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THE FUNCTIONAL CHARACTERISTICS OF THE ARTIFICIAL HOLOCHAMBER

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Key words: solions, environment factors, halochamber, halotherapy, physical exercises, children.

Abstract. This paper presents experimental data obtained using the main methods and techniques for measuring and monitoring artificial aerosols in halochamber for the treatment of respiratory diseases and improvement of functional parameters of the cardio-respiratory and psycho-motional systems of the children involved in intense physical exercises. The focus is on the "in situ" methods for determination in real time of the functional characteristics of the NaCl aerosols, highlighting multiple solions effects.

Introduction

Air quality is one of the thorniest problems of mankind; it is very closely related to safety of life on our planet. Environment has undergone radical changes due to both internal or endogenous and external or exogenous factors. The change of the natural components by impurification with various pollutants, due to human activities, has harmful effects on health, creates discomfort or prevents the use of the air elements essential to life. Tempering the body by air bath and sunlight may increase the body's resistance, not only to bad weather, but also to gas aggressiveness, air nanodispersions and infectious diseases. Among the diseases affecting the body, because of its lack of natural resistance to environmental factors, there are the ENT types (rhinitis, sinusitis, laryngitis, tonsillitis etc.), the respiratory ones (asthma, bronchopneumonia, silicosis etc.). The lack of resistance

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of the organism as a result of insufficient hardening has its impact especially at young ages, on children, for which exercises have the most importance for the proper functioning of heart and lungs. Increased morbidity of the persons suffering from inflammatory lung diseases such as asthma or bronchitis is associated with increased pollution (Barnea, 1978).

Knowing the therapeutic effects of caves and underground excavations on the body, scientists sought to create microclimates to „simulate” the conditions in the salt mine. Artificial salt mines (halochambers) have become a convenient and considerably cheaper alternative to natural ones. Both natural and artificial saline aerosols used in therapy lead to improved quality of life. Halotherapy/salt mine therapy is a very simple procedure of therapy, not involving in any way the use of medication or supplements, immobilization in bed or diets. But as simple the process is, as complex is the salt aerosols mechanism in the body. Halotherapy involves on one hand respiratory inhalation of saline aerosols and on the other hand, their absorption through the skin. Negative ionic charges neutralize the positively charged particles caused by tobacco smoke, or electrosmog, thus restoring balance in the body. Salt is an essential element for the functioning of the body, having multiple local effects. Salt therapy, being a natural therapy, has many advantages, including rapid action, high salt concentration, lack of contraindications.

Rigorous control of concentration and of the dimensional distribution of solions in halotherapy media is very important for the medical treatment of various respiratory diseases and for the creation of an ambient with „clean air” (Sandu et al., 2004a and b). Depending on the solions concentration, saline areas may have both a therapeutic effect (in case of large concentrations of 1-6 mg NaCl solions/m^3 as stationary for 1-4 hours) and a prophylactic one (concentration below 1 mg NaCl solions/m^3, but with a longer presence of 8 to 16 hours daily).

In order to determine the therapeutic or prophylactic role of natural and artificial saline spaces it is necessary to know and apply the methods and techniques for measuring and monitoring the structural and functional characteristics of solions. To this end, the work has focused on the involvement of modern instrumental techniques for determining in real-time the solion nanodispersions characteristics in the atmosphere of a halochamber used to work with students in sports classes to improve their physical condition.

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1. Experimental Part

2.1. Halochamber for exercises with students. The experimental halochamber is a classroom specially equipped with four devices „Salin II” type (large), manufactured by TEHNOBIONIC Buzau. The structure and function of the room allow the solions concentration levels and varying the chemical nature of the cations or anions active structure, the conditions required for various purposes and prophylactic therapy of respiratory diseases and for improving cardio-respiratory and psychosocial-neuromotor parameters of the human subjects involved in intense physical activity (Sandu et al, 2003, 2004a, b, 2006 and 2010c). It corresponds to halochamber dynamic systems, the inventions being patented at OSIM Bucharest and Chisinau AGEPI (Sandu et al, 2009a-f).

To achieve the optimal concentrations of aerosols required in such activities, the classroom was especially equipped, having a size of 6m(L)x4m(l)x2,5m(h), corresponding to a volume of 60 m^3 air, windows ionized with UV filters and it was equipped with four dry aeroions generation devices Saline II, diaphragms which contained 4.0-6.3 mm diameter pellets made by extrusion of the humid paste evaporated to inflorescence in the rock salt mixed with other salts: KCl, $MgCl_2$, $CaCl_2$ and KI, the 98:1,0:0,3:0,3:0,4 in the mass ratio. The air in the room is continuously recirculated by means of a fan, which allows a circulation of 0,25...0,35 m^3/s. The air in the room is previously conditioned at 60...80% RH and 20...22^oC. The devices are started with at least 24 hours before the halochamber sport classes and the functional halochamber characteristics are measured before and after the sport program.

For measuring and monitoring the atmosphere composition of the halochamber, in addition to methods for determining the climatic parameters of an enclosure, such as: work rooms or halls, gyms, swimming pools etc., specific methods were also used, such as: conductometric determination of solions concentration, the amount of particles with optical numbering of particles with laser counting, aeroions dispenser and others (Pascal et al, 2009, Sandu et al, 2010d).

Characteristics of aerosol particles in general and solions environments are determined by the source and the environmental factors. Therefore, we discussed the functional characteristics that describe a source of solion (aerosol size and density, speed of generation of particle flow source, the gaseous environment enrichment factor, the lifetime of the particles), the selection model optimal generator and structural properties of nano-and micro-physical aerosol (aerosol concentration and its variation over time, particle size distribution, dynamic behavior of aerosol, diffusion, mobility and drift velocity of particles and limit of the environmental humidity beginning formation of condensation nuclei), for a better understanding of their involvement in climate averages.

To determine the concentration, the granulometry, the capacity and life time of solions in the saline environment of the above instrumental methods were used particle counting method based on laser optical system and the method using differential conductometry device for aeroions.

2.2. Instrumental method for determining solion characteristics

2.2.1. Optical number of particle with laser counter. Solions concentration represents the number of particles per unit volume. Usually, numerical concentration of all aerosol particles is equivalent to the number of Aitken particles per unit volume as the number of medium and large particles is negligible compared with the Aitken. The concentration of particles was performed using laser optical device known as the number of particles SIBATA GT 321 (Fig. 1) indicating the number of particles between 0.3 and 5 microns, the ranges of 0,3-0,5, 0,5-1, 1-2, 2-5 and over 5 microns, with values expressed as number of particles per cubic foot.

Fig. 1 - Optical particle counter SIBATA GT 321

Particle counts GT 321 SIBATA allows determinations following grids: number between 0 and 108 particles/m^3 solions; areas dimensional (particle diameter): 0,3; 0,5; 1,0; 2,0; and 5,0 μm; halochamber working temperature range: 0-50 °C, processed aerosol gas flow: 2,83 L/min.

With particle counter optic SIBATA GT 321 we determined, first, the number of particle size groups, from which to assess their total aerosol concentration in mg/m^3, in the three sampling points on specific weight of rock salt, which is 2,165 x 10^6 g/m^3.

Particle counting method, the only available method of analysis "in situ" for verifying the conductometric method, has some disadvantages, on the one hand due to errors induced by calculation, on the other hand the presence in halochamber and other particles (Sandu, 2004a and b).

2.2.2. Conductometric differential method. Mentioned disadvantages can be eliminated by using, to determine concentrations of NaCl discrete gaseous environments, the differential conductivity technique, using a set of glass devices provided (Fig. 2), slips through the suction type, with flow controlled by rotameters, each having an adjustment system/filling volume water slips and a set of electrodes and transducers (conductivity and temperature compensator) incorporated in a standard cell rigid plastic embedded in a differential analysis installation facility (Fig. 3), coupled to a digital conductometer, which presents a computer interface [Pascu et al., 2009].

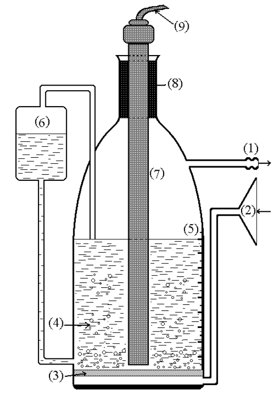


Fig. 2 - A typical "slips" vacuumed glass electrode transducers incorporated: 1 – extension to the vacuum pump; 2 – aerosol intake funnel; 3 – bubbling dissipator; 4 – solution under analysis; 5 – indicator for solution volume; 6 – system to adjust/complete the volume of the bubbler with tri-distilled and de-oxygenized water; 7 – electrodes transducers encapsulated in a rigid plastic sheath, type standard cell; 8 – rubber stopper for encapsulated electrodes and sealing device; 9 – connection conductor to the digital conductometer

Conductivity type C833, produced by CONSORT Belgium analysis system used in the scheme, has the following functional characteristics: pH range -2 ... +16; the potential □2000 mV; conductivity 0 ... 2000 mS/cm; resistivity 0 ... 200 M□ cm; salinity 0 ... 100 g/L; temperature 0 ... 100 □C.

Plant analysis is based differential scheme in figure 4.

Branches I and II of the plant for making parallel determinations and branch III determining background air conductivity changes without NaCl, which was held in vessels washers (5) and (6).

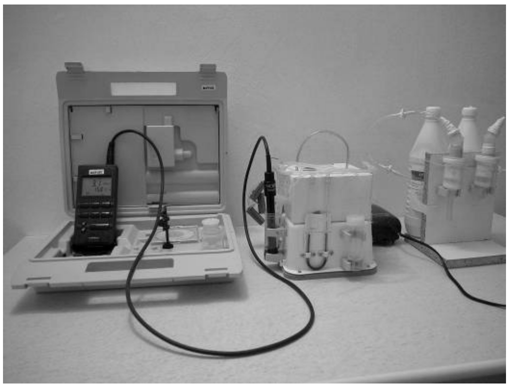


Fig. 3 - Overview of the system of analysis used in the laboratory

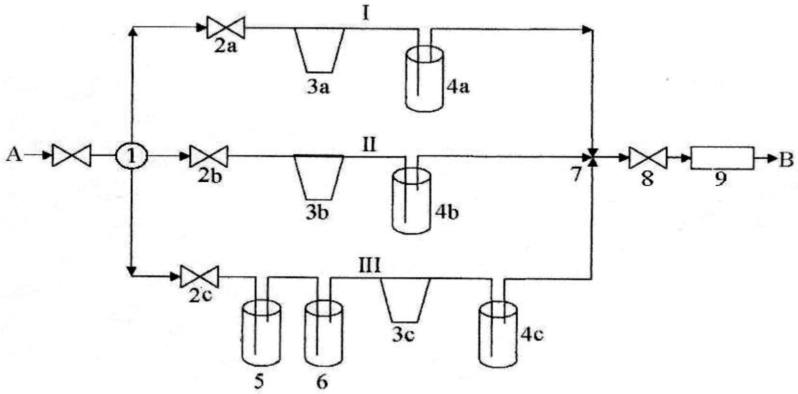


Fig. 4 - Scheme of operation of the analysis:

I, II and III – branches or routes; A – gas intake point; B – gas discharge; 1 – distributor; 2 (a, b and c) – flow taps; 3 (a, b and c) – rotation meters or manometers; 4 (a, b and c) – glass devices for bubbling aerosol generator; 5 and 6 – additional recipients for restraining NaCl solions; 7 – differential collector; 8 – final tap; 9 –vacuum pump

In the conductivity type C833 circumstances, working with the following parameters: $\square_{\text{apă tridistilată}}$ = 1,2 □S/cm, while the bubbling of a sample (t) = 15 min. and bubbled air flow (Q) = 0,6 L/min. (every device in glass) and by extension the standard chart of Fig. 5 to determine the amount of NaCl taken from the volume of air bubbled, denoted by m_{NaCl}, according to the equation:

$$m_{NaCl} = \text{conc.}/100 \text{ (mg)}.$$

Knowing the flow rate Q, the volume V of analyzed air was determined: V = Q x t, where the concentration of NaCl aerosol in the air will be: $C_{aerosol} = 1000\ m_{NaCl}/V$.

Standard curve in Figure 5 is □tg= 0,4762 , which shows that for an increase in conductivity of □S/1cm, corresponding to an increase in concentrations ranging from 0,4□7,02 mg/L solution. Conductance value determined for an experimental period of bubbling default (depending on concentration and diameter reached or made aerosol particles present) is extrapolated on the standard curve, obtained when the NaCl concentration for a given volume of solution, then the tables conversion or calculation, to evaluate the aerosol analyzed salt loading in mg/m3.

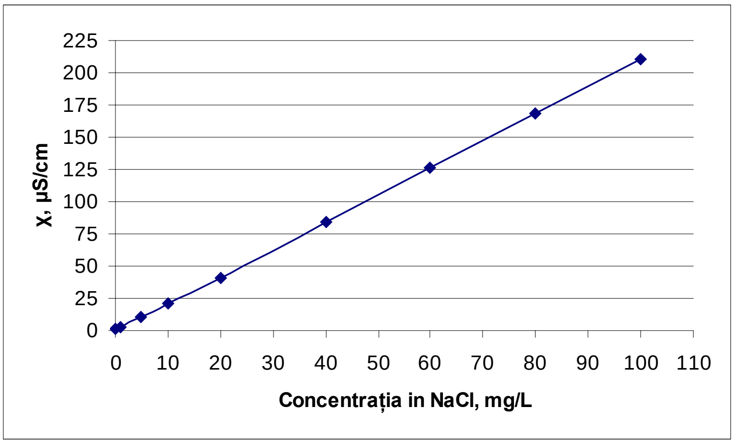


Fig. 5 - Standard curve (graph $\chi = f(c)$ for water solutions of NaCl, within the range of actual concentrations)

Temperature and relative humidity (RH) were measured using a digital electronic higro-thermometer, pressure with a barometer and electronic lighting with a light meter. The lifetime of aerosols was estimated based on the concentration evolution of halochamber solions time after reaching the maximum level possible and to the minimum of activity which does not allow practical implications.

2.2.3. Method using the aeroions counter. This version of Ionomers (Fig. 6) no heating takes a long time you change polarity, that 3 decimals are not shown when the polarity changes. To make measurements with Air ion counter, the polarity should be checked prior to the „+" or „-". Ionomers takes away the body (arm length) or let down as synthetic fibers in clothing repellent. MEASURE button turned, the fan will start and will make all 3 decimal visible about 20 sec. After only 20 seconds, decimal will remain central. Ionomers works best when connected to earth or before the measurement is achieved by a grounded object. If not grounded, Ionomers can have a significant static charge that attracts ions reject or influences the readings. Ionomers black all over (including 4 rubber feet) is electrically conductive.

Fig. 6 - Ionomers

Ionomers displayed in units of 1000 ions/cc, that is multiplied display with 1000 (ie – 0,28 = 280 negative ions/cc). The air is checked into the opening at the top of ionomers. Keep ionomers in one place at least 10 seconds on MEASURE until reading is stable, to get a correct reading.

Polarity can be changed at any time, decimal points will return for about 30 seconds. The fan will stop, then return one (no need to RE-ZERO). Most readings can be made in the most sensitive (19,99). If the scale shows over the field, the button returns to 199,9 or 1999. Should be re-zero after changing (for RE-ZERO, first return to STANDBY, then wait about 20 seconds for the display to be stable) and RE-ZERO every 5 minutes (or more often if the temperature is changing rapidly).

For reading faster and more accurate to measure the entire surface in one polarity, then changes polarity and re-measure the entire surface. If the ion concentration is less than 100 (0,10) a longer STANDBY should be used before RE-ZERO (display will take longer to reach a final value when the measurement if the ion concentration is very low). If measurement is performed on the fly, then ionomers should be held vertically and at the arm length. This will cause air to move perpendicular to the incoming air directly to the machine (under windy conditions, is intended to be vertical or at least perpendicular to the wind, if air enters the top quickly, ionomers read easily, and if the air rapidly enters the fan, reading is more difficult). To achieve equilibrium temperature, allow at least 30 minutes OFF ionomers in the environment will be measured.

3. Results and discussions

The dynamics of aerosol emissions from halochambers is influenced by environmental conditions. Therefore, the determinations made were kept at constant parameter values and we monitored the microclimate air pumped in the halochamber. In the experiments, we created artificial conditions of temperature and humidity.

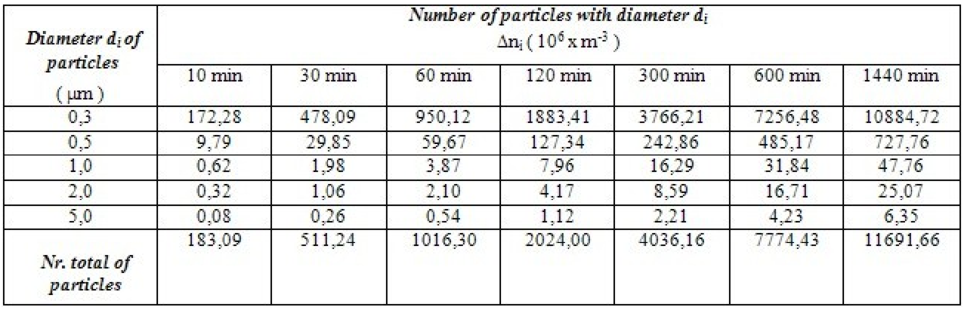
Tab. 1 - Values of climatic parameters halochamber

Temp. (°C)	**Rel. Humidit. (%)**	**Atmospheric Pressure (mmHg)**	**Lighting (lx)**
20-22	60-80	756-770	80-120

The environmental conditions and characteristics of the halochamber were noted before and after the hours of sports of the students.

With particle counting to determine particle size of halochamber, issued in a certain period of time (24 hours), change the number of particles, their total volumes and concentrations achieved in a period of time (Tables 2 and 3).

Tab. 2 -Temporal variation in the number of particles with diameter di, dimensional groups

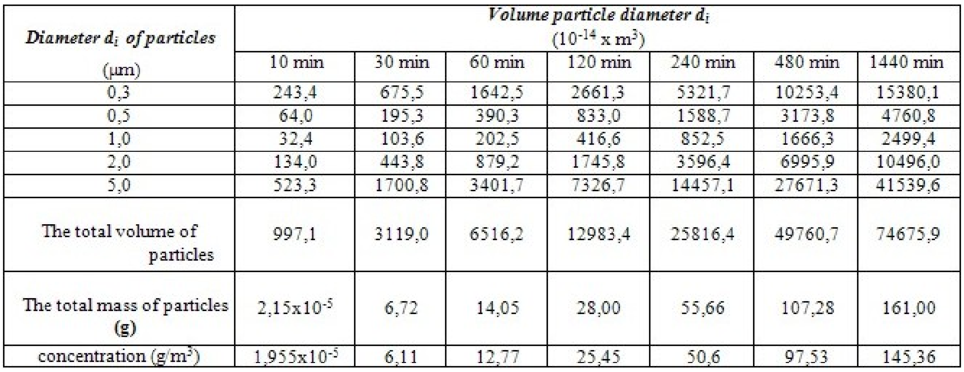


Diameter d_i of particles (µm)	*Number of particles with diameter d_i* Δn_i (10^6 x m^{-3})						
	10 min	30 min	60 min	120 min	300 min	600 min	1440 min
0,3	172,28	478,09	950,12	1883,41	3766,21	7256,48	10884,72
0,5	9,79	29,85	59,67	127,34	242,86	485,17	727,76
1,0	0,62	1,98	3,87	7,96	16,29	31,84	47,76
2,0	0,32	1,06	2,10	4,17	8,59	16,71	25,07
5,0	0,08	0,26	0,54	1,12	2,21	4,23	6,35
Nr. total of particles	183,09	511,24	1016,30	2024,00	4036,16	7774,43	11691,66

The data in tables 2 and 3 reveal micron and submicron particle dynamics of the aerosol, which satisfy the same objective laws of evolution as for giant particles

[Sandu et al., 2004]. Also, according to the total mass and concentration variation obtained in different periods of time for micron and submicron particles taken together (Table 2), orders of magnitude are close to the giant particles.

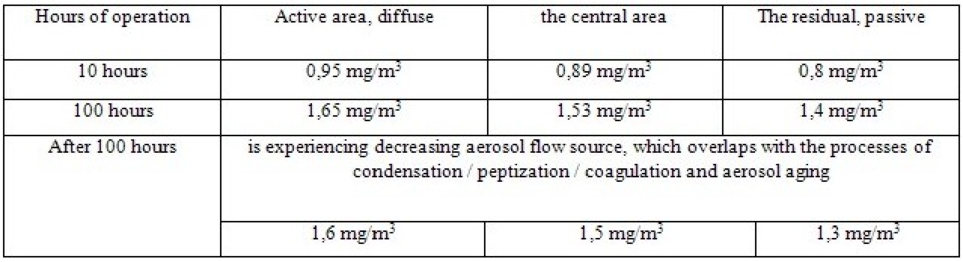
Tab. 3 - Temporal variation of the total volume of particles with diameter d_i, dimensional groups



Diameter d_i of particles (μm)	***Volume particle diameter d_i*** (10^{-14} x m^3)						
	10 min	30 min	60 min	120 min	240 min	480 min	1440 min
0,3	243,4	675,5	1642,5	2661,3	5321,7	10253,4	15380,1
0,5	64,0	195,3	390,3	833,0	1588,7	3173,8	4760,8
1,0	32,4	103,6	202,5	416,6	852,5	1666,3	2499,4
2,0	134,0	443,8	879,2	1745,8	3596,4	6995,9	10496,0
5,0	523,3	1700,8	3401,7	7326,7	14457,1	27671,3	41539,6
The total volume of particles	997,1	3119,0	6516,2	12983,4	25816,4	49760,7	74675,9
The total mass of particles (g)	$2,15x10^{-5}$	6,72	14,05	28,00	55,66	107,28	161,00
concentration (g/m^3)	$1,955x10^{-5}$	6,11	12,77	25,45	50,6	97,53	145,36

Concentration variation over time for the three sampling sites in the halochamber was determined by the differential conductometric method (Table 4).

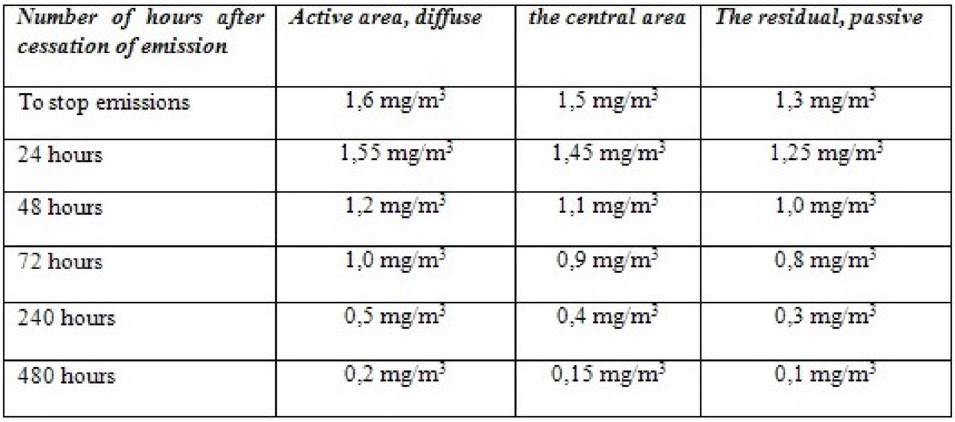
Tab. 4 - Variation of aerosol concentration in the three sampling points of halochamber: active area, the diffuse, the residual or passive



Hours of operation	Active area, diffuse	the central area	The residual, passive
10 hours	0,95 mg/m^3	0,89 mg/m^3	0,8 mg/m^3
100 hours	1,65 mg/m^3	1,53 mg/m^3	1,4 mg/m^3
After 100 hours	is experiencing decreasing aerosol flow source, which overlaps with the processes of condensation / peptization / coagulation and aerosol aging		
	1,6 mg/m^3	1,5 mg/m^3	1,3 mg/m^3

In the first 10 hours of operation (Table 4) in the three sampling sites, we achieved half of the maximum concentration, 0.95 mg/m^3 in the active area near the micro-ultra-filter (the entry point into the halochamber), 0.89 mg/m^3 in the center - diffuse and 0.8 mg/m^3 in the residual or passive, the evacuation of halochamber. At 100 hours of operation, we reached the halochamber maximum concentration (1.65 mg/m^3 in the core, 1.53 mg/m^3 to 1.4 mg/m^3 diffuse area in the passive), then we felt a strong decrease in the aerosol flow source, which overlaps with the processes of condensation/peptization/coagulation and aerosol aging. After stopping the emission (Tab. 5), a decrease of aerosol concentration over time occurred. Within 24 hours, there was a slight decrease in concentration, controlled by nucleation and condensation processes, followed by a drop in the next 48 hours. The processes were peptization/coagulation, as concentration decreases the rate reduction in three stages between 72 and 240 hours, then between 240 and 480 hours and respectively between 480 and 720 hours, the last step aging effect dominates the resulting particle accumulation.

Tab. 5 - Concentration variation of halochamber aerosols after stopping the emission



Number of hours after cessation of emission	*Active area, diffuse*	*the central area*	*The residual, passive*
To stop emissions	1,6 mg/m^3	1,5 mg/m^3	1,3 mg/m^3
24 hours	1,55 mg/m^3	1,45 mg/m^3	1,25 mg/m^3
48 hours	1,2 mg/m^3	1,1 mg/m^3	1,0 mg/m^3
72 hours	1,0 mg/m^3	0,9 mg/m^3	0,8 mg/m^3
240 hours	0,5 mg/m^3	0,4 mg/m^3	0,3 mg/m^3
480 hours	0,2 mg/m^3	0,15 mg/m^3	0,1 mg/m^3

We intend to extend our research, conducted in a therapeutic environment with saline aerosols, natural or artificial, positively influencing the functioning of the body on the influence of a program that helps sports activities, we may adjust it for age and individual peculiarities of students. Training in a beneficial environment of saline aerosols is generally known to enhance respiratory ventilation, the functional capacity of the circulatory system, to increase blood hormone levels, accelerate metabolism, boost growth processes, increase muscle mass, increase resistance to stress and increase overall state of comfort (will improve movement, creativity, concentration power, memory, emotional stability, etc.).

Conclusions

The control of the concentration and distribution of media solions in dimensional halotherapy is very important for its effects in the medical treatment of various respiratory ailments and in creating an environment with „clean air”, so that the function of the body can be positively influenced by performing sports in a therapeutic environment, such as natural and artificial saline aerosols (saline or halochamber).

Using appropriate methods and techniques, we studied the dynamics of aerosol emissions under normal conditions of temperature and relative humidity. Then we determined the changes in the lifespan of the aerosol halochamber after the emissions stopped.

The particles were analyzed with a micron and submicron size optical particle counter, with laser beam and the concentration variation over time was determined by differential conductometry in three sampling points in the halochamber: the core or nucleation, the diffuse or median (nucleation processes which compete with condensation/peptization/coagulation) and the residual or passive, dominated by condensation processes of aging/peptization/coagulation.

Our research led to the following conclusions:

-within 10 hours of operation, we achieved, in the three sampling sites, half of the maximum concentration, 0,95 mg/m^3 respectively in the core, 0,89 mg/m^3 in the middle - diffuse and 0,8 mg/m^3 in the residual or passive, to 100 hours of operation performed halochamber maximum concentration (1,65 mg/m^3 in the core, 1,53 mg/m^3 to 1.4 mg/m^3 diffuse area in the passive), after that we felt a strong decrease of the aerosol flow;

-after stopping the emission, the aerosol concentration decreases slightly during the first 24 hours (there are nucleation processes of condensation) after which there was a drop in the next 48 hours, due to the peptization-clotting process, then lower concentrations and the rate decreases in three stages: between 72 and 240 hours, between 240 and 480 hours respectively between 480 and 720 hours, the last step requiring the aging effect, the resulting particle accumulation.

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