Effect of Air-Ion Concentration on Microflora in Living Spaces

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Abstract. *Using the aeroscopic method and aspiration capacitor the effect of the density of ion concentration on the number of bacterial colonies in selected spaces was examined. The experiment was carried out in a Faraday cage and in a laboratory of the Department of Theoretical and Experimental Electrical Engineering (DTEEE). During the measurement the current value of the density of air ions was recorded. In the paper the methodology is described for the measurement of ion fields and the results are given of the change in the number of bacterial colonies due to short-term ionization of a closed space. A comparison of the measurement results obtained for different ion concentrations indicates the possibility of reducing pathogenic bacteria and fungi by increasing the concentration of air ions in closed spaces.*

Keywords: aspiration capacitor, measurement of ion concentration.

1. Introduction

Air ions are extremely important for human health. Air ions affect the metabolic functions of cells in the lungs, the blood supply in the organism, and also the psychic functions of man. Through their electric charge the air ions also affect the earth's atmosphere and the environment we live in. The metrology of air ions has been known for a long time. One of its methods is based on measurement using the aspiration capacitor. This method is applied in the measurement described in this paper. The aim of the study described is to verify the hypothesis of reducing the number of bacteria and fungi in the air of living spaces.

2. Measuring method

An aspiration capacitor with variable electric field and an electrometer for measuring small currents were used to measure the concentration of various kinds of ions (light-weight, light heavy-weight, heavy-weight) and ions of different polarities. The principle of the measuring method is obvious from Fig. 1; it has been taken over from [1] and [2]. A known amount of air under examination $M = 1.021 \,.\, 10^{-3}$ m/s (volume rate of flow) flows through a cylindrical capacitor, which has polarization voltage U ($U = 0 - 100$ V).

Electrostatic forces attract the air ions to the electrodes. The number of ions captured by the electrode create a small electric current I. The concentration of ions of one polarity is proportional to the magnitude of this current according to the relation

$$n = \frac{I}{M \cdot e} \qquad (1)$$

where $e = 1.6 \,.\, 10^{-19}$ C is the electron charge.

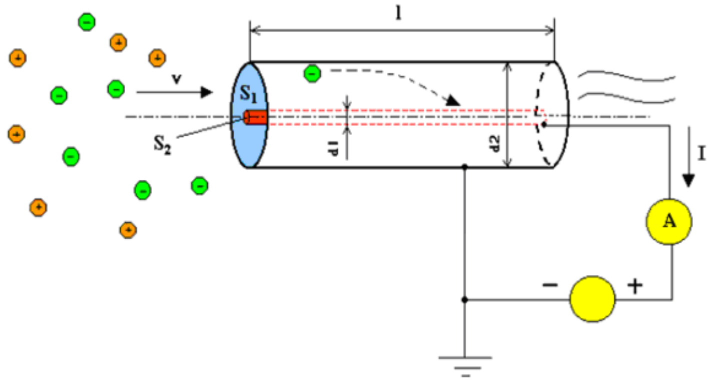

Fig. 1. Principle of measuring air ions, using aspiration capacitor.

The capacitor collector captures all ions whose mobility is lower than the minimum mobility given by the relation

$$k_m = \frac{M}{4 \cdot \pi \cdot C \cdot U} = \frac{M \cdot \ln \frac{d_2}{d_1}}{2 \cdot \pi \cdot l \cdot U}, \tag{2}$$

where M is the volume rate of flow of air through the capacitor, C is the capacitor capacitance, U is the voltage across the electrodes, and d_1, d_2 and l are the dimensions of the aspiration capacitor. The methodology of measuring and the calculations are described in more detail in [1, 2 and 3].

Aeroscopic measurement of air was carried out in cooperation with the Department of Preventive Medicine of Masaryk University in Brno. Samples of air were taken using the BIOTEST HYCON RCS Plus measuring instrument. Used as the culture medium was the strip for total capture of bacteria. The volume of air taken was 200 l and the results were converted to values per 1 m^3.

3. Experimental results

Two different spaces were chosen for the measurement. The first was a Faraday cage with a minimum magnitude of electric field. We assumed that the negative air ions would be concentrated in the centre of the cage and that the number of bacteria and fungi would be comparable with the laboratory space. In the course of measuring the quality of air by the aeroscopic method the density of ions in the space being measured was recorded during and after ionization. The space was ionized by a BIV-06 ionizer.

The other space was an infrequently used laboratory. This space approaches working and living spaces in which people will usually stay for quite some time. The measurement proceeded in the same way as in the case of Faraday cage.

Measurement in the Faraday cage
The BIV-06 ionizer was axially positioned 2.5 m from the aspiration capacitor opening. In the course of the measurement of ions, samples of air were taken simultaneously. The first two measurements were performed without ionization and the results were averaged. Another two measurements took place after 10 minutes' ionization and the results were again averaged. The results of measuring the ion fields are given in Fig. 2. On this figure the ion concentration

increases after 60 and then it decays. This effect could have been caused by air turbulences what was started up after closing the Faraday cage door. With a natural ion concentration in the Faraday cage of ca. 700 ions/cm^3 (Fig. 2, left) an average of 198 bacterial colonies per 1000 l of the air being measured and 2 colonies of fungi were measured. The results show the evident effect of ionization on the number of bacteria in the space. After 10 minutes' ionization, the number of bacterial colonies dropped by 7.5%.

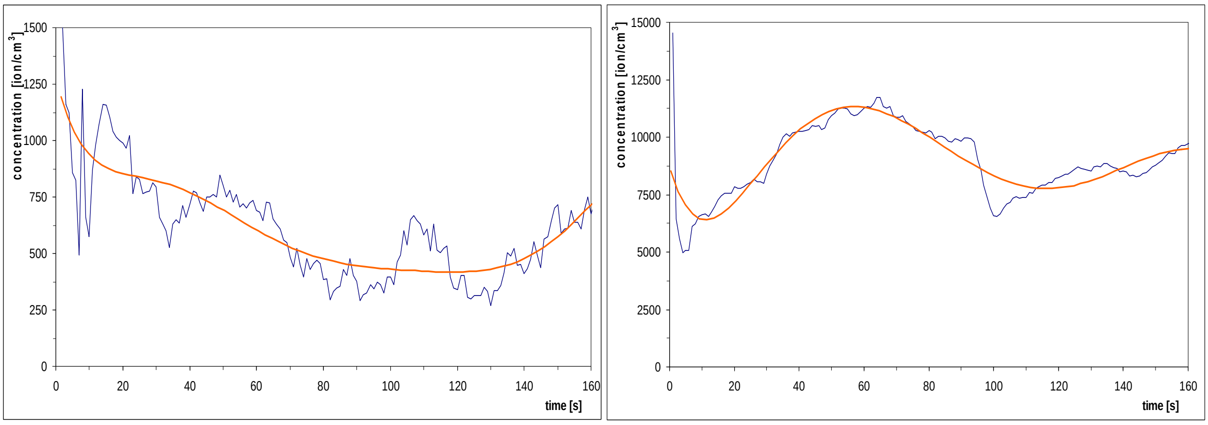

Fig. 2. Natural concentration of air ions in Faraday cage, left – before ionization, right – after ionization.

Measurement in the living space

The BIV-06 ionizer was used for the measurement in the living space. The ionizer was positioned in the axis of aspiration capacitor at a distance of 2.3 m from its opening. Prior to the ionization, 125 ions/cm^3 (Fig. 3), 300 bacterial colonies and 1 colony of fungi were measured in the space.

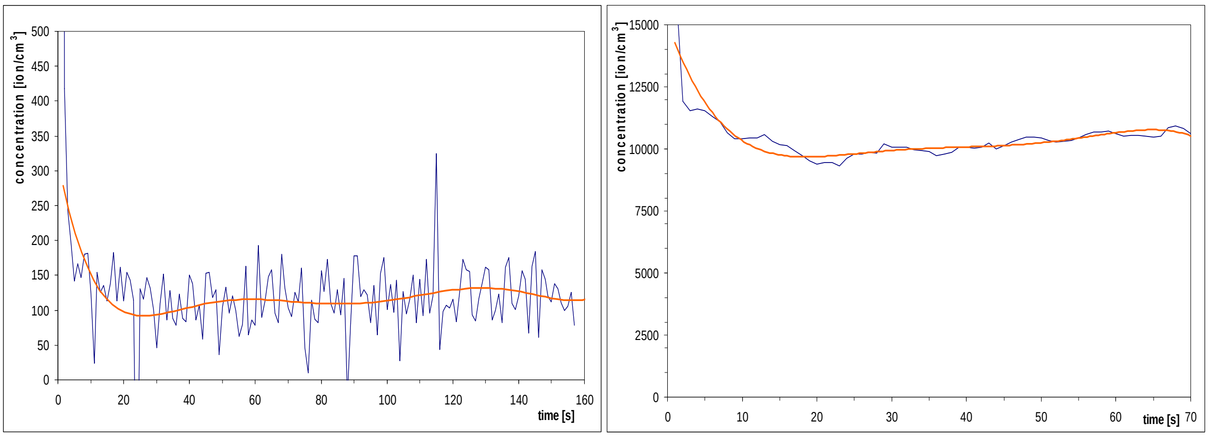

Fig. 3. Natural concentration of air ion in the laboratory, left – before ionization, right – after ionization.

After 25 minutes' ionization in the laboratory an average of 10 500 ions/cm^3 (Fig. 3), 125 bacterial colonies and no fungi were measured. The drop in the number of bacterial colonies was 58 %.

4. Conclusion

In cooperation with the Department of Preventive Medicine of Masaryk University in Brno the effect of the concentration of air ions on the number of bacteria was measured in two spaces. An electromagnetically shielded Faraday cage and the space of a DTEEE laboratory were chosen as spaces for the experiment. In the two spaces the natural concentration of air ions was measured using an aspiration capacitor while natural microflora was measured by the aeroscopic method. In the Faraday cage an average air ion density of 900 ions/cm^3 was measured while the value for the living space was 150 ions/cm^3. The high number of air ions in the Faraday cage corresponds with the reduced recombination of ions in a space with markedly reduced electric field. For the above density of air ions and average of 200 bacterial colonies per 1000 l of air were measured in the Faraday cage and an average of 275 bacterial colonies per 1000 l of air in the living space. After the measurement of natural concentration of air ions, the air in the Faraday cage was ionized by a BIV-06 ionizer for a period of 10 minutes. After the 10-minute ionization the average ion density measured for the cage was 9000 ions/cm^3 and the average number of bacterial colonies was 180 per 1000 l of air. The same measurement was carried out in the living space. After 25 minutes of ionization by the BIV-06 ionizer, 10 500 ions/cm^3 were measured while the number of bacterial colonies dropped to an average of 110 per 1000 l. It follows from the results measured that the density of air ions and the time of ionization affect the number of bacterial colonies in ionized spaces. With an initial ion density of 10 500 ions/cm^3 and an ionization duration of 25 minutes, a 60 % drop in bacterial colonies was established in the living space. In the Faraday cage after 10 minutes of ionization, 9000 ions/cm^3 and a 7.5 % drop in bacterial colonies were established. The higher drop in the number of bacterial colonies in the living space could have been caused by a longer time of ionization. The measurement results show that ionization reduces the number of bacterial colonies and fungi, which is very favourable to the health of people staying in such an environment.

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References

[1] Bartušek K. Měření spektrálních charakteristik iontových polí. http://www.elektrorevue.cz/clanky/01038/index.html, 2001.

[2] Steinbauer M., Fiala P., Bartušek K., Szabó Z. Experiments of Accuracy Air Ion Field Measurement, Progress In Electromagnetics Research Symposium 2007, http://piers.mit.edu/piers/, 2007.

[3] Bartušek K. Měření s aspiračním kondenzátorem, http://www.elektrorevue.cz/

[4] Alpin K. L. Instrumentation for atmospheric ion measurements, PhD. Thesis, University of Reading, August 2000.