Impact of tending work on pigsty inner climate in winter

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Abstract. Inner climate at pigsty is in strong correlation with outdoor climate and tending work. Up to now, main research has been conducted to investigate air temperature and relative humidity, in order to be able to offer solutions to pigsty ventilation. At the same time, little data can be found about pigsty air gas content depending on pigs' function work.

With the aim of investigating the impact of outdoor climate and tending work on the inner climate at a pigsty of fatlings and youngs, the research was conducted to measure the air temperature, relative humidity and the content of oxygen, carbon dioxide and ammonia at these pigsties in winter time diurnally at the height of 1.5 meters. To measure the inner climate, Data Logger, appropriate sensors and the computer program PC AMR Win Control were used. At the same time, the winter outdoor air temperature and relative humidity were measured using Rotronic logger. The results of the research presented in the article concern the air temperature and velocity, relative humidity and the content of oxygen, carbon dioxide and ammonia of the working environment, measured in different places and heights of the room during daytime and diurnally above the pigpen. It became evident that the pigsty's inner air temperature was within the extent recommended, but the air relative humidity increased partly very high. The carbon dioxide content partly exceeded the established limits. The average measured ammonia also exceeded the limits in some cases but always increased during the tending work.

Key words: outdoor climate, inner climate, working environment, tending work, feeding, cleaning, air temperature, relative humidity, oxygen, carbon dioxide, ammonia, air velocity, Data Logger

INTRODUCTION

Inner climate is in strong correlation with outdoor climate and tending work (MWPS, 33, 1989; Kender et al., 1998; Reppo et al., 2003). So far main research has been conducted to investigate air temperature and relative humidity, in order to be able to offer solutions to pigsty ventilation. There exist few data about the effect of tending work on pigsty air gas content. At the same time, little data can be found about pigsty air gas content. With the aim of investigating the impact of outdoor climate and tending work on the inner climate at the pigsty of fatlings and youngs, the research was conducted to measure the air temperature, relative humidity and velocity and the content of oxygen, carbon dioxide and ammonia at these pigsties at winter time diurnally from the height of 1.5 meters. To measure the inner climate, Data Logger, appropriate sensors and the computer program AMR Win Control were used. At the same time, the outdoor air temperature and relative humidity were measured using Rotronic logger.

MATERIALS AND METHODS

When preparing the methodology of the research, the Health Protection Act of the Republic of Estonia (http://riigiteataja.ee...25048), Finnish standards (Karhunen, 1992) and Russian OST-standards (Rjabzev, 1981) were used as a basis. From there it becomes evident that the inner climate parameters of the working environment can be measured at a standard height of 1.0 m for animals at pigsties and 1.5 m for people at the workplace. With the objective of studying changes in the pigsty inner climate depending on the time, conduct of technological processes, activities of a tender and behavioural patterns of animals, air temperature, relative humidity, velocity and the content of oxygen, carbon dioxide and ammonia were measured at a pigsty for 62 fatlings and 48 sows (110 animals in total) and at a pigsty for 150 youngs, named below pigsty No 1 and pigsty No 2, respectively (Table 1), at winter time diurnally from the height of 1.5 meters from the pen floor of fatlings and youngs and not less than 1.0 meters from the wall. At the same time, the outdoor air temperature and relative humidity were measured diurnally.

When selecting the pigsties for the research on the inner and outdoor climate of the working environment, the prerequisite was that different keeping technologies of animals be used (Table 1).

The pigsties have been built as typical structures using calcium silicate bricks or concrete constructions, respectively. At pigsty No 1 feeding, watering and cleaning of pens is done manually. Sawdust is used as litter. Natural ventilation is used. Pigsty No 2 has undergone a complete renovation. The pigsty consists of two rooms, both of them feature five pens. Animals are fed with liquid feed three times a day using the automatic feeding line Pellon. Watering is carried out using nipple drinkers. Youngs are kept on a grate floor, whereas the slurry that gathers under it is removed by dripping. Electrical floor heating and a properly functioning forced ventilation system controlled by an automatic regulating system are used.

Table 1. Data on pigsties.

Pigsties No	1	2
Number of pigs	62 fatlings, 48 sows	150 young pigs
Way of keeping	Wing pen	Wing pen, grate floor
Ventilation	Natural	Compulsion ventilation
Air control	Ventilation stack	Automatical
Heating	Missing	Partial
Fodder delivery	Wheelbarrow	Liquid feed automatic
Manure disposal	Chainscraper flow line	Liquid manure
Litter	Sawdust	Sawdust
Drinking	Trough	Nipple

To research the parameters of the inner climate, ALMEMO Data Logger 8990-8 and 2690-8, connected to the sensors measuring the air temperature, relative humidity, velocity and the content of oxygen, carbon dioxide and ammonia, were used. The parameters were studied using the computer program AMR WinControl, the results were processed and presented in the form of a table and charts.

The air temperature and relative humidity were measured using the corresponding AMR company sensor FH646-1 with the measuring range of -20…+80°C (with the accuracy of 0.01°C) and 5–98% (with the accuracy of 0.1%). The oxygen sensor ZA9000-AK2K prepared by AMR company has the measuring range of 0–100% and accuracy of 0.01%. The carbon dioxide sensor used was FY A600–CO_2, with the measuring range of 0–2.5% and accuracy of 0.01%. In order to measure the air velocity, the thermo-anemometer FHA645TH2 with the measuring range of 0–2m/s and resolution of 0.001 m s^{-1} was used. The content of ammonia in the air was measured with the sensor ZA 3601-FS2, made in the company EIT Co, with the measuring range of 0–100 ppm and accuracy of 0.01 ppm. In order to measure the outdoor temperature and relative humidity, the device HygroLog of the company Rotronic along with sensor HygroClip S (with the measuring range of -40…+85°C and 0–100%, accuracy ±0.3°C and ±1.5%, respectively) was used. The measurement results were analysed with the computer programs HW3 and MS Excel (Kiviste, 1999).

RESULTS AND DISCUSSION

The most important parameters of the inner climate of pigsties (shall) include the following: indoor air temperature, relative humidity and the content of ammonia. The lowest indoor air temperature limit allowed for pigs is 5°C, the highest limit is 32–34°C and the optimum is deemed to be 10–28°C (CIGR, 1984), depending on the age and live weight of an animal (Maatalouden, 1990; Praks, 2001; Liiske, 2002). The recommended relative humidity of air is within the limits of 60–75%, but not over 85% as, in such a case, other microclimate indicators have also usually declined (Veinla, 1986). Excessive humidity creates drop water, mould and growth of fungi on the enclosures of the building.

Low humidity of air (below 55%) may cause mouth mucous membrane dryness in animals and dust in rooms (Mothes, 1977; Veinla, 1986).

It becomes evident from the results of the research (Tables 2 and 3) that the average air temperatures measured at the pigsties were 7.69 and 16.31°C at the outdoor air temperatures of –20.0 and –3.5°C, respectively.

In the case of the low outdoor air temperature measured at pigsty No. 1 (-13.3...-23.5°C), the temperature of the pigsty of fatlings and sows, according to diurnal measurement, was between +5.6…+9.9°C, being considerably lower than the optimum air temperature (+10...+28°C). The lower the air temperature falls from that specified as optimum, the worse the fatling growth results become (CIGR, 1984; Liiske, 2002, Maatalouden, 1990). In order to prevent this, the pigsty should be heated.

The average air relative humidity at the pigsties was 99.30 and 76.42%, exceeding this recommended for pigsty No 1. The air humidity decreased to some extent, following spreading out litter during evening tending work (Fig. 1).

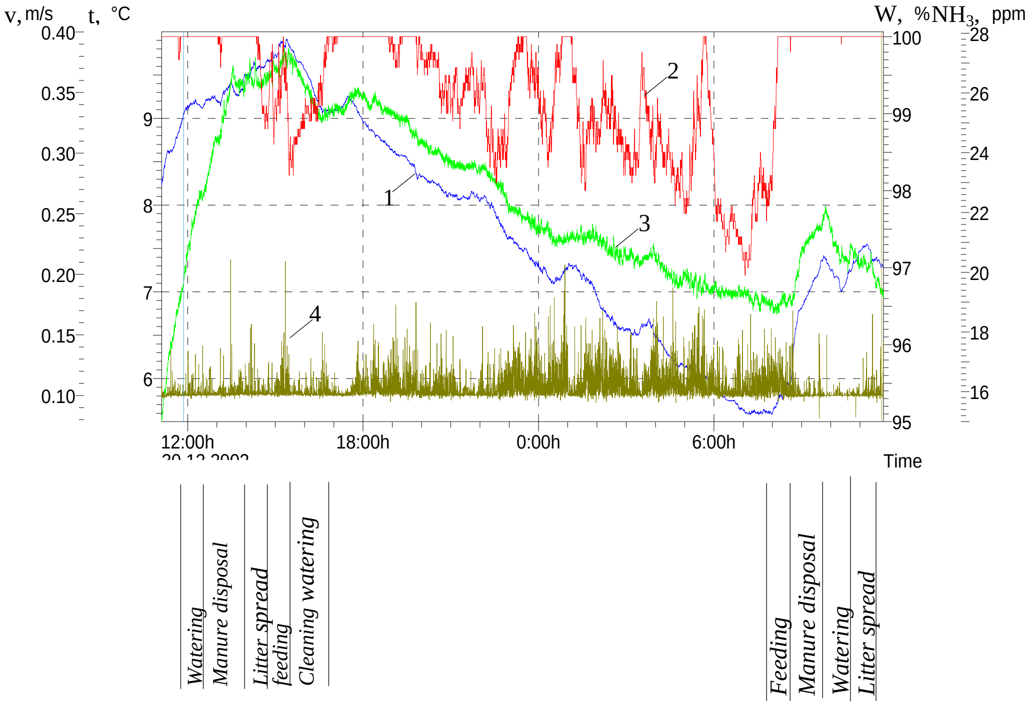

Fig. 1. Inner climate diurnal parametric differences at pigsty No 1:
1 – temperature, 2 – relative humidity, 3 – ammonia, 4 – air velocity.

The air relative humidity at pigsty No 2 was 71.4–84.8%, being quite satisfactory, although the maximum air relative humidity exceeds that set forth as a standard, to a little extent. The air relative humidity increased during feeding as liquid feed was used (Fig. 3).

The average content of carbon dioxide in the pigsties' air was 0.25 and 0.32%. At pigsty No 2, the maximum content of carbon dioxide increased during the evening tending work and morning feeding (Fig. 3) to 0.39%, exceeding the recommended level (CIGR, 1984; Liiske, 2002), but remained within the sertified limits of the Work Environment Act of the Republic of Estonia (http://riigiteataja.ee...73153), pursuant to (0.5%) industrial safety regulations. With the increase in the content of carbon dioxide, the content of oxygen in the air decreased (Fig. 4).

There exist different data about the biggest allowed concentration of ammonia in the air. The maximum allowed rate for the European Union is 20 ppm (CIGR, 1984). The authors (Tuunanen & Karhunen, 1984; Kender et al, 1998) and Estonian standards (http://riigiteataja.ee...73153) specify the average allowed limit concentration in the work area inhaled air to be 25 and 20 ppm, respectively.

The ammonia concentration measured at a pigsty for 220 fatlings has been 6–12 $cm^3\,m^{-3}$ (Karhunen, 1994).

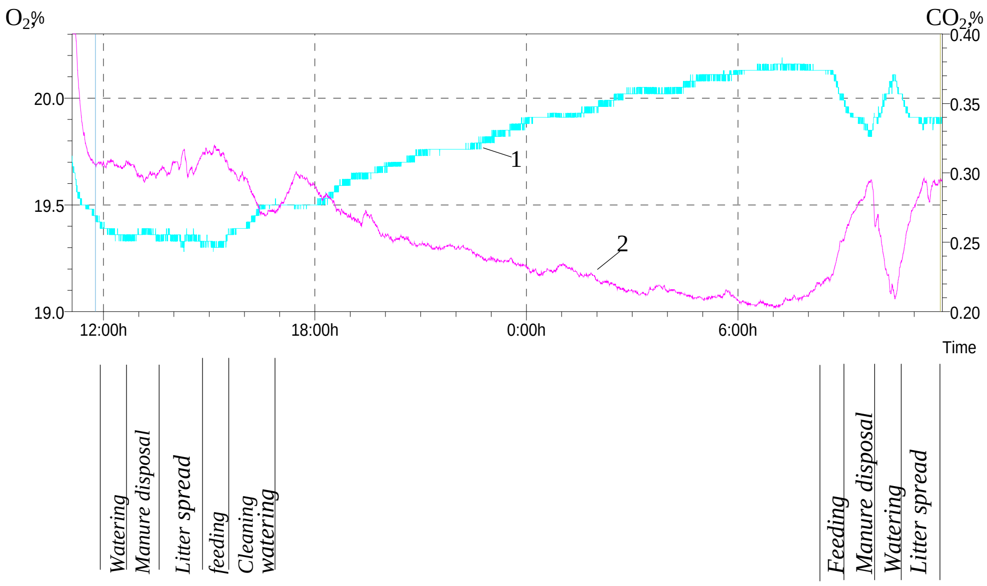

Fig. 2. Differences in inner climate diurnal parameters at pigsty No 1:
1 – oxygen, 2 – carbon dioxide.

Our findings of the average content of ammonia measured at the pigsties ware 22.47 and 10.26 ppm (Tables 2 and 3), remaining within the allowed (20 ppm) limits (http://riigiteataja.ee...73153; CIGR, 1984). But at pigsty No 1, the content of ammonia exceeded, during evening tending work, the standard level, being 27.18 ppm (Fig. 1; Table 2).

The diurnal measurements of the inner climate in winter indicated that the pigsty air temperature is more stable at the pigsty with properly insulated walls and ceilings. The measurements indicated (Table 2) that the air temperature was higher during tending work, while the animals were awake and moved around, and lower during the early hours when the pigs were lying and the outdoor temperature was low as well.

At pigsty No 1, the content of ammonia in the air was between 18.58–27.49 ppm (Table 2) and increased during tending work when the pigs were awake, moved around, trod on manure and carried it round. Being awake, pigs vacate the floor area increasing thus the emission of ammonia into the air. During the morning tending work, the temperature remained between 5.6–7.5°C (Table 2; Fig. 1). During the evening cleaning work, the concentration of ammonia rose once to 27.49 ppm, exceeding the allowed level (20 ppm).

Following the evening cleaning work at pigsty No 1, the content of ammonia in the air decreased (Fig. 1), whereas at night when the animals were resting it fell again until the morning feeding (18.58 ppm).

Table 2. The transformation of the inner climate parameters at pigsty No 1.

Measured parameters	Min	Max	Average $\overline{x}$	Standard deviation σ
		Daily conclusions		
Temperature, °C	5.60	9.90	7.69	1.277
Relative humidity W, %	96.9	100.0	99.3	0.777
Oxygen O_2, %	19.28	20.19	19.78	0.274
Carbon dioxide CO_2, %	0.20	0.32	0.25	0.035
Ammonia NH_3, ppm	18.58	27.49	22.47	2.559
Air speed v, m/s	0.08	0.21	0.11	0.010
Outdoor temperature, °C	-23.5	-13.3	-20.0	0.246
Outdoor relative humidity, %	74.5	59.7	71.5	0.987
		In the evening function*		
Temperature, °C	8.20	9.80	9.23	0.33
Relative humidity W, %	98.6	100.0	99.9	0.31
Oxygen O_2, %	19.28	19.73	19.39	0.07
Carbon dioxide CO_2 %	0.29	0.32	0.31	0.03
Ammonia NH_3, ppm	14.91	27.49	23.44	3.40
Air speed v, m/s	0.10	0.21	0.10	0.01
Outdoor temperature, °C	-16.5	-13.3	-14.2	0.46
Outdoor relative humidity, %	74.5	62.6	67.5	1.56
		In the morning function**		
Temperature, °C	5.60	7.50	6.87	0.64
Relative humidity W, %	97.8	100.0	99.9	0.47
Oxygen O_2, %	19.82	20.16	19.99	0.10
Carbon dioxide CO_2 %	0.21	0.30	0.25	0.03
Ammonia NH_3, ppm	18.58	22.21	20.26	0.93
Air speed v, m/s	0.08	0.17	0.10	0.01
Outdoor temperature, °C	-22.7	-22.4	-22.6	0.78
Outdoor relative humidity, %	74.3	73.7	74.7	0.96

* drinking, manure diposal, litter spreading, feeding, cleaning and drinking (Figs 1–2)
** feeding, manure disposal, drinking, litter spreading (Figs 1–2)

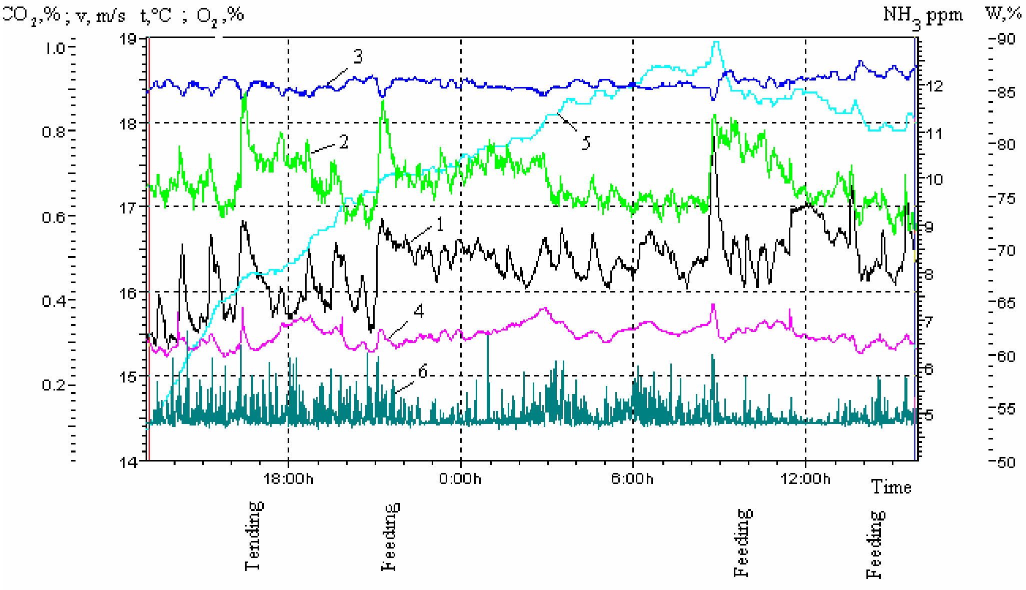

Fig. 3. Inner climate diurnal parametric differences at pigsty No 2:
1 – temperature, 2 – relative humidity, 3 – oxygen, 4 – carbon dioxide, 5 – ammonia, 6 – air speed.

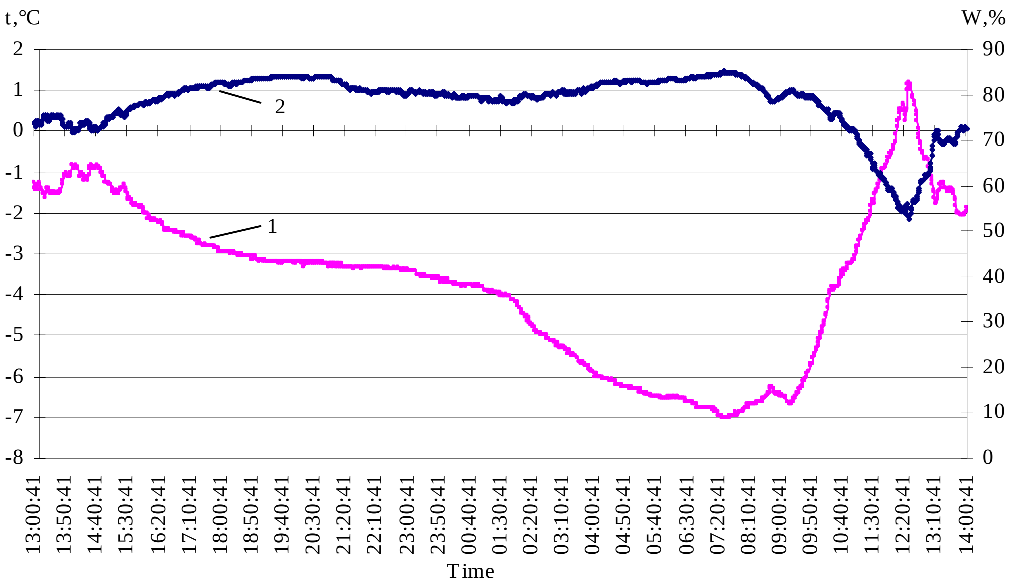

Fig. 4. Diurnal changes of outdoor air temperature (1) and relative humidity (2) measured near pigsty No 2.

Table 3. Indoor and outdoor climate parameter values at pigsty No 2.

Mesured parameters	Min	Max	Average $\overline{x}$	Standard deviation σ
1	2	3	4	5
Daily conclusions				
Temperature, °C	15.31	17.82	16.31	0.32
Relative humidity W, %	71.4	84.8	76.4	2.45
Oxygen O_2, %	18.26	18.72	18.45	0.07
Carbon dioxide CO_2 %	0.26	0.39	0.32	0.02
Ammonia NH_3, ppm	4.68	12.91	10.26	1.32
Air speed v, m/s	0.09	0.33	0.13	0.03
Outdoor temperature, °C	-7.0	1.2	-3.5	1.08
Outdoor relative humidity, %	52.69	85.06	78.02	1.78
Feeding in the evening				
Temperature, °C	15.62	16.81	16.37	0.36
Relative humidity W, %	73.7	84.8	79.11	3.21
Oxygen O_2, %	18.26	18.50	18.40	0.08
Carbon dioxide CO_2 %	0.27	0.38	0.30	0.02
Ammonia NH_3, ppm	7.54	7.99	7.81	0.15
Air speed v, m/s	0.10	0.29	0.13	0.03
Outdoor temperature, °C	-3.4	-3.1	-3.3	1.04
Outdoor relative humidity, %	75.7	81.1	77.0	1.46
Tending work				
Temperature, °C	16.31	17.82	17.82	0.49
Relative humidity W, %	73.4	82.8	82.8	3.22
Oxygen O_2, %	18.26	18.59	18.59	0.09
Carbon dioxide CO_2 %	0.30	0.39	0.39	0.03
Ammonia NH_3, ppm	12.13	12.91	12.91	0.22
Air speed v, m/s	0.10	0.27	0.27	0.04
Outdoor temperature, °C	–2.9	–2.6	–2.8	0.89
Outdoor relative humidity, %	80.2	82.1	81.0	1.89
Recreation in the night				
Temperature, °C	16.03	16.74	16.38	0.16
Relative humidity W, %	72.6	80.3	76.1	1.73
Oxygen O_2, %	18.32	18.54	18.44	0.04
Carbon dioxide CO_2 %	0.29	0.38	0.33	0.02
Ammonia NH_3, ppm	10.08	12.38	11.20	0.78
Air speed v, m/s	0.09	0.32	0.13	0.03
Outdoor temperature, °C	-7.0	-3.1	-5.7	1.06
Outdoor relative humidity, %	78.7	85.1	82.0	0.62

Table 3. (Continuation).

1	2	3	4	5
Feeding 2 in the morning				
Temperature, °C	16.20	17.82	16.83	0.50
Relative humidity W, %	73.7	82.8	80.0	2.07
Oxygen O_2, %	18.26	18.61	18.46	0.12
Carbon dioxide CO_2 %	0.30	0.39	0.33	0.03
Ammonia NH_3, ppm	11.87	12.91	12.47	0.32
Air speed v, m/s	0.10	0.27	0.13	0.04
Outdoor temperature, °C	–6.9	–6.1	–6.6	0.45
Outdoor relative humidity, %	78.7	81.1	79.0	0.26

CONCLUSIONS

The paper studies the diurnal air temperature, relative humidity and velocity and the content of oxygen, carbon dioxide and ammonia above the pigpen by fixing simultaneously temporally the work being carried out inside the rooms. The devices used for the research included Data Logger, corresponding sensors and the computer programme AMR WinControl. While studying the inner climate, the outdoor air temperature and relative humidity were also measured at the pigsties.

It became apparent from the research results that the numerical values of the pigsties' inner climate parameters are affected by feeding of animals and removal of manure. The outdoor climate affects the inner climate more at a pigsty with insufficiently insulated rooms. The average air temperature (7.67 and 16.31°C) was lower at the pigsty whose building was poorly insulated and where the air relative humidity was high (pigsty No 1). At pigsty No 2, the temperature remained within the recommended limits, but the average content of carbon dioxide amounted to 0.32%. In the case of low air temperature (-20°C), the diurnal inner air temperature at pigsty No 1 was low (7.69°C), affecting thus the air relative humidity which amounted to 99.3% on average, exceeding in large amounts that recommended by the standards. In order to improve the inner climate, a mechanical ventilation system with preheating of air should be installed. Although the diurnal content of ammonia in the air of the pigsties was 22.47 and 10.26 ppm, it increased to 27.49 ppm at pigsty No 1 during the evening tending work. At the same time, the concentration of carbon dioxide in the air was high for the animals but warrantable for the work environment.

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