Methods of air disinfection in livestock premises with a combination device

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Abstract. In agricultural premises, the air environment contains many pathogenic microorganisms. The spread of microorganisms occurs from animals, room surfaces, with ventilation air from wet feeds. Microorganisms spread over long distances with the help of aerosols. Retention of various microorganisms on aerosols can take up to four hours. To exclude infection, it is necessary to clean, disinfect and deodorize the air. The purpose of the work is to increase the efficiency of air disinfection in agricultural premises. Measurements of microbial contamination of the air were made by bacteriological culture test using Petri dishes, before and after disinfection of the air in the premises. The results were processed in a microbiological laboratory. Calculations of bactericidal efficacy were carried out. The combination of an electric air filter and an ultraviolet lamp Phillips TUV 15W/G5 T8 showed the best results of airflow disinfection. The operation of the unit does not affect animals, since the concentration of ozone released is more than five times lower than the maximum permissible concentration for animals. Consequently, animals receive dust-free and disinfected air, which leads to a decrease in animal mortality and, possibly, to an increase in their productivity.

1. Introduction
In agricultural premises, the air environment contains many pathogenic microorganisms. The spread of microorganisms occurs from animals, room surfaces, with ventilation air from wet feeds. Microorganisms spread over long distances using aerosols [1-9, 11]. Retention of various microorganisms on aerosols can occur for up to 4 hours. With the help of aerosols, microorganisms spread over various distances. With the help of an aerosol, these microorganisms are deposited on various surfaces. When keeping a large number of animals indoors, rapid infection with microorganisms occurs. Saprophytes are one of the main species compositions of microorganisms in livestock premises.

The quality of the ventilation system, the quality of the sewage system, sanitary and hygienic requirements for equipment and construction, and some other factors affect the number of microorganisms in the livestock premises. Where there is a failure to comply with these requirements, there is a surge of bacteriological contamination of the air. Opportunistic bacteria are the main cause of the high incidence of disease in cattle [2, 5, 6].

To exclude infection, it is necessary to clean, disinfect and deodorize the air. First of all, it is necessary to observe and timely comply with all norms and rules for the maintenance and feeding of animals, it is necessary to organize the operation of microclimate systems in an uninterrupted format, timely manure cleaning, constant cleaning and disinfection of agricultural premises.
To reduce the level of air contamination around the farm, it is necessary to emit contaminated air from the agricultural premises upwards, with a torch, to the height of the air shadow level [12-15]. It is necessary to allocate places for supply air intake on the end parts of buildings. Because in these cases, the MPC does not exceed 20 percent of the concentration of harmful gases and microflora. It is necessary to install canopy on axial exhaust fans, pipes having a bend in the lower part, which will help to reduce contaminated air from two to five times [2, 5, 6, 8, 12]. We will consider microbial air contamination in more detail below.

We will consider the main methods of air disinfection in agricultural premises. This can be both the use of ozone-producing units, aerosol generators and ultraviolet air disinfection units.

One of the most effective methods is air ozonation. Ozone is a blue gas with a strong smell, a strong oxidizer, 2.5 times heavier than oxygen. By oxidizing impurities of various substances and microorganisms, ozone disinfects the air. The effectiveness of air ozonation can be explained by the fact that there is a partial destruction of virus envelope, so that they can no longer multiply and connect with the cells of living organisms. But there is also a negative side of the ozone use, namely, that it is most effective in large quantities, therefore, it is necessary to treat the premises in the absence of people and animals. If there are living organisms in the premises, then it can burn the mucous membrane of the respiratory organs, which has a detrimental effect. Ozone can be obtained using an electric corona discharge.

Aerosol generators are a series of devices that produce and spray aerosols. They are: mechanical (pneumatic, ultrasonic and disk) and thermomechanical. In agriculture, thermomechanical aerosol generators have become the most widespread. The principle of their operation is as follows: the aerosol is produced as a result of mechanical crushing of the aerosol forming liquid when it is fed into the combustion chamber of the air-fuel mixture, subsequent evaporation, after which vapors enter the environment and mix with the outside air, condensation and transformation into an aerosol. With the help of such generators, in addition to air disinfection, it is possible to spray medicines in livestock premises. Also, to create the effect of air conditioning, which is important when using recirculation ventilation, mechanical, both disk and ultrasonic aerosol generators can be used. The disadvantage may be an increase in air humidity and, in some cases, the presence of extraneous noise, which can have an adverse effect on the health of animals and service personnel.

Ultraviolet air filtration has also found wide application in air disinfection systems in the agro-industrial complex. Due to the fact that the air with dangerous microorganisms is irradiated, the structure of their DNA is destroyed by exposure to ultraviolet light, receiving sterile air at the outlet. Also, due to exposure to ultraviolet light, organic components can break down into water and carbon dioxide, which do not have a negative impact on living organisms. One of the most significant advantages of using ultraviolet light is that there are practically no traces of ozone release, which makes the use of the unit the most convenient, since there is no need to leave the premises empty. Another positive property of using the unit is that it is silent, which also does not cause discomfort in the presence of living organisms in the premises where the unit works. There is also an insignificant consumption of electrical energy, which neither ozonators nor aerosol generators can guarantee. Also, during the use of ultraviolet air disinfection units, the air is cleaned of dust, which is deposited in dust collectors, which also distinguishes this unit from the ozonator and aerosol generator installations.

The purpose of the work is to increase the efficiency of air disinfection in agricultural premises.

2. Materials and Methods

Measurements of microbial contamination of the air were made by bacteriological culture test using Petri dishes, before and after disinfection (unit diagram Figure 1) of indoor air [10, 12, 13]. The results were processed in a microbiological laboratory [8]. We calculate the bactericidal efficiency by the expression:

\[
BE = \frac{n_d - n_p}{n_d} \cdot 100\%,
\]
where \( n_d \) is the number of microorganisms before irradiation; \( n_p \) is the number of microorganisms after irradiation.

If the bactericidal efficiency (BE) is more than 99%, then disinfection is effective, if less, then it is ineffective and it is necessary to choose another sample of the disinfection source, respectively, repeat the experiments to determine the bactericidal effectiveness [8].

\[
\text{BE} = \frac{n_d - n_p}{n_d} \times 100\%
\]

If BE > 99%, disinfection is effective; if BE < 99%, it is ineffective and it is necessary to choose another sample of the disinfection source, respectively, repeat the experiments to determine the bactericidal effectiveness [8].

![Figure 1. Block diagram of the unit.](image)

The following designations are used in the diagram: - electrical energy; - mechanical energy; - air flow. 1 – Power supply source; 2 - High-voltage power supply source; 3 - Fan motor; 4 - Fan; 5 - Electric corona filter; 6 - Disinfection chamber (ultraviolet or ozone).

### 3. Results

When studying the operation of an electronic filter in conjunction with the Phillips TUV 15W/G5 T8 ultraviolet lamp, with a wavelength of 253.7 nm of predominant irradiation, without ozone release, the data given in Table 1 (Figure 2) were obtained. The experiments were carried out by bacteriological culture test using Petri dishes. The exposure time is 20 minutes.

| Unit operation time \( t \), min | Number of colonies of microorganisms in the room before treatment with the unit, \( N_0 \) | Number of colonies of microorganisms in the room after treatment with the unit, \( N_1 \) |
|----------------------------------|-----------------|------------------|
| 0                               | 347             | 347              |
| 20                              | 347             | 228              |
| 40                              | 347             | 43               |
| 60                              | 347             | 0                |

The ozone concentration was measured with a SIGNAL-4E gas analyzer and data were obtained that the ozone concentration is 5 times lower than the MPC level, which makes it possible to judge the safety of the joint operation of the electric corona filter and ultraviolet irradiation for living organisms (Figure 3).

When studying the operation of the electric filter and the disinfecting ozonizer "KUPOL", with an ozone capacity of 8 g/hour and a power of 250 W, with the number of on/offs equal to 7 per day, the
data given in Table 2 were obtained (Figure 2). The experiments were carried out by bacteriological culture test using Petri dishes. The exposure time is 20 minutes.

Table 2. The results of the joint work of the electric filter and the disinfecting ozonizer "KUPOL".

| Unit operation time t, min | Number of colonies of microorganisms in the room before treatment with the unit, N₀ | Number of colonies of microorganisms in the room after treatment with the unit, N₂ |
|---------------------------|---------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| 0                         | 347                                                                              | 347                                                                              |
| 20                        | 347                                                                              | 187                                                                              |
| 40                        | 347                                                                              | 16                                                                               |
| 60                        | 347                                                                              | 0                                                                                |

Even if disinfection is better, but there is a disadvantage, the concentration of ozone released is almost 2 times higher than the MPC. Consequently, it is not recommended to use such a joint device in premises where living organisms are located (Figure 3).

![Figure 2. Diagram of the obtained results of air disinfection.](image)

Symbols on the diagram: N - Number of colonies of microorganisms in the premises; t - Operating time of the unit, minutes; N₀ - Number of colonies of microorganisms in the premises before treatment with the unit; N₁ - Number of colonies of microorganisms in the premises after treatment with the unit with the ultraviolet lamp; N₂ - Number of colonies of microorganisms in the premises after treatment with the unit with disinfecting ozonizer.
Figure 3. Diagram of the obtained results of ozone emission during the unit operation. Symbols on the diagram: General subject –MPC of ozone in the working area, mg/m³; t - Operating time of the unit, minutes; General subject N1 - Ozone release by the unit with ultraviolet lamp, mg/m³; General subject N2 - Ozone release by the unit with disinfecting ozonizer, mg/m³.

4. Discussions
Disinfection of the air flow passing through the electric filter and the disinfection chamber consisting of the ultraviolet lamp shows its effectiveness. This is due to partial disinfection by side ozone released during the operation of the electric filter, as well as by treating the air flow with ultraviolet light. Consequently, it is clear from the results obtained that this combination shows its effectiveness.

5. Conclusion
The combination of an electric air filter and an ultraviolet lamp Phillips TUV 15W/G5 T8 showed the best results of airflow disinfection. The operation of the unit does not affect animals, since the concentration of ozone released is more than five times lower than the maximum permissible concentration for animals. Consequently, animals receive dust-free and disinfected air, which leads to a decrease in animal mortality and, possibly, to an increase in their productivity.

The joint work of the electric filter and the disinfecting ozonizer "KUPOL", with an ozone capacity of 8 g/hour and a power of 250 W, has shown greater efficiency of air disinfection, but at the same time there is a large increase in ozone concentration, several times higher than the maximum permissible concentration for animals.

With such a combined unit operation, there is a need to free the premises from animals for disinfection and ozone decay, which, in turn, leads to inconvenience and, in some cases, to the impossibility of using such a combination of devices.

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