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Changes in Ion Concentration in the Air During the Breathing Process of a Human Being

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Abstract

This work discusses the influence of the human being on concentrations and mobility of aeroions in the atmosphere. The performed investigations show that the concentration of anions and cations decreases, in the vicinity of the human, by about 26-44 %. This is the result of their recombination with charges existing in the human body. In the process of breathing there are no crucial changes to the concentration of ions of both polarization, while there is a conciderable increase (by several hundred percent) in the number of large ions.

Keywords: human being, aeroions, recombination, polarization, large ions

Introduction

The Independent Section for Medical Computer Science (SPIM) at the Medical University in Gdansk has been conducting research on air-ions for a number of years. This research has focused mainly on the measurement of the concentration of air-ions and the mobility of their background. Measurements of the changing values of these parameters have been conducted in various conditions, both outdoors [7] and indoors (offices and homes) [6]. This paper also discusses time-dependent changes of the physical parameters of air-ions in closed spaces, caused by the presence of people. This presence (which causes a rapid increase on the condensation of large positive ions, i.e. harmful ions) leads us to believe that any further research on the influence of air-ions on human beings must be preceded by research on the processes which accompany breathing. It is knowledge about the degree of changes in the concentration and mobility of ions in the lungs that will, for example, help us decide how rational it is to treat various diseases by means of ionic inhalation [8]. Inhalation which uses the suitable ions will probably also be helpful in increasing the fitness of sportsmen without causing any negative side effects in their bodies (subject to further research). Thorough study of the ionic conditions of the air in the breathing process also requires research on the influence of the body itself on the immediate atmosphere, i.e. the one which is introduced into the lungs. The ionization of such an atmosphere can differ significantly from that which fills empty closed spaces. Results which illustrate the entire phenomenon are presented in this paper, and they can be a reference point in considering many other problems connected with the way air-ions affect people.

Measurement Method

Research on air exhaled by people was carried out at the University School of Physical Education in Gdansk on a group of 18 males aged 20-22. Concentration and mobility values of air-ions were determined by means of very sensitive equipment which was able to register ionic density under 20 ions/cm^3 as described in other sources [8].

In order to avoid any external disturbances, the measurement was conducted always in the same room, in similar temperatures ranging from 20°C to 23°C and always with closed doors and windows. In this way we eliminated the possibility of external influence on air-ion concentration outside the building resulting from diftferent positions of the sun and various other climatic and weather factors [6]. The time span of 15 minutes between the particular measurements performed on our subjects guaranteed that the ionic condition in the room was stable. It was possible to lower the global error margin of all the measurements down to 20%, i.e. to the level corresponding to natural fluctuations of air-ion density in the air.

Relative humidity in the room was kept at the level of 60-75%.

Since experiments with air-ions can be easily disturbed by electrically charged clothes or the flow of electric charges through the person to the ground, the measurements were conducted on topless people whose remaining clothes were not susceptible to electrification, i.e. always stayed electrically neutral, and who wore shoes which are characterized by high electric resistance.

The distance of the examined subjects from the equipment was approx. 10 cm in both measurements, i.e. the measurements of concentration and measurements of air--ion mobility. This guaranteed that the measurement chambers detected virtually all ions in the vicinity of the person or emitted by their lungs, without interfering with the laminar flow of the air through the measurement device. The lack of any turbulent motions in the air-ion measurement chambers is the basic condition for obtaining reliable data.

Results

The preliminary measurements of air-ion parameters in the air exhaled by a human being was conducted by means of measurement devices which register the total number of ions [8]. The only thing that we were able to determine as a result of the measurements was the fact that there are no significant changes in the concentration of the exhaled anions and cations before and after endurance tests (Harvard Step Test), which were performed by Kuziemski and Suchanowski [3]. What changed, of course, was the amount of air exhaled in a unit of time, but the n^- and n^+ values (i.e. the number of anions and cations in 1 cm^3 of air) which were measured before and after STH effort, did not differ from each other by more than 10%. Significant differences in concentration, however, occurred between the exhaled air and the atmospheric background of the room. All n^- and n^+ values clearly pointed towards a lack of correlation with the minimal values of measure mobility μ_{min} determined during their measurement. This parameter limits the range of the registered air-ions and the measurement device considers only ions characterized by the mobility of $\mu > \mu_{min}$ [8]. The determination of various ranges of mobility limits changed the n^- and n^+ values, even their direction, in the exhaled air with regard to background. This points to the fact that in the breathing process of a human being, it is not only the number but also the type of air-ions that changes. Further measurements were therefore conducted without endurance tests, but only on measurement devices which registered the values of air-ion currents with regard to mobility, in other words determining the so-called distribution spectrum of air-ions. It insignificantly limited the number of the registered ions because the measurement device we used can detect ions of the mobility of $\mu > 0.2$ $cm^2s^{-1}V^{-1}$. But this is the maximum range which does not interfere with the measurements, and the main intensity of currents of air-ions are detected anyway. A further lowering of the μ limit would require the application of tensions higher than 250 V to the measurement

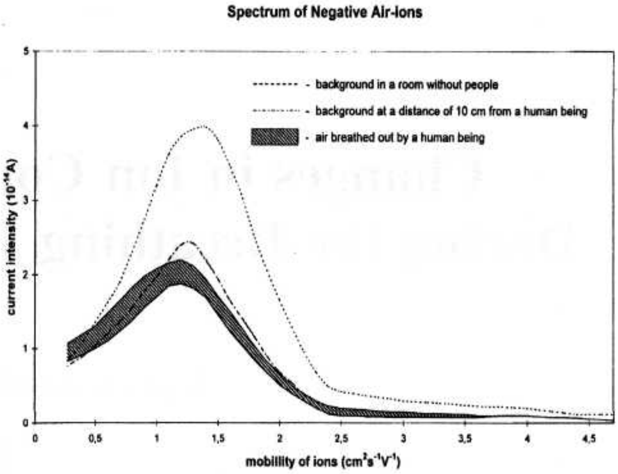

Fig. 1. The influence of a human being on the change in the spectrum of air-ions into anions.

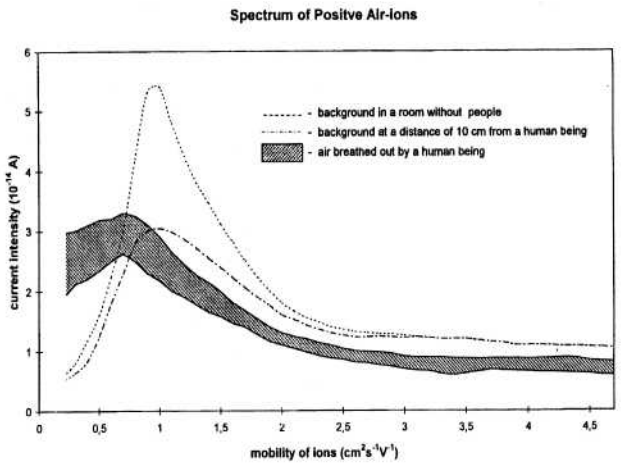

Fig. 2. The influence of a human being on the change in the spectrum of air-ions into cations.

chamber, which in turn would distort the results in an avalanche effect. Spectra for this type of room atmosphere without people, or for a situation when the measurement device is 10 cm distant from a single person and air is exhaled are given in Fig. 1 (anions) and Fig. 2 (cations).

A characteristic effect observed during the measurements of particular spectra was that there was a significant drop in the intensity of the air-ion currents with regard to background. This occurred when the measurement device was placed 10 cm away from a human body. The flow of these currents for 18 persons showed remarkable stability, but the differences in intensity for all mobilities did not exceed 7%. Hence, they were much less than the mentioned 20% error margin resulting from natural density fluctuations of air-ions in the air. Therefore, in both Figs. 1 and 2, these functions are represented by means of single curves, and the maximum margin of error of 20% has been neglected due to its constant nature [7]. Air-ion concentrations corresponding to these spectra are as follows:

Table 1. The value of the mobility of ions, corresponding to the maximum concentration of air-ion currents.

The background	U_{max} ($cm^2s^{-1}V^{-1}$) – anions	U_{max} ($cm^2s^{-1}V^{-1}$) – cations
in a room without people	1.37 ± 0.32	0.98 ± 0.20
in a room at a distance of 10 cm. from a human being	1.25 ± 0.22	1.00 ± 0.35
outdoors	2.20 ± 0.1	1.20 ± 0.1

for a room without people:
n^- = 777 ion/cm^3, n^+ = 772 ion/cm^3, 10 cm distant from a person:
n^- = 432 ion/cm^3, n^+ = 568 ion/cm^3 (All the above values *n* have been obtained through the integration of the area under the curves in Figs. 1 and 2 [5]. They are also affected by the constant error margin of 20%).

Despite big differences in values of ion concentration, which correspond to both the discussed spectra (the background of a room without people and background with a person), their maxima do not point to any major shifts. It is visible in both the curves and in Tab. 1, where the mobility values μ_{max} for the particular maxima have been put together (the given maximum error margins result from the already mentioned natural 20% fluctuations of ion concentration in the air). As for cations there is in fact no such shift. It is more distinct for the anions, but it still stays within the limit of measurement precision, which is even better seen when we compare respective diameters of *d* ions. This is a parameter which is calculated with great reservations, since in various sources (e.g. [2, 4, 5]) these values differ up to 30%, but taking the ion diameter in the same paper by Niziol [5], it can be seen that for μ_{max}=1.4 ion/cm^3 d ≈ 0.55 nm and for μ_{max} = 1.25 ion/cm^3 *d* ≈ 0.60 nm, which means that the difference between them is approx. 9%. These results prove that the same human skin, despite its strong influence on the concentration of ions, does not change their mobility to a significant extent, and therefore their type. However, comparing these values with corresponding intensities of currents of air-ions outdoors, we can observe [6] that they are shifted, and for anions, in particular, towards ions of lower frequency. In open spaces μmax for anions equals 2.2 ± 0.1 $cm^2s^{-1}V^{-1}$, which corresponds to the mobility of the O_2^- in the air [5, 7], and for cations μ_{max} = 1,2 ± 0.1 $cm^2s^{-1}V^{-1}$ corresponds to the mobility of N_2^+ and O_2^+ [1, 7]. This kind of decrease in value of μ_{max} does not only concern the room in which the presented research took place, but is an effect characteristic for all closed indoor spaces.

This decrease in concentration of air-ions of both values (i.e. anions and cations) close to a human being makes us pose the question about the reasons for this phenomenon. Korniewicz et al. *[2]* consider, for example, the hypothesis that the flow of current of air-ions through the human body is responsible for this effect. Its source would be the difference in potentials between the earth and ionosphere, equal to approx. 280 kV, which close to the earth surface creates an electrostatic field of the value of approx. 130 V/m. The approximate calculations of the authors [2] suggest that the current density flowing between the ionosphere and the earth is about 6.24 • 10^{-16} A/cm^2. Taking the effective surface of a human body as 707 ÷ 5.5 • 10^4 cm^2 we obtain the following value of the current flowing through it: 0.44 pA ÷ 34 pA. Korniewicz [2] assumes that the figures correspond to the situation when a human being is standing on an earthen surface, and the values drop by half when the body is isolated from the ground. The results of measurements presented in this paper do not confirm this hypothesis. The only agreement with the figures given in the paper [2] (apart from the problem of isolation of the examined people from the ground) concerns the possible density of the hypothetical current flowing between the ionosphere and the earth. When we take into consideration the parameters of the measurement instrument used in the discussed measurements as: efficiency - 1600 cm^3/s, horizontal cross-section of the measurement chamber - 80 cm^2, and the given differences in the concentration of anions - (345 ion/cm^3), we obtain the following density of this current:

for anions: j = 1.104 • 10^{-15} A/cm^2,
for cations: j = 6.528 • 10^{-16} A/cm^2.

It is clear that values given here differ from the ones given at [2] by 77% and 4.6% respectively. When we take into consideration the approximate calculations of [2] they are a good approximation, even for anions. Despite this consistency, we cannot identify the decrease in ions in the presence of a human being with the flow of current through his body. One of the good reasons is that during the measurements (the values which we quote in Figs. 1 and 2) the subjects were wearing shoes which did not conduct current. What is more, if the subjects stood without shoes on the ground isolated by means of aluminum foil, then the obtained results with regard to anions did not change, and with regard to cations the opposite effect than the expected one was observed. In the case of subjects who stood on the foil without shoes on, there was a drop in the density level of positive ions with respect to the background. It was approx. 15% less than the result which was obtained when the same subjects wore shoes that isolated them from the ground. The results point to the fact that the reason for the significant drop in the concentration of air-ions of both types close to a human being (order of magnitude of 25-45%) is their recombination with electric charges present in human bodies. This theory is also confirmed by the changes in cation concentration, distinctly different from those presented by [2]. The reason for the described effect is that the more mobile negative charges flowed to the ground from the body of a person standing on isolating foil. Therefore, the field of positive air-ions around a human being was reduced to a lesser extent due to recombination. This effect, however, cannot be observed in the case of negative air-ions because the flow of less mobile positive ions from the surface of the human body is too small.

The decrease in concentration of air-ions close to a human being is connected with the problem of estimating the extent of the effect when the given person moves. All the values given in this paper concern subjects who stand motionless in the measurement chamber. It can be expected that the drop in air-ions for a moving human being is smaller. This is most probably the case, but the differences in concentration with regard to the values given in this paper may be too great. One of the reasons could be that ionization of the air is estimated in a few milliseconds [2]. It would be a completely insignificant effect if not for the fact of longer (at least a few-second-long) periods, when air-ions flow onto the human body. Unfortunately, for the time being we have to limit ourselves to hypotheses because exact measurements of the influence of human movement on the concentration of air-ions around the body is very difficult. As for now, there is no technical possibility to move the large and sensitive instruments (such as the chambers to measure air-ion parameters) along with the moving body of the examine person. The disturbances caused by their movement would yield completely distorted results. Our centre, therefore, used a completely different method. We simulated the movement of the subjects by blowing air onto them. The selected velocity was in accordance with the average rate of movement of a human being, i.e. approx. 5 km/h. The results obtained in such a way carried, however, a much bigger error margin of 40%. This can be explained by the fact that there were the much bigger fluctuations of the atmosphere caused by the effect of the blown air bouncing off the bodies of the subjects. Despite these disturbances it was possible to establish that in such cases the concentration values of negative air-ions with regard to the background decreased on average by approx. 35%, and for positive ones by 20%. Therefore, it can be assumed (as a working hypothesis) that around the body of a moving person the concentration of ions of both signs is higher by an order of magnitude of 5-10% than in the surroundings of a person standing motionless.

All the parameter values given so far and connected with the state of ionization around a human being concern only a situation when the subject does not wear any clothes that could be electrically induced. In cases when the subject wore clothes that were not electrically indifferent, it was not possible to determine any regular patterns of correlation concerning ionization in the surrounding air. It is so because various fabrics can get covered in charges of both various density and charges.

The presented spectra of air-ions, measured close to the body of a motionless human being were obtained by means of a measurement instrument positioned in such a way that the air exhaled from the lungs was excluded. Hence, air-ions form a kind of background for the exhaled air. The spectra for the exhaled air (additionally presented in Figs. 1 and 2 did not show such consistency for all 18 subjects who were examined as they did when the measurements were performed close to the human body. In this case, the differences between the intensity of ion currents in slow motion (especially for positive ions) went up to 50%. Therefore, in both curves, the air-ion spectra corresponding to the exhaled air and presented in the form of an area, comprise the whole range of obtained results. The lower curve embracing the given area represents the concentration of anions of 353 ion/cm^3, and the upper one the concentration of anions of 432 ion/cm^3. These values are for cations 406 ion/cm^3 and 513 ion/cm^3, respectively. Despite a significant spread in the measured values of the air-ion current (additionally it overlapped with the 20% constant error), Figs. 1 and 2 show certain trends in the shapes of the spectra with regard to the measurements performed close to the human body. Fig. 1. illustrates the fact that the lungs do not change concentration or mobility; in other words, do not change the kind of negative ions. Although the mean values of the current of air-ions in the exhaled air (within the spectrum corresponding to the mobility of $1 < \mu < 2.2$ cm^{2}s^{-1}V^{-1}) are lower for ions with regard to the measurements performed close to the human body, they reach the maximum value of 18.5%. They are, therefore, smaller than the 20% constant error margin. Bigger changes occur at the mobility of $\mu = 0.2$ cm^{2}s^{-1}V^{-1} where, for a change, the average density of the air-ion current in the exhaled air is higher than close to a human body by 28.6%, but it concerns low intensity of this current. Therefore it can be concluded that a human being changes the atmospheric negative ion count mainly by interacting with the surface of his body. The exhaled air has a relatively insignificant influence on the structure. This fact is reflected in the results of the measurements of the atmospheric condition in closed spaces. The results are presented in [6], where it is shown that there is no human influence on the structure of negative ions, even after a person has spent many hours in a closed space.

A different situation occurs in the case of positive ions. For cations, the differences in the spectra for measurements close to the surface of the human body and for the exhaled air are significant (Fig. 2). The range corresponding to the mobility of $\mu > 1$ cm^{2}s^{-1}V^{-1}, the current of air-ions connected with the exhaled air remains on a level of 25-35%, which is lower than the current measured close to the human body. This situation is reversed for the mobility of $\mu < 1$ cm^{2}s^{-1}V^{-1}, when the value of the ion current connected with exhaling increases rapidly. For ions, characterized by the mobility of $\mu = 0.2$ cm^{2}s^{-1}V^{-1}, the mean value of mobility if compared with the current close to the human body increases by 387%. This effect is reflected in the results of measurements of air-ion parameters in closed spaces with human beings inside. We observe a constant increase in the concentration of large positive ions, which have a negative influence on living organisms [6-8].

Conclusions

To sum up, all the results presented in this paper can lead to the following conclusions concerning the influence of a human being on the state of ionization of his surroundings:

- In the closest proximity (i.e. up to 10 cm) of a motion less human being, the average concentration of air-ions is smaller than the surrounding background by 44% for anions, and 26% for cations. The values for concentrations close to a human being moving with the speed of 5 km/h decreases approximately 35% for anions and 20% for ca tions. The reason for this decrease is the recombination of air-ions with the charges present in the human body.
- In the process of breathing, there are no significant changes in the human body as far as the concentration and

type of anions is concerned. An insignificant general decrease in their density with regard to the immediate atmospheric surroundings (on average approx. by 9%), as well as an increase in the number of negative ions characterized by the mobility of $\mu < 0.5\ cm^2s^{-1}V^{-1}$ on the average by 28.6% have little influence on the anion count in the atmosphere. (The latter figure is due to the fact that these constitute a small percentage of all the air-ions.) What follows from that, among others, is that the given changes are dominated by natural fluctuations of air-ion density, amounting to approx. 20%.

- In the process of breathing in the human lungs there is a relatively small decrease (on average by 19%) of total cation density, but their type changes significantly. As we breathe, the number of smaller ions decreases (on average by 30%), i.e. ions of the mobility of $\mu > 1\ cm^2s^{-1}V^{-1}$, while the number of less mobile ions of mobility in the range of $0.2\ cm^2s^{-1}V^{-1}$ (i.e. those which are considered harmful for living organisms), increases by a couple of hundred per cent.
- Physical exercise changes neither the concentration, not the kinds of ions present in the air exhaled by a human being.

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