# A COMPARATIVE EVALUATION OF THE EFFECTIVENESS OF BACTERIA TRAPS USING AN OBJECTIVE METHOD FOR DETERMINING THE CONCENTRATION OF A BACTERIAL AEROSOL

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Foreign Technology Division
Wright-Patterson Air Force Base, Ohio

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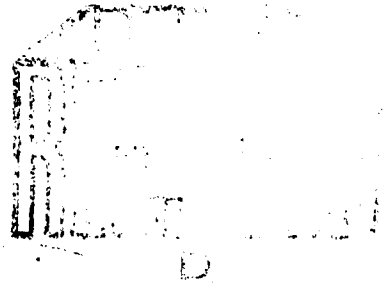

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# A COMPARATIVE EVALUATION OF THE EFFECTIVENESS OF BACTERIA TRAPS, USING AN OBJECTIVE METHOD FOR DETERMINING THE CONCENTRATION OF A BACTERIAL AEROSOL

V. S. Kiktenko, S. I. Kudryavtsev
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In order to determine the microorganism content in air, a large number of devices based on various principles has been proposed for catching bacteria. Most of the devices do not have sufficient effectiveness with respect to determining the particles of the bacterial and viral aerosols.

A comparative analysis of the effectiveness of the various bacteria traps cannct be accomplished due to the absence of objective methods for determining the bacterial aerosol concentrations. The most accurate data which describe the actual effectiveness of the devices could have been obtained by comparing the obtained results with the determination data on the bacterial aerosol concentration per unit volume of air in the period samples were taken. However, the existing methods for a qualitative description of the aerosol, in addition to being tedious and time consuming, to a considerable degree are based on subjective methods of estimation, which does not provide for accurate results of studies.

We attempted to apply the objective method for determining the particle concentration in bacterial aerosols, based on using flow-through ultramicroscope VDK. Based on the latter we developed a highly sensitive device with an electromechanical counter, which permits us to count the number of aerosol particles passing through a cuvette automatically. Using the new method for determining the aerosol concentration, we carried out a comparative evaluation of the traps property of the devices designed by V. S. Kiktenko, S. S. Rechmenskiy, P. P. D'yakonov, A. Ye. Vershigora, and N. M. Rudenko, and of the soluble filters made from gelatin foam, and also cotton filters impregnated with a 3% solution of gelatin and vaseline mixture, i.e., devices based on the filtration of aerosols through the liquid and dense soluble filters, and also on the settling of aerosols by the dispersed liquid. The procedure for setting up and using the devices was in accordance with the instructions set up by the authors of these bacteria traps. In the experiments we produced droplet-type and dense aerosol phases of Chromobacterium prodigiosum (strain No. 1266) with particle dispersion from 0.6 to 3.4 μ and Bacillus subtilis (strain No. 8236) with the average particle radius value equal to 5 μ. Bacterial suspensions containing 0.5 billion microbe cells were prepared from a physiological solution with an addition of 15% glycerine and 5% sucrose solution; in preparing suspensions of chromobacterium prodigiosum bacillus we also used gelatin phosphate buffer (gelatin - 2 g, $Na_2HPO_4$ - 4 g, distilled water - 1000 ml; pH - 7.0). Suspension containing Bacillus subtili spores was heated with shaking at 70-80° for a period of 5-10 min before use. The sampling was carried out simultaneously by 4 bacteria traps, 10 liters of air was passed through each, the sampling period lasted 1-3 min.

The study results are presented in Table 5.

Table 5. Comparative effectiveness evaluation of the bacteria traps (average data from 32 series of studies).

| No. | Devices | Average number of microorganisms determined in 1 ℓ of air | |
|---|---|---|---|
| | | Chromobacterium prodigiosum bacillus | Bacillus subtilis |
| | Bacteria-catcher designs: | | |
| 1 | v. S. Kiktenko..... | 5,581 | 6,286 |
| 2 | S. S. Richmenskiy..... | 3,189 | 4,281 |
| 3 | P. P. D'yakonov..... | 3,081 | 3,862 |
| 4 | N. M. Rudenko..... | 1,859 | 2,303 |
| 5 | A. Ye. Vershigora..... | 1,451 | 2,402 |
| 6 | Soluble filters made from gelatin foam..... | 152 | 1,922 |
| 7 | Cotton filters: | | |
| | a) dry cotton wool..... | 21 | 861 |
| | b) dry glass wool..... | 42 | 693 |
| | c) glass wool impregnated with a 3% solution of gelatin and vaseline mixture..... | 37,218 | 42,680 |
| | d) cotton wool impregnated with a 3% solution of gelatin and vaseline mixture..... | 26,534 | 31,871 |

As seen from the presented data, the greatest number of microorganisms per 1 ℓ of air was determined by means of the impregnated cotton filters. The insignificant number of microorganisms determined on the cotton wool and glass wool filters without impregnation is evidently explained by death of Chromobacterium prodigiosum bacillus, which is supported by the results of the study of Bacillus subtilis. We should also take into account the difficulty connected with washing out the microorganisms from the cotton.

Data presented in Table 5 obtained their confirmation during the study of the retaining property of devices, using the nephelometry method with respect to the oil mist particles and Chromobacterium prodigiosum bacillus aerosol. The particle size of the oil mist was 0.31-0.34 μ.

The study results are presented in Table 6.

Table 6. The slip-through factor in various devices with respect to oil mist and bacterial aerosol particles.

| Filter material | Amount of material (in g/ml) | Slip-through factor (in %) | |
|---|---|---|---|
| | | Oil mist | Bacterial aerosol |
| Glass wool..... | 10 | 2.1 | 5.5 |
| Cotton wool..... | 5 | 0.08 | 1.05 |
| Glass wool impregnated with a 3% solution of gelatin and vaseline mixture..... | 10 + 12 ml of impregnation | 8.1 | 0.35 |
| Impregnated cotton wool..... | 5 + 12 ml of impregnation | 0.1 | 0.02 |
| Bacteria traps of different designs..... | 4-40 ml of filtered liquid | 42-48 | |

As shown by the data (presented in Table 6) the highest slip-through factor was observed in the devices of various designs; the lowest retaining property was noted in the soluble filters made from gelatin foam in which the slip-through factor comprised 92-98%. The device designed by V. S. Kiktenko had a slip-through factor in the range of 42-48% with respect to the oil mist.

Bacterial aerosol concentration in the chamber was determined during the sampling period by means of a photoelectronic device (Table 7).

Table 7. Aerosol particle concentration in the chamber during the air sampling period (average data based on 18 series of studies).

Readings by the photoelectronic particle counter (in 1 l of air)

| Immediately after spraying | after 3 min | 5 min | 10 min | 15 min | 20 min | 25 min | 30 min |
|---|---|---|---|---|---|---|---|
| 1 441 700 | 1 438 286 | 1 396 018 | 1 106 321 | 1 028 046 | 987654 | 967304 | 804206 |

The aerosol concentration was calcu. ted by the formula:

$$n = \frac{N}{V} = \frac{d \cdot N}{W},$$

where N - number of counted flashes (particles); W - aerosol volume; d - constant of the given diaphragm opening with a given optical system; V - aerosol volume in which the number of particles was counted.

As seen from the data presented in Table 7 the aerosol concentration in the chamber dropped only 5% ten minutes after the suspension was sprayed relative to its initial concentration determined immediately after the suspension was sprayed. Consequently, no significant change in aerosol concentration was noted during the sampling period.

Considering the fact that the photoelectronic counter determines the total concentration of aerosol whose particles do not necessarily contain the microorganisms, it seemed advisable to compute the approximate number of particles containing the microbe cells per unit volume.

To determine the total number of particles of the bacterial aerosol containing microbe cells, we used the method of drying the droplet phase of the bacterial aerosol by passing it through

the silica gel desiccating columns. Concentration of the bacterial aerosol particles (solid or droplet-nuclear fraction) determined by means of the photoelectronic particle counter comprised on the average 43,250/1 l of air in the chamber during the sampling by the devices, which comprised about 3% of the total number of aerosol particles. Using this method to determine the number of aerosol particles containing the microorganisms and, also, taking into account the evaluation results of the device effectiveness, it is possible to determine an approximate quantity which characterizes the trapping property of a particular device. Thus, taking into consideration the data in Table 5, we find that with the aid of the bacteria trap with cotton filters impregnated with a 3% solution of gelatin and vaseline mixture, 89% of all microorganisms found in a unit volume of the chamber air are determined; the trappingproperty of other devices varies in the range of 0.3 to 14%. It is necessary to indicate that the presented data do not include the percent of microorganisms that die during the spraying and sampling using the bacteria traps of various designs.

## CONCLUSIONS

1. The methods used by various authors to determine the effectiveness of the bacteria traps based on the sedimentation and filtration principle rely on subjective methods of estimation, which affects the accuracy of the obtained results.

2. We propose an objective method for estimating the effectiveness of the bacteria traps, using the photoelectronic particle counter which enables one to determine the traps property of devices taking into account the concentration of the bacterial aerosol particles during sampling.