Journal of
Physics
Students
http://www.jphysstu.org

The correlation between air ion concentration and altitude in suburbs areas

F. A. Mandija

Physics Department, Faculty of Natural Sciences, University of Shkodra,Sheshi 2 Prilli, Shkodër, Albania.
e-mail: fmandija@yahoo.com
Postal address: Lagja "Vojo Kushi", Rruga "Clirimi", Nr.53, Shkoder, Albania
Tel. +3552247736, Cel.+355692272755 Fax. +3552243747

Received 25 March 2008; accepted 4 May 2008

Abstract - In this paper is presented a study of air ionisation level in the outdoor ambient in correlation with the altitude. The measurements are made in the regions of Shkodra suburbs, Albania. The principal factor studied is small air concentration and the correlation of this concentration with the attitude in the suburbs areas.

PACS: 51.10.+y
Keywords: air ion, aerosol, concentration

1. Introduction

One of the most important properties of the atmosphere is its electric activity [1,2]. The atmospheric electrical conductivity is strongly correlated with the air ion concentration, their properties and spatial distribution. The air ion concentration is correlated with the meteorological parameters [3, 4], the concentration of aerosols [5, 6], the radiation level [7] and the altitude [8]. Some of these principal factors are correlated with the altitude. The measurements have been done in the Republic of Albania near the lake of Shkodra (suburbs of the city of Shkodra).

The study concerns primary on the correlation between the concentration of small air ions and the altitude. It's important to say that the coefficients of the functional correlations determined by the experimental results are related with the conditions of the weather and the specific characteristics of the zones where the measurements have been made.

2. Experimental apparatus and method

The apparatus used is Air Ion Counter [9, 10] which measures selectively the concentration of air ions of both polarities in the intervals $10\text{-}2{\cdot}10^6$ jons/cm^3. In the inner part is a metallic box, with two collector plates inside with distance d=4mm and applied field E=1000 V/m. The velocity of air entering between the plates is Q=200 cm^3/s (linear velocity 40 cm/s). The number of ions captured by the plates in sec is calculated measuring the electrostatic potential of the plate which is grounded by the resistance $R=10^{10}\Omega$. The correlation of the measured electric potential V and the air ion concentration n not taking into account the side effects of the plates, is presented by the Eq. (1).

$$n = \frac{V}{RQq_j} \tag{1}$$

where q_j is the electric charge of the air ion.

3. Results and discussions

The measurements of air ion concentration are made in the suburbs zones of the city of Shkodra (Albania). The concentration of small air ions in these zones is higher than in urban areas [11, 12]. In this paper is treated mostly the correlation between the concentration of small air ions and the altitude. On the other side the presence of aerosols influences in the reduction of the concentration of small air ions [13-15]. The radon concentration in the air and the concentration of aerosols are both related with the altitude. The measurements have been made in different altitudes in the interval 0-15 m.

The measurements results for the different polarities are presented at figures 1 - 3.

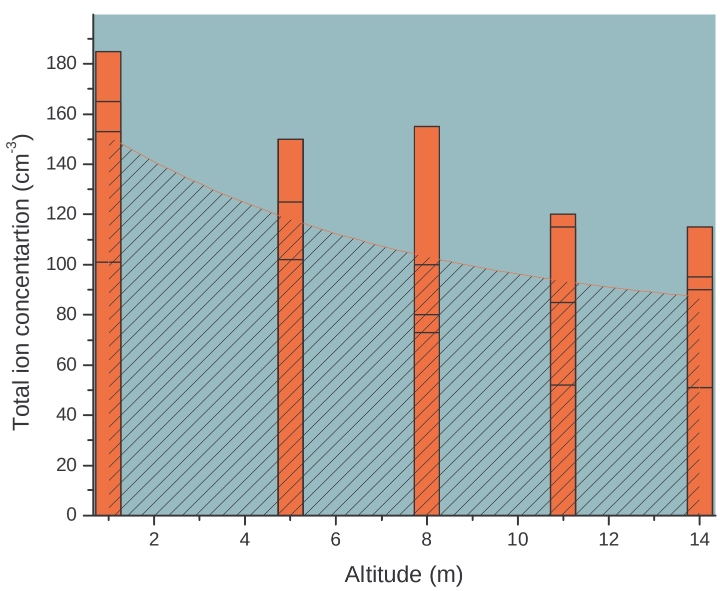

Fig. 1. Total air ion concentration altitude profile n=n(z)

The functional correlations between the concentration of the small air ions and the altitude are both exponential decay:

$$n(z) = a + be^{-\frac{z}{c}} \tag{2}$$

and

$$n_{\pm}(z) = a_{\pm} + b_{\pm}e^{-\frac{z}{c_{\pm}}} \tag{3}$$

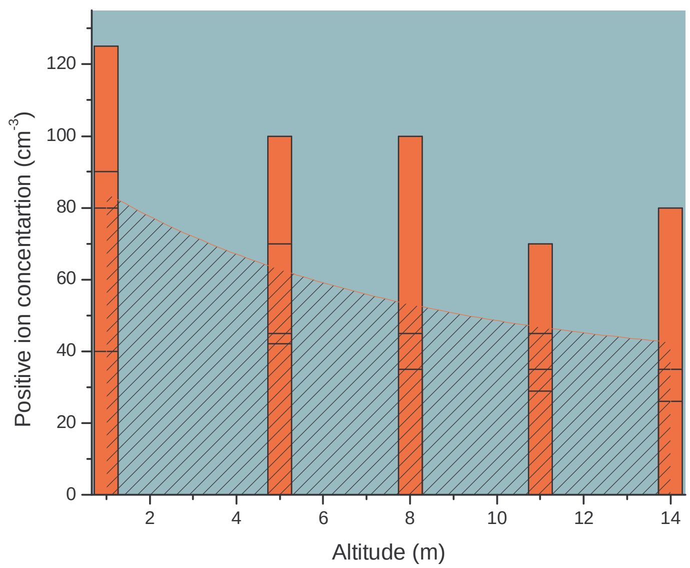

Fig. 2. Positive air ion concentration altitude profile $n_+=n_+(z)$

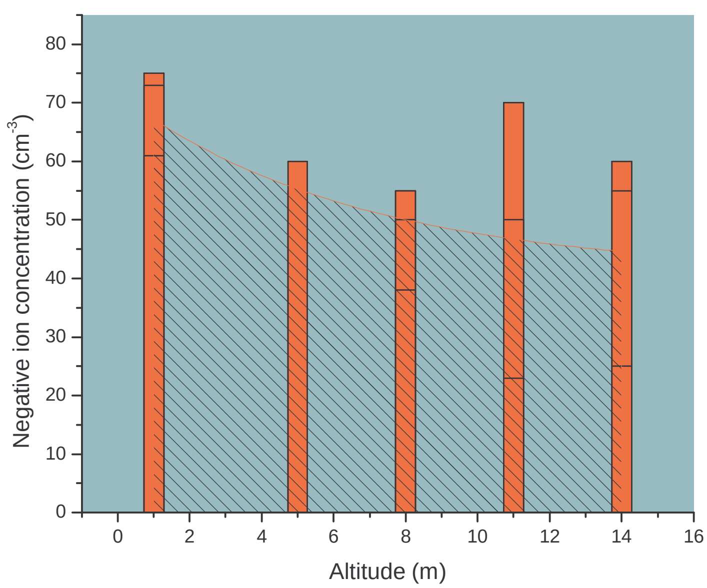

Fig. 3. Negative air ion concentration altitude profile $n_-=n_-(z)$

where experimental constants are:

	a	b	c
Positive	34.56	57.03	7.12
Negative	40.96	30.47	6.60
Total	75.47	87.51	6.95

(4)

From the experimental measurements we find this condition:

$$\left|\frac{dn_+(z)}{dz}\right| = \frac{a_+}{b_+}e^{-\frac{z}{b_+}} > \left|\frac{dn_-(z)}{dz}\right| = \frac{a_-}{b_-}e^{-\frac{z}{b_-}} \quad (5)$$

So the positive air ion concentration decay with the altitude is stronger than negative polarity decay. The air ion concentration reduces with the altitude.

From the theoretical argumentations we have:

$$dn = \alpha n dz \quad (6)$$

where α is the relative decrement of the air ion concentration.

Integrating Eq. (6) we can obtain:

$$n(z) = n(0)\cdot e^{-\alpha z} \quad (7)$$

Eq. (7) presents the theoretical function of the altitude profile of the air ion concentration. For the positive and negative polarities:

$$n_\pm(z) = n_\pm(0)\cdot e^{-\alpha_\pm z} \quad (8)$$

Comparing functions (2-3) and (7-8) and using the boundary conditions, we find the theoretical coefficients:

$$\begin{matrix} n(0) = a + b \\ n(0)_\pm = a_\pm + b_\pm \end{matrix} \quad \text{and} \quad \begin{matrix} \alpha = \dfrac{1}{h}Ln\left[\dfrac{(a+b)}{\left(a + b\cdot e^{-\frac{h}{c}}\right)}\right] \\ \alpha_\pm = \dfrac{1}{h}Ln\left[\dfrac{(a_\pm + b_\pm)}{\left(a_\pm + b_\pm\cdot e^{-\frac{h}{c_\pm}}\right)}\right] \end{matrix} \quad (9)$$

So the theoretical-experimental relations for the total and both polarities of air ion concentrations are:

$$n(z) = (a+b)\cdot e^{-\frac{1}{h}Ln\left[\frac{(a+b)}{\left(a+b\cdot e^{-\frac{h}{c}}\right)}\right]\cdot z} \quad (10)$$

and

$$n_{\pm}(z) = (a_{\pm} + b_{\pm}) \cdot e^{-\frac{1}{h} Ln\left[\frac{(a_{\pm} + b_{\pm})}{\left(a_{\pm} + b_{\pm} \cdot e^{-\frac{h}{c_{\pm}}}\right)}\right] \cdot z} \tag{11}$$

Substituting the experimental values (4) in the equation (11), we obtain:

$$\begin{aligned} &\alpha_{+} = 0.0528 \quad \alpha_{-} = 0.0321 \quad \alpha = 0.0429 \\ &n_{+}(0) = 91.59 \quad n_{-}(0) = 71.43 \quad n(0) = 162.98 \end{aligned} \tag{12}$$

From the Eq. (12), it's clearly seen that the theoretical condition $\frac{dn_{+}(z)}{dz} > \frac{dn_{-}(z)}{dz}$ is satisfied too. Based on the experimental Eqs. (3-5) and the obtained relations (9), we find this condition for the coefficients α:

$$\alpha_{+} = \frac{1}{h} Ln\left[\frac{(a_{+} + b_{+})}{\left(a_{+} + b_{+} \cdot e^{-\frac{h}{c_{+}}}\right)}\right] > \alpha_{-} = \frac{1}{h} Ln\left[\frac{(a_{-} + b_{-})}{\left(a_{-} + b_{-} \cdot e^{-\frac{h}{c_{-}}}\right)}\right] \tag{13}$$

The theoretical-experimental condition (13) satisfies the experimental condition (5), indicating that the theoretical-experimental Eqs. (10-11) are in agreement with the experimental Eqs. (2-3).
The variation of the unipolarity factor with the altitude is given in Eq. (14).

$$k(z) = \frac{n_{+}(z)}{n_{-}(z)} \tag{14}$$

Substituting the experimental functions $n_{+}(z)$ and $n_{-}(z)$, we obtain the experimental correlation of unipolarity factor with altitude:

$$k(z) = \frac{a_{+} + b_{+} e^{-\frac{z}{c_{+}}}}{a_{-} + b_{-} e^{-\frac{z}{c_{-}}}} \tag{15}$$

The theoretical-experimental function of the unipolarity factor is given by Eq. (16):

$$k(z)=\frac{(a_+ + b_+)\cdot e^{-\frac{1}{h}Ln\left[\frac{(a_+ + b_+)}{\left(a_+ + b_+\cdot e^{-\frac{h}{c_+}}\right)}\right]\cdot z}}{(a_- + b_-)\cdot e^{-\frac{1}{h}Ln\left[\frac{(a_- + b_-)}{\left(a_- + b_-\cdot e^{-\frac{h}{c_-}}\right)}\right]\cdot z}} \tag{16}$$

Putting the experimental values in the equation of unipolarity factor, can be obtained the functional relation of the unipolarity factor with the altitude in suburbs areas.

$$k(z)=\frac{34.56+\frac{57.03}{e^{0.14}}z}{40.96+\frac{30.47}{e^{0.15}}z} \tag{17}$$

This function is somewhat complicated and it is altitude decay also.

4. Conclusions

According the measurements results, the functional correlations for two polarities of air ions are both exponential decay. The theoretical functions are in good accordance with the experimental functions. The reduction of the concentration of small ions in higher altitudes is due the reduction of the radon concentration in the air, and this reduction is more evident for the positive polarity. The unipolarity factor is altitude dependent also.

So, based in experimental measurements, are determined the coefficients of the altitude profile of the small air ion concentration of both polarities and the unipolarity factor near the ground, in the suburbs areas.

References

[1] L. Laakso, PhD-thesis, University of Helsinki, 2004.
[2] H. Israel, Atmospheric Electricity, Vol.1, (Israel Program for Sci Transl., Jerusalem, 1973).
[3] I. H. Kornblueh, Clinical Medicine **8**, 69, (2003).
[4] S. Israelsson, H. Tammet, Journal of Atmospheric and Solar-Terrestial Physics **63**, 1693 (2001).
[5] L. Laakso, T. Petäjä, K. Lehtinen, M. Kulmala, J. Paatero, U. Hõrrak, H. Tammet, and J. Joutsensaari, Atmos. Chem. Phys. **4**, 1933, (2004).
[6] R. Wilding, A. Ellis and R. Harrison, University of Reading, UK, 2005.
[7] H. Tammet, U. Hõrrak, L. Laakso and M. Kulmala, Atmos. Chem. Phys **6**, 3377, (2006).
[8] A. Tuktagulov, Sapphire Company, Kazan, 2003.
[9] P. Kolarž and B. Marinković, Review of Scientific Instruments **76**, 1, (2005).

[10] K. Aplin, PhD-thesis, University of Reading, UK, 2000.

[11] F.Vila and F.Mandija, Studies about atmospheric electricity, 6th International Conference of the Balkan Physical Union, Istanbul, Turkey, 2006, (American Institute of Physics, New York, 2007).

[12] U. Hõrrak, PhD-thesis, University of Tartu, 2001.

[13] R. Wildinga and R. Harrison, Atmos. Environ. **39**, 5876 (2005).

[14] F. Mandija and F. Vila, Proceedings of the International Conference on Atmospheric Electricity, Beijing 2007, (ICAE press, Beijing, 2007).

[15] L. Wahlin, Atmospheric Electrostatics, (Research Studies Press, NY, 1989).