

Conference Paper

The Environmental Impact of Pig Farming

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Abstract

This study aimed to develop a methodology to evaluate the protection of animals and people from the harmful effects of the farm's microclimate and environment, taking into consideration the energy, economic and environmental indicators. To achieve this goal, the following were determined for 2019 for the eight countries which are the world leaders in the field of pig farming: the volumes of carbon dioxide pollution, ammonia, dust and manure, and the analytical dependencies between the feed consumption, pig productivity and the concentration of ammonia inside the farm. The weight gain of pigs reduced by 15% with an increase in the concentration of ammonia in the internal air of livestock houses to 20 mg/m³, but the feed wastage increased by 12%. Mathematical models were developed to estimate the relationships between the feed consumption, pig productivity and the concentration of harmful gas (ammonia) which is one of the main parameters of the microclimate. The results will be used in making technical and technological decisions in the field of microclimate, cleaning and disposal of farm manure.

Keywords: pig, farming, ecology, environment.

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1. Introduction

With the extensive development of pig farming, which is characterized by the predominance of small and medium-sized farms, the ecological system is disrupted for a short time and usually quickly restored. And, on the contrary, with intensive development, which is characterized by large pig farms and complexes, the air, soil, surface and groundwater are maximally polluted. In modern conditions, most of the leading countries in the field of pig farming (see Table 1) have chosen an intensive development path due to the objective reasons. The data presented in Table 1 based on the data from the official websites of the following organizations: Food and Agriculture Organization of the

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United Nations (FAO), United States Department of Agriculture (USDA), the Ministry of Agriculture of the Russian Federation (RF MA), the Unified Interdepartmental Statistical Information System of the Russian Federation (RF UISIS).

Farms are powerful sources of environmental pollution. Annually, billions of cubic meters of water vapour, carbon dioxide, ammonia, hundreds of thousands of cubic meters of hydrogen sulfide, tens of thousands of tons of dust, and pathogenic microflora are released from the premises of livestock farms in Russia [1, 2].

According to Belarusian scientists, the Sozh pig complex in the Gomel region for 108 thousand pigs emits 56 kg of ammonia and 15-20 kg of dust into the atmosphere in 1 hour, and unpleasant odours spread to a distance of 5 km [3].

Modern technologies for housing animals specify high requirements to the microclimate in livestock premises. According to scientists, livestock specialists and technologists, the productivity of animals is 50... 60% determined by feed and water consumption, 15... 20% - by care and 10... 30% - by the microclimate in the livestock premises [1, 4–8]. Deviation of microclimate parameters from the set of optimal values leads to a reduction of live weight gain by 20...35%, increasing the waste of young stock to 5...40%, consumption of additional quantities of feed, reducing the service life of equipment, machinery and buildings, and leads to a negative impact on staff, reducing the resistance of livestock to diseases [2, 9–12].

Currently, as opposed to other scientists and specialists, we distinguish more than 10 environmental parameters that affect the livestock inside the farm: temperature, humidity and airspeed, atmospheric pressure; concentration of harmful gases (carbon dioxide, ammonia, hydrogen sulfide); concentration of dust and microbial bodies; production noise, illumination and electromagnetic fields [1, 2, 13, 14].

This paper considers only one parameter of the environment inside the farm (microclimate) – the concentration of ammonia.

Ammonia is poisonous. It strongly irritates the mucous membranes. Acute ammonia poisoning causes damage to the eyes and respiratory tract, shortness of breath, and inflammation of the lungs. [15]

The source of ammonia in the air of premises for livestock is the decomposition of various substances containing nitrogen (urine, faeces). Especially a lot of ammonia occurs in stables, as well as in pigsties and calf premises in the case of floor permeability, absence or poor operation of sewerage and ventilation.

Ammonia is highly soluble in water, so it is primarily absorbed by the mucous membranes of the nasopharynx, upper respiratory tract and conjunctiva of the eyes,

TABLE 1: Dynamics of the livestock of pigs, million heads

No. The place occupied by a country/region in the world/country	1995	2000	2005	2010	2015	2017	2018	2019	2019, in % by 2000
1. China	441.7	416.3	433.2	464.6	451.1	433.3	428.2	310.4	74.56
2. USA	58.2	59.1	61.5	64.9	68.9	73.1	75.6	77.3	130.80
3. Spain	18.1	22.1	24.9	25.7	28.4	30.0	30.8	31.2	141.18
4. Germany	23.7	25.8	27.0	26.9	27.7	27.6	26.4	26.1	101.16
6. Russia	22.6	15.7	13.8	17.2	21.5	23.1	23.7	25.2	160.51
Canada	11.5	13.6	15.1	12.7	13.6	14.2	14.0	13.9	102.21
France	14.5	15.2	15.1	14.3	13.3	13.4	13.7	13.5	88.82
Poland	20.3	17.0	18.7	14.8	10.6	11.9	11.0	11.2	65.88
Regions of Russia:									
4. Pskov region	0.14	0.084	0.064	0.074	0.65	1.02	1.15	1.3	1547.6
16. Krasnodar krai	1.75	1.53	1.3	1.00	0.43	0.41	0.53	0.63	41.18
Moscow oblast	0.47	0.18	0.143	0.3	0.3	0.32	0.33	0.33	183.33

Information on some of the largest pork producers (5. Brazil, 7. Vietnam, Mexico, Korea) is not presented in the table.

causing severe irritation to them. Coughing, sneezing, eye tearing are followed by inflammation of the mucous membranes of the nose, larynx, trachea, bronchi and conjunctiva. With a high content of ammonia (1000...3000 mg/m³) in the inhaled air, animals have spasms of the glottis, tracheal and bronchial muscles, death occurs from pulmonary oedema or respiratory paralysis [16].

When ammonia passes the blood through the lungs (the alveolar epithelium can pass ammonia), it turns the haemoglobin of red blood cells into alkaline hematin, which reduces the amount of haemoglobin and the number of red blood cells; anaemia is observed, and blood clotting increases [17].

According to experts, in the case of prolonged inhalation of air containing ammonia (0.33...0.97%), the amount of haemoglobin, blood alkaline reserve, gas exchange, digestibility of nutrients (protein, fat, fibre) reduce in livestock and the productivity decreases. The intake of large amounts of ammonia into the blood causes a strong excitation of the Central nervous system of the brain, spinal cord and especially the medulla oblongata, convulsions of the entire body, and in the intervals between them, there is a comatose state, an increase in blood pressure, finally, paralysis of the respiratory centre and death. The continuous and long-term effect on livestock of ammonia

at a concentration of 0.15% or more worsens the general condition, food is poorly digested, daily weight gains fall, and the number of respiratory diseases increases. At higher concentrations, ammonia causes acute poisoning, accompanied by rapid death of livestock [1].

The symptoms of chronic human poisoning are the following: in the workers of chemical plants (at the concentration of 0.5...24 mg/m³), it was observed the cases of anosmia or hyposmia, neurasthenia, decreased bioelectric activity of the brain, increased activity of glutamic pyruvate transaminase and decreased level of vitamin C in the blood, decreased excretion of urea, increased need for vitamin B1. The incidence of upper respiratory tract catarrh, angina, tonsillitis is increased. It was registered the changes in fat and protein metabolism and the increased incidence of catarrhal diseases of the upper respiratory tract in adolescents undergoing practical training at the factory, even with a 3-hour working day and the concentrations that do not exceed the maximum allowed [1].

Based on the collected and processed material, the dependences of the influence of the concentration of ammonia in the internal air of the farm on the productivity of pigs and feed consumption are investigated, and they are shown in Figure 1.

2. Methods

Based on some research [14, 18–21], it was established that the average specific indicators of pollution and waste by pigs have the following values: carbon dioxide CO₂ – 0.12078 kg/h/head; ammonia NH₃ – 0.0007 kg/h/head; dust – 0.0002 kg/h/head; manure – 6.6 kg/day/head.

Using these values, it was calculated the approximate volumes of pig pollution during the period of 2019 for the countries and regions of the Russian Federation, which are presented in Table 1. These results are presented in Table 2.

The development of methodological techniques for calculating, designing and solving a complex problem with zooengineering, engineering and technical, sanitary and hygienic, environmental aspects was based and carried out using the provisions, laws and methods of probability theory, mathematical modelling, statistics, and optimization.

To find the optimal technologies for forming microclimate parameters inside the farm, the results of scientific research in this area were explored and summarized, based on which the mathematical models were developed to investigate analytical dependencies between feed consumption, pig productivity and ammonia concentration [22-28].

3. Results

TABLE 2: Volumes of pig farming pollution in 2019 for some countries and regions of the Russian Federation

No. The place occupied by a country/region in the world/country	The number of pigs, million heads	The amount of pollution, Gkg/year			
		Carbon dioxide, CO ₂	Ammonia NH ₃	Dust	Manure
1. China	310.4	328.41	1.9034	0.5438	747.75
2. USA	77.3	81.79	0.4740	0.1354	186.22
3. Spain	31.2	33.01	0.1913	0.0547	75.16
4. Germany	26.1	27.61	0.1600	0.0457	62.87
6. Russia	25.2	26.66	0.1545	0.0442	60.71
Canada	13.9	14.71	0.0852	0.0244	33.49
France	13.5	14.28	0.0828	0.0237	32.52
Poland	11.2	11.85	0.0687	0.0196	26.98
Regions of Russia:					
4. Pskov region	1.3	1.38	0.0080	0.0023	3.13
16. Krasnodar krai	0.63	0.67	0.0039	0.0011	1.52
Moscow oblast	0.33	0.35	0.0020	0.0006	0.79

Important: 1 Gkg = 1x10¹² kg = 1x10⁹ t

Based on the collected and processed material, the dependences of the influence of the concentration of ammonia in the internal air of the farm on the productivity of pigs and feed consumption are investigated, and they are presented in Figure 1.

In Figure 1, it can be noticed that when the concentration of ammonia in the internal air of the livestock premises increases to 20 mg/m³, the weight gain of pigs decreases by 15%, and the overconsumption of feed increases by 12%.

Based on the dependencies of Figure 1, it was calculated the regression equations (1, 2) for the effect of the concentration of ammonia in the internal air of the farm μ_{17} (NH₃), mg/m³ on the weight gain of pigs Cwg (the coefficient of weight gain), % and the feed consumption Cfc (the coefficient of feed consumption), %

$$Cwg = -9.7 \cdot 10^{-6} \cdot (\mu_{17})^3 + 0.00284 \cdot (\mu_{17})^2 - 0.88675 \cdot \mu_{17} + 101.4292, \text{ at } 0 \leq \mu_{17} \leq 150 \quad (1)$$

$$Cfc = 0.56 \cdot \mu_{17} + 100.2 \text{ at } 0 \leq \mu_{17} \leq 20 \quad (2)$$

4. Discussion

To make the most complete and comprehensive assessment of technological decisions in the field of microclimate, cleaning and utilization of farm manure, experts are often suggested using four groups of indicators: functional and technological; structural and layout; operational and energy; economic.

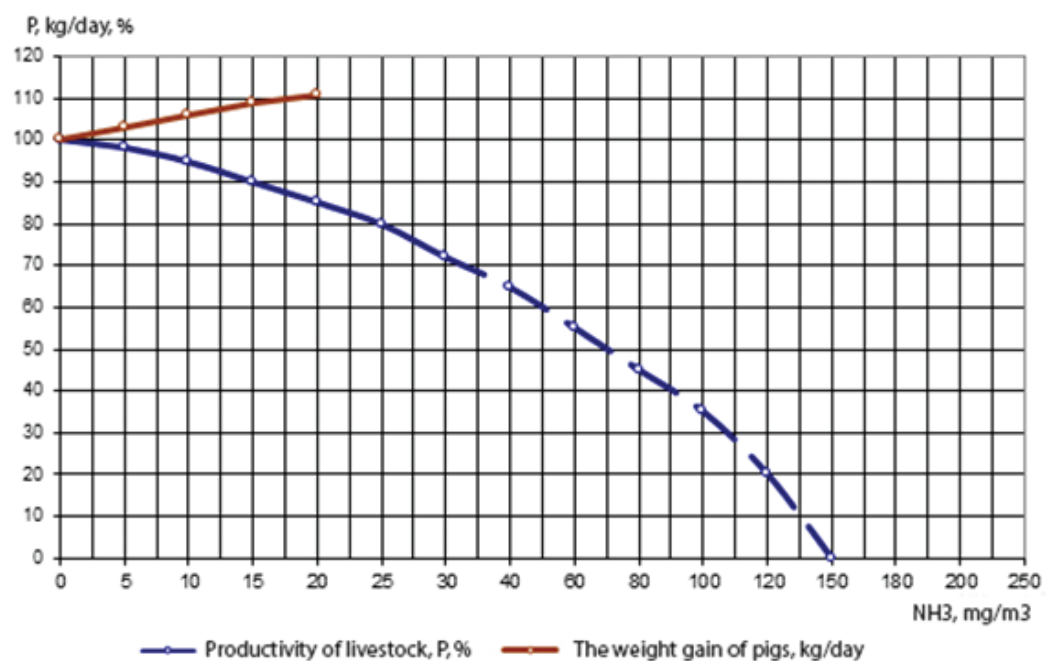


Figure 1: Influence of ammonia concentration in the indoor air of the farm on the pig weight gain and feed consumption

Functional indicators characterize the degree to which the system performs the specified functions, that is, for the microclimate systems, it is the degree to which the normalized parameters of the air environment are provided: its purity, gas composition, temperature, relative humidity, mobility, etc. Quantitative assessment of the required parameters is the initial stage of evaluating the decisions made and directly affects the technological parameters. Technological indicators are the values of heat, cold, air and water consumed for humidification and purification, and chemicals for air purification from harmful gases that are necessary for the systems to perform the specified functions. Since technological indicators are adequate to the functional parameters that characterize the law of system functioning, they are combined into one group.

The group of design and layout indicators includes various types of material costs: material consumption, occupied construction space, ease of installation.

Operational and energy indicators include the energy assessment of the system, operating conditions, information about energy consumption (it can be expressed as an energy efficiency coefficient).

Economic indicators express all the previous ones in money terms. In general, they are represented as capital, operating and reduced costs.

It should be noted that, as a rule, “environmental” indicators are not taken into account in technological decisions.

Therefore, it is necessary to introduce the fifth group of indicators – environmental.

5. Conclusions

The EU countries are implementing a long-term program for the development of environmentally-friendly agriculture, including pig farming. This program has five strategic directions:

1. Protection of livestock and people from the harmful effects of the farm’s microclimate and the environment;

In this direction, the authors of the article draw the following conclusions:

- 1.1. The existing model systems forming the microclimate of livestock farms is based on the control of the temperature and humidity ratio of the air in the premises up to 3...5 times/hour, so the coefficient of efficiency of the heat of the farm indoor air in winter does not exceed 25...30%, while the harmful gases (ammonia, carbon dioxide, hydrogen sulfide), dust and microbial bodies are released into the environment;

- 1.2. To explore energy-saving, economic and environmental technologies of formation of parameters of a microclimate of pig farms, it was reviewed and summarized research results in this field and it was developed a mathematical model allowing to obtain analytical dependencies between the feed consumption (energy), the productivity of pigs and the concentration of a harmful gas (ammonia), which is one of the main microclimate parameters.

2. Development of environmentally-friendly production of outputs and measures that promote such production;

3. Development and improvement of equipment for waste disposal and cleaning of livestock emissions;

4. Development of regulatory documents on environmental protection;

5. Reducing product losses during transportation.

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