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Research of techniques of microclimate improvement in poultry houses

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Creating an optimal microclimate in poultry houses is an important condition for implementing the genetic potential of poultry productivity and minimizing the specific costs of material and technical resources. Such microclimate parameters as the content of harmful gases in the air of the poultry houses and its microbial contamination have a significant impact not only on the survival and productive parameters of the poultry, but also on the health of the staff, and the ventilation emissions from the poultry houses - on the environment. Therefore, the development of techniques and technological methods aimed at reducing the content of these 'harmful factors' in the air of the poultry houses is of paramount importance for modern poultry farming. The first experiments were carried out in two similar industrial poultry houses for egg laying hens, 18×96 m in size. Hens were kept in 4-tier Hellmann cage batteries with a belt removal system and integrated air ducts. The capacity of each poultry house was 47,280 laying hens. The purpose of the experiment was to study the influence of the device for the neutralization of microorganisms in the air of the poultry house and its mode of operation on the microbial contamination of the air of the poultry house and the productive parameters of the poultry. The poultry of the Lohmann Brown crossbreed was used. The next experiment was carried out in the same poultry houses as in the previous one. The purpose of the experiment was to study the effects of the application of the method of purifying the air of the poultry house from the ammonia in the scrubber on the contents of this gas in the air of the poultry house and the productive parameters of the poultry. The poultry of the Lohmann Brown crossbreed was used in the experiments. It was established that at application of a bactericidal device with 24 bactericidal tubes TUV-75 caused a decrease of microbial contamination of the air, which positively influenced the survival and productive parameters of the poultry. After 210 days of the productive period, the poultry's survival in the experimental poultry house was higher by 0.8% ($P<0.001$); 1.3 pcs. of eggs more ($P<0.05$) per one egg laying hen were obtained in this poultry house; and the egg mass was higher by 0.7 g ($P<0.05$) than in the control poultry house. With the hens from the experimental poultry house, a greater bactericidal and lysozyme activity of the blood serum was observed than with the ones from the control poultry house ($P<0.05$) at the age of 30 and 47 weeks. Some advantage of the poultry from the experimental poultry house was determined by the absolute mass of individual internal organs, but this advantage was not statistically probable. It was proved that in the cold season, the scrubber provided a decrease in the ammonia content in the air (when comparing the air before and after the scrubber) by 3.2-2.2 times, in the poultry house (when compared with the control) - by 2.1-1.5 times. It was established that in the experimental poultry house the poultry's survival was greater by 0.7% ($P<0.001$), 1.6 pcs., or by 1.0% ($P<0.01$) eggs more per one egg laying hen were obtained and egg mass was higher by 212 g, or by 2.1% than in the control poultry house.

Keywords: Toxic gases; poultry house; ventilation; scrubber; microclimate; poultry litter; ammonia; adsorbent; air treatment

Introduction

The beginning of the 21st century has witnessed not only the existence of global risks and the ecological crisis, but also the gradual perception of the danger of unlimited human activity, as evidenced by the change in the discourse of the scientific community. At one time V.I. Vernadsky noted that scientific activity is increasingly specialized not in disciplines, but in problems. Such concepts as 'global warming', 'sustainable development', 'climate change', 'meso- and microclimate', 'technical and technological development' nowadays are the markers by which the design of projects for the further development of the system 'nature - man - society', where technologyization acts as a matrix of the interaction of elements of this system.

Modern specialists (Kopnina et al., 2018) underline the transformation of the scientific paradigm. This situation is the answer to those processes that determine the nature of the present, making it impossible monologism in solving environmental problems of our time.

The scientific and technological development of the last decades has made it possible to reflect on the issues that were articulated by I. Kant. The urgency of these issues is beyond doubt, since the confrontation between man and nature only intensified with the development of technical and technological capabilities of society. Unfortunately, 'intellectual saturation' was not aimed at constructive interaction of the elements mentioned above; as a result, the problem of human responsibility for environmental existence remained out of sight (Wienhues, 2017). These assertions are a contributing factor in modern poultry farming tendencies which has a significant impact on the environment.

The microbial contamination of the air is a factor of microclimate in the poultry house, which is significantly influenced by the storage methods and condition of the litter in the poultry house. Poultry, litter, excreta in cagel batteries, dust, feed, and water in the poultry houses are known to be a good environment for the development and spread of microorganisms, including pathogens (Dumas et al., 2011; Ishchenko et al., 2019; Sabluk, 2009). According to the studies carried out at the Sumy National Agrarian University, three months after setting, the number of microorganisms in the air of the poultry house for the keeping of egg laying hens is about 1 mln. units per 1 m^3, and after 12 months it exceeds 6 mln. units (Baidevliatov, 2001). When growing a large number of poultry on a limited area and a relatively satisfactory general sanitary condition of the premises and the poultry welfare in respect to infectious diseases, from 23 thous. to 1.4 mln. microbial units 1 cm^2 were found on the surfaces of material objects. After 21 weeks of keeping the laying hens in cages 1.9 min. units per 1 cm^2 of their surface were found (Awoniyi, 2003).

During cage growing of chickens the concentration of microorganisms in the air of the poultry house significantly exceeded the standards (Salifou et al., 2013) and had rather significant differences at different periods of the day: during the relative rest of the bird from 10 p.m. to 4 a.m. it was 814 thous. units/m^3, from 5.10 a.m. to 8.10 a.m. - 2102 thous. units/m^3, while feeding - 11,005 thous. units/m^3 of the air (Ruff, 1999). While studying the dynamics of microbial contamination of the air in the poultry house and its influence on the growth and development of rearing flocks, it was found that during the entire period of growing young poultry it increased and after 80 days it exceeded 10 mln. units/m^3. With daily wet cleaning of premises with the use of disinfectants and the air treatment with lactic acid, it was possible to significantly reduce the microbial contamination of the air, which contributed to a 3.5% increase in poultry's survival and the increase of its live weight by 200 g (Mormile et al., 2013).

According to the Idustry-specific process engineering standard for the Agro-Industrial complex 04.05, the maximum permissible concentration (MPC) of microorganisms in the air of the poultry house with the cage-keeping of adult poultry is 220 thous. units/m^3 of the air, with keeping on the floor - 500 thous. units/m^3. For young poultry, when growing in the cage batteries and on the floor of the MPC of the microorganisms in the air of the poultry house is: for hens aged 1-4 weeks - 30 thous. units/m^3, 5-9 weeks - 50 thous. units/m^3, 10-14 weeks - 100 thous. units/m^3, 15-22 weeks - 150 thousand units/m^3. According to most scientists, the high microbial contamination of air negatively affects the survival and productive parameters of the poultry (Gujvinska et al., 2018; Nieminen et al., 2012).

A number of specialists (Carvalho et al., 2015; Paliy et al., 2018; Wheelock, 1990) believe that, in many cases of the manifestation of viral and bacterial pathogens, a pathogen is only a trigger. A significant role in the occurrence and course of diseases is played by the concentration of opportunistic pathogenic microflora. By means of systematical reducing the microbial contamination of the poultry house, microbial pressure on the poultry can be forced down, thereby increasing the survival, activating the body's reserves for more complete realization of its genetic productivity potential. Now the problem of reducing the microbial contamination of the poultry house is solved in a variety of ways and means (Calvet et al., 2010; Paliy et al., 2018; Fernanda et al., 2017):

- By treatment with special chemicals (disinfectants), by a wet, aerosol or gas method;
- By affecting the microorganisms with various physical factors (ultraviolet irradiation, ultrasound, high temperature, etc.);
- By cleaning the contaminated air with special filters.

The treatment (disinfection) of poultry houses for the purpose of disposal of microorganisms is mainly carried out in the absence of poultry during the sanitation of permises (Chidambaranathan & Balasubramanium, 2017; Paliy et al., 2018). However, as noted above, such disinfection does not always guarantee that the level of microbial contamination is not exceeded during the period of growing or keeping the poultry. In this regard, many experts point to the need for disinfection in the presence of the flock (Linlin et al., 2018). However, the choice of methods and means for such disinfection, which would have no negative impact on the health of the staff and the poultry, the quality of products and the environment is very limited.

The most effective way of disinfection is to influence the object of disinfection with ultraviolet irradiation. It is an invisible for the naked human eye electromagnetic irradiation that occupies a spectral band between visible and X-rays within the wavelength range from 100 to 400 nm. Ultraviolet irradiation in the range of 280 to 200 nm, or the so-called 'C' range, has the greatest bactericidal effect. The wavelength of 253.7 nm has the maximum bactericidal effect. Electro-lamps, the main part of spectrum of which is ultraviolet irradiation in this part of the spectrum, have been called bactericidal. However, ultraviolet

irradiation of the bactericidal region of the spectrum is detrimental not only to microorganisms, but also to the skin and eyes of humans and animals. Therefore, when using them, appropriate precautionary measures and means of protection should be used. Ultraviolet irradiation of the spectral region of 280-400 nm is called erythemic. It causes erythematous and antirachitic effect and in certain doses positively affects humans and poultry. However, its bactericidal effect is one to two orders of magnitude lower than that of the bactericidal portion of the spectrum (Wells et al., 2010).

A significant number of scientific works is devoted to the study of the influence of ultraviolet irradiation on microorganisms. It is established that ultraviolet irradiation causes dimerization of thymine in DNA molecules. The accumulation of such changes in the DNA of microorganisms leads to a slowing down of their reproduction and death (Michael et al., 2001). The use of ultraviolet irradiation in poultry houses promotes the reduction of microbial contamination of the air and the surface of material objects, improves the physiological state of the poultry, strengthens its skeleton by improving the assimilation of vitamin D3, in general, positively affects the growth and development of the poultry, the quality and dressed weight of the meat. There are more nitrogenous compounds found in the chest muscles of the irradiated poultry (Zhang et al., 2006).

The scientist (Chornyi, 2001) recommends, when keeping egg laying hens, to use ultraviolet irradiation of the erythemic region of the spectrum at doses of 40-50 mer/h. per m^2 of space, as a source of ultraviolet irradiation, to apply high-pressure mercury arc lamp, fluorescent mercury erythemic and high pressure mercury-tungsten arc-discharge lamps as a source of ultraviolet irradiation.

It is proposed to arrange the sources of ultraviolet irradiation in a chess order at a height of 2.3 m above the floor, and for keeping in cage batteries - at a height of 1.0-1.1 m above the upper tier of the cage battery at a distance of 5-6 m apart. Emitting radiation from the erythemic lamps is directed downwards, that from bactericidal lamps - upwards. The sources of ultraviolet irradiation are switched on for 10-12 h in the premises for keeping young poultry and for 8-9 h per day - in permises for grown-up poultry (Veterany et al., 2004).

This way of disinfecting the air is proposed in another work (Guerrero-Beltrn & Barbosa-Cnovas, 2004). The sources of ultraviolet irradiation are placed at a height of at least 2 m above the floor. The specific capacity of bactericidal lamps should be 0.75-1.0 W/m^3 of poultry house volume. The maximum irradiation at an altitude of 1.8 m should not exceed 5 mb/m^2 at 5-6 hour exposure during the day. The application of this technology allows one to reduce the microbial contamination of the air by 60%. For typical poultry houses, the 10 times increase in specific power with the lamps DB-30 does not lead to an increase in ozone concentration above the MPC.

Radiators and recirculators are used as sources of ultraviolet irradiation. Recyclers are used if it is necessary to exclude direct exposure of ultraviolet irradiation to humans, animals or poultry. At the same time, the use of ultraviolet irradiation sources directly in the poultry house has certain disadvantages, especially when keeping the poultry in cages, since it requires the installation of a significant number of lamps in poultry houses, the observance of appropriate protection measures, does not ensure uniform exposure to the air and the poultry, complicates the performance of work during sanitation of the poultry houses.

Ozone is sufficiently widely used for disinfection of various premises and materials. Ozone can also play a positive role in purifying the air in poultry houses from toxic gases such as ammonia and hydrogen sulfide. The process of oxidation and decomposition of these toxic gases takes place under the influence of ozone (Schreiber & Mitch, 2007).

The application of ozonizers while keeping egg laying hens in cages allowed to reduce the ammonia content in the air inside cages from 12 to 2 mg/m3, hydrogen sulfide content from 0.3 to 0.03%, contamination of the air by more than 100 times, and also increased the egg productivity of the laying hens and the incubation quality of eggs (Brian & Brown, 1986).

The effective concentration of ozone in the air of the poultry house is about 20 mg/m^3 of its volume. This concentration is sufficient for a significant reduction in the number of microorganisms, and at the same time it is considered to be harmless to the poultry. The disadvantages of the ozonation method, as already noted earlier, include the complexity of the uniform distribution and maintenance of the necessary concentration of ozone throughout the room and the high cost of its distribution system (Whistler & Sheldon, 1989).

It should be noted that ozone is formed also when working with sources of ultraviolet irradiation, along with it, the level of aeroions in the room also increases. After operation of bactericidal tubes DB-30 for one hour, the concentration of light aeroions in the room increased by 10 times, while one ozone molecule formed per a pair of ions (Lewis & Gous, 2009). At the same time, there are few actual data on the influence of various levels of microbial contamination of the air on the poultry, its productive parameters and this issue requires a more detailed study. It is also necessary to further improve the way of reducing the microbial contamination of the air when growing and keeping the poultry.

Materials and Methods

The scientific and economic experiment was carried out in two similar poultry houses, 18 × 96 m in size, with keeping the poultry in Hellmann 4-tier cage batteries with built-in air ducts. A bactericidal device, consisting of 24 Philips bactericidal TUV lamps with a power of 75 W, placed in two concentric series, was introduced into the collector air duct of a poultry litter drying system of one poultry house. The total bactericidal flow in the air duct was 612 W (the volume dose of ultraviolet irradiation 60 J/m^3). The amount of the air supplied by the duct was 30 thous. m^3/h on the average. The litter from the poultry houses was removed once in five days.

The second poultry house was a control one, bactericidal devices were not placed in it and a typical system of drying of the litter was used.

The rest of the parameters of keeping the poultry in the two poultry houses were similar. Each poultry house contained 47,280 hens of the Lohmann Brown crossbreed. The study was carried out during seven months (from October to April).

The general microbial contamination of the air and the content of toxic gases in it were studied: before its irradiation (in the area of the air duct before bactericidal lamps), in the air duct installed over the litter removal conveyor of the cage battery), as well as in the poultry house according to the standard techniques given above. Each parameter was determined once a month. The samples were taken in each of these places: in the air ducts not less than three in each place, in the poultry house - 6 samples along the diagonal to the poultry house at the level of the first and fourth tiers of the cage batteries. The total number of samples was 300. During the experiment, daily records were kept of the poultry'ssrvival and egg productivity. Once a month, the average weight of eggs was determined by weighing 200 eggs from each poultry house for five consecutive days. In the beginning and at the end of the experiment 100 hens from each poultry house were weighed. In the beginning (the age of the poultry - 16 weeks), in the middle (the age of the poultry - 30 weeks) and at the end of the experiment (the age of the poultry - 47 weeks), blood samples for hematologic analyzes were taken from 5 hens from the experimental and 5 from the control poultry house.

At the end of the experiment 10 heads of the poultry from each poultry house were slaughtered to study the development of the internal organs of the poultry. The next scientific and economic experiment was carried out simultaneously with the previous one, in two similar poultry houses, equipped with the same cage batteries. Each poultry house also contained 47,280 egg laying hens of the Lohmann Brown crossbreed. The study was carried out during seven months (from October to April). A scrubber was placed in the chamber of an air-mixing unit in the experimental poultry house. Phosphogypsum was selected as a reagent. The frequency of litter removal in the poultry house and the frequency of replacement of the reagent in the scrubber were once every five days, 150 kg of a reagent were loaded into the scrubber once.

The second poultry house was a control one, with a typical litter drying system, adsorbents or reagents to reduce the emission of toxic gases were not used in it. The remaining poultry keeping parameters in the two poultry houses were similar.

The study was carried out during (from October to April). In the experimental and control poultry houses, the relative humidity and temperature of the air, the content of toxic gases in the air at 3 points along the diagonal of the poultry house at the level of the first and fourth tiers of cage batteries, in the mixing chamber and in the collector air duct of the air supply in the built in air ducts according to the standard techniques were determined in the air, shown above. Each parameter was determined once a month in three replies. During the experiment, the daily record of the survival and egg productivity of the poultry in both poultry houses was carried out. Once a month, the average weight of eggs was determined by weighing 200 eggs from each poultry house for five consecutive days.

In the beginning, middle and at the end of the experiment we weighed 100 heads of poultry of one and the same kind from each poultry house.

In the beginning (the age of the poultry - 16 weeks), in the middle (the age of the poultry - 30 weeks) and in the end of the experiment (the age of the poultry - 47 weeks) samples of blood were taken for the analysis of hematological parameters from 5 hens from experimental and 5 from the control poultry house.

In the end of this experiment 10 heads of poultry from each poultry house were slaughtered for studying the internal organs of the poultry.

Results and Discussion

Microbial contamination of the air in the poultry house and productive parameters of the poultry when using a bactericidal device. A bactericidal device with 24 bactericidal tubes TUV-75 was used in the experiment. With application of this device the best indicators of neutralization of microorganisms were obtained. The results of the studies of microbial contamination of the air in the experimental and control poultry houses are shown in Table 1.

Table 1. Microbial contaminationof the air in the experimental and control poultry houses in different seasons, thous. per 1 m^3.

Place of measurement of the content of toxic gases	**Month of the year**	
	Control poultry house	**Experimental poultry house**
Transition season (October-November, March-April): air exchange rate is 1.5 m^3/h per 1 kg of live mass of the poultry)		
In the collector air duct in front of the placement of bactericidal lamps	138.9 ± 19.6	72.8 ± 12.3
In the air duct above the belt conveyor for poultry litter removal	141.5 ± 17.8	29.9 ± 3.3
In the poultry house	435.2 ± 26.3	196.6 ± 17.4***
Cold season (December-February): air exchange rate is 0.7 m^3/h per 1 kg of live mass of the poultry		
In the collector air duct in front of the placement of bactericidal lamps	256.7 ± 27.8	96.8 ± 8.5
In the air duct above the belt conveyor for poultry litter removal	262.4 ± 21.5	24.7 ± 2.6
In the poultry house	521.0 ± 23.4	183.4 ± 15.1***

Note: *** - P<0.001 (compared with the control poultry house).

The studies have shown that microbial contamination of the air in the experimental poultry house was lower than that in the control one: by 2.8 times in the cold season (December-February), 2.2 times - in the transition season (October-November and March-April). In the warm season, the air from the poultry house was not recycled and the ultraviolet irradiation of the air was off.

In addition, the air treatment by ultraviolet irradiation contributed to a decrease in ammonia concentration (Table 2).

Table 2. The content of toxic gases in the air of the experimental and control poultry houses.

Place of measurement of the content of toxic gases	**Month of the year**	
	Control poultry house	**Experimental poultry house**
October-November, March-April (air exchange rate is 1.5 m^3/h per 1 kg of live mass of the poultry)		
In the collector air duct in front of the placement of bactericidal lamps:		
Ammonia, mg/m^3	4.7 ± 0.25	3.3 ± 0.21***
Carbon dioxide, %	0.05 ± 0.0025	0.05 ± 0.0027
Hydrogen sulfide, mg/m^3	-	-
In the air duct above the belt conveyor for poultry litter removal:		
ammonia, mg/m^3	4.7 ± 0.27	2.6 ± 0.24***
Carbon dioxide, %	0.05 ± 0.0023	0.04 ± 0.0024
Hydrogen sulfide, mg/m^3	-	-
In the poultry house:		
Ammonia, mg/m^3	12.5 ± 0.39	10.6 ± 0.45**
Carbon dioxide, %	0.10 ± 0.0029	0.09 ± 0.0027
Hydrogen sulfide, mg/m^3	-	-
December-February (air exchange rate is 0.7 m^3/h per 1 kg of live mass of the poultry)		
In the collector air duct in front of the placement of bactericidal lamps:		
Ammonia, mg/m^3	7.3 ± 0.23	4.9 ± 0.27***
Carbon dioxide, %	0.07 ± 0.0029	0.07 ± 0.0024
Hydrogen sulfide, mg/m^3	-	-
In the air duct above the belt conveyor for poultry litter removal:		
Ammonia, mg/m^3	7.3 ± 0.22	3.2 ± 0.21***
Carbon dioxide, %	0.07 ± 0.0034	0.06 ± 0.0038
Hydrogen sulfide, mg/m^3	-	-
In the poultry house:		
Ammonia, mg/m^3	14.8 ± 0.46	12.0 ± 0.33***
Carbon dioxide, %	0.15 ± 0.0037	0.14 ± 0.0042
Hydrogen sulfide, mg/m^3	-	-

Note: ** - P<0.01; *** - P<0.001 (compared with the control).

Compared with the poultry house, in which the air treatment with ultraviolet irradiation was not carried out, the content of ammonia in the air of the experimental poultry house in the cold season was reduced by 1.23 times, that of carbon dioxide - by1.07 times, in the transition season, by 1.18 and 1.11 times, respectively; but the difference between poultry houses on the carbon dioxide content was statistically unprobable.

Productive parameters of the poultry during 7 months of the experiment are given in Table 3.

Table 3. Productive parameters of egg laying hens of Lohmann Brown crossbreed when using an experimental bactericidal system.

Names of the parameters	**Control poultry house**	**Experimental poultry house**
Initial amount of poultry in the poultry house, heads	47280	47280
Cost of a bactericidal device with a set of replaceable lamps, UAH	-	8700
The age of the poultry in the beginning of the experiment, weeks	17	17
Duration of the experiment, days	210	210

Poultry's survival, %	96.9	97.7***
Electricity consumption for the device of bactericidal irradiation of the air, kWh	-	7632
Cost of electricity consumed by the bactericidal device, UAH	-	3587
Amount of eggs obtained per one initial egg laying hen, pcs.	167.1	168.4*
Average weight of one egg, g	59.7 ± 0.28	60.4 ± 0.21*
Weight of eggs per an initial egg laying hen, kg	9.976	10.171
Total amount of eggs obtained in the poultry house:		
Thous. pcs.	7900.488	7961.952(+61.464x)
Tons of eggs	471.659	480.902(+9.243x)
Feed costs, kg:		
Per 10 eggs	1.392	1.381(-0.011x)
Per 1 kg of eggs	2.332	2.286(-0.046x)

Note: * - P<0.05; *** - P<0.001 (compared with the control); x - more or less to the specified value compared with the control.

As the study showed, the reduction of microbial contamination of the air positively influenced the survival and productive parameters of the poultry. After 210 days of the productive period, the poultry's survival in the experimental poultry house was higher by 0.8% (P<0.001), 1.3 pcs. (P<0.05) of eggs more were obtained per an initial egg laying hen in this poultry house, and the egg mass was higher by 0.7 g (P<0.05) than in the control poultry house. In total, during 7 months 61.464 thous. pcs. of eggs, or 9.243 t more, were obtained in the experimental poultry house. In adition to this, somewhat lower specific feed costs: by 0.8% - for 10 eggs and 2.0% - per 1 kg of egg mass, were shown in the experimental poultry house. Immediately after setting, after 3 and 7 months of keeping, blood samples for hematological analyzes were taken from 5 hens from each poultry house (Table 4).

Table 4. Hematological indices of the poultry in the experimental and control poultry houses, (M ± m, n=5).

Indices	**Poultry house**	
	Control	**Experimental**
The age of the poultry - 17 weeks (immediately after setting the poultry)		
Erythrocytes, T/l	3.4 ± 0.28	3.4 ± 0.35
Leucocytes, G/l	34.37 ± 0.86	35.69 ± 0.73
Lysozyme activity of serum, %	37.1 ± 3.56	36.7 ± 3.73
Bactericidal activity of serum, %	47.8 ± 1.35	45.3 ± 1.56
ESR, mm/h	2.91 ± 0.22	2.86 ± 0.18
The age of the poultry - 30 weeks (after 3 months of keeping)		
Erythrocytes, T/l	3.5 ± 0.29	3.3 ± 0.33
Leucocytes, G/l	38.17 ± 0.81	34.47 ± 0.93
Lysozyme activity of serum, %	36.5 ± 3.48	38.2 ± 3.41
Bactericidal activity of serum, %	44.3 ± 1.51	49.8 ± 1.46*
ESR, mm/h	3.12 ± 0.17	3.14 ± 0.21
The age of the poultry - 47 weeks (after 7 months of keeping)		
Erythrocytes, T/l	3.4 ± 0.28	3.3 ± 0.33
Leucocytes, G/l	41.2 ± 3.1	35.7 ± 2.17
Lysozyme activity of serum, %	37.4 ± 3.04	39.9 ± 3.14
Bactericidal activity of serum, %	43.9 ± 1.51	49.7 ± 1.79*
ESR, mm/h	3.15 ± 0.26	3.14 ± 0.17

Note: * - P<0.05.

According to the analysis of blood samples taken from the poultry from the experimental poultry house, a greater number of red blood cells (T/l) and lower of leukocytes (G/l) were observed. At the same time, the difference between poultry houses on these indicators was statistically imprpbable, so we can only talk about the tendency of the positive effect of the air disinfection in the poultry house on the state of the poultry. The poultry from the experimental poultry house had a greater bactericidal and lysozyme activity of the blood serum than those in the control poultry house (P<0.05) at the age of 30 and 47 weeks, which also indicates the positive effect of the proposed technique on the overall resistance of the poultry's organism.

In general, during the experiment, hematological inices of poultry's blood samples from both poultry houses did not go beyond the permissible values.

In addition, in the end of the experiment, 10 heads of poultry from each poultry house were slaughtered to study the development of the internal organs of the poultry. The results of these studies are presented in Table 5.

Table 5. Development of internal organs of the poultry in the experimental groups the age of the poultry - 47 weeks).

Name of internal organ	Control poultry house		Experimental poultry house	
	Absolute mass of the organ, g	Relative mass of the organ (% of live weight of the poultry)	Absolute mass of the organ, g	Relative mass of the organ (% of live weight of the poultry)
Liver	34.5 ± 1.77	1.8	35.3 ± 1.35	1.7
Spleen	3.5 ± 0.31	0.2	3.7 ± 0.25	0.2
Heart	9.7 ± 0.23	0.5	9.9 ± 0.17	0.5
Gizzard stomach	37.1 ± 1.14	1.9	39.2 ± 1.19	2
Kidneys	14.7 ± 0.42	0.7	14.9 ± 0.53	0.8

Live weight of the poultry in this age was: in the control poultry house - 1943 ± 24.3 g, in the experimental poultry house - 1952 ± 27.8 g.

A certain advantage of the poultry from the experimental poultry house in the absolute weight of individual internal organs was determined, but this benefit was not statistically probable. At the same time, in the absence of pathological changes, it also indicates a tendency for positive effects of air treatment to reduce its microbial contamination.

The effect of air treatment in a scrubber on the content of toxic gases in it and productive parameters of the poultry. The content of toxic gases in the air of the experimental and control poultry houses is given in Tables 6 and 7.

Table 6. The content of toxic gases in the air of the control and experimental poultry houses in the cold season (December-February - air exchange rate is 0.7 m^3/h per 1 kg of live mass of the poultry).

Place of measurement of the content of toxic gases	Days of accumulation of the litter		
	1st	3rd	5th
Fresh air:			
Ammonia, mg/m^3	-	-	-
Carbon dioxide, %	0.03	0.03	0.04
Control poultry house			
Air in the collector air duct:			
Ammonia, mg/m^3	4.3 ± 0.37	5.9 ± 0.63	6.7 ± 0.45
Carbon dioxide, %	0.05 ± 0.0029	0.05 ± 0.0043	0.06 ± 0.0039
Air in the poultry house:			
ammonia, mg/m^3	8.7 ± 0.47	11.6 ± 0.37	13.5 ± 0.54
Carbon dioxide, %	0.09 ± 0.0039	0.10 ± 0.0051	0.11 ± 0.042
Experimental poultry house			
Air in the poultry house passing through a scrubber:			
Ammonia, mg/m^3	1.3 ± 0.34	3.4 ± 0.37	6.2 ± 0.41
Carbon dioxide, %	0.09 ± 0.0027	0.09 ± 0.0031	0.11 ± 0.0039
Air in the в collector air duct:			
Ammonia, mg/m^3	0.6 ± 0.27***	1.7 ± 0.33***	3.2 ± 0.46***
Carbon dioxide, %	0.05 ± 0.0032	0.04 ± 0.0030	0.06 ± 0.0042
Air in the poultry house:			
Ammonia, mg/m^3	4.2 ± 0.34***	5.9 ± 0.47***	8.9 ± 0.57***
Carbon dioxide, %	0.09 ± 0.0026	0.09 ± 0.0032	0.11 ± 0.0038

Note: *** - P<0.001 (compared with the control poultry house).

As the study showed, during the cold season the scrubber provided a reduction in the content of ammonia in the air by 3.2-2.2 times (the air before and after the scrubber being compared), in the poultry house (when compared with the control) - by 2.1-1.5 times.

Table 7. Toxic gases content in the air of the control and experimental poultry houses in the transition period of the year (October-November, March-April - air exchange rate is 1.5 m^3/h per 1 kg of live mass of the poultry).

Place of measurement of the content of toxic gases	**Days of accumulation of the litter**		
	1st	**3d**	**5th**
Fresh air:			
Ammonia, mg/m^3	-	-	-
Carbon dioxide, %	0.03	0.03	0.03
Control poultry house			
Air in the collector air duct:			
Ammonia, mg/m^3	4.3 ± 0.41	5.2 ± 0.46	6.6 ± 0.38
Carbon dioxide, %	0.05 ± 0.034	0.06 ± 0.0041	0.06 ± 0.0033
Air in the poultry house:			
Ammonia, mg/m^3	7.6 ± 0.56	9.3 ± 0.49	11.6 ± 0.43
Carbon dioxide, %	0.010 ± 0.0048	0.11 ± 0.0036	0.12 ± 0.047
Experimental poultry house			
Air in the poultry house after passing through a scrubber:			
Ammonia, mg/m^3	1.3 ± 0.36	3.1 ± 0.43	5.6 ± 0.53
Carbon dioxide, %	0.08 ± 0.0035	0.08 ± 0.0043	0.09 ± 0.0048
Air в collector air duct:			
Ammonia, mg/m^3	0.4 ± 0.11***	1.0 ± 0.38***	1.9 ± 0.44***
Carbon dioxide, %	0.05 ± 0.0029	0.05 ± 0.0042	0.07 ± 0.0047
Air in the poultry house:			
Ammonia, mg/m^3	3.9 ± 0.34***	6.9 ± 0.47**	8.4 ± 0.57**
Carbon dioxide, %	0.10 ± 0.0032	0.10 ± 0.0046	0.12 ± 0.0039

Note: ** - P<0.01; *** - P<0.001.

During the transition season the content of ammonia in the experimental poultry house and in the control poultry house was lower than during the cold season. In turn, in the experimental poultry house, the content of ammonia was 1.9-1.4 times lower than in the control poultry house. Thus, the emissions of ammonia into the atmosphere decreased.
The treatment of the air in the poultry house with the scrubber did not significantly affect the content of carbon dioxide in the air. Hydrogen sulfide content was not recorded during any research period in any of the poultry houses.
Productive parameters of the poultry during the 7-month experiment duration are shown in Table 8.

Table 8. Productive parameters of egg laying hens of Lohmann Brown crossbreed when cleaning the air in the poultry house by the experimental scrubber.

Names of the parameters	**Control poultry house**	**Experimental poultry house**
Initial amount of poultry in the poultry house, heads	47280	47280
The age of the poultry in the beginning of the experiment (weeks)	17	17
Cost of the experimental scrubber, thous. UAH	-	0.5
Duration of the experiment, days	210	210
Poultry's survival, %	95.6	96.3***
Amount of eggs obtained per one initial egg laying hen, pcs.	165.8	167.4**
Average weight of one egg, g	59.5 ± 0.23	60.2 ± 0.19*
Weight of eggs per an initial egg laying hen, kg	9.865	10.077 (+0.212x)
Total amount of eggs obtained in the poultry house		
Thous. pcs.	7839.024	7914.672 (+75.648x)

Tons of eggs	466.422	476.463 (+10.041^{x})
Feed costs, kg:		
Per 10 eggs	1.374	1.368
Per 1 kg of eggs	2.301	2.272 (-0.025^{x})
Costs of phosphogypsum, tons	-	6.3

Note: * - P<0.05; ** - P<0.01; *** - P<0.001 (compared with the control); x - more or less to the specified value compared with the control.

As can be seen from the table, reducing the content of ammonia in the poultry house has had a positive effect on the survival and productive parameters of the poultry. Thus, in the experimental poultry house, the poultry's survival was greater by 0.7% (P<0.001); 1.6 pcs. or 1.0% (P<0.01) more eggs and 212 g or 2.1% more of egg mass per one egg laying hen were obtained than in the control poultry house. In the same poultry house an average egg mass was 0.7% greater (P<0.05). As a result, during 210 days of the experiment, 75.648 thous. pcs. of eggs and 10.041 tons of egg mass more were received in the experimental poultry house than in the control one. In the experimental poultry house, feed costs per 1 kg of egg mass were slightly lower (by 1.3%).

As in the previous experiment, after setting the poultry, after 3 and 7 months of keeping blood samples were taken for hematological analyzes from 5 hens from each poultry house (Table 9).

Table 9. Hematological indices of the poultry in the experimental and control poultry houses, (M ± m, n=5).

Indices	**Poultry house**	
	Control	**Experimental**
The age of the poultry - 17 weeks (immediately after setting the poultry)		
Erythrocytes, T/l	3.5 ± 0.27	3.4 ± 0.32
Leucocytes, G/l	36.41 ± 0.92	37.89 ± 0.84
Lysozyme activity of serum, %	36.3 ± 2.93	36.5 ± 3.15
Bactericidal activity of serum, %	46.7 ± 1.11	44.3 ± 1.69
ESR, mm/h	2.82 ± 0.38	2.73 ± 0.43
The age of the poultry - 30 weeks (after 3 months of keeping)		
Erythrocytes, T/l	3.3 ± 0.34	3.4 ± 0.28
Leucocytes, G/l	43.24 ± 1.09	40.17 ± 0.87
Lysozyme activity of serum, %	37.1 ± 3.16	39.3 ± 2.84
Bactericidal activity of serum, %	44.3 ± 1.51	51.8 ± 2.01*
ESR, mm/h	2.72 ± 0.17	2.88 ± 0.23
The age of the poultry - 47 weeks (after 7 months of keeping)		
Erythrocytes, T/l	3.3 ± 0.25	3.4 ± 0.36
Leucocytes, G/l	46.1 ± 0.92	43.2 ± 1.19
Lysozyme activity of serum, %	36.9 ± 2.93	39.3 ± 3.04
Bactericidal activity of serum, %	42.7 ± 1.66	56.7 ± 1.84**
ESR, mm/h	2.95 ± 0.19	3.03 ± 0.16

Note: * - P<0.05; ** - P<0.01.

According to the results of the analysis of blood samples from hens from the experimental poultry house, a slightly larger number of erythrocytes per 1 mm^3 of blood and smaller amount of leukocytes was noted and, although differences between poultry houses were statistically improbable according to these indicators, one can note the tendency of the positive effect of the proposed technique on the poultry. The hens from the experimental poultry house had also a greater lysozyme and bactericidal activity of the serum than the ones from the control poultry house. According to the latter indicator, the difference in the poultry at the age of 30 and 47 weeks was statistically probable, indicating a positive effect of the proposed technique on the overall resistance of the poultry. In general, during the experiment, hematological blood indices did not go beyond the permissible values.

As in the previous experiment, 10 heads of poultry from each poultry house were slaughtered in the end of this experiment to study the development of internal organs (Table 10). The live weight of the poultry in this age was: in the control poultry house - 1943.5 ± 29.4 g, in the experimentalpoultry house - 1964.2 ± 33.7 g. Some advantage of hens from the experimental poultry house in absolute weight of individual internal organs was determined, although this advantage and was not statistically probable.

Table 10. Development of internal organs of the poultry in the experimental groups (the age of the poultry - 47 weeks), (M ± m, n=10).

Name of internal organs	Control poultry house		Experimental poultry house	
	Absolute mass of the organ, g	Relative mass of the organ (% of live weight of the poultry)	Absolute mass of the organ, g	Relative mass of the organ (% of live weight of the poultry)
Liver	34.9 ± 1.63	1.8	35.6 ± 1.48	1.8
Spleen	3.6 ± 0.27	0.2	3.7 ± 0.24	0.2
Heart	9.9 ± 0.32	0.5	9.9 ± 0.26	0.5
Gizzard stomach	38.2 ± 1.23	1.9	40.6 ± 1.27	2
Kidneys	14.4 ± 0.26	0.7	15.2 ± 0.35	0.8

Thus, on the basis of the analysis of the results of this experiment, it can be concluded that the proposed technique is effective in the conditions of industrial production of hen eggs. The problem of reduction of anthropogenic loading by the results of modern poultry farming resonates with the issue of ecological consciousness, as evidenced by the emergence of a new direction - postenvironmentalism (post-ecologism). In the opinion of (Swyngedouw & Ernstson, 2018), the ideology of the self-value of the nature (environmentalism) is being replaced by postenvironmentalism. The latter focuses on the problem of responsibilityof people for the results of their own actions, and the person acquires the features of the creator, demiurge in the context of the new geological era.

Postenvironmentalism is emerging as a trend that harmonizes the latest scientific advances in poultry farming and philosophical methodological principles, forming a new coordinate system, where social and technological practices are deployed. In this context, design technologies (a set of measures and actions aimed at counteracting the unwanted consequences of technological and technological activity of modern society) deserve attention. The issue of coordinating the realization of existing potential and possible costs of material and technical resources in poultry farming with the awareness of the possible negative impact of the results of human activity on the environment acquires a new configuration. In this context, technologies appear to be 'responsible', taking into account the possible risks and dangers of its use; the axiological component of technological systems determines the scientific discourse of now-a-days.

At present, forced ventilation is a conventional way of removing harmful substances from poultry houses, which entails a high cost of energy and, accordingly, an increase in the cost of finished products. In addition, the removed air contaminates the environment. In this case, the part of the air emitted through the system of inflow ventilation falls back into the poultry house. And if a purification system from organic compounds for the air emitted is not previewed, the effectiveness of such ventilation is drastically reduced (Costa et al., 2012).

One of the least costly ways to solve this problem, according to (Salifou et al., 2013), is a partial cleaning the air in the poultry house by creating an internal recirculation system. Such a system allows partial cleaning the air in the poultry house from organic dust, disinfecting and deodorizing the air, significantly improving the sanitary and hygienic conditions for the poultry keeping. The basis of such a system is the technology of decontamination of the air, based on its irradiation by short-wave ultraviolet irradiation with the simultaneous introduction of small amounts of ozone into the air. As a result of the combined action of UV radiation and ozone, there is an effect of mass death of microorganisms in the air, including bacteria, viruses, spores and mold in the poultry houses. In addition, ozone present in the treated air actively deodorizes the air, destroying aromatic substances.

A series of photochemical ozone generators has been specially developed for sanitary treatment of the air in the poultry houses (Destaillats et al. 2014; Waring & Siegel, 2011). These generators use special high-frequency sources of UV radiation, which together with the generation of short-wave UV radiation form ozone in the irradiated air. Ozone is a strong disinfectant. When 0.01 m^3 of ozonized air is added to 1 m^3 of the purified air, the content of ammonia, hydrogen sulfide and carbon dioxide in the purified air is reduced to the MPC. Such concentrations of ozone do not harm the poultry or the environment.

In the first experiment we studied how the bactericidal device, which included 24 bactericidal tubes TUV-75W consisting of 12 radiators OBNP-PV 2 × 75, placed in two concentric ranges in the collector of the air duct mixer affects the poultry. The studies have shown that nicrobial contamination of the air in the experimental poultry house was less than in the control poultry house: in the cold season (December-February) - by 2.8 times on the average, in the transition season (October-November and March-April) - by 2.2 times.

It has been established that the treatment of air with ultraviolet irradiation contributed to some reduction in the concentration of toxic gases in it. The content of ammonia in the air of the experimental poultry house in the cold season was reduced by 1.23 times, carbon dioxide - by 1.07 times, compared with the control poultry house; in the transition season, - by 1.18 and 1.11 times, respectively, but the difference in carbon dioxide content between poultry houses was statistically improbable.

The reduction of microbial contamination of the air positively influenced the survival and productive parameters of the poultry. During 212 days of the productive period, the poultry's survival in the experimental poultry house was higher by 0.8% ($P<0.001$), 1.3 pcs. ($P<0.05$) of eggs more were obtained per one egg laying hen, and the egg mass was higher by 0.7 g ($P<0.05$) than in the control poultry house. Generally, during 7 months, 61.464 thous. pcs. or 9.243 tons of eggs more were obtained in the experimental poultry house, the specific feed costs in this poultry house were lower: by 0.8% per 10 eggs and by 2.0% per 1 kg of egg mass.

According to the analysis of blood samples from the poultry from the experimental poultry house, a larger number of red blood cells in 1 mm^3 of blood and smaller of leukocytes was noted, but due to the fact that the differences between poultry houses on these indicators were statistically improbable, we can only talk about the positive effects of the air treatment with ultraviolet irradiation on the physiological state of the poultry. The poultry from the experimental poultry house also had a greater lysozyme and bactericidal activity of the serum than the ones in the control poultry house. According to the latter indicator, the difference in the age of the poultry of 30 and 47 weeks was statistically probable ($P<0.05$). In general, during the hematological test, blood indices did not go beyond the permissible values, indicating no negative effect of the proposed technique on the poultry. Some advantage of the hens from the experimental poultry house in terms of the absolute mass of individual internal organs was determined, although this benefit was also not statistically probable.

In the other experiment, the effect on on the poultry's main productive parameters and the clinical state of the proposed technique of reducing the content of toxic gases in the air by cleaning it in a scrubber was studied. It was found that in the cold season, the scrubber provided the 2.1-1.5 times reduction of the ammonia content in the air of the poultry house during the first-fifth day of use of the active substance compared with the control. In the transition season, the content of ammonia in the experimental poultry house and in the control poultry house was lower than in the cold season. The content of ammonia in the experimental poultry house was 1.9-1.4 times lower compared with control. The treatment of the air in the poultry house in the scrubber did not significantly affect of carbon dioxide content in the air. Hydrogen sulfide has not been recorded during any research period in any of the poultry houses.

Lowering the ammonia content in the poultry house had a positive effect on the poultry's survival and its productive parameters. Thus, in the experimental poultry house, the poultry's survival was 0.7% higher ($P<0.001$), 1.6 pcs. of egg or by 1.0% ($P<0.01$) more were obtained and the egg mass was 212 g or 2.1% higher per one egg laying hen than in the control poultry house. In the same poultry house an average egg mass was 0.7% greater ($P<0.05$). As a result, during 210 days of the experiment, 75.648 thous. pcs. of eggs and 10,041 tons of egg mass more were received in the experimental poultry house than in the control one. In the experimental poultry house, feed costs per 1 kg of egg mass were slightly lower (by 1.3%). The results obtained are also consistent with the results obtained by several other authors (Casey et al., 2010; Naseem & King, 2018), which noted the positive effect of reducing the microbial contamination of air and ammonia content in poultry houses on productive parameters of the poultry.

Conclusion

The use of the proposed techniques in the production verification, including: disinfection of the air in the system of drying of the litter with ultraviolet irradiation and the installation of the mixer of a scrubber with a phosphogypsum reagent in the chamber provided a reduction of microbial contamination and the ammonia content in the air of the poultry house to a level below the MPC, increasing the poultry's survival by 1.5% and their egg laying capacity by 2.2 pcs. of eggs, and reducing feed costs by 2.3% per 1 kg of egg mass.

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