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ANIMAL WASTE AS A SOURCE OF GREENHOUSE GAS EMISSIONS AND A FACTOR OF CLIMATE CHANGE

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Abstract

The anthropogenic impact of agricultural production on the atmosphere occurs as a result of the release of decomposition products of organic waste into it – greenhouse gases, which contribute to global warming and climate change, and thus to a decrease in the efficiency of agriculture. Livestock waste due to mass accumulation is not only a valuable organic fertilizer, but also a producer of environmental pollution, as it causes a significant ecological load on soils, surface and underground waters. The article examines the problem of environmental pollution by greenhouse gases in the livestock industry, the main trends of climate change, causes and consequences. The harmful impact on the natural environment of the activities of large livestock complexes is analyzed. The livestock sector has a significant contribution to the total greenhouse gases emissions, which reach 18% and exceed emissions from transport (14%). The main greenhouse gases are characterized and their role in creating the greenhouse effect is revealed. Certain promising directions for solving the considered problems have been outlined, which will make it possible to minimize the negative impact of livestock farming on the environment.

Key words: *animal husbandry, climate change, greenhouse gases, pollution, waste.*

INTRODUCTION

Solving the issue of increasing the greening of livestock production is given priority in modern global approaches to reducing the negative impact of agricultural production on the environment (Smith et al., 2008; Tubiello et al., 2014; Caro, 2019). Agricultural production is closely related to environmental conditions, availability and exploitation of natural resources – land, water, forests, flora and fauna (Smith et al., 2008; Demchuk et al., 2010; Mykhailova, 2016).

The future of the country is impossible without a powerful agricultural sector of the economy, the success of which requires the stable development of animal husbandry. The development of this industry remains an important condition for food security, a stable socio-economic state of the state, and a significant reserve for the export of agricultural products (Demchuk et al., 2010; Binkovska and Shanina, 2016; Furdychko et al., 2019). At the same time, the activity of agricultural enterprises leads to an increase in the anthropogenic load on the environment, due to the accumulation, simultaneously with the main products (milk, meat, eggs, etc.) of a significant amount of by-products of animal origin, in particular waste (Johnson et al., 2007; Herrero et al., 2013; MacLeod et al., 2013). Due to the accumulation of manure, the formation and emission of greenhouse gases into the surrounding natural environment – methane (CH_4), carbon dioxide (CO_2), oxide (NO) and nitrous oxide (N_2O), etc., which act as moving factors of climate change (Khodorchuk et al., 2014; Caro, 2019; Pinchuk and Borodai, 2019). Protection of the natural environment is considered one of the most important tasks,

because without scientifically based and purposeful work in this direction, effective management of the livestock industry will be impossible.

Greenhouse gases, entering the atmosphere, absorb heat and retain thermal radiation, thereby contributing to the increase in the average annual temperature of the Earth's surface, which causes the rise in the level of the oceans, the frequency and power of natural disasters and cataclysms (desertification, landslides, hurricanes, droughts, floods), the occurrence of acid rains, the formation of atmospheric aerosol and the reduction of drinking water supplies (Monteny et al., 2001; Johnson et al., 2007; Binkovska & Shanina, 2016).

Climate change on the planet is one of the most urgent environmental problems today in the context of the development and implementation of strategies to reduce greenhouse gas emissions and the gradual transition to low-carbon development of all sectors of the economy and components of human life (Khodorchuk et al., 2014; Mykhailova, 2016; Caro, 2019). Thus, taking into account the danger of the occurrence of the greenhouse effect at the global level, great efforts are currently being made to reduce greenhouse gas emissions into the environment.

Ways of solving this issue are reflected in a number of successively concluded international agreements (Kholod, 2009; Udova et al., 2014; Pinchuk, 2015). In particular, the United Nations Framework Convention on Climate Change was adopted in 1992. Five years later, the Kyoto Protocol was adopted in the Japanese city of Kyoto – an international agreement on limiting emissions of greenhouse gases into the atmosphere (Kholod, 2009; Udova et al., 2014). Given that with the help of the tools provided by the first two agreements, it was not possible to achieve a significant reduction in greenhouse gas emissions, the Paris Agreement was concluded, which is aimed at reducing the level of greenhouse gas emissions and limiting the increase in air temperature to 1.5ºC from the pre-industrial level. In the Paris Agreement, Ukraine undertook to limit greenhouse gas emissions to a level that would not exceed 60% of the 1990 level by 2030 (Mykhaylova, 2016; Tymoshchuk et al., 2022).

An objective assessment of climate change is periodically provided by the Intergovernmental Panel on Climate Change (IPCC). In 2007, the IPCC in the IV Report on the assessment of climate change notes that the concentration of CO_2, compared to the pre-industrial era, has increased by a third, and there has also been an increase in the level of methane and nitrous oxide. Over the 100-year period (1906-2005), the temperature increase according to the linear trend is equal to 0.74°C. (Mykhaylova, 2016). In 2018, the IPCC in its V report, which became the scientific basis for the Paris climate agreement, emphasized that human activities have caused 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. The VI Climate Change Assessment Report (2021) emphasizes that human activity, accompanied by emissions of greenhouse gases and aerosols, has led to an increase in temperature in the climate system at rates unprecedented in at least the last 2,000 years. The increase in temperature occurs more over land (by 1.6°C) than over the sea (0.9°C). It is believed that the critical limit of the increase in the average annual temperature is 2-2.5°C, since its further increase will lead to a catastrophic state of the biosphere. The document states that the concentration of carbon dioxide has increased by 47% since 1750, and that of methane by 156% (Timoshchuk et al., 2022).

Considering the above, it is necessary to use the potential of agriculture under the conditions of minimizing the negative consequences of global warming. In order to ensure a sustainable ecological situation on our planet, maintaining a balance between production and cost-effective ways of disposing of organic waste is an extremely important condition in the livestock industry.

The purpose of the article is to highlight the problems of environmental pollution with greenhouse gases in the livestock industry.

MATERIALS AND METHODS

Data from scientific literature, periodicals of foreign and domestic scientists, regulatory documents, systematic and complex approaches to the level of environmental pollution due to the activity of livestock

complexes served as the theoretical and methodological basis of the analysis. The following methods were used to process information: empirical-theoretical (collection, anamnesis and synthesis of scientific information), theoretical (definition, description, interpretation) and abstract-logical (logical approach to the formation of conclusions and proposals), etc.

RESULTS AND DISCUSSIONS

Agricultural enterprises are powerful sources of environmental pollution because they produce much more waste than can be disposed of in their surrounding areas (Smith et al., 2008; Demchuk et al., 2010; Binkovska and Shanina, 2013). Millions of tons of organic waste from livestock farms, processing enterprises, etc. are accumulated annually in our country, that leads to certain problems with their storage and further use (Aneja et al., 2008; Burlaka et al., 2016; Korbych, 2021). It is known that in Ukraine, more than 52 million tons of manure is produced from cattle, pigs and poultry kept by enterprises of the agro-industrial complex (Buzovsky et al., 2008). In particular, on large livestock complexes, the amount of manure per year can be: on pig complexes with a livestock of 12,000 heads – up to 36,000 m^3, on complexes for beef production with a herd of 10,000 heads – 95 thousand m^3, on large farms for milk production with a herd of 800 cows – 16 thousand m^3 (Burlaka et al., 2016). A typical 100,000 pig farm produces about 1,000 m^3/day (up to 365,000 m^3/year) of manure (Zakharchenko, 2017).

Most manure is produced in cattle breeding (44%), pig farming (39%) and poultry farming (17%) (Pinchuk and Boroday, 2019). For example, for each liter of milk (with a productivity of 5 thousand liters per year), 4 kg of excrement are produced, for 1 kg of pork (for live weight gains of 600 g per day) – 11 kg, for 1 kg of beef – 30 kg (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 the water and litter that gets into the manure (Buzovsky et al., 2008). It is also known that the production of 8,000 eggs is accompanied by the accumulation of 277 kg of droppings. In particular, one laying hen produces 40-65 kg of droppings with a moisture content of 65-75% per year, which is three times more than the resulting egg mass, which is 15-18 kg, and the latter exceeds the hen's own weight by 5 times (Zhukov, 2016). It should be noted that in order to ensure food security, domestic producers must produce 8,230,000 tons of milk, 135,000 tons of beef, 600,000 tons of pork, and 1,620,000 tons of poultry meat. and eggs 14,100 million pieces. Taking into account the above, the priority tasks are not only the need to provide the population with the optimal amount of livestock products, but also the corresponding quality, as well as to minimize the negative impact on the environment of the by-products obtained at the same time, to guarantee the welfare of animals and at the same time the profitability of the industry. Therefore, large livestock complexes require special attention. According to Clause 23 of the Resolution of the Cabinet of Ministers of Ukraine No. 808 dated August 28, 2013 "On approval of the list of activities and facilities that pose an increased environmental hazard", livestock complexes for raising pigs in the amount of 5 thousand heads or more, cattle livestock – from 2,000, fur animals – from 3,000, poultry – from 60,000 laying hens and 85,000 broilers, as well as meat plants and meat processing enterprises, productions for processing and disposal of animal waste origin, in particular, poultry farming, fish farming and leather tanning operations belong to objects of increased ecological danger (Palapa et al., 2016).

Livestock waste is characterized by a high content of nutrients. However, they are not only a valuable fertilizer, but also represent a significant ecological burden on the air environment, soils, water reservoirs and groundwater, contribute to the spread of pathogenic microorganisms, weed seeds, eggs and larvae of helminths, flies, etc. (Melnyk, 2009; Demchuk et al., 2010; Iashchenko, 2010). Thus, violation of the technology of keeping animals and storing waste causes nitrogen, phosphorus and other substances to enter surface waters, which pollute them and harm wetlands and coastal ecosystems. Enrichment of a reservoir with biogenic elements causes its eutrophication, i.e. rapid development of algae and an increase in the number of zooplankton, resulting in the death of algae, the formation of phenols and

hydrogen sulfide, which leads to the poisoning of all living organisms in the reservoir (Palapa et al., 2016; Korbych, 2021).

When a large amount of waste is accumulated, in particular manure, as a result of the decomposition of organic matter, both in aerobic and anaerobic conditions, under the action of microorganisms, the formation of volatile decomposition products occurs, as a result of which a significant number of gaseous air pollutants of various origins are released into the atmosphere, including greenhouse gases (Monteny et al, 2001; Moller et al, 2004). 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: pig farming accounts for 46%, cattle breeding – 30%, poultry farming – 20%, other types of animals – 4% (Vovk, 2021; National inventory of anthropogenic emissions). Only one pig farm for 100,000 pigs or a cattle complex for 35,000 animals pollutes the environment as much as a large industrial center with a population of 400-500,000 people (Maksishko and Malyk, 2012; Zakharchenko, 2017). Methane emissions from cattle are about 90 million tons per year, or almost 16% of the annual global emissions of this greenhouse gas (Pinchuk, 2015). Violations of manure and litter storage technologies cause air emissions of 7% of the total volume of nitrous oxide emissions (Palapa et al., 2016). During the 15 months of its growth, the calf gains about 500 kg of weight and at the same time emits into the atmosphere the amount of methane equivalent, from the point of view of the greenhouse effect, to 75 thousand km of mileage of an average car, which is 5 times more than the car travels in the same period of time (Binkovska and Shanina, 2013). Poultry droppings accumulated throughout the year in poultry farms, where up to 400,000 laying hens are grown, decompose and release into the atmosphere: up to 700 tons of biogas, of which 208 tons of carbon dioxide or 30%, 462 tons of methane, i.e. 66% and up to 5% – other gases and compounds – hydrogen sulfide, skatole, indole, ammonia, hydrogen, etc. (Dutka, 2018). Thus, the average anthropogenic load on the territory of Ukraine from poultry waste is 0.22 million tons/km^2 that for every thousand of population is 3000 tons (Iashchenko, 2010).

The exhaust ventilation system in complexes with livestock of 10-40 thousand pigs emits up to 6.05 kg of dust, up to 14.4 kg of ammonia, up to 5 kg of hydrogen sulfide and up to 83.4 billion microbial bodies into the atmospheric air within an hour (Krychkovska et al., 2013; Zakharchenko, 2017; Vovk, 2021). 8.7 billion microbial bodies, 0.75 kg of dust, 4.8 kg of ammonia and 2,058 kg of moisture in the form of aerosols are released per hour from a farm with a capacity of 2,000 cows. In a complex for 10,000 calves, 103.9 billion microbial bodies, 6.2 kg of dust and 23 kg of ammonia are released into the air in one hour in winter. A farm with 720,000 poultry emits up to 41.1 kg of dust, up to 13.3 kg of ammonia, up to 1490 m^3 of carbon dioxide and up to 174.8 billion bacteria into the air in one hour (Krychkovska et al., 2013). The amount of ventilation emissions from one typical poultry house for keeping laying hens or raising broilers is 10-50 thousand m^3/h in winter, and 200-500 thousand m^3/h of polluted air in summer. In a poultry house, an average of 25 mg of ammonia, 15 mg of hydrogen sulfide, and 8 mg of carbon dioxide are released per hour from one m^2 of litter surface, and from each m^2 of litter-free litter of natural moisture – 8 mg/h, respectively; 5 and 5 mg/h. The emission of these gases increases significantly with an increase in the humidity of the waste and non-compliance with the regulatory parameters of the microclimate (Melnyk, 2009).

The harmful effect of pollution can be more significant when livestock complexes are located near settlements or water resources (Smith et al., 2008; Demchuk et al., 2010). It should be noted that as a result of waste storage, unsanitary conditions are created not only directly on the territory of this farm, but also at a considerable distance from it. Thus, the spread of a specific smell from a complex for growing and fattening 10,000 heads of cattle occurs at a distance of up to three kilometers. At the same time, air pollution and smell spread from the pig complex for 108,000 heads up to 5 km (Dubin & Vasylenko, 2014).

It should be noted that greenhouse gases are not ordinary pollutants with a direct local effect, they act cumulatively, indirectly, globally, therefore the cumulative effect (greenhouse effect) determines the need to monitor emissions (Khodorchuk et al., 2014). According to the National Inventory of Anthropogenic Emissions from Sources and Adsorption of Greenhouse Gas Absorption in Ukraine, the inventory covers emissions of 6 greenhouse gases of direct action: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride (Mykhaylova, 2016, Korbych, 2021).

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According to estimates by the World Food and Agriculture Organization, the livestock sector emits 18% of all greenhouse gas emissions, which is more than emissions from transport (14%) (Tubiello et al., 2014; Palapa et al., 2016; Korbych, 2021). If deforestation is also taken into account, the share of agriculture in total greenhouse gas emissions increases to 30% (Demyanenko and Butko, 2012). On the other hand, agriculture is a key sector that, along with forestry, with effective management can slow down and stabilize the process of greenhouse gases entering the atmosphere (Udova et al., 2014; Mykhailova, 2016). In particular, forests in the world absorb up to 25 billion tons of carbon dioxide annually, but they are unable to fully reduce the concentration of greenhouse gas emissions into the environment (Mykhaylova, 2016).

The livestock sector accounts for the formation of about 9% of global emissions of carbon dioxide (retention time in the atmosphere is 50-200 years), 37% of anthropogenic methane, 64% of ammonium emissions, and 65% of nitrous oxide, that is, the industry affects atmospheric air and is potentially an important additional source of emissions directly related to climate change (Gerber et al., 2013; Binkovska & Shanina, 2016; Vovk, 2021). Greenhouse gases have different physical and chemical properties and can remain in the atmosphere for different periods of time (from a few days to centuries), that is, they have a certain greenhouse potential. Therefore, for each gas, an indicator is determined as the potential of global warming, which is calculated as the ratio of one kilogram of greenhouse gas that entered the atmosphere to one kilogram of CO_2 over a certain period of time (100 years) (Tymoschuk et al., 2022). So, for carbon dioxide, the global warming potential is one. CO_2 flows between the atmosphere and ecosystems are regulated by absorption through plant photosynthesis and release during respiration and decomposition of organic matter (Symbirskyi, 2013). The potential impact of methane on the planet's climate is 21-34 times higher than that of CO_2, and this gas can persist in the atmosphere for up to 12 years (Koneswaran & Nierenberg, 2008; Asgedom & Kebreab, 2011; Herrero et al., 2013). Methane is released in the process of methanogenesis in anaerobic conditions in soils and manure storages, in the process of enteral fermentation, and in the case of incomplete combustion of organic matter (Symbirskyi, 2013; Binkovska & Shanina, 2016). Ammonium emissions significantly contribute to acid rain and acidification of ecosystems (Binkovska & Shanina, 2016). The role and potential of N_2O in the process of global warming is on average 265-310 times greater than that of CO_2 (Koneswaran & Nierenberg, 2008; Asgedom & Kebreab, 2011; Caro, 2019). The main sources of oxide emissions are industries engaged in animal husbandry, storage and processing of manure, including the process of applying it to the soil (Simbirskyi, 2013; Palapa et al., 2016). Nitrous oxide contributes to the destruction of the stratospheric ozone layer, which protects living beings from the sun's harmful ultraviolet radiation (Binkovska & Shanina, 2016). An indirect source of potential greenhouse gas N_2O

is ammonia, which is released mainly during the formation of manure on fields, when it is stored in lagoons and applied to fields. This gas settles in surface waters and can cause their eutrophication. Ammonia emissions lead to acid rain, which damages crops and natural ecosystems, causes soil acidification, reduces the nitrogen content, and therefore the value of manure as a fertilizer. Ammonia emissions are associated with the formation of aerosols that can pose a health hazard to people (Blunden & Aneja, 2008; Korbych, 2021). An air pollutant such as hydrogen sulfide is considered one of the most toxic gases with an unpleasant smell, among the by-products of manure decomposition. It is formed due to bacterial reduction of sulfate and decomposition of sulfur-containing organic compounds in manure. Hydrogen sulfide is one of the factors in the occurrence of acid rain, and therefore in climate change (Aneja et al., 2008; Blunden & Aneja, 2008). According to the data of the European Union, more than 80% of the ammonia that pollutes the atmosphere and 10% of the methane that destroys the ozone layer comes from manure when it is untimely buried in the soil, when it is stored in open storage facilities (lagoons) (Maksishko & Malyk, 2012).

According to the latest data, the concentration of greenhouse gases in the atmosphere has increased significantly. In particular, the amount of carbon dioxide over the last 100 years has increased on average by more than 40%, which is the highest level in the last 650 thousand years, while the concentration of methane, relative to the pre-industrial period, has increased by 2.4 times, and nitrous oxide – by 20% (Udova et al., 2014). The analysis of literary sources shows that the concentration of methane in the air increases annually by 1.2-1.5%, the level of N_2O increases by 0.3%, and other gases by 4%. Thus, in general, by the middle of the 21st century, the greenhouse effect of CH_4 and N_2O may be equal to the effect of doubling the concentration of CO_2 in the atmosphere (Palapa et al., 2016). It is predicted that emissions of the main greenhouse gases will increase by 25-90% by 2030, if a number of measures to improve the situation are not adopted, relative to the indicators of 2000 (Smith et al. 2008; Udova et al., 2014). According to the forecast of IPCC experts at the United Nations, by 2050 climate changes may make a large part of the territory of Africa and Asia uninhabitable, which will contribute to migration processes.

In the agriculture, forestry and fisheries sector, according to the Food and Agriculture Organization of the United Nations, greenhouse gas emissions have doubled over the past 50 years (Gerber et al., 2013; Tubiello et al., 2014). Thus, agriculture in general, and animal husbandry in particular, which often suffers from climate change, is simultaneously a significant source of greenhouse gas emissions into the atmosphere, that is, one of the causes of this change (Vovk, 2021). Since human production activity causes disruption of the natural environment, society has to take care of restoration of its properties and protection from further degradation. Therefore, prevention of environmental pollution by greenhouse gases formed in the natural environment from by-products of animal origin remains an urgent issue and is an important aspect in the functioning of enterprises of the agro-industrial complex. Promising ways to solve the problem of disposal and use of livestock waste are its storage in storage facilities (lagoons) with possible further composting or anaerobic fermentation of biomass, which ensures zero waste production (Boldrin et al., 2009; Demchuk et al., 2010; Binkovska & Shanina, 2016). Processing of organic waste is an important component of any biologically oriented system. It is known that 1 gol. of cattle produces 45 kg of manure per day on average, from which 2.5 m^3 of biogas can be produced, the output of manure and gas from 1 head. pigs – 6.5 kg and 0.3 m^3, poultry – 0.137 kg and 0.02 m^3, respectively (Vovk, 2021). Analysis of literary sources shows that on average 52 m^3 of biogas is released from one ton of manure, 60% of which is methane, which is a greenhouse gas. In particular, the processing of animal waste products by the method of biological fermentation is of great ecological importance, since all chemical substances are fully utilized, as well as pathogenic microflora and weed seeds are destroyed, that is, the properties of manure as fertilizers are improved, thereby reducing to a minimum pollution of water, air and soil (Demchuk et al., 2010; Korbych,

2021). Thus, thanks to the introduction of waste-free technologies in animal husbandry, the problem of waste disposal is not only eliminated, but also the protein-mineral-vitamin feed base increases, the share of renewable energy increases, and there is a resource for increasing and restoring soil fertility due to the return of biomass nutrients in the most readily available form. Therefore, the use of this technology will allow to transform organic livestock waste from harmful to the environment into a profitable and useful product and ensure high competitiveness and profitability of the industry. Solving the problems of effective and rational disposal of waste in animal husbandry will contribute to increasing the productivity of animals, obtaining good-quality ecologically safe products and will ensure the proper ecological condition in the area of operations of farms, thereby increasing the efficiency of the industry.

CONCLUSIONS

It is theoretically substantiated and confirmed that the livestock industry causes significant damage to the environment. During the production of livestock products, the external environment must be reliably protected from pollution by its waste, as an integral part of the technological process. Thus, it is advisable to use the technology of waste processing and utilization, in which manure is considered not only as an object that creates an environmental hazard, but is also taken into account as a raw material for obtaining additional products in the form of biogas and biomass – with their subsequent use in various industries.

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