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REDUCTION OF THE GREENHOUSE GAS EMISSIONS FROM THE PIG MANURE USING INORGANIC SUBSTANCES

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Abstract

Pig farming is one of the most productive and early maturing branches of animal husbandry, which plays an important role in the meat balance of the state. Simultaneously with the production of the main products a significant amount of by-products of animal origin accumulates. A large number of pollutants of various origins are released into the atmosphere during the decomposition, including greenhouse gases, which causes pollution of the soil, surface and underground waters. Therefore, the basis of the planned research was to find out the emission of the greenhouse gases from the pig manure under the influence of different doses of inorganic substances (natural sorbents). According to the results of the conducted research, it was established that the level of release of the studied gases – methane (CH_4), carbon dioxide (CO_2) and nitrogen oxide (NO) from the pig manure (in vitro) when using different doses of natural sorbents – vermiculite and saponite with a simultaneous shift of the pH to the acidic side respectively, was 5.31 and 5.67, against 6.2–6.5 in the control. In a comparative assessment of the effect of the investigated sorbents on the emission of greenhouse gases from the pig manure, it should be noted that the level of release of CH_4 from the substrate in the variants with vermiculite decreases to 18.6%, CO_2 to 37.5%, and NO to 25.7%, and with saponite, respectively up to 7.2%, 20.2 and 22.3%. Therefore, the obtained data indicates the expediency of the usage of the studied sorbents, in particular vermiculite, to reduce the emission of greenhouse gases during the storage of the manure in the storage facilities (lagoons) and directly in the premises, which will make it possible to minimize the negative impact of intensive pig farming on the state of the environment.

Key words: *carbon dioxide, methane, natural sorbents, nitrogen oxide, pig manure.*

INTRODUCTION

Animal husbandry is an important branch in the formation of food security and independence of the state, as its share in the food structure is more than 45% (Myhalko, 2021; Lykhach et al., 2021). In the structure of the production of livestock products, the leading role belongs to the pig industry, which provides food products in a relatively short period of time, which have a stable and wide demand on the consumer market (Lozynska, 2014). In the structure of meat production, pig farming is the second largest after poultry farming (Nykyforuk & Zhukorskyi, 2014). The share of pork in total meat consumption is more than 20%. Today, the consumption of this product in our country is lower than the recommended norms. In particular, the state provides the needs of the domestic market in meat consumption – at the level of 52 kg per person per year, which is 28 kg less than the rational norm which is 35%. In the structure of the world meat balance, the first place is taken by pork (about 37.6%), the second place is poultry meat (35%), the third one is beef (22.8%) (Myhalko, 2021). However, the increase in food supply, both for the population of our country and for export demand, is accompanied by the accumulation of a much larger amount of by-products of animal origin, especially of waste. Thus, during the production of 1 kg of pork (for the growth of 600 g per day), 11 kg of waste is obtained, which is a source of gases entering the environment – methane, carbon dioxide, nitrous and nitrogen oxide (Monteny et al.,

2001; Nykyforuk & Zhukorskyi, 2014; Marszałek et al., 2018).

According to the Food and Agriculture Organization of the United Nations (FAO), in the agriculture, forestry and fisheries sector, greenhouse gas emissions have doubled over the past 50 years, and their further increase is predicted until 2050 by 30% (Tubiello et al., 2014). According to the evaluations of foreign scientists, animal husbandry causes emissions – 44% of anthropogenic methane, 53% of nitrous oxide and 5% of anthropogenic carbon dioxide, which provokes acidification and eutrophication of ecosystems and contributes to global warming process (Gerber et al., 2013). An analysis of a number of literary sources shows that methane has a 21-34 times higher global warming potential than carbon dioxide and is able to accumulate in the atmosphere for up to 12 years (Herrero et al., 2013, Marszałek et al., 2018, Caro, 2019). The climate potential of such a greenhouse gas as nitrous oxide is 265-310 times higher than CO_2 (Dennehy et al., 2017; Marszałek et al., 2018; Caro, 2019). The latter also causes the destruction of the stratospheric ozone layer, which protects living or-anisms from the sun's ultraviolet radiation. The accumulation of greenhouse gases in the atmosphere contributes to the increase in the average annual temperature, the appearance of acid rain, droughts, floods, the formation of atmospheric aerosol and the reduction of drinking water supplies, etc. (Monteny et al., 2001; Khodorchuk et al., 2014; Caro, 2019).

In the structure of animal husbandry pig farming ranks second in the level of greenhouse gas emissions (methane and nitrous oxide), after cattle breeding, and first in terms of their excretion from the manure (Nykyforuk & Zhukorskyi, 2014). Thus, according to the data of V.V. Herman (2009), methane emissions from intestinal fermentation of pigs with the amount of 1.5 kg/head/year and from the manure decomposition – 3.19 kg/head/year (Herman, 2009). According to the National Cadastre of anthropogenic emissions of greenhouse gases the second place in terms of the volume of their formation in Ukraine belongs to animal excrements and pig farming accounts for 46% of all branches of animal husbandry. Thus, the priority tasks in pig farming are not only the need to ensure the growing demand for pork, but also to significantly reduce the impact of the production of this product on the environment.

A large number of studies, both of domestic and foreign scientists, are devoted to the prevention of environmental pollution as a result of the activities of agricultural enterprises. However, in literary sources, organic materials or acids are mainly used to reduce gas emissions from waste, he last ones which are dangerous and harmful to use (Cicek et al., 2004; Shah & Kolar, 2012; Petersen et al., 2014; Misselbrook et al., 2016; Maurer et al., 2017; Dalby et al., 2022). Also, in the studies of many scientists the attention is focused on the adsorption of moisture from organic waste and reducing the level of ammonia or hydrogen sulfide release (Alvarado et al., 2015; Broshchak et al., 2018). At the same time, the problem of the negative impact on the environment of emissions from by-products of animal origin of the set of the greenhouse gases – CH_4, CO_2, NO – remains relevant and poorly studied. Thus, the search for the effective ways and means to reduce the level of environmental pollution with greenhouse gases from the waste products (manure) of pigs has both scientific and practical importance, which will thereby increase the efficiency of pig farming.

The aim of the study was to find out the effectiveness of different doses of natural sorbents – vermiculite and saponite on the emission of greenhouse gases (CH_4, CO_2, NO) from the pig manure (*in vitro)*.

MATERIALS AND METHODS

The research on establishing the influence of different doses of natural sorbents on the level of greenhouse gas emissions from pig manure was carried out using laboratory, statistical and analytical methods. To carry out the experiment, samples of pig manure were taken from the State Enterprise "Experimental farm Radekhivske" Institute of agriculture of the Carpathian Region of the National Academy of Agrarian Sciences of Ukraine.

The study was conducted *in vitro* (Skliar et al., 2019). Hermetically sealed containers were used in the experiment, ensuring anaerobic conditions. For the stability of the biofermentation

process, the humidity of the substrate was 92%. During the experiment, the temperature was within the psychrophilic regime.

To reduce the emission of greenhouse gases after passing through the stages of hydrolysis, oxidation, acetogenesis, natural sorbents were added to the fermented pig manure for 11 days in different doses, presented in the following options: Option I – control (without adding substances); II – vermiculite, 2.5%; III – vermiculite, 5%; VI – vermiculite, 10%; V – saponite, 2.5%; VI – saponite, 5%; Option VII – saponite, 10%. Each variant of the experiment was repeated three times.

In the control and experimental variants, the level of emissions of gases – CH_4, CO_2 and NO was measured one day after the introduction of the substances, and thereafter every three days until the end of the research. Determination of the amount of greenhouse gas emissions during anaerobic fermentation of pig manure *(in vitro)* was carried out with the Dozor S-M-5 gas detector-analyzer (certificate of verification of legally regulated measuring equipment No. 84709/92 and certificate of conformity No. UA.TR.002. CB.1234-19). In the experiment, acidity (pH) was determined at the beginning and at the end of the experiment with a Tur N5170 pH meter. During the research, mixing of the fermented mass was carried out by shaking the containers. The conditions of the biofermentation process were similar in all variants, both in the control one, where anaerobic fermentation of the substrate took place due to the natural microflora of manure, and in the experimental analogues with the introduction of the investigated natural sorbents in different doses.

Statistical analysis of research results was carried out using the methods of variational statistics with the help of *Microsoft* Excel and *AtteStat* programs using the Student's t-test. A simple avarage (M) and its errors (±m) were calculated. Differences between simple averages were considered probable according to: * $P<0.05$; ** $P<0.01$; *** $P<0.001$.

RESULTS AND DISCUSSIONS

During the research, it was established that the introduction of natural sorbents into the pig manure contributed to the inhibition of fermentation processes and is confirmed by the shift of the pH indicator (Figure 1) to the acidic side. In particular, in the versions with natural sorbents – vermiculite and saponite, a lower pH level of 5.31 and 5.67 respectively, was observed, which indicates the inhibition of the vital activity of microorganisms due to a higher concentration of H+ ions. In the control (without introduction of the substances), the pH of the studied substrate *(in vitro)* throughout the experiment, both at the beginning and after its completion, was in the range of 6.2-6.5.

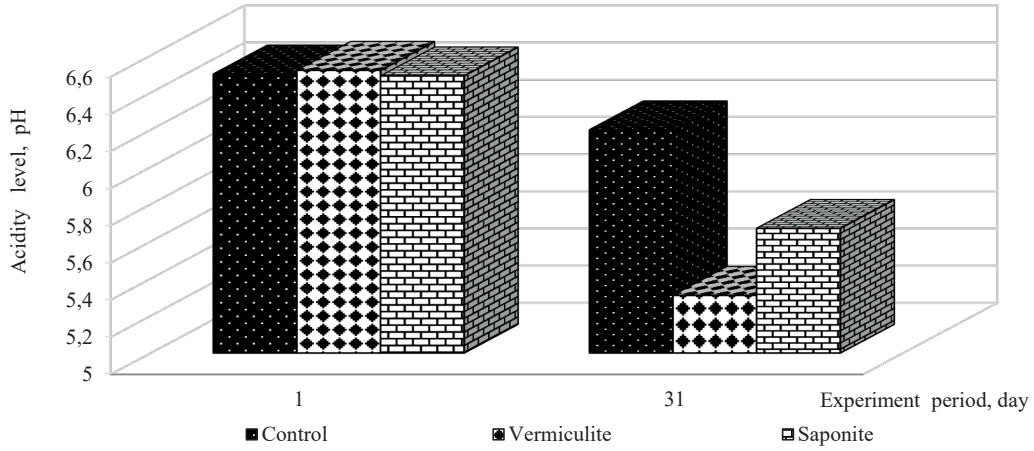

Figure 1. Level of acidity pig manure using natural sorbents

On the basis of the obtained experimental data, it was established that the studied natural sorbents, at the same time as the pH of pig manure decreases, cause a decrease in the emission of greenhouse gases – CH_4, CO_2, and NO.

The analysis of research results shows that the most effective effect on reducing the level of greenhouse gas emissions from pig manure *(in vitro)* when using natural sorbents – vermiculite, saponite – is observed on the fourth day. At the same time, the prolongation of the positive effect on the reduction of the emission of the investigated gases from the fermented substrate with the introduction of sorbents gradually decreased up to 31st day of the research.

The obtained experimental data indicates that the process of emission of greenhouse gases from the pig manure depends on the duration of its storage.

In the course of the experiment, it was established that the addition of the natural sorbent vermiculite in doses of 2.5%; 5 and 10% contributes to a lower level of CH_4 release (Figure 2) from pig manure *(in vitro)*, compared to the control, namely: first day – by 11.8% ($P<0.05$); 15.1 ($P<0.001$) and 14.6% ($P<0.01$), with an increase in the effectiveness of exposure on the 4th day, respectively – 14.8% ($P<0.01$); 18.6 ($P<0.001$) and 16.3% ($P<0.01$), and on the last day of the experiment – by 2.4-5.5% ($P<0.05$). The introduction of saponite in the above-mentioned quantities into the fermented researched substrate leads to a decrease in methane emissions, depending on the day of the experiment, respectively, by 2.5%; 6.5 ($P<0.01$) and 5.3% – on the first day, by 2.8%; 7.2 ($P<0.01$) and 5.8% ($P<0.05$) – on the fourth day, by 0.3-0.4% – on the 31st day of research, in relation to the control analogue.

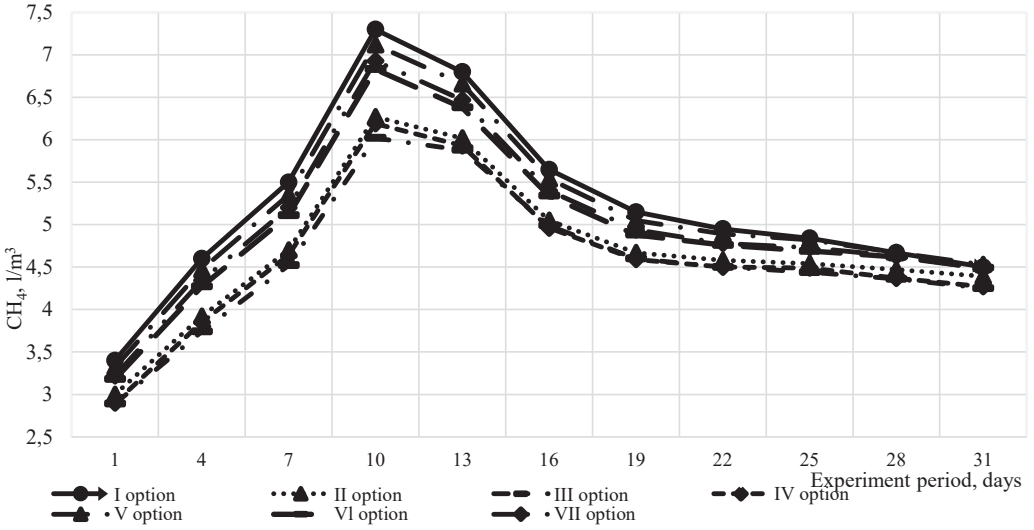

Figure 2. The level of CH_4, emission in variants with the use of different doses of natural sorbents – vermiculite and saponite

The use of different doses of the studied natural sorbents – vermiculite and saponite – also has a positive effect on reducing the level of carbon dioxide release (Figure 3) from pig manure. In the variants with the addition of vermiculite, there is a decrease in CO_2 emission from the investigated substrate in the process of anaerobic fermentation *(in vitro)*, depending on the quantities – 2.5%; 5 and 10%, respectively, 1st day – by 25.4%; 33.2 and 29.5%, 4th day – by 29.7% ($P<0.01$); 37.5 ($P<0.01$) and 32.5% ($P<0.01$), and on the last day of the experiment – by 7.5%; 8.9 and 6.5%, compared to the control. The obtained research results show that adding saponite to pig manure in similar doses contributes to lower release of carbon dioxide, compared to the control, by 4.5%; 16.6 and 10.2% – 1st day, by 6.7%; 20.2 ($P<0.05$) and 12.7% – 4th day, by 0.8-5.3% – 31st day, respectively.

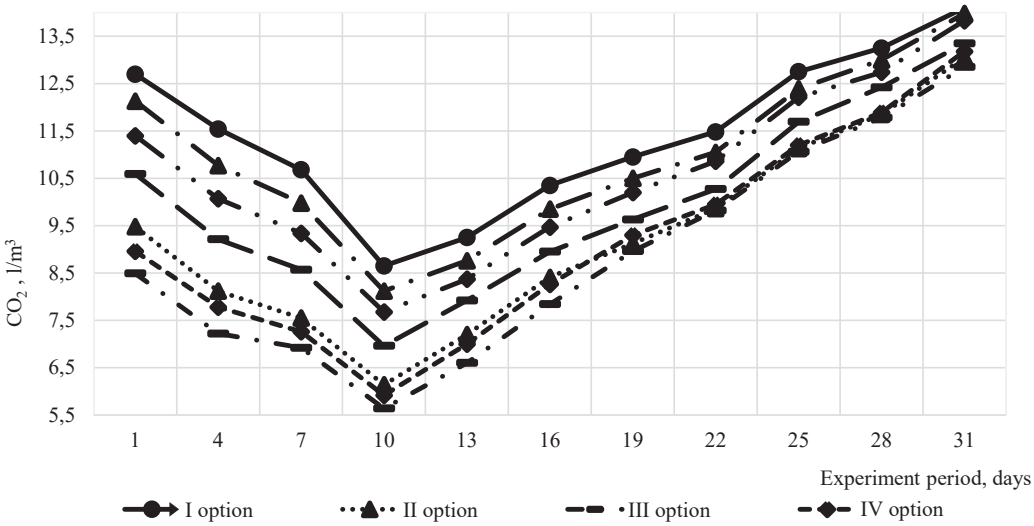

Figure 3. The level of CO_2 emission in variants with the use of different doses of natural sorbents – vermiculite and saponite

The emission level of nitrogen oxide from pig manure *(in vitro)* using the natural sorbent vermiculite in doses is 2.5%; 5 and 10% decreases, depending on the day of the experiment, by 14.3% (P<0.05); 20.2 (P<0.05) and 18.1% (P<0.05) – 1st day, by 18.8% (P<0.05); 25.7 (P<0.01) and 21.3% (P<0.05) – 4th day and 5.9-7.1% – the last day of the experiment, compared to control. The use of saponite in similar quantities leads to a decrease in the release of NO from the fermented researched substrate, respectively: by 6.1%; 17.7 (P<0.05) and 7.6% – 1st day, by 13.2% (P<0.05); 22.3 (P<0.01) and 8.6% – 4th day, by 1.5-6.1% – 31st day of the experiment.

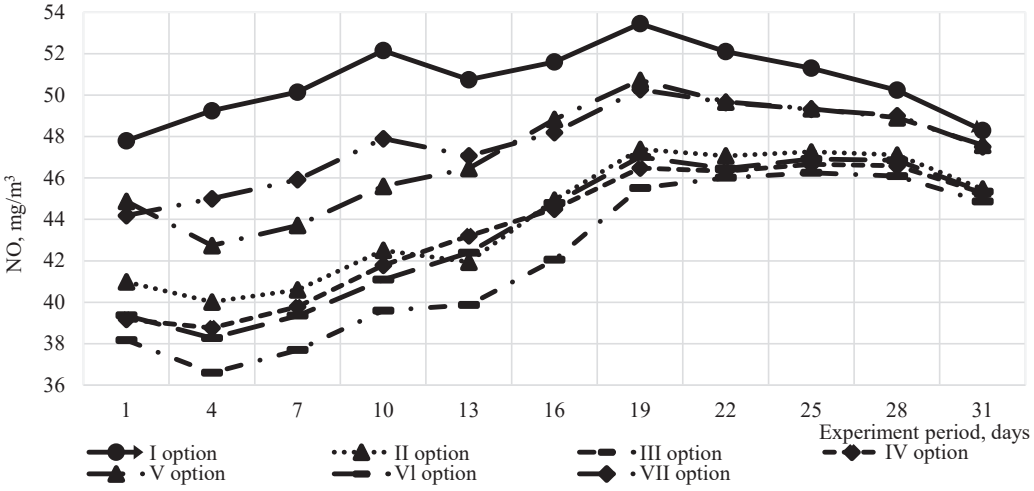

Figure 4. The level of NO emission in variants with the use of different doses of natural sorbents – vermiculite and saponite

Therefore, based on the analysis of the obtained research results, it should be noted the positive effect of different doses of the investigated natural sorbents – vermiculite and saponite during anaerobic fermentation of the pig manure *(in vitro)* on the reduction of the

greenhouse gas emissions – CH_4, CO_2 and NO. It was experimentally established that the most effective impact on the reducing of the level of greenhouse gas emissions from the studied substrate was observed both when using vermiculite and saponite in the amount of 5%, while increasing the dose of natural sorbents did not show a better result.

Summarizing the data obtained in the course of the research, it should be noted that the best results for reducing the emission of investigated greenhouse gases from pig manure *(in vitro)* from natural sorbents (vermiculite, saponite) were obtained in variants with vermiculite (by 18.6-37.5%) in the optimal amount (5%), while saponite in a similar dose causes a lower level of gases compared to the control – by 7.2-22.3%. Thus, vermiculite has a more effective impact on reducing the emission of the gases – CH_4, CO_2 and NO from the investigated substrate – by 3.4-17.3%, compared to perlite.

Therefore, the results of the research indicate the prospects of using the studied natural sorbents to reduce the level of greenhouse gas emissions, both in the premises where pigs are kept, and in the manure storage facilities (lagoons) when storing by-products of animal origin.

CONCLUSIONS

The positive effect on the reduction of the emission of greenhouse gases – CH_4, CO_2 and NO from pig manure during anaerobic fermentation *(in vitro)* has been experimentally confirmed of the investigated natural sorbents in the various doses. It is experimentally proven that the use of vermiculite and saponite is most effective in a dose of 5% and causes a lower level of gas release – CH_4, CO_2 and NO from the waste products (manure) of pigs by 18.6-37.5% and 7.2-37.5%, respectively.

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