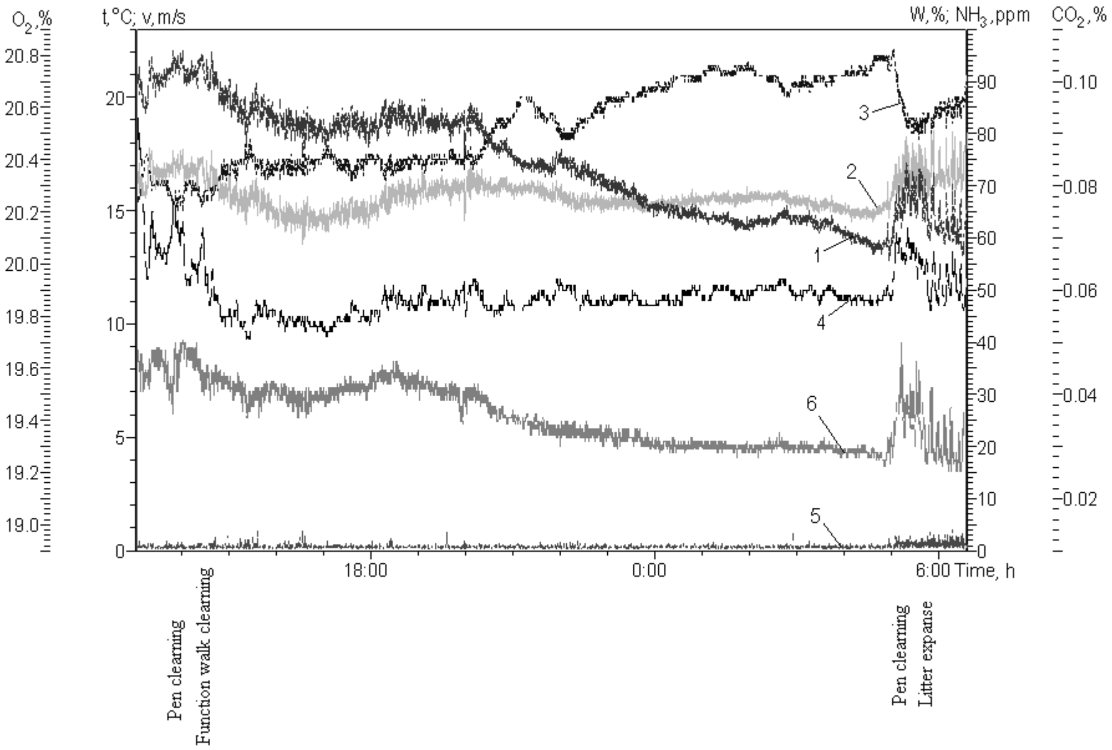

Fig. 3. **Daily change of numeric values of indoor climate parameters in Pigsty A:**
1 – temperature; 2 – relative humidity; 3 – oxygen; 4 – carbon dioxide; 5 – air velocity; 6 – ammonia

The information also varies in case of the highest concentration of ammonia in the air. The allowed concentration of ammonia in the air is up to 20 ppm in the European Union [6]. Estonian standards [17] and the authors [12] refer to 20 and 25 ppm as the allowed average standard limit in the air inhaled in the human working zone. The ammonia content 6-12 $cm^3 \cdot m^{-3}$ was measured in the piggery for 220 fattening pigs [11].

According to relevant literature [14; 19; 20] elevated air temperature and moist litter in the animal-keeping premises increase the air emission of ammonia. The data provided by several authors [7; 19; 20; 21] reveal that the air emission of ammonia in the premises used for animal keeping depends on the handling of manure, air temperature and relative humidity. It is also noted that the amounts of ammonia emitted from the manure are higher in the case of higher air temperature and higher relative humidity.

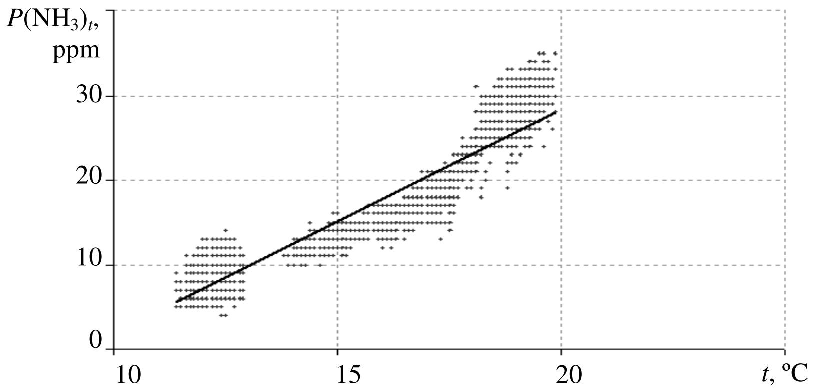

Fig. 2. **Ammonia content correlation in air temperature in Pigsty A**

The results of the study in summer and winter altogether of the indoor climate carried out in the deep-litter Piggery A, also reveal that higher concentration of ammonia $P(NH_3)_t$ (ppm) was measured in the case of higher air temperature t (ºC) of the piggery (Fig. 2), and it can be calculated by using formulas 1 (R^2_1=0.8843, n=3 600):

$$P(NH_3)_t = 2.614 \cdot t + 24.166 \quad (1)$$

The results of the study in summer and winter altogether of the indoor climate carried out in the piggery with the system of liquid manure, i.e., Piggery B, also reveal that higher concentration of ammonia $P(NH_3)_t$ and $P(NH_3)_w$ (ppm) was measured in the case of higher air temperature t (ºC) and in the case of bigger relative humidity W (%) of the piggery (Fig. 3), and it can be calculated by using formulas (R^2_2=0.7887, n=1 440 and R^2_3=0.9451, n=1 440), 2 and 3 respectively:

$$P(NH_3)_W=1.1836 \cdot W-85.876, \quad (2)$$

$$P(NH_3)_t=1.6286 \cdot t-21.113. \quad (3)$$

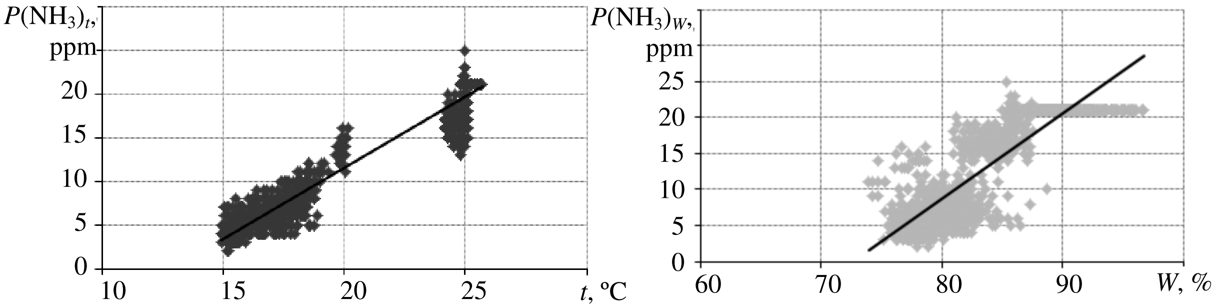

Fig. 3. **Emission of pigsties with system of liquid manure in summer and winter**

Considering that the relative humidity of piggeries also depends on the air temperature [20], this study also included determining of the effect of the air temperature t (ºC) and relative humidity W (%) on the emission of ammonia $P(NH_3)_{tW}$ (ppm), which was expressed by formulas (R^2_4=0.918, n=7 200; R^2_5=0.949, n=1 440) with regard to Piggery A (Fig. 4) and Piggery B (Fig. 5), 4 and 5 respectively:

$$P(NH_3)_{tW}= -51.02+3.227 \cdot t+0.239 \cdot W \quad (4)$$

$$P(NH_3)_{tW}=32.24+1.424 \cdot t+0.184 \cdot W \quad (5)$$

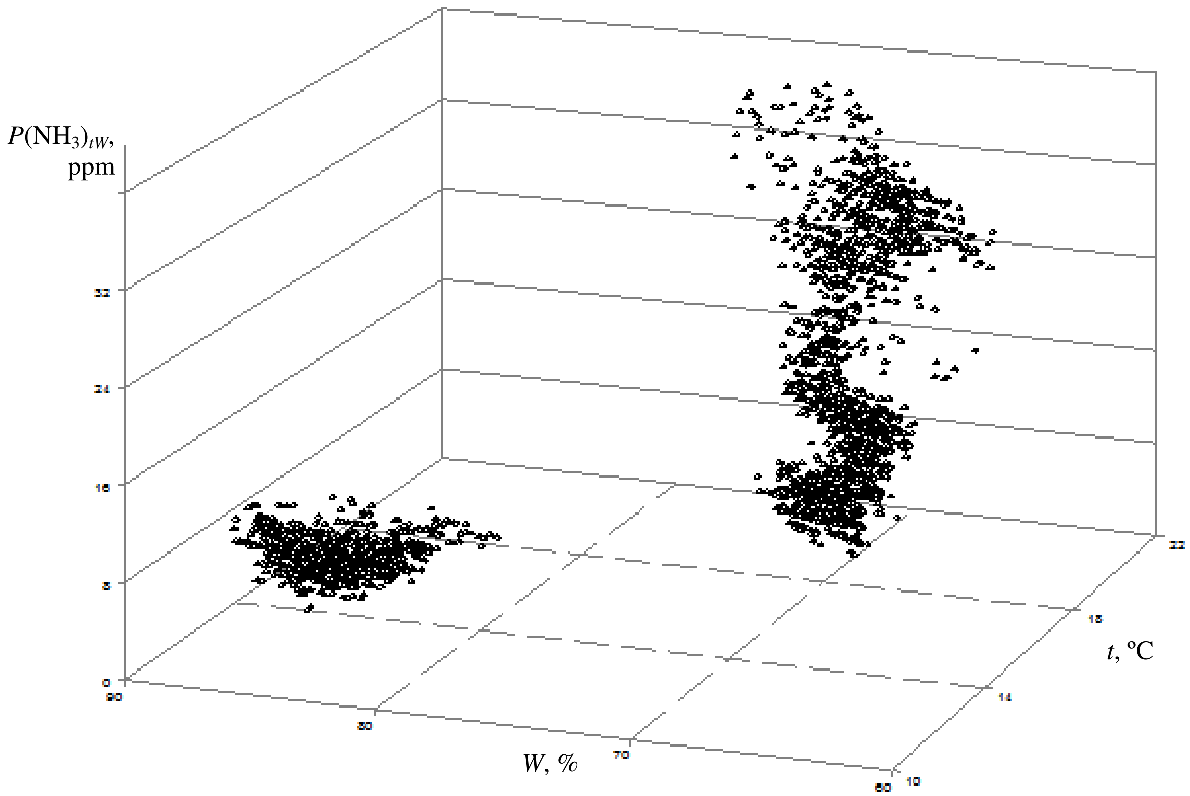

Fig. 4. **Ammonia content correlation in air temperature and relative humidity in Pigsty A**

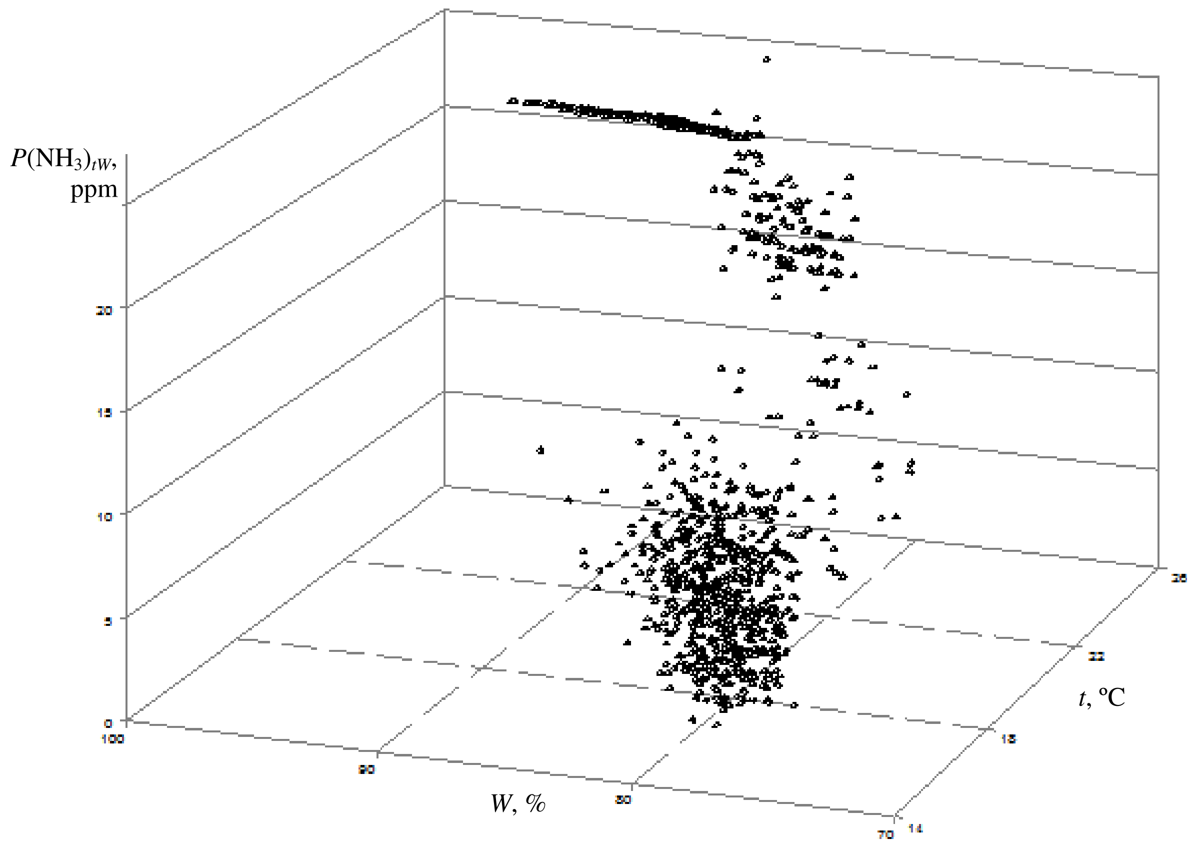

Fig. 5. **Ammonia content correlation in air temperature and relative humidity in Pigsty B**

Considering the potential difference between these relationships depending on whether measured in summer or in winter, further studies are needed.

Conclusions

1. During the research in summer and winter in piggeries with the system of deep litter and liquid manure the air temperature, relative humidity and ammonia content were measured in the night time as animal rest time, at 18-4 o'clock, above the pig pen in height 1.5 meters.
2. Data Logger with appropriate sensors and programmes AMR WinControl, Pac III Software 3.nn, were used for the research, the measurement data were statistically processed.
3. As a result of this study the graphical and empirical relationships were determined between the concentration of ammonia and as the indoor temperature and relative humidity (Fig. 2 and 3; formulas 1-3) and as also between the concentration of ammonia and combined effect of the temperature and relative humidity of the indoor air in summer and winter (Fig. 4 and 5; formulas 4 and 5).
4. The found out in the pigsty with deep litter values of air temperatures 11.4-21.4 ºC and liquid manure 14.93-25·7 ºC within the limits and relative humidity respectably 63.3-88.7 % and 73.9-96.7 % in the pigsties were not in the limits.
5. The ammonia concentration was respectably within 5-38 ppm and 2-25 ppm exceeded the limits.
6. Ammonia emission is affected by the temperature and relative humidity.

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