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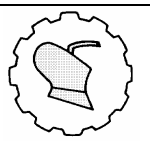

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NITROUS OXIDE AND CARBON DIOXIDE CONCENTRATION IN FARROWING PENS WITH PERMANENT LIMITED RANGE OF MOTION FOR LACTATING SOWS

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Abstract: Nitrous oxide (N_2O) and carbon dioxide (CO_2) are two of the most important gases causing global warming. Production of mentioned gases is pig housing considerable. The aim of the paper was a comparison of the N_2O and CO_2 concentration in the different places in pig barn. Measurements were done in the Experimental Centre for Livestock of Department of Animal Husbandry in FAaFR, SUA in Nitra, Slovakia, where sows of Large White breed with their piglets were housed. There were individual farrowing pens with permanent limited range of motion for lactating sows. Samples of air were collected in each pen both in sow zone and piglets zone. The photo acoustic field gas system consisted of INNOVA devices (photo acoustic field gas-monitor INNOVA 1412 and multipoint sampler INNOVA 1309). There were used for measurement of the gases concentration. Data were analysed by using Kruskal-Wallis Test after normality test by using Kolmogorov-Smirnov test and homogeneity of variance by using Levene's test. Used software was SAS® 9.2. Average values of N_2O and CO_2 concentration ranged from 0.51898 to 0.52106 ppm and from 515.293 to 519.580 ppm, respectively. Data have shown no statistically significant differences between N_2O and CO_2 concentration in the zones of lactating sows and piglets at the 95.0% confidence level. Air circulation between the zones of lactating sows and piglets in the pig barn was on the sufficient level.

Key words*: lactating sow, piglets, farrowing pens, limited motion, nitrous oxide, carbon dioxide*

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INTRODUCTION

Agriculture contributes significantly to total greenhouse gases (GHGes) emissions [1, 2, 15]. Approximately 20 and 35 % of the global greenhouse gas (GHG) emissions originate from agriculture [3]. Livestock is the source of many pollutants such as gases, odors, dust and microorganisms. In the livestock buildings were found 136 gases [4]. Ventilation systems reduce and control dust concentration in pig houses [5, 6].

Agriculture in general, and livestock production in particular, contribute to global warming through emissions of the GHGes: nitrous oxide (N_2O) and carbon dioxide (CO_2). Air pollution is the third largest threat to our planet after biodiversity loss and climate change (most affected by CO_2).

Global atmospheric concentration two of these the most important greenhouse gases have increased significantly within the last 150 years [3] and it affects the atmospheric environment – increased GHG emissions [7].

Nitrous oxide is related to the nitrogen (N) cycle with chemical fertilizers and manures as the most important sources. Nitrous oxide production only takes place under specific conditions since it results from combined aerobic and anaerobic processes nitrification and denitrification, respectively. Normally, conditions in manure are strictly anaerobic and nitrification and denitrification processes will not occur [1]. Most of the N_2O is produced in the field (manure excreted during grazing, animal manure and chemical fertilizers applications to land), and from animal houses where straw or litter is used [8, 9]. Nitrous oxide warming potential is 290 to 310 times higher in the comparison with carbon dioxide warming potential [10]. Carbon dioxide can usually estimate that livestock production is compensated by photosynthesis of plants used as feed [11].

Carbon dioxide emissions differ from one rearing system to another, e.g. weaning and fattening pigs [2, 12-15]. Gases, especially CO_2, production by animals and waste are an essential parameter for ventilation rate estimation using a mass balance method [16]. Methods of manure removal affect the production of harmful gases in the evaluated barns for fattening pigs [17].

The process of releasing GHG into the atmosphere depends on methods of livestock husbandry, nutrition conditions, manipulation with slurry and manure and its storage and land application [18], number and weight of animals, type and time of manure removal, temperature in barn, moisture, pH reaction of litter, C:N ratio, etc. Type and power of the ventilation system significantly affects gas concentration in the pig building [19, 20]. The gaseous emissions from livestock houses are thus dependent on the housing and on the floor systems [14].

The aim of our research was a comparison of the CO_2 and N_2O concentration in the different places in pig barn in the zones of lactating sows and piglets.

MATERIAL AND METHODS

Research place

Measurements were done in the Experimental Centre for Livestock of Department of Animal Husbandry of Faculty of Agrobiology and Food Resources of the Slovak

University of Agriculture in Nitra, Slovakia. Pigs were housed in farrowing pens with permanent limited range of motion of lactating sows (Fig. 1).

Figure 1. Farrowing pens with permanent limited range of motion for lactating sows

Animal characteristics

Sows of Large White breed with their piglets were used in the experiment. Basic characteristics of pigs are shown in the Tab. 1.

Table 1. Basic characteristic of lactating sows and piglets

Sample point	*Sow weight (kg)*	*Piglets age (days)*	*Piglets weight range (kg)*	*Average piglet weight (kg)*	*Order of farrowing*	*Number of piglets (pcs)*
1	*303*	*8*	*1.26 – 2.69*	*1.99*	*5*	*14*
2	*333*	*15*	*2.35 – 7.50*	*6.03*	*4*	*6*
3	*304*	*14*	*3.97 – 5.06*	*4.62*	*3*	*9*

Samples of air were collected in each pen both in sows zone and piglets zone.

Measuring devices

Devices of INNOVA (LumaSense Technolgies, Inc., Denmark) were used for measurement of the gases concentration [21, 22].

Measuring system consist of three main parts:

- INNOVA 1412 – Photoacoustic field gas-monitor. Measurement system is based on the photoacoustic infrared detection method. Gas selectivity is achieved through the use of optical filters. Detection limit is typically in the ppb (part pre bilion) region.
- INNOVA 1309 – multipoint sampler. This devices is a 12 channel multiplexer, enabling gas samples to be drawn from up to 12 different sampling locations and delivered to the gas monitor INNOVA 1412.
- Third main part is computer with software supplied by manufacturer where data were saved.

Statistical analysis

Data were analyzed by using Kruskal-Wallis Test after normality test by using Kolmogorov-Smirnov test and homogeneity of variance by using Levene's test. Used software was SAS ® 9.2 (SAS Institute, Inc.; Cary; North Carolina, USA).

Graphic processing of results was performed using software STATISTICA 7 (Statsoft, Inc.; Tulsa, Oklahoma, USA).

The Kruskal-Wallis test tests the null hypothesis that the medians within each of the six samples are the same. Since the P-Value is greater than or equal to 0.05, there is not a statistically significant difference amongst the medians at the 95.0 % confidence level.

RESULTS AND DISCUSSION

There were monitoring three farrowing pens with permanent limited range of motion in the same barn. Samples of air were collected in each pen both in **L**actating **S**ow **Z**one (**LSZ**, number) and **P**iglets **Z**one (**PZ**, number).

Nitrous oxide

Table 2. Summary statistics of N_2O concentration for all sampling places

Sampling place	*Sample size*	*Average (ppm)*	*Standard deviation*	*Minimum (ppm)*	*Maximum (ppm)*	*Range (ppm)*
LSZ1	*248*	*0.518977*	*0.0432896*	*0.425695*	*0.674368*	*0.248673*
LSZ2	*248*	*0.521060*	*0.0397523*	*0.438490*	*0.661470*	*0.222980*
LSZ3	*248*	*0.520767*	*0.0403427*	*0.424323*	*0.635510*	*0.211186*
PZ1	*248*	*0.520834*	*0.0413241*	*0.422859*	*0.704919*	*0.282061*
PZ2	*248*	*0.520576*	*0.0421729*	*0.423914*	*0.641467*	*0.217553*
PZ3	*248*	*0.519975*	*0.0421712*	*0.428340*	*0.631028*	*0.202688*

Average of N_2O concentration ranged from 0.51898 to 0.52106 ppm (Tab. 2). The P-Value in the Kruskal-Wallis test is greater than 0.05 (P-Value = 0.991333) (Table 3). There is not a statistically significant difference among the medians of N_2O concentration in the three farrowing pens in the zones of lactating and piglets at the 95.0 % confidence level.

Table 3. Kruskal-Wallis test of N_2O concentration for all sampling places

Sampling place	*Sample Size*	*Average Rank*
LSZ1	*248*	*727.024*
LSZ2	*248*	*748.387*
LSZ3	*248*	*749.373*
PZ1	*248*	*750.667*
PZ2	*248*	*746.841*
PZ3	*248*	*744.728*

Test statistic = 0.521028, P-Value = 0.991333

Differences in the range between the minimum and maximum values are relatively high. It could be cause by the outlier values, especially in the first piglet zone and in the first and second lactating sow zones (Fig. 2).

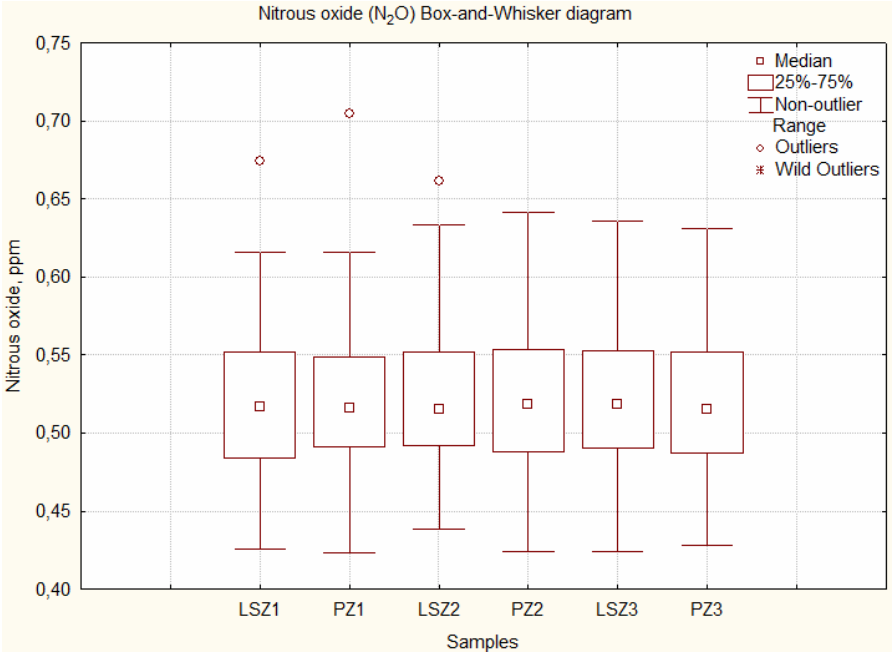

Figure 2. Box-and-Whisker plot of N_2O concentration for all sampling places

Carbon dioxide

Average of CO_2 concentration ranged from 515.293 to 519.580 ppm (Tab. 4). The P-Value in the Kruskal-Wallis test is greater than 0.05 (P-Value = 0.989537) (Tab. 5). There is not a statistically significant difference among the medians of CO_2 concentration in the three farrowing pens in the zones of lactating sows and piglets at the 95.0 % confidence level.

Table 4. Summary statistics of CO_2 concentration for all sampling places

Sampling place	*Sample Size*	*Average (ppm)*	*Standard deviation*	*Minimum (ppm)*	*Maximum (ppm)*	*Range (ppm)*
LSZ1	*248*	*515.293*	*75.6973*	*329.270*	*662.563*	*333.293*
LSZ2	*248*	*517.817*	*74.1871*	*338.775*	*659.284*	*320.509*
LSZ3	*248*	*518.303*	*75.9395*	*331.052*	*659.448*	*328.396*
PZ1	*248*	*515.397*	*75.2527*	*337.468*	*642.123*	*304.654*
PZ2	*248*	*517.553*	*74.5180*	*322.925*	*667.537*	*344.611*
PZ3	*248*	*519.580*	*75.4791*	*334.014*	*663.164*	*329.150*

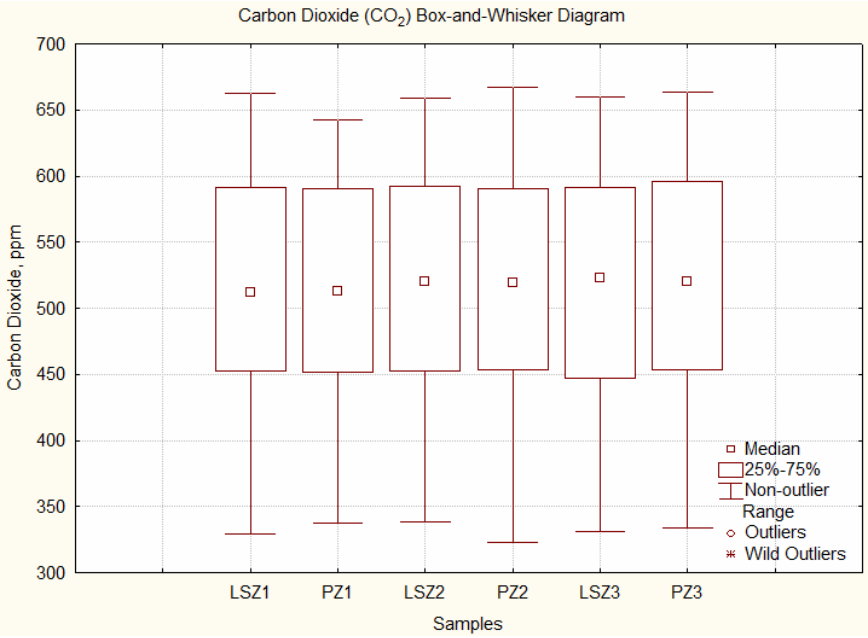

Figure 3. Box-and-Whisker plot of CO_2 concentration for all sampling places

Lowest and highest ranges of values were measured in the first and second piglets zones, respectively. It could be cause by the activity of piglets, because it was in the pens where piglets had a different age and weight (Tab. 1).

Table 5. Kruskal-Wallis test of CO_2 concentration for all sampling places

Sampling place	*Sample Size*	*Average Rank*
LSZ1	*248*	*734.060*
LSZ2	*248*	*747.117*
LSZ3	*248*	*748.679*
PZ1	*248*	*734.093*
PZ2	*248*	*745.179*
PZ3	*248*	*757.871*

Test statistic = 0.565285, P-Value = 0.989537

CONCLUSIONS

The aim of our evaluation was a comparison of the nitrous oxide and carbon dioxide concentrations in the zones of lactating sows and piglets in the farrowing pens. Pigs were housed in farrowing pens with permanent limited range of motion. Sows of Large White breed with their piglets were used in the experiment. Three farrowing pens in the same barn were monitored. Air samples were collected in each pen both in lactating sows zone and piglets zone. Average values of greenhouse gases ranged from 0.51898 to 0.52106 ppm and from 515.293 to 519.580 ppm for nitrous oxide and carbon dioxide, respectively. There was used Kruskal-Wallis test. The P-Values in the Kruskal-Wallis test for nitrous oxide and carbon dioxide were 0.991333 and 0.989537, respectively. P-Value for each gas were greater than 0.05. There is not a statistically significant difference among the medians of N_2O and CO_2 concentration in the three farrowing pens with permanent limited range of motion in the zones of lactating sows and piglets at the 95.0 % confidence level. Differences in the range between the values of N_2O gas were relatively high. It could be caused by the outlier values, especially in the first piglets zone and in the first and second lactating sows zones. Lowest and highest ranges between the values of CO_2 gas were measured in the first and second piglets zones. It could be caused by the activity of piglets, because piglets had a different age and weight. Based on our results, air circulation between the zones of lactating sows and piglets in the pig barn was on the sufficient level.

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KONCENTRACIJA N_2O I CO_2 U BOKSOVIMA ZA PRAŠENJE SA STALNO OGRANIČENIM PROSTOROM ZA KRETANJE KRMAČA U LAKTACIJI

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Sažetak: N_2O i CO_2 su dva najvažnija gasa koji izazivaju globalno zagrevanje. Produkcija pomenutih gasova u objektima za svinje je značajna. Cilj ovog rada bilo je poređenje koncentracija N_2O i CO_2 na različitim mestima u objektu za svinje. Merenja su izvršena u eksperimentalnom Centru za stočarstvo Departmana za stočarstvo na FAaFR, SUA kod Nitre u Slovačkoj, gde se drže krmače rase Large white sa prasadima. Objekti za prašenje su opremljeni pojedinačnim boksovima za prašenje sa stalno ograničenim prostorom za kretanje krmača u laktaciji. Uzorci vazduha su uzimani u svakom boksu i u obe zone: zoni krmača i zoni prasadi. Foto akustični system se sastoji od uređaja INNOVA (foto akustični monitor gasova INNOVA 1412 i višekanalni sempler INNOVA 1309). U ovom slučaju uređaj je upotrebljen za merenje koncentracije gasova. Podaci su analizirani upotrebom Kruskal-Wallis testa, posle testa normaliteta upotrebom Kolmogorov-Smirnov testa i homogenosti varijanse upotrebom Levene testa. Korišćen je programski paket SAS® 9.2. Srednje vrednosti koncentracija N_2O i CO_2 nalazile su se u intervalima od 0.51898 do 0.52106 ppm i od 515.293 do 519.580 ppm, redom. Rezultati su pokazali da nema statistički značajnih razlika među koncentracijama N_2O i CO_2 u zonama krmača i zonama prasadi, pri nivou poverenja od 95.0%. Strujanje vazduha između zona krmača i prasadi u objektu bilo je zadovoljavajuće.

Ključne reči*: krmača u laktaciji, prasad, boksovi za prašenje, ograničeno kretanje, N_2O, CO_2*

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