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RESEARCH ON THE IMPACT OF SALINE AEROSOLS UPON THE PERFORMANCE OF MIDDLE-DISTANCE RUNNERS

ABSTRACT

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Motto:
"Salt is born of the purest parents:
the Sun and the Sea"
Pythagoras

The doctoral thesis entitled **"Research on the impact of saline aerosols upon the performance of middle-distance runners "** was elaborated based on experimental data and on the study regarding the diversification of procedures and devices that generate saline aerosols in artificial halochambers, used to improve the morphostructural, functional characteristics and the exercise capacity of athletes, especially of middle-distance runners. The foundation of these studies was a critical and complex analysis of the state of the art in the domain, based on which I have reviewed the scientific literature regarding the studies that concern the use of saline aerosols. When formulating the objectives and themes, I have taken into account the findings of several research groups, especially of the one within the "Alexandru Ioan Cuza" University of Iaşi, of the Chemistry Institute within the Moldavian Academy of Sciences and of the "Grigore T. Popa" University of Medicine and Pharmacy, Iaşi. All of them have a long tradition in the domain.

For the beginning, the research focused on elaborating new halochambers and devices for the generation of NaCl-based saline aerosols, patentable as such or in combination with other halogens involved in the prophylaxis or treatment of diseases, as well as in the improvement of morphostructural and functional characteristics related to sports performance. Afterwards, I have elaborated halochambers for sports training, where I have studied the impact of aerosols on certain groups of athletes, differentiated by age levels, compared to similar groups who did the same sports training program outdoors; we have considered them witness groups.

The research purpose concerns the impact of saline aerosols within natural and artificial halochambers upon the morphostructural and functional characteristics of athletes, in order to improve individual performances. I have monitored permanently, for three years, the level and activity of aerosols within the halochambers used in the experiments, as well as the influence of other salts upon the generation mechanism.

The theme of the doctoral thesis represents an important chapter of the environment science and technology, and it involves the use of intelligence from adjacent domains – chemistry, physics, sports medicine, climatology, sport, etc – for the chemical and physicostructural characterization of saline aerosols and of the environment within natural and artificial halochambers. I have used information from other domains also for the determination of working parameters and of the alterations in the respiratory and cardiac indices at rest, during and after effort, alongside the evolution of individual performances of middle-distance runners.

The choice of this theme is justified by the need to elaborate new types of halochambers and high-performance of saline aerosol devices, for multiple modern applications. I refer here to the improvement of physical and intellectual performances of human subjects of various ages, as well as to the creation of closed environments for work or recreation, with "fresh air," which correspond to the current demands and standards.

During the elaboration of the doctoral thesis, I have taken into account **two groups of objectives:**

a. **Theoretical objectives** – related to *the critical study and the documentary synthesis* of the state of the art in the field concerning the production of environmental settings with saline aerosols, their physicostructural, chemical and microbiological characterization. These objectives are also related to *the critical analysis* of the main generating sources and on their practical application, as follows: natural and artificial sources of aerosols; benefits of halotherapy; documentary research and training to determine the optimal working parameters in artificial halochambers and in salt mines.

b. **Practical objectives –** they follow several research directions, based on working protocols: selection of the athletes' groups used in the three-year experiments; characterizing and testing the behaviour of various artificial generation devices for saline aerosols; elaboration and construction of two new patentable artificial halochambers; determining the optimal halotherapy conditions, by using the levels and activities of aerosols within the Cacica salt mine and the two artificial halochambers – static and dynamic – used in the experiments. Among the research directions, I also mention the influence of porous NaCl granules combined with other beneficial salts upon the improvement of physical and intellectual performances; this study was finalized by recording the evolution of morphostructural and functional characteristics, alongside the growth indices of individual performances of middle-distance runners. I have also processed the experimental data and I elaborated several papers for various national and international events. Finally, I presented the new halochambers patented at world invention exhibitions.

Within the second group of objectives, special attention was paid to *the seven experimental protocols*:

a. selecting the groups of athletes, middle-distance runners, aged between 14 and 16, for the sports training sessions in natural and artificial halochambers, based on their morphostructural and somatic characteristics;

b. elaboration and construction of two new artificial halochambers – one static and one dynamic – with generating sources for NaCl-based aerosols and for aerosols from other beneficial salts for the improvement of physical and intellectual performances;

c. selection of analytical methods and techniques to determine, on one hand, the chemical and physicostructural characteristics of saline aerosols and of the environmental setting within halochambers in order to assess the working parameters within the halochamber and their optimal levels, respectively;

d. the choice of methods and techniques for determining the cardiovascular and respiratory indices at rest, during and after effort, alongside a series of control tests regarding the evolution of individual performances of athletes, middle-distance runners;

e. determination of microclimate parameters and of the activity of aerosols within the Cacica salt mine and the two artificial halochambers used in the experiments;

f. assessment of the impact of other beneficial salts upon the generation rate of saline aerosols by the physically-doped porous NaCl granules, by entraining – through an air current – the nanoparticles from the surface efflorescence.

g. determination of the impact of aerosols upon the athletes, by comparing the data of the ones who worked in halochambers (Cacica salt mine, static and dynamic artificial halochamber) to those of the athletes who trained outdoors, who represented the witness group.

In this sense, based on prior experiences of our collective, this thesis proposes a new approach to saline aerosols: an approach related to natural and artificial halochambers, by studying and delimitating them based on the trimodal behaviour of in various generation systems. The systems I refer to are as follows: *Aitken module* (between the singular ion – as such or solvated – and nano-structural aggregates smaller than 50μm), *average accumulation module* (diameter ranging between 100 and 500μm) and *coarse sedimentation module* (diameter larger than 500μm, up to 1000μm). Hence, the research has found that these aerosols acquire different shapes and structures, depending on the exogenous and endogenous factors (related to the composition, shape, size and porosity of granules, to the hydration degree and to the generation system, alongside the carrying airflow).

In the papers written for publication and during the elaboration of this thesis, a series of specific names have been used referring to saline aerosols (expressing their behaviour in time, after their generation) and to their involvement in various actions upon living organisms, as follows:

- saline aerosols – salt nanoparticles of inorganic electrolytes, usually with negative charge;

- saline aero-anion – nano-structural salt aggregate with negative superficial charge;
- halo-aerosol – nano-structural halite aggregate with negative charge, anhydrous, semihydrated or hydrated;

The scientific and practical importance of this domain is provided by a series of elements with high degree of novelty and originality, among which it is worth mentioning the following:

- inclusion within the thesis of the *seven experimental protocols,* well differentiated and with high degree of specificity, for a clear emphasis and an effective representation of the research, related to the state of the art;
- elaboration and exploitation of two new halochambers patented at OSIM Bucharest and AGEPI Chișinău;
- statistical processing of the data concerning the evolution of morphostructural and functional characteristics, as well as the individual performance indicators, under the influence of environments that included saline aerosols;
- elaboration of ten papers, three of which were part of national and international conferences and symposia, two of which were published in IDB journals and three in volumes with ISBN, while two were published in ISI journals;
- numerous medals and awards for the two groups of patented inventions, at international exhibitions of inventions.

They all required detailed scientific research, mostly a thorough study of the field, including of the latest contributions. I have also benefited from many and documentation and experiment mobilities at the Salina salt mine, at Tehnobionic Buzău – manufacturer of granules and devices of saline aerosols, at the Institute of chemistry within the academy of Sciences in Chișinău, and others.

The results opened new research perspectives, mostly concerning further studies on the generating mechanisms for saline aerosols under the influence of various dopants and depending on the technology used for obtaining the porous granules and on the nano-structural division-dispersion processes. Further studies are also required for determining their conversion rate by structural reformation depending on exogenous and endogenous agents.

The thesis comprises 245 pages and it is structured into two parts: *theoretical part* – comprising *two* chapters; and *Experimental part* – that includes *six* chapters, as follows:

The first chapter presents an analysis of *the current research on the physicostructural characteristics and the generating sources of saline aerosols: nano-structural and microphysical properties of saline aerosols; size and shape of NaCl aerosols particles; natural sources of saline aerosols (marine aerosols and salt mine aerosols); artificial sources of aerosols (generating*

processes, portable devices and surface halochambers). The chapter ends with a series of conclusions that determined the elaboration of the seven protocols.

Chapter 2 refers to *the practical applications of saline aerosols*: *pollution and role of saline aerosols in environment ecologization; prophylaxis and therapy of cardiorespiratory conditions; other positive effects of halotherapy on the human subjects* and *physiology of halotherapy.*

This chapter, like all the subsequent ones, features a set of conclusions meant to generate future research directions.

Chapter 3 inaugurates the original part of the thesis, which is extended to the following seven chapters.

Chapter 3 features a detailed *description of the two artificial halochambers patented* at AGEPI Chişinău and currently assessed for patenting at OSIM Bucharest. After a critical presentation of the halochambers patented by the elaboration of the new ones, I presented a series of examples concerning their elaboration, advantages and claims.

Chapter 4 a concerned *studying the behaviour in time of the characteristics of aerosols in the Salina salt mine and the two new artificial halochambers by correlation with the microclimate parameters.* These data led to determining the microclimate with minimal levels of aerosols used in the experiments with the athletes.

Chapter 5 presents *the experimental results assessing the impact of certain halogens upon the generation rate of aerosols by the physically-doped NaCl porous granules*, by entraining – through an air current – the nanoparticles from the surface efflorescence. This chapter also explains the generating mechanisms of aerosols in the three phases: nucleation, peptisation-coagulation and extinction-sedimentation.

Chapter 6 comprises *the investigation of morphostructural and anatomo-functional parameters of athletes involved in the experiment*, as well as an assessment of performance indicators. I have taken into account the characteristics of the cardiovascular and respiratory system at rest, during and after effort, along with the specific tests for assessing the exercise capacity.

Chapter 7 presents *the experimental date on the influence of saline aerosols upon the evolution in time of the athletes' anatomo-functional parameters (middle-distance runners),* who trained in the three halochambers, compared to those who trained outdoors or in regular gymnasiums. In this sense, I have elaborated an experimental protocol regarding the selection of athletes by age groups and their repartition by initial performance criteria.

Chapter 8 comprises *the general conclusions* of the thesis. There is emphasis on the author's original contributions, as well as on the perspectives of using the results in future research, concerning mainly the data obtained through the experiments based on the seven experimental

protocols. The focus is on the impact of aerosols upon the improvement of cardiorespiratory and exercise capacity parameters of the athletes used in the experiments.

According to the system of experimental data processing regarding the evolution of the performances achieved by middle-distance runners, analyzed through a set of tests, – carefully selected based on the experimental protocol elaborated according to the standards of the Romanian athletics Federation, differentiated by age groups, comprising athletes born in 1996, 1995 and 1994, – the following conclusions and their specific results can be drawn:

- The training sessions at the Cacica salt mine and in the two artificial halochambers of the experimental group have shown a good body resistance to infectious diseases; the results of periodical medical exams were good throughout the entire centralized and supervised training.
- The training focused on the improvement of specific psychomotor skills, on increase in exercise capacity, on psychological training, on complex post-effort recovery intensified in the muscle sector, mainly in the lower limbs, the hydroelectrolytic rebalancing, avoiding protein or aminoacid excess.
- The two groups carried out the sports training sessions for two hours, six days a week; only the experimental group carried out training sessions in halochambers three days a week, for two hours.
- During the training camps, the sports training sessions took place twice a day: in the morning, at the Cacica salt mine, and in the afternoon, around the locality, in fields with various slopes and in climatic conditions specific to the season (winter and summer). One day a week, a recovery session took place, where the athletes took walks in the salt mine, executed breathing exercises, deep and forced inhaling and exhaling, as well as stretching for muscle relaxation.
- The intermediary and final tests of the experimental groups showed better results; the training sessions took longer and required more effort, considering the adaptation of the cardiovascular and respiratory system to the microclimate of the salt mine and of artificial halochambers.
- By analyzing the results of the control tests, athletes in the experimental group were found to have better results than those of the witness group. Though, at some tests, the initial mean values were very close, while at others the homogeneity of the witness group was better than that of the experimental group, it was proved that the experimental group made more progress.
- After interpreting the data, it can be stated that the use of an environment with saline aerosols from the Cacica salt mine or of the artificial one created in the halotherapeutic setting – in order to improve the performance of middle-distance runners – led to better results than the traditional method used by the witness group.
- It is known that the microclimate of salt mines – through its optimal concentration of aerosols – has a major impact on the human body. Numerous studies conducted thus far have found better results only for the treatment of non-chronic respiratory conditions, but they failed to assess the impact upon the physical and intellectual performances of human subjects. This determined our

collective to approach this new research direction by using young people for the experiments. The target-group of the thesis is that of performance athletes, upon whom aerosols had a special influence.

For the elaboration of the thesis, I have used 63 figures and 53 tables, alongside primary experimental data, featured in annexes II, III, IV and V. I have also used a bibliography comprising 278 references within the national and foreign scientific literature; I am the co-author of ten scientific papers and of two inventions, and the first author of three of the ten papers.