Scientific Papers. Series D. Animal Science. Vol. LXVII, No. 1, 2024
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

THE EFFECTIVENESS OF THE INFLUENCE ON THE EMISSION OF HARMFUL GASES FROM PIG MANURE DURING STORAGE IN LAGOONS THE ADDITION OF MINERAL FERTILIZERS

Mariia VOROBEL[1], Oleh KLYM[1], Vasyl KAPLINSKYI[2], Myron PETRYSHYN[1], Taras PRUDYUS[2], Oksana SMOLIANINOVA[2], Olha STEFANYSHYN[2], Mariia TSAP[2], Andrii PYLYPETS[2], Ivan LUCHKA[2]

[1]Institute of Agriculture of the Carpathian Region NAAS, 5 Mykhaila Hrushevskoho Str., v. Obroshyne, Lviv Region, Ukraine
[2]Institute of Animal Biology NAAS, 38 Vasylya Stusa Str., Lviv, Ukraine

Corresponding author email: vorobelmariia@gmail.com

Abstract

In the structure of the animal husbandry production, a prominent place belongs to the pig industry thanks to the valuable products and quick payback. However, when providing the population with food, a large amount of waste accumulates, which is not only a valuable organic fertilizer, but also a producer of environmental pollution, since gaseous air pollutants are emitted into the atmosphere during their decomposition. As a result of the conducted research, the effectiveness of the investigated mineral fertilizers – phosphorite flour and slaked lime in reducing the level of ammonia (NH_3), carbon dioxide (CO_2), methane (CH_4), nitrogen oxide (NO) and hydrogen sulfide (H_2S) emissions from pig manure at storing it in lagoons was established. In particular, it was established that the addition of phosphorite flour and slaked lime to the pig manure in lagoons contributes to lower emissions of gases (NH_3, CO_2, CH_4, NO, H_2S), respectively by 18.4-33.6% and 8.8-30.8%. At the same time as the emission of the studied gases decreases, mineral fertilizers provide a lower level of the pH, i.e. it shifts to the acidic side. Thus, the establishment of the effectiveness of the investigated mineral fertilizers on the reduction of emissions of harmful gases from pig manure during its storage in lagoons indicate the perspective of their use to prevent environmental pollution in the pig industry.

Key words: *harmful gases, mineral fertilizers, pig farming, pollution, waste.*

INTRODUCTION

Animal husbandry is a strategic branch of the national economy, as it provides not only the domestic market of our country with food, but is also a significant reserve for the country's export potential. It also provides the crop industry, in particular agriculture, with organic fertilizers, that is, manure (Demchuk et al., 2010; Palapa et al., 2016; Zakharchenko, 2017). The largest amount of manure is produced in cattle breeding – 44%, pig farming – 39%, poultry farming is responsible for the accumulation of 17% of waste (Pinchuk & Borodai, 2019). In particular, 4 kg of excrements is produced for each liter of milk (with a productivity of 5 thousand liters per year), 11 kg for 1 kg of pork (for live weight gains of 600 g per day), 30 kg for 1 kg of beef (for gains of 1 kg per day), and 4.6 kg of waste is generated for 1 kg of poultry meat. And this is without taking into account water and litter that enters the manure (Buzovskyi et al., 2008).

Agricultural production is closely related to environmental conditions, the availability and possibility of exploitation of natural resources – land, water, forests, plants and animals (Smith et al., 2008; Demchuk et al., 2010; Mykhailova, 2016). Agricultural enterprises are powerful polluters of air, water sources and soil, which leads to a decrease in their profitability and competitiveness. Only one pig farm of 100,000 pigs pollutes the natural environment as much as a large industrial center with a population of 400-500,000 people (Maksishko & Malik, 2012; Zakharchenko, 2017). The specific smell from a piggery complex with 108,000 pigs spreads to a distance of up to 5 km (Dubin & Vasylenko, 2014). In modern conditions, environmental protection is one of the most important issues. Effective management of the livestock industry is impossible without a purposeful, scientifically based approach in this area (Smith et al., 2008; Tubiello et al., 2014; Caro, 2019). Therefore, the priorities in the livestock industry are not only to meet food needs, but also the minimization of the negative impact of by-products on the environment, ensuring the welfare of animals and at the same time increasing the profitability of the industry.

In agriculture currently the second place in the production of livestock products, after poultry, is occupied by the pig industry (Nykyforuk & Zhukorskyi, 2014). The anthropogenic impact of the functioning of agricultural enterprises on the atmosphere occurs as a result of the entry into it of the decomposition products of organic waste – harmful gases that cause the deterioration of the ecological situation and, therefore, climate change (Khodorchuk et al., 2014; Pinchuk & Borodai, 2019; Caro, 2019). The fight against climate change is a global challenge, the ways to solve this issue are reflected in a number of successively concluded international agreements: the United Nations Framework Convention on Climate Change (1992), the Kyoto Protocol (1997) and the Paris Agreement (2016). (Kholod, 2009; Udova et al., 2014; Pinchuk, 2015). Taking into account that with the help of the tools provided by the first two agreements, it was not possible to achieve a significant reduction of greenhouse gas emissions, the Paris Agreement was concluded. The latter is aimed at reducing greenhouse gas emissions to a level that by 2030 will not exceed 60% of the 1990 level and limiting the increase in air temperature to 1.5ºC from the pre-industrial level (Mykhaylova, 2016; Tymoshchuk et al., 2022).

According to estimates by the World Food and Agriculture Organization, the livestock sector is responsible for 18% of all greenhouse gas emissions, which is more than emissions from transport (14%) (Tubiello et al., 2014; Palapa et al., 2016; Korbych, 2021). The livestock sector accounts for the formation of about 9% of global carbon dioxide emissions (the duration of its retention in the atmosphere is 50-200 years), 37% of anthropogenic methane (the global warming potential is 21-34 times higher than CO_2), 64% of ammonium emissions and 65% – nitrous oxide (potential of influence is 265-310 times higher than CO_2) (Gerber et al., 2013; Binkovska and Shanina, 2016). An indirect source of potential greenhouse gas – N_2O is ammonia, which causes eutrophication of water bodies, leads to acid rain, soil acidification and is associated with the formation of aerosols (Blunden & Aneja, 2008; Korbych, 2021). Among the by-products of manure decomposition, the most toxic gas with an unpleasant smell is considered to be hydrogen sulfide, which is one of the factors in the occurrence of acid rain and, therefore, climate change (Blunden & Aneja, 2008). It is predicted that emissions of the main greenhouse gases will increase by 25-90% by 2030 relative to the indicators of 2000, if a number of measures to improve the situation are not adopted (Smith et al., 2008; Udova et al., 2014).

According to the National Register of Anthropogenic Emissions of Greenhouse Gases in Ukraine, the second place belongs to animal excrement, and pig farming occupies 46%. Methane emissions from the decomposition of pig manure are known to be higher (3.19 kg/head/year) compared to emissions from intestinal fermentation (1.5 kg/head/year) (Herman, 2009).

In the sources of scientific and and patent literature there are known methods of reducing emissions into the atmosphere of some particular gases from pig farming waste, mainly ammonia, hydrogen sulfide, somewhat less methane, with the use of peat (Portejoie et al, 2003), an additive "ManureMax" (Shah & Kolar, 2012), basalt tuff (Broschak et al., 2017), the preparation "Bioprogress" (Broschak et al., 2020). At the same time, it is urgent to reduce the negative impact of emissions of a complex of harmful gases on the environment – NH_3, CO_2, CH_4, NO, H_2S from organic waste.

The purpose of the study was to establish the effectiveness of the influence of mineral fertilizers on the emission of harmful gases (NH_3, CO_2, CH_4, NO, H_2S) from pig manure when stored in lagoons.

MATERIALS AND METHODS

A study on the effectiveness of using mineral fertilizers to reduce the emission of harmful gases from pig manure when it is stored in lagoons was conducted at Ugryniv Eco Ferm LLC, Chervonohrad District, Lviv Region. The experiment was performed using: electrochemical, mathematical-statistical and analytical methods.

To reduce the level of emissions of harmful gases (NH_3, CO_2, CH_4, NO, H_2S) from pig manure in the lagoons, mineral fertilizers were applied in the optimal pre-installed (*in vitro)* dose – 2.5%: Option I – control (without adding substances); Option II – phosphorite flour;

Option III – slaked lime. The emission level of the studied gases was determined with the help of a portable gas analyzer – Dozor C-M-5 (device inspection certificate type UA.TR.001 212-18 and certificate of conformity No. UA.TR.002.CB.1234-19). Determination was carried out once a week for a month after the application of the studied mineral fertilizers.In the course of the experiment, acidity was monitored using the pH-Meter Typ N5170.

The statistical analysis of the obtained research results was carried out by the methods of variational statistics using the standard package of Microsoft Excel and AtteStat application programs using the Student's t-test. The differences between the average arithmetic values were considered probable for: * P<0.05; ** P<0.01; *** P<0.001.

RESULTS AND DISCUSSIONS

On the basis of the conducted experimental studies, it was established that the most noticeable effect in reducing the emission level of the studied gases – NH_3, CO_2, CH_4, NO, H_2S when using mineral fertilizers – phosphorite flour and slaked lime from pig manure during its storage in lagoons was observed on the seventh day. The duration of the positive effect on the reduction of emission of harmful gases from pig manure in the lagoons with the use of the studied fertilizers gradually decreased up to 31st day of research.

In the process of conducting experimental studies, it was established that the addition of phosphorite flour to pig manure in lagoons contributes to a lower level of ammonia emission (Figure 1), depending on the day of the experiment (1st, 7th and 31st), respectively by 21.3%, 27.0 (P<0.05) and 9.8% (P<0.05). When using slaked lime, a decrease in the NH_3 release from pig waste when stored in lagoons was noted: by 11.4% on the 1st day, by 19.7% (P<0.05) on the 7th day and by 6.6% on the 31st day of the experiment.

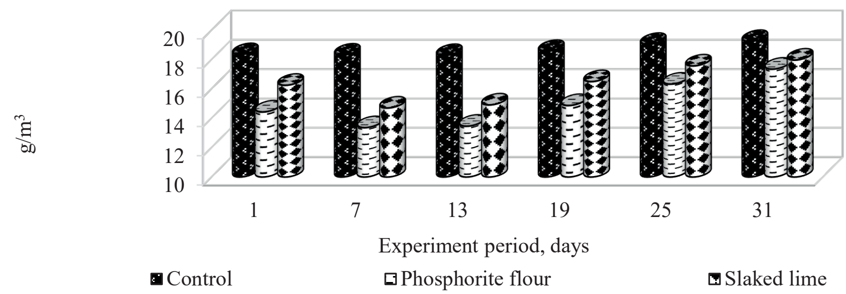

Figure 1. Effect of mineral fertilizers on the level of NH_3 emission from pig manure during its storage in lagoons

The analysis of the results shows the effectiveness of phosphorite flour on the level of carbon dioxide emission (Figure 2) from pig manure in the lagoons, which decreases compared to the control, respectively: by 27.0% (P<0.05), 28.4 (P<0.05) and 8.7% depending on the day of the experiment – 1st, 7th and 31st day.

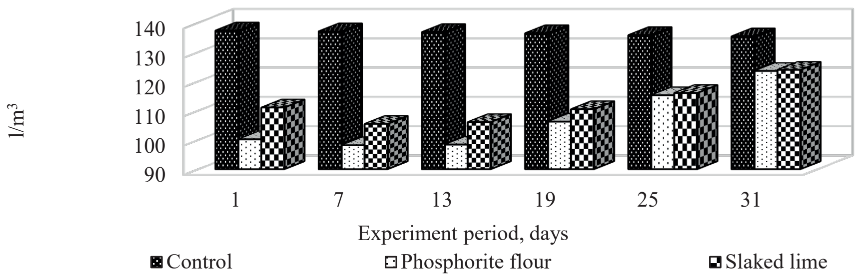

Figure 2. The influence of mineral fertilizers on the level of CO_2 emissions from pig manure during its storage in lagoons

When applying slaked lime, there is a decrease in CO_2 release from pig waste when stored in lagoons – by 19.1% (P<0.01) on 1st day, 23.1% (P<0.01) on 7th day and by 8.5% – on the 31st day of research.

According to the research results, it was established that the addition of phosphorite flour causes a lower level of methane emission (Figure 3) from pig manure in the lagoons, respectively: on the 1st day – by 15.0% (P<0.05), on the 7th day – by 18.4% (P<0.05) and on the 31st day – by 5.7% (P<0.05) relative to the control. Somewhat worse results regarding the reduction of CH_4 emissions from pig waste when stored in lagoons were obtained with the use of slaked lime. The difference, compared to the control, was 7.1%, 8.8 and 3.2%, depending on the day of research – 1st, 7th and 31st day.

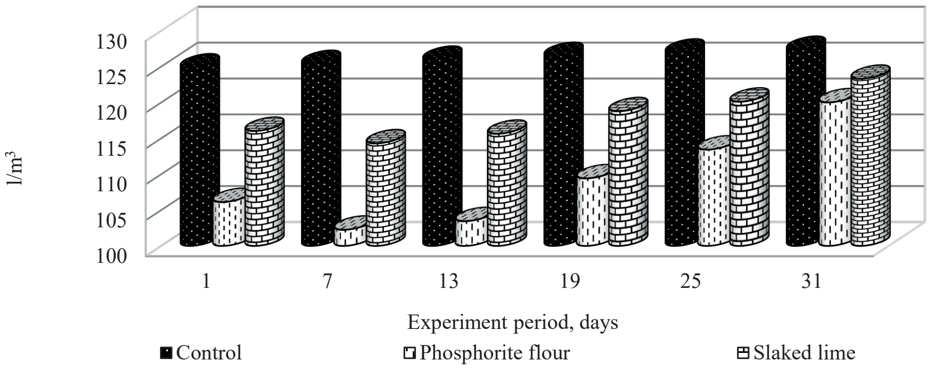

Figure 3. The influence of mineral fertilizers on the level of CH_4 emission from pig manure during its storage in lagoons

The introduction of phosphorite flour helps to reduce the level of nitrogen oxide emissions (Figure 4) from pig manure in the lagoons, depending on the day of the experiment, respectively: by 23.7% (P<0.05) – on 1st day, 33.6% (P <0.05) – on the 7th day and by 7.7% – on the 31st day. When slaked lime is added to pig waste in lagoons, NO release decreases by 19.7% (P<0.05), 30.8 (P<0.05) and 6.9%, depending on the period of research – 1st, 7th and 31st day.

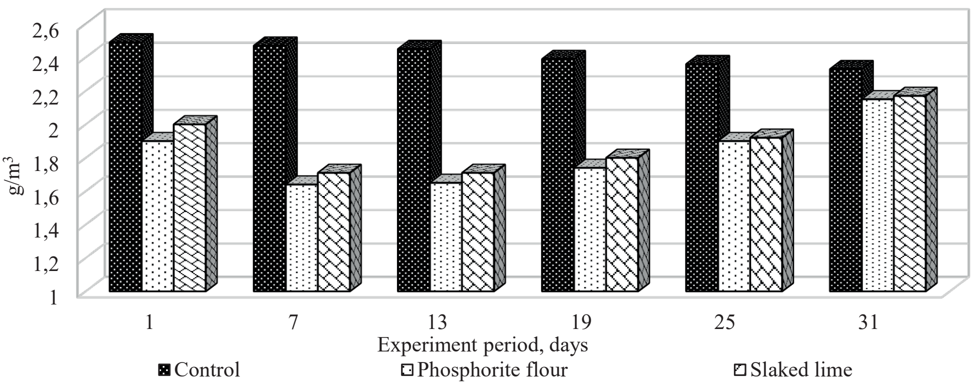

Figure 4. Effect of mineral fertilizers on the level of NO emission from pig manure during its storage in lagoons

Experimental data confirm that the use of phosphorite flour contributes to a lower level of hydrogen sulfide emission (Figure 5) from pig manure when it is stored in lagoons, compared to the control, depending on the day of the experiment: on the 1st day – by 15.8%, on the 7th day – 27.9% (P<0.05) and on the 31st day – by 7.4%. The addition of slaked lime causes a decrease in H_2S release from pig waste in lagoons, respectively – by 10.5% ($P<0.01$), 24.6% ($P<0.01$) and 6.1% ($P<0.05$), depending on the period of research (1st, 7th and 31st day).

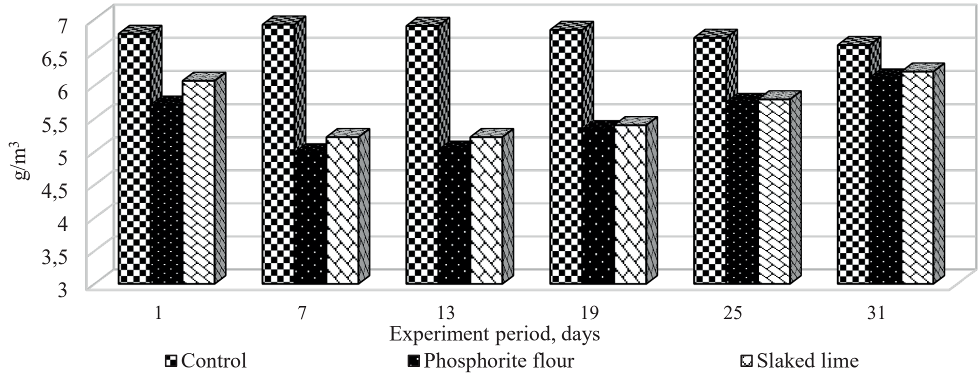

Figure 5. Effect of mineral fertilizers on the level of H_2S emission from pig manure during its storage in lagoons

On the basis of the obtained results, it was established that the pH value of pig manure when stored in lagoons (Figure 6) in control was 6.44-6.58, and when mineral fertilizers were applied – phosphorite flour and slaked lime – it decreased to 5.65 and 5.81, respectively.

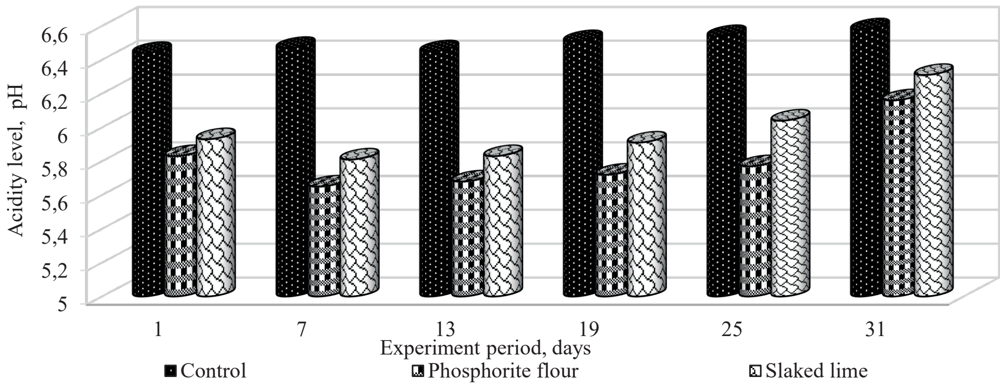

Figure 6. Changes in the level of acidity of pig manure when it is stored in lagoons, options with mineral fertilizers

Summarizing the above, it should be noted that those investigated substances, which provided the lowest pH value, made it possible to reduce the emission level of harmful gases, NH_3, CO_2, CH_4, NO, H_2S, from pig manure when stored in lagoons to the greatest extent.

Therefore, the analysis of research results shows the effectiveness of mineral fertilizers – phosphorite flour and slaked lime on reducing emission of the studied gases from pig manure when it is stored in lagoons.

It was experimentally established that the best results of the tested mineral fertilizers (phosphoric flour and slaked lime) in reducing by 18.4-33.6% the level of gas emissions, NH_3, CO_2, CH_4, NO, H_2S, from pig manure when it is stored in lagoons were obtained using phosphorite flour. Slaked lime contributed to lower gas emissions relative to the control on 8.8-30.8%. Thus, phosphorite flour has a more effective effect on reducing the emission of the studied gases from pig manure in lagoons – by 2.8-9.6%, relative to slaked lime.

Therefore, the research results indicate the feasibility of adding the studied mineral fertilizers to pig manure in lagoons to reduce emissions of harmful gases when storing by-products of animal origin, which will make it possible to prevent environmental pollution and preserve nature purity for future generations, and thus increase the profitability and competitiveness of the pig farming industry.

CONCLUSIONS

The expediency of using the studied mineral fertilizers – phosphorite flour and slaked lime to reduce the emission of harmful gases – NH_3, CO_2, CH_4, NO, H_2S from pig manure during its storage in lagoons due to changes in the pH of the substrate has been theoretically substantiated and proven. It was experimentally confirmed that in the comparative evaluation of the action of mineral fertilizers – phosphorite flour and slaked lime, the most effective reduction of emissions of the studied gases from pig manure in lagoons occurs by the use of phosphorite flour – 18.4-33.6%.

REFERENCES

Binkovska, G.V., & Shanina, T.P. (2016). Assessment of greenhouse gas emissions in agricultural waste management systems of Odesa region. *Bulletin of KNU named after V.N. Karazin*, 14, 91–97.

Blunden, J., & Aneja, V.P. (2008). Characterizing ammonia and hydrogen sulfide emissions from a swine waste treatment lagoon in North Carolina. *Atmospheric environment*, 42 (14), 3277–3290.

Broschak, I.S., Malyuta, Yu.S., & Guivan, M.D. et al. (2016). Patent UA 143443. The method of disposal of waste from pig farms. No. u202001658; statement 19.09.16; published 27.07.2020. Bul. No. 14.

Broschak, I.S., Malyuta, Yu.S., & Sobko, V.I. et al. (2016). Patent UA 114527. The method of reducing emissions of harmful substances into the atmosphere from pig complexes. No. u201609643; statement 19.09.16; published 10.03.17. Bul. No. 5.

Buzovskyi, E.A., Vytvytska, O.D., & Skrypnychenko, V.A. (2008). Non-traditional sources of energy – requirements of the time. *Scientific Bulletin of the NAU of Ukraine*, 119, 289–294.

Caro, D. (2019). Greenhouse gas and livestock emissions and climate change. *Encyclopedia of food security and sustainability*, 1, 228–232.

Demchuk, M.V., Reshetnyk, A.O., & Laiter-Moskalyuk, S.V. (2010). Problems of manure disposal in modern animal husbandry. *Scientific Bulletin of LNUVM and BT named after S.Z. Gzhytskyi,* 12, 3 (4), 188–195.

Dubin, O.M., & Vasylenko, O.V. (2014). Ecological assessment of the composition of atmospheric air in the area of livestock complexes. *Collection of scientific works of the UNU of Horticulture*, 85, 20–25.

Gerber, P.J., Steinfeld, H., & Henderson, B. et al. (2013). Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities. *FAO of the UNO, Rome:* Available online: http://www.fao.org/3/a-i3437e.pdf.

Herman, V.V. (2009). Ecological safety in the production of livestock products. *Agroecological journal,* 2, 5–8.

Khodorchuk, V.Y., Aliieva, I.V., & Martkoplishvili, M.M. (2014). Minimization greenhouses gas emissions from agriculture. *Agrarian Herald of the South*, 1, 168–173.

Kholod, M. (2009). Emission of greenhouse gases and formation of the quota market for their emissions. *Bulletin of the Sumy State University*, 2, 35–42.

Korbych, N.M. (2021). Environmental problems in animal husbandry. *Ecological problems of the environment and rational nature use in the context of sustainable development: materials of the IV intern. sc. and pract. conf.,* Kherson, 143-146.

Maksishko, L.M., & Malyk, O.H. (2012). Biological disposal of harmful greenhouse gases, which are part of biogas, as well as hydrogen sulfide and ammonia in water by an association of biologically useful microorganisms. *Scientific Bulletin of LNUVM and BT named after S.Z. Gzhytskyi,* 14 (3/2 (53)), 353–361.

Mykhailova, E.O. (2016). Emissions of greenhouse gases in Ukraine and the world. *Problems of technological and ecological safety: education, science, practice: mat. of the All-Ukrainian sc. and pract. conf.*, Kharkiv, 183-184.

Nykyforuk, O.V., & Zhukorskyi, O.M. (2014). Emission of greenhouse gases from pig farms of different capacity. *Scientific Bulletin "Askania-Nova"*, 7, 244–252.

Palapa, N.V., Pron, N.B., & Ustymenko, O.V. (2016). Industrial animal husbandry: ecological and economic consequences. *Balanced nature management*, 3, 64–67.

Pinchuk, V.O. (2015). Greenhouse gas emissions in livestock Ukraine. *Bioresursy i pryrodokorystuvannia.,* 7 (1/2), 115–118.

Pinchuk, V.O., & Borodai, V.P. (2019). Emission of ammonia and greenhouse gases from by-products of animal origin. *Tavrian Scientific Bulletin*, 110 (2), 190–198.

Portejoie, S., Martinez, J., Guiziou, F., & Coste, C.M. (2003). Effect of covering pig slurry stores on the ammonia emission processes. *Bioresour Technol*., 87 (3), 199–207.

Shah, S.B., & Kolar, P. (2012). Evaluation of additive for reducing gaseous emissions from swine waste. *Agricultural Engineering International: CIGR Journal*, 14 (2), 10–20.

Smith, P., Martino, D., & Cai, Z. (2008). Greenhouse gas mitigation in agriculture. *Philosophical transactions of the royal Society B: Biological* Sciences, 363, 789–813.

Tubiello, F.N., Salvatore, M., & Cóndor Golec, R.D., (2014). Agriculture, forestry and other land use emissions by sources and removals by sinks. 1990-2011 analysis. *FAO Statistics Division, Working Paper Series ESS/14-02*, 89 p.

Tymoshchuk, O.A., Tymoshchuk, O.B., & Matviychuk, B.V. (2022). Greenhouse gas emissions from agricultural activities and their dynamics during 1990–2020. *Ukrainian Journal of Natural Sciences*, 1, 174–186.

Udova, L.O., Prokopenko, K.O., & Didkovska, L.I. (2014). The impact of climate change on the development of agricultural production. *Agricultural Economics*, 3, 107–120.

Zakharchenko, O.V. (2017). Utilization of waste of natural origin of agrarian formations: a problematic aspect. *Bulletin of KNAU named after V.V. Dokuchaeva*, 1, 58–67.