Paulina MIELCAREK, Wojciech RZEŹNIK
Institute of Technology and Life Sciences, Poznan Branch,
Department of Environmental Management in Livestock Buildings and Air Protection
ul. Biskupińska 67, 60-463 Poznań, Poland
e-mail: p.mielcarek@itep.edu.pl

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THE EFFECT OF SEASON ON THE CONCENTRATION OF ODOURS IN DEEP-LITTER PIGGERY

Summary

The aim of the study was to investigate the effect of season on the concentration of odours in mechanically ventilated deep-litter piggery. In studied facility growing-finishing pigs were kept (25-110 kg). The study included five production cycles. In the period from July 2013 to February 2015 46 series of measurements were made. During the study a total of 92 air samples were collected. The sampling point was located inside the piggery, close to the ventilation duct removing air from the building. Air samples were analysed in the olfactometric laboratory within 24 hours from the time of collection. The concentration of odours in the air samples were determined by dynamic olfactometry with the olfactometer TO 8, according to PN-EN 13725:2007. The geometric mean value of odour concentration during all study was 1,085 $ou_E \cdot m^{-3}$, and for studied seasons: spring – 1,048 $ou_E \cdot m^{-3}$, summer - 760 $ou_E \cdot m^{-3}$ and autumn-winter - 1,776 $ou_E \cdot m^{-3}$. The odour concentration was correlated with outside temperature (r=-0.63), which determined microclimate parameters in piggery. Additionally, odour concentration was correlated with inside temperature (r=-0.66) and relative humidity (r=0.65). The statistical analysis showed statistically significant differences in odour concentrations only between summer and autumn-winter period (p≤0.05).

***Key words**: odour concentration, fattening pigs, deep-litter piggery, season*

WPŁYW PORY ROKU NA STĘŻENIE ODORÓW W TUCZARNI NA GŁĘBOKIEJ ŚCIÓŁCE

Streszczenie

Celem pracy było określenie wpływu pory roku na stężenie odorów w tuczarni na głębokiej ściółce z wentylacją mechaniczną. W badanym obiekcie były utrzymywane świnie od 25 do 110 kilogramów. Badania obejmowały pięć cykli produkcyjnych. W okresie od lipca 2013 do lutego 2015 roku wykonano 46 serii pomiarowych. Podczas badań pobrano łącznie 92 próbki powietrza. Punkt poboru próbek był zlokalizowany wewnątrz tuczarni, przy kanale wentylacyjnym usuwającym powietrze z budynku. W ciągu 24 godzin od pobrania, próbki powietrza były analizowane w laboratorium olfaktometrycznym. Stężenie odorów w próbkach powietrza było określane metodą olfaktometrii dynamicznej, przy użyciu olfaktometru TO 8, zgodnie z normą PN-EN 13725:2007. Średnia geometryczna wartość stężenia odorów dla całego okresu badawczego była równa 1085 $ou_E \cdot m^{-3}$, a dla pór roku: wiosna – 1048 $ou_E \cdot m^{-3}$, lato – 760 $ou_E \cdot m^{-3}$, okres jesienno-zimowy – 1776 $ou_E \cdot m^{-3}$. Stężenie odorów było skorelowane z temperaturą zewnętrzną (r=-0,63), która kształtuje parametry mikroklimatyczne w tuczarni. Ponadto stężenie odorów było skorelowane z temperaturą wewnętrzną (r=-0,66) i wilgotnością względną powietrza (r=0.65). Analiza statystyczna wykazała statystycznie istotne różnice w stężeniu odorów jedynie między latem a okresem jesienno-zimowym (p≤0.05).

***Słowa kluczowe:** stężenie odorów, tuczniki, głęboka ściółka, pora roku*

1. Introduction

Agricultural production affects the environment, including emissions of various gaseous pollutants, such as methane, nitrous oxide, and ammonia [13]. The emission of odours, mainly related to livestock production for the last years has become an important problem. Odours are emitted mainly from the excrements (faeces and urine), animals and feed. The odours from animal manure (which are a complex mixture of undigested remnants of food, endogenous secretions, bacterial cells and their metabolic intermediate compounds) are considered as more unpleasant and annoying odours [4, 8]. Odours from livestock production were widely accepted for a long time. The intensification and concentration of livestock production and the migration of urban residents to rural areas have contributed to an increase in the number of complaints against odour nuisance for last years [6, 12]. The odour emissions from agricultural sources depends on many factors: the animal species and age, the activity of animals, the housing and feeding system, the type of nutrition, the microclimatic conditions in livestock buildings, the methods of storage and application of natural fertilizers, as well as weather conditions [3, 5, 9]. The development of effective methods for reducing odour emissions from livestock production requires the detailed knowledge of odour formation and emission processes.

Seasonal variation of odour concentrations and emissions depends on the weather conditions, mainly air temperature. There are some publications about the effect of the season on the concentration and emission of odours from livestock buildings for pigs. But, the studies were conducted in the facilities with non-litter housing systems, and their results are not always conclusive [1, 17, 18]. There are only a few studies on the seasonal changes in the concentration of odours in litter housing systems for pigs, which are still popular in Poland.

The aim of the study was to determine the effect of the season on the concentration of odours in the deep-litter piggery.

2. Material and methods

Studied object

From July 2013 to February 2015 a research on the concentration of odours in commercial deep-litter piggery was carried out. The pigs were fatted in open cycle, from 25 to 110 kg. The studied building had 10-rooms. Measurements were made in one of the rooms, which had two pens (nominal stock-100 pigs) (Fig. 1). The piggery was equipped with a mechanical negative pressure ventilation system. It was controlled by temperature. Characteristics of studied object is presented in Table 1.

Table 1. Characteristics of room in studied piggery
Tab. 1. Charakterystyka komory w badanej tuczarni

Parameter	Unit	Value
Length	m	10.6
Width	m	8.1
Height	m	3.5
Area	$m^2 \cdot pig^{-1}$	0.77
Cubic capacity	$m^3 \cdot pig^{-1}$	3.23
Maximum ventilation rate	$m^3 \cdot h^{-1} \cdot pig^{-1}$	125
Nominal number of pigs	-	100
Initial pig mass	kg	25
Final pig mass	kg	110
Time of fattening period	month	3.5

Source: own work / Źródło: opracowanie własne

Weather and microclimate parameters measurement

The air temperature and relative humidity were monitored outside and inside the piggery for determining the relationship between weather parameters and the concentration of odours. Measurements were made during the air sampling by using the multi-measuring instrument Testo 435-4 with accuracy 0.2ºC and 2%.

Air sampling

The study included 46 series of measurements. A total of 92 air samples were collected. The air was sampled at point located inside the building, close to the ventilation duct removing air. In the morning between 9:00 and 11:00, two samples of air were collected during one series of measurements. Each air sample was collected for 5 minutes to disposable 8 dm^3 Nalophan (PET) bag using sampler CSD30 of ECOMA.

Determination of odours concentration

The analysis of air samples was made in an accredited olfactometric laboratory of the Institute of Technology and Life Sciences in Poznan, in 24 hours after collection. The concentration of odours was determined using dynamic olfactometry and olfactometer TO 8, according to PN-EN 13725:2007 [10]. Each time, the evaluation of odour concentration was carried out by the same team of four experts. This experts panel has been selected based on the designation of individual threshold of odour using n-butanol as indicator. The method yes/no was used for the assessment of the odour concentration. The experts indicate "yes" when the odour was perceptible. Assessment of each air sample had four cycles, and a single cycle was a presentation of a series of decreasing dilutions to all experts.

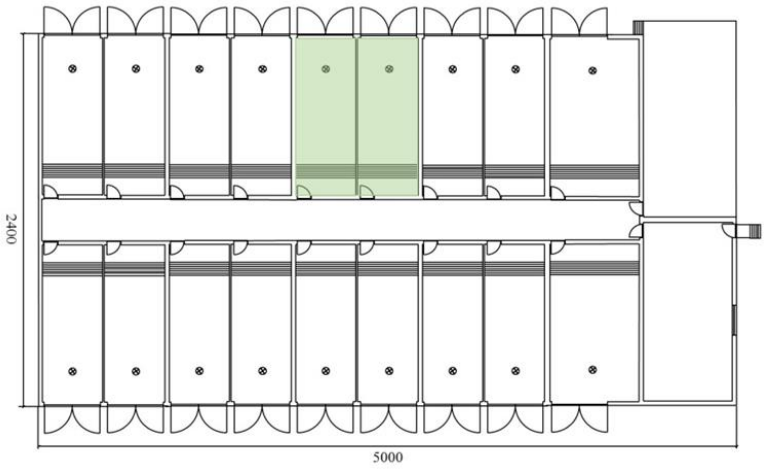
3. Results and discussion

The research on odour concentration was conducted in each season, between July 2013 and February 2015. Because of non-typical temperature during winter, autumn and winter thermal conditions were similar. Therefore, the research time was divided into three periods: spring, summer and autumn-winter. The number, mass of pigs and the momentary ventilation rate are shown in Table 2. The mean value for the whole period of the study is given in parenthesis.

Table 2. The number, mass of pigs and the momentary ventilation rate during measurements
Tab. 2. Liczba i masa świń oraz chwilowa wymiana powietrza

Parameter	Unit	Value
Number of pigs	-	78-108 (100)
Pig mass	kg	34.2-99.3 (64.3)
Momentary ventilation rate	$m^3 \cdot s^{-1} \cdot pig^{-1}$	0.003-0.031 (0.019)

Source: own work / Źródło: opracowanie własne



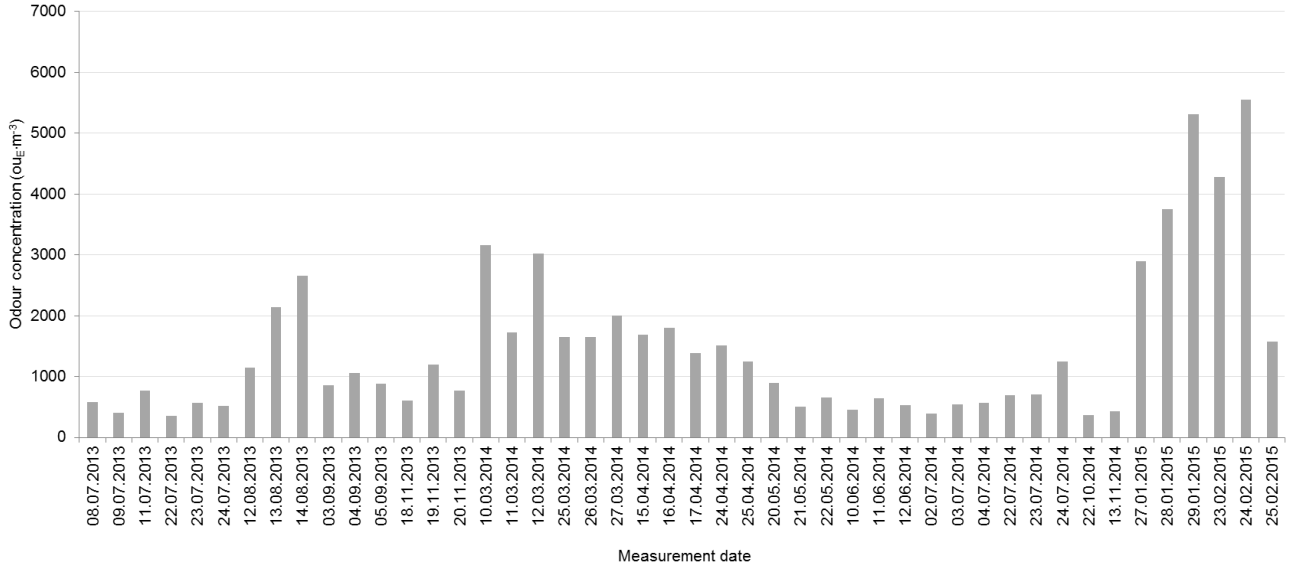
Source: own work / Źródło: opracowanie własne

Fig. 1. The studied deep-litter piggery
Rys. 1. Tuczarnia na głębokiej ściółce

Table 3. Temperature and relative humidity in measuring periods
Tab. 3. Temperatura i wilgotność względna powietrza

Season	Value	Air temperature (ºC)		Air relative humidity (%)	
		outside	inside	outside	inside
Spring	Min	5.9	19.0	40.9	63.5
	Max	23.6	25.9	89.4	95.2
	Mean	15.2	22.5	64.5	78.9
	SD	7.2	2.4	14.9	10.1
Summer	Min	18.0	22.3	27.1	54.7
	Max	28.8	26.6	84.5	93.5
	Mean	22.5	23.9	48.9	67.5
	SD	3.2	1.2	17.1	9.1
Autumn-Winter	Min	2.8	19.6	46.8	74.6
	Max	11.1	21.5	98.2	98.6
	Mean	7.1	20.3	72.1	88.4
	SD	2.4	0.6	17.0	9.3

Source: own work / Źródło: opracowanie własne



Source: own work / Źródło: opracowanie własne

Fig. 2. Odour concentrations in studied piggery
Rys. 2. Stężenie odorów w badanej tuczarni

Table 3 presents the relative humidity and temperature values in measuring periods. Analysis of temperature and relative humidity showed statistically significant differences in values between the seasons ($p \leq 0.05$).

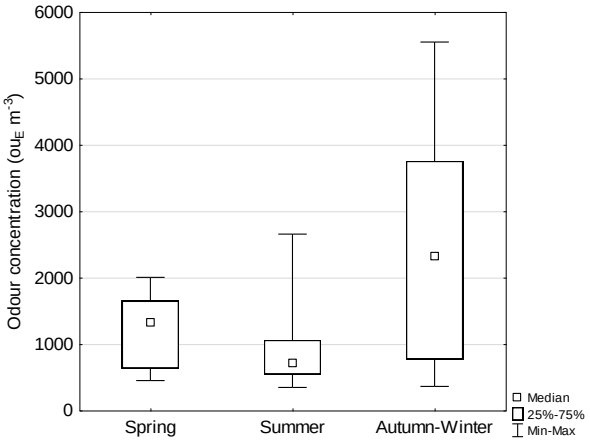
The chronologically ordered values of odour concentration in studied piggery are shown in Figure 2.

The concentration of odours ranged from 347 to 5,547 $ou_E \cdot m^{-3}$ in the studied piggery and the geomethric mean value was equal to 1,085 $ou_E \cdot m^{-3}$. The odour concentration was higher than the values presented in few papers about odour concentration in deep-litter systems for pigs. Low concentration of odours measured. Wang et al. [16] measured low concentration of odours - 67.5 $ou_E \cdot m^{-3}$, but the study was conducted in experimental room. Kołodziejczyk et al. [7] and Rzeźnik et al. [11] made the research of odours in commercial deep-litter piggeries. The odour concentrations were much higher than the value obtained during investigation in laboratory (experimental room) and the mean was 790 $ou_E \cdot m^{-3}$ (724-856 $ou_E \cdot m^{-3}$) and 413 $ou_E \cdot m^{-3}$ (146-1,204 $ou_E \cdot m^{-3}$), respectively. Presented in the literature values are varied, but this is quite normal variation in sensory analyses [14]. Moreover, the differences in odour concentration in litter piggeries may result from many factors: the type and amount of litter, bedding frequency, animal activity, temperature of air and litter, air relative humidity, etc.

Correlation analysis showed that the outside air temperature and relative humidity determined those parameters inside the piggery ($p \leq 0.05$). The coefficient of Spearman correlation between inside and outside temperature was 0.89 and between inside and outside relative humidity was 0.67. It may cause the differences in odour concentration between seasons. Moreover the outside, inside temperature and inside relative humidity were correlated with odour concentration, and the coefficients of correlation were -0.63, -0.66 and 0.65, respectively.

The values of odour concentration were grouped according to the season. Figures 3 shows median, minimum, maximum and the first and third quartile values of odour concentrations.

Higher concentrations of odours were observed in the autumn-winter months and lower in the spring and summer months. Occasionally, also during the summer period one noted concentrations of odours, which might be the result of warm and humid weather at that time. The mean odour concentration was 1,048 $ou_E \cdot m^{-3}$ for spring, 760 $ou_E \cdot m^{-3}$ for summer and 1,776 $ou_E \cdot m^{-3}$ for autumn-winter season.



Source: own work / Źródło: opracowanie własne

Fig. 3. Odour concentrations in studied seasons in the piggery
Rys. 3. Stężenia odorów w badanych porach roku, w tuczarni

The analysis of the impact of seasons on odour concentrations was made based on the non-parametric univariate test of variance. The Kruskal-Wallis tests showed statistically significant differences between mean concentrations of odours for summer and autumn-winter period ($p \leq 0.05$). While, the spring concentration of odours did not differ from values in other periods ($p \leq 0.05$). The results of this study are comparable to those presented in the available literature, which concerned only non-litter systems. Guo et al. [2] carried out the long-term research of odour concentrations for the various technological groups of pigs. They noted the highest odour concentration in winter - mean 4,334 $ou_E \cdot m^{-3}$, and the lowest in summer - mean 1,225 $ou_E \cdot m^{-3}$. Van Langenhove and Defoer [14] measured the differences in odours concentration between seasons in piggery. The values of odour concentrations differed between all studied seasons. Higher concentrations were in spring (1,456-13,361 $ou_E \cdot m^{-3}$) and winter (737-13,109 $ou_E \cdot m^{-3}$), whereas lower in summer (553-10,058 $ou_E \cdot m^{-3}$) and autumn (899 to 9,468 $ou_E \cdot m^{-3}$). In the Netherlands, Verdoes and Ogink [15] studied the influence of seasons on the odour concentration. Measured by them the odour concentrations, for various technological groups of pigs in piggeries, generally were lower in summer than in winter. Akdeniz et al. [1] also observed seasonal differences in odour concentrations in piggeries. They measured the highest odour concentrations in winter, lower in summer and the lowest in autumn.

4. Conclusions

The geometric mean value of odour concentration during all study was 1,085 $ou_E \cdot m^{-3}$, and for studied seasons: spring - 1.048 $ou_E \cdot m^{-3}$, summer - 760 $ou_E \cdot m^{-3}$ and autumn-winter 1,776 $ou_E \cdot m^{-3}$.

The odour concentration was correlated with outside temperature (r = -0,63), inside temperature (r = -0,66) and inside relative humidity (r = 0,65).

The statistical analysis showed statistically significant differences in odour concentration between summer and autumn-winter period ($p \leq 0.05$). The concentration of odours in spring did not differ from values in other seasons ($p \leq 0.05$).

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