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Studying The Dynamics Of Air Pollution In Cattle-Breeding Premises Using Bactericidal Emitters.

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ABSTRACT

The article presents the results of studies of the dependence of the level of air contamination of livestock buildings on the methods of its reduction, using the example of the use of ultraviolet irradiators of a closed type. Based on the research recommendations are given on the calculation of the number and productivity of such irradiators, depending on the level of seeding, the volume of the premises and other conditions of keeping the animals.
Keywords: dissemination, microorganism isolation, bactericidal efficiency, recirculate

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INTRODUCTION

In modern conditions of industrial livestock farming, the task of ensuring the veterinary well-being of the herd, where the state of the air environment of animals is of paramount importance, comes first [1].

The air environment is an essential factor in aerogenic airborne transmission of various aerogenic infections, which forces veterinary service workers to take appropriate measures to reduce the air pollution in the premises for keeping animals [3].

There is a direct correlation between the state of animal health and the level of contamination, including bacterial, of the air they breathe. Therefore, a decrease in the dissemination of the air environment is, in such conditions, one of the main tasks in ensuring the veterinary welfare of animals. [2, 4].

The aim of this work is to predict, based on mathematical models, the level of airflow of livestock premises, depending on the methods of reducing it, using the example of the use of ultraviolet irradiators of closed type (recirculation) with forced air supply.

MATERIAL AND METHODS

To construct a mathematical model for the dynamics of the level of air concentration (concentration) in livestock buildings, the methods of process idealization are used to simplify the real multifactorial picture, methods of generalization that involve studying the process without using the numerical values of a particular indicator of the process. In the work, methods of mathematical analysis of the solution of differential equations were also used, and for application of the graphs, the applied programs «Matematica-5».

The mathematical model was constructed on the assumption that in the room of volume *V* there is a source (sources) of continuous entry of microorganisms into the air, with a productivity of *Q*, which, getting air, increasing its seeding *n*.

It should be noted that due to the natural death of microorganisms in the air, such an increase cannot occur indefinitely and leads to a certain "saturation" state, depending on such factors as air temperature and humidity, illumination, dustiness, biochemical and dispersed dust composition and.

The intensity of natural death of microorganisms in the air will be characterized a parameter λ, inversely proportional to the average lifetime of microorganisms in the air

The mathematical model of such a saturation process can be described by means of a differential equation:

$$dn = \frac{Q}{V}dt - \lambda \cdot n \cdot dt \quad (1)$$

n – current seeding (concentration), pcs/ m^3;
Q – capacity of the source, bt/s;
V – room volume, m ^{3}:
t – time, s;
λ – the indicator of natural death of microorganisms, 1/s.
m.b./s – microbial bodies per second.
The solution of this equation has the form:

$$n(t) = \frac{Q}{\lambda \cdot V}(1 - e^{-\lambda t}) \quad (2)$$

Expression (2) shows the increase in the dissemination of the premises, depending on the time *t*, at the initial moment, ($t = 0$) in the "pure" state.

The use in this environment of bactericidal radiators of the closed type, with a forced air supply (recirculation), reduces the level of air contamination of livestock premises, depending on their productivity *V* and bactericidal efficiency *J*, showing the ratio of seeding at the inlet of the circulator and at its outlet.

The mathematical model of the dynamics of variation of the seeding, in this case, can be described by a differential equation of the form:

$$dn = \frac{Q}{V}dt - \lambda \cdot n \cdot dt - n\frac{\dot{V}}{V}\left(1 - \frac{1}{J}\right) \quad (3)$$

$\dot{V}$ – productivity of the recirculator on pumped air, m^3/s

J – bactericidal efficiency of the recirculator

The solution of this differential equation has the form:

$$n_p(t) = \frac{Q}{V \cdot \left(\lambda + \frac{\dot{V}}{V}\left(1 - \frac{1}{J}\right)\right)}\left(1 - e^{-\left(\lambda + \frac{\dot{V}}{V}\left(1 - \frac{1}{J}\right)\right)\cdot t}\right) \quad (4)$$

$n_p(t)$ - current seeding of the premises when using a recirculator, pcs/m^3.

Or, in a more familiar form:

$$n_p(t) = \frac{Q}{V \cdot \left(\lambda + \frac{\dot{V}}{V}\left(1 - \frac{1}{J}\right)\right)}\left(1 - \exp\left(-\left(\lambda + \frac{\dot{V}}{V}\left(1 - \frac{1}{J}\right)\right)\cdot t\right)\right) \quad (5)$$

RESULTS AND DISCUSSION

For the visual perception of the relationships (2) and (5), the changes in the air distribution of premises with the conditions in which such a population is observed are presented in Fig. 1 appropriate timetable.

The indicated graph is constructed in dimensionless coordinates. The horizontal axis represents the dimensionless quantity λt which can be called the reduced time, and along the vertical axis a dimensionless quantity $\frac{n\lambda V}{Q}$ which can be called reduced contamination.

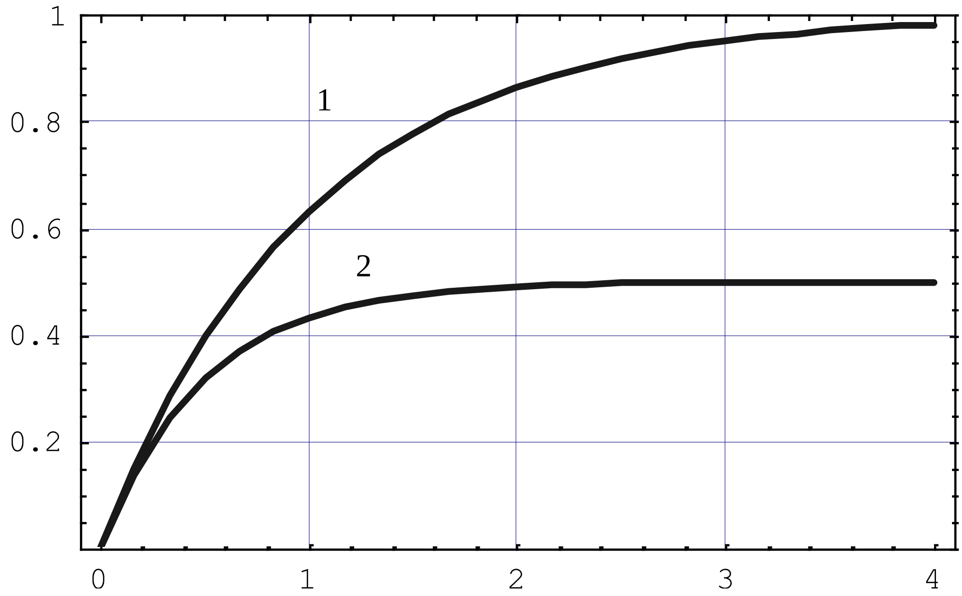
For specific calculations of seeding, it is possible to use simplified formulas (6) and (7) for established contamination, which is obtained from formulas (2) and (5), respectively.

$$n = \frac{Q}{\lambda \cdot V} \quad (6)$$

$$n_p = \frac{Q}{V \cdot \left(\lambda + \frac{\dot{V}}{V}\left(1 - \frac{1}{J}\right)\right)} \quad (7)$$

The first of them allows us to determine the established air contamination in the livestock house at a known volume, as well as the known values of the productivity of supply to the air of microorganisms and the rate of natural death of microorganisms.

The second formula allows us to determine the established air contamination in the cattle-breeding room under the same conditions as the previous one but with the addition of technological parameters of the recycle, namely, the air productivity and bactericidal efficiency.



1. Without recycling. 2. Using the recirculator.

Figure 1: Dynamics of changes in seeding depending on air parameters premises and technological parameters of the recirculator.

As an example, consider the application of formulas for real cases. We will estimate the dissemination of air on the premises for keeping animals. Let it be known that the room in which the animals are kept has a volume V = 50000 m^3, let the productivity of the source of microorganisms entering the air is Q = 50000 microbial bodies/s, we also assume that the index of natural death of microorganisms in the air is $\lambda = 10^{-4}$ 1/s. Then, in accordance with (6), we get that the steady seeding is:

$$n = \frac{5 \cdot 10^4}{10^{-4} \cdot 5 \cdot 10^3} = 10^5 = 100000 \ m.b./m^3$$

Thus, we have obtained that the established contamination will amount to 100 thousand microbial bodies per 1 m^3 of air.

We calculate the seeding of the same room under the same conditions, but with the addition of a recirculator whose air capacity is V = 5 m^3/s, and the efficiency of the bactericidal efficiency of the recirculator is J = 20. In this case, in accordance with (7) we obtain:

$$n_p = \frac{5 \cdot 10^4}{5 \cdot 10^3 \cdot \left(10^{-4} + \frac{5}{5 \cdot 10^4}\left(1 - \frac{1}{20}\right)\right)} = 0.51 \cdot 10^5 = 51000 \ m.b./m^3$$

In this way, seeding is established by calculation, equal to 51 thousand microbial bodies per 1 m^3 of air.

CONCLUSION

The analytical expressions obtained above linking the dissemination with other parameters of the process make it possible not only to predict the importance of the dissemination of any livestock premises but also to meaningfully carry out measures to reduce it, using various techniques and technical means, including recirculators. At the same time, it should be noted that for the successful use of the relationships obtained, studies are needed that are related to the refinement of such process parameters as an indicator of the natural death of microorganisms and the productivity of the source.

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