Geosport for Society
ISSN 2393-1353, e-ISSN 2393-2353

vol. 25, no. 2/2026, pp. 163-186
DOI 10.30892/gss.2504-154

Tracing the Evolution of Air Ionisation Research in Romania. Nearly a Century of Scientific Progress and Interdisciplinary Perspectives

Adrian-Călin CIUCIU[1]*

[1] Department of Geography, Tourism and Territorial Planning, Faculty of Geography, Tourism and Sport, University of Oradea, Romania

***Correspondence:** Adrian-Călin CIUCIU; e-mail: adriancalin2980@yahoo.com

Citation: Ciuciu, A.-C. (2026). Tracing the Evolution of Air Ionisation Research in Romania. Nearly a Century of Scientific Progress and Interdisciplinary Perspectives. *Geosport for Society*, 25(2), 163-186. https://doi.org/10.30892/gss.2504-154

Article history: Received: 09.07.2026; Revised: 18.09.2026; Accepted: 09.10.2026; Available online: 26.10.2026

Abstract: Air ionisation is an important component of atmospheric electricity, with implications for environmental quality, bioclimatology, and human health. Although research on this phenomenon has a long tradition in Romania, its historical development and diversification across scientific disciplines require systematic synthesis. This study employs a historical-descriptive review of scientific publications, research reports, conference proceedings, and studies conducted in Romania from 1938 to 2026. The literature was examined chronologically and thematically, focusing on major scientific contributions, measurement approaches, investigated environments, and reported relationships between air ionisation and environmental factors. The earliest measurements were conducted by Mircea Herovanu in 1938–1939, followed by systematic atmospheric observations and biomedical investigations developed by Salvator Cupcea and Mauriciu Deleanu. Subsequent research expanded toward geographical and bioclimatic assessments, particularly in Romanian spa resorts. The national symposia organized in Botoşani in 1984 and 1986 contributed to interdisciplinary collaboration and methodological development. More recent studies have investigated underground, urban, and indoor environments. Measurements in the Cacica Salt Mine revealed total ion concentrations ranging from 9,026.5 to 11,464.5 ions/cm^3, while research in the Suceava Metropolitan Area demonstrated pronounced seasonal and spatial differences between positive and negative ion concentrations. Recent investigations have also incorporated aeroionic measurements into indoor air quality assessments. Romanian research on air ionization has evolved from isolated atmospheric observations into a diversified interdisciplinary field encompassing environmental, geographical, biomedical, and indoor microclimate studies. Further standardized measurements and long-term investigations are necessary to improve comparability and clarify the relationships between air ionization, environmental conditions, and potential health effects.

Keywords: air ionisation, atmospheric electricity, ions concentrations, historical review, environmental monitoring, positive ions, negative ions

Introduction

Atmospheric ionization is a fundamental component of the global atmospheric electrical system, determined by the processes of production, transformation, and loss of electrically charged particles. In the lower troposphere, ion formation is primarily associated with cosmic radiation and radiation emitted by natural

radionuclides, while ion concentration and distribution are governed by processes such as ionic recombination, attachment to aerosol particles, atmospheric transport, and local meteorological conditions. The complexity of these interactions imparts a pronounced spatiotemporal variability to atmospheric ionization, justifying its investigation within the fields of atmospheric physics, climatology, and environmental sciences (Hoppel and Frick, 1986; Hirsikko et al., 2011).

From a physical perspective, characterizing atmospheric ionization entails determining the concentrations of positive and negative ions, their electrical mobility, and their distribution across size classes. The interpretation of these parameters depends on the complex relationships between the electrical properties and the physical characteristics of the particles. Tammet (1995) highlighted the specific aspects of the electrical mobility of ions and nanometric particles, contributing to the development of methods for their characterization. Simultaneously, by modeling ion–aerosol attachment processes, Hoppel and Frick (1986) demonstrated the significance of particle concentration and size in determining the distribution of electrical charges. These contributions have strengthened the theoretical foundation required to interpret variations in atmospheric ionization under diverse atmospheric conditions.

Observational research has shown that the aero-ionic regime of the atmosphere cannot be characterized solely through point measurements; rather, systematic observations are required to capture diurnal, seasonal, and multi-year variability. Through a statistical analysis of atmospheric ion mobility spectra recorded at the Tahkuse Observatory in Estonia, Hõrrak et al. (2000) contributed to the classification of aero-ion populations and highlighted their differentiation based on electrical mobility. The importance of long-term observations was subsequently confirmed by a synthesis conducted by Hirsikko et al. (2011), who—based on an analysis of a large body of international research—demonstrated that the mean concentrations of small atmospheric ions typically range between 200 and 2,500 ions/cm^3 for each polarity, with higher concentrations also reported under certain conditions. These findings underscore the dynamic nature of aero-ionization and the necessity of interpreting measured values in the context of the specific characteristics of the atmospheric environment.

The relationship between aero-ionization and aerosol formation processes represents a major focus of contemporary research. Iida et al. (2006) investigated the contribution of ion-induced nucleation to the formation of new atmospheric particles, emphasizing the importance of simultaneous observations of both ions and nanometer-sized particles. Methodological advancements achieved by Laakso et al. (2007) enabled improvements in determining the electrical charge state of ultrafine particles, contributing to the differentiation of the mechanisms governing their

formation and growth. Subsequently, experiments conducted as part of the CLOUD project at CERN demonstrated that ionization can influence atmospheric nucleation under specific conditions of chemical composition and temperature (Kirkby et al., 2011). These findings broadened the significance of research into air ionization, highlighting the role of ions in microphysical processes relevant to the evolution of atmospheric aerosols.

An important dimension of international research involves investigating the geographical variations in atmospheric ionization. A multicenter study conducted by Manninen et al. (2010), based on measurements taken at 12 European stations, highlighted the variability of atmospheric particle formation processes under diverse geographical and meteorological conditions. The results of such investigations demonstrate the value of comparative approaches and the use of standardized instrumental methods, which ensure a consistent interpretation of data obtained in distinct environments. In this context, analyzing atmospheric ionization in natural, urban, coastal, mountainous, or underground settings is significant for identifying the factors that govern the distribution of atmospheric ions and for assessing the aero-electrical characteristics of various types of environments.

Despite theoretical and instrumental advancements, the comparability of results concerning atmospheric ionization remains limited by differences in measurement methods, the mobility ranges analyzed, meteorological conditions, and the specific characteristics of observation sites. Furthermore, the relationships between atmospheric ion concentrations, aerosol properties, and environmental factors are complex; interpreting them requires integrating information on ionization sources, ion loss processes, and atmospheric dynamics. From this perspective, systematizing previous research is of particular importance—not only for reconstructing the evolution of scientific knowledge but also for identifying methodological continuities, paradigm shifts, and areas that have not yet been sufficiently explored. In this context, an analysis of the evolution of research on air ionization at the national level reveals how international scientific interests have been reflected in the development of atmospheric, bioclimatological, and interdisciplinary investigations. This article aims to provide a historical-scientific synthesis of research on air ionization in Romania by identifying key stages of development, significant contributions, thematic focuses, and methodological advancements. The analysis traces the transition from initial observations of the electrical properties of the atmosphere to systematic research on the spatiotemporal variability of air ionization, its relationships with environmental factors, and the expansion of its interdisciplinary applications.

Materials and methods

The present study is based on a historical and descriptive review of the scientific literature addressing air ionization research in Romania, covering the period from 1938 to 2026. The bibliographic corpus comprises 76 publications, including original research articles, scientific communications presented at national symposia, experimental investigations, and specialized publications documenting the development of this research field (Figure 1).

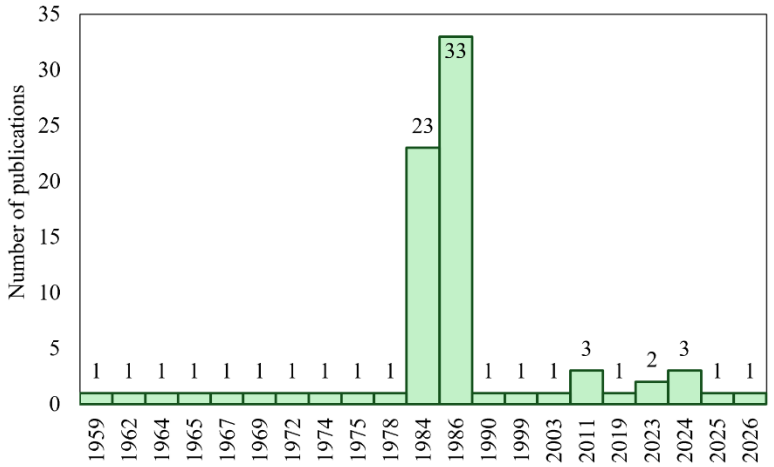


Figure 1. Temporal distribution of scientific publications on air ionisation research in Romania, according to their year of publication

The documentary material encompasses publications originating from different stages in the development of Romanian air ionization research, including early atmospheric electricity measurements, investigations conducted within meteorological institutions, biomedical and bioclimatological studies, and contributions presented at the National Symposia on Air Ionization held in Botoşani in 1984 and 1986. Particular attention was also given to more recent investigations carried out in balneoclimatic resorts, urban and rural environments, underground spaces, educational buildings, and cultural heritage sites. This selection enabled the reconstruction of the main research directions and their evolution across different geographical settings and scientific disciplines.

The reviewed publications were examined using a chronological and thematic approach. For each study, relevant information was identified and organized according to the year of publication, authorship, geographical location, investigated environment, research objectives, measurement procedures, and principal findings. Where available, additional information was considered regarding observation periods, seasonal and diurnal measurement schedules, sampling locations, positive

and negative air ion concentrations, unipolarity coefficients, and relationships with meteorological and environmental parameters. Studies addressing biological effects, therapeutic applications, and artificial ionization were examined in relation to their contribution to the diversification of research objectives and experimental approaches.

The analysis was structured around successive stages in the historical development of the field, from the first atmospheric measurements and systematic observations to the expansion of interdisciplinary applications and contemporary environmental investigations. Thematic synthesis was used to identify major scientific contributions, changes in research priorities, methodological developments, and the progressive extension of investigations from natural outdoor environments to underground and indoor spaces.

Given the considerable heterogeneity of the reviewed studies in terms of instrumentation, observation periods, sampling strategies, geographical conditions, and reported parameters, the analysis was primarily qualitative. Quantitative findings were retained as reported in the original publications and interpreted within their respective methodological and environmental contexts. No statistical meta-analysis or direct standardization of historical measurements was performed. Instead, the synthesis emphasizes the evolution of scientific knowledge, the geographical diversification of research, and the emergence of new interdisciplinary perspectives on air ionization in Romania.

Results and discussion

Regarding the research on air ionization in Romania, it can be said that this is of recent date. Important studies began in the first part of the 20th century by Mircea Herovanu, a physicist by training, who carried out the first measurements of air ionization, between 1938 and 1939, in Mangalia, but a broader approach, in our country, on air ionization can be said to have begun in the second half of the 20th century.

Starting in 1949, measurements were made on air ionization at the Atmospheric Physics Observatory in Bucharest, which belonged to the Institute of Meteorology and Hydrology, led by Mircea Herovanu, over a period of 30 years, by determining several electrical parameters of the air.

The approach to the issue of air ionization in Romania was initiated, in a first stage, mainly in the medical field, in the context of concerns regarding the influence of physical environmental factors on human health. Physicians were, thus, among the first researchers to show interest in studying air ionization and in identifying its physiological and hygienic-sanitary implications.

In this context, the research of Professor Dr. Salvator Cupcea, one of the personalities who contributed to the development of studies on air ionization in Romania, also falls within this context. He served as director of the Institute of Public Health in Cluj-Napoca and head of the Department of Hygiene at the Institute of Medicine and Pharmacy (IMF) in Cluj-Napoca.

Through his scientific concerns, the issue of air ionization was approached from the perspective of the relationship between physical environmental factors and the health of the population, contributing to the shaping of a research field at the intersection of hygiene, physiology and environmental medicine. Professor Salvator Cupcea is considered a pioneer in Romania in studying air ionization on human health and using air ionization as an indicator of air pollution, and launched the idea that air ionization is an important factor in animal and human life.

Among the main scientific contributions of Salvator Cupcea to the medical study of air ionization are several investigations conducted between 1956 and 1959. Cupcea (1956) examined the effects of air ionization on anaphylactic shock in guinea pigs, while his subsequent research addressed the influence of ionized air on living organisms (Cupcea, 1957) and the trophic changes of the gastric mucosa in experimental ulcers (Cupcea, 1959). Cupcea's scientific activity also extended to international publications. In a study published in 1959, he investigated the influence of air ionization on pathological changes in the stomach. Subsequently, Cupcea (1960) examined the geographical distribution of air ionization across Romania in a paper published in Prague, contributing to the understanding of the spatial variability of this atmospheric phenomenon. The research presented at the balneoclimatology conference held in Plitvice in 1958 preceded a study conducted by Cupcea et al. (1959), which investigated air ionization in several balneoclimatic resorts in Romania. This study contributed to the geographical characterization of air ionization by examining its concentrations in different spa environments.

The research team coordinated by Professor Cupcea also included Mauriciu Deleanu, who, after his death in 1958, continued the research activity devoted to the study of air ionization. Deleanu's scientific activity was materialized through numerous works published both in Romania and in specialized journals abroad, contributing to the development and promotion of research on air ionization and its implications on the body.

Among Deleanu's scientific contributions to the study of aeroionization, particular attention should be given to the research conducted in collaboration with Elges. Deleanu and Elges (1967) investigated atmospheric ionization in Cluj over an 11-year period (1955–1965), presenting their findings in the *Proceedings of the Meteorological Institute*. Their study provided systematic observations of the temporal variability of air ionization in Romania. The significance of this research lies

in both the extended observation period and the systematic measurement approach, which enabled the identification of variations in atmospheric ionization in relation to different atmospheric factors.

Deleanu's scientific interests also extended to the relationship between atmospheric aeroionization and human health. Deleanu (1975) examined the aeroionic characteristics of forest environments and their potential implications for human health, emphasizing the sanitary significance of natural air ionization. Subsequently, Deleanu et al. (1988) provided a comprehensive examination of negative air ionization, addressing its physical mechanisms, biological effects, and potential medical applications.

In their work, Deleanu et al. (1988) discussed the physical processes underlying natural air ionization, the operating principles of negative air ion generators, and the effects of air ions on living organisms. Particular attention was given to the influence of air ionization on plants and animals, as well as to its potential applications in the prevention and treatment of certain diseases. The authors also examined the possible effects of air ionization on the productivity of selected plant and animal species, highlighting the interdisciplinary nature of research in this field.

From a geographical perspective, Deleanu et al. (1988) analyzed the spatial distribution and variability of atmospheric ion concentrations, drawing on investigations conducted in Romania and other countries. By integrating findings from previous studies with their own measurements, the authors provided comparative information on atmospheric ionization levels across different geographical environments. For Romania, they reported average concentrations ranging from approximately 600 to 2,200 pairs of small air ions/cm^3, indicating considerable spatial variability in atmospheric ionization.

In the preface of the work "*Negative Air Ionization*" the need to develop research on this phenomenon in Romania and to stimulate collaboration between specialists from different fields is emphasized. The authors aim to attract as many researchers as possible to the study of air ionization, starting from the concept that the organism cannot be analyzed separately from its living environment. This perspective contributes to the integration of research on air ionization into the broader framework of the study of the relationship between environmental factors and the functioning of the organism.

Mauriciu Deleanu's scientific activity also had an important international dimension. Among the works published in specialized journals and volumes outside Romania, together with other authors, are: *L'amélioration des résultats de l'entraînement chez les sportifs sous l'influence de l'aéro-ionisation négative modérée* (Straus et al., 1965), *Beiträge zum Studium der Luftionisation als Umweltfaktor und ihrer Wirkung auf den Organismus* (Deleanu, 1966), *Non-specific biological action of*

air ionization (Deleanu and Frits, 1967), as well as *À propos de l'intervention des aéro-ions dans les processus de régulation de la lipémie et de la cholestérolémie* (Straus and Deleanu, 1968), which addresses the role of air ions in the body's regulatory processes. His research also focused on the effects of negative air ionization on physiological and biological processes, as indicated in the work *Die Wirkung negativer Luftionisation auf die Länge des Oestruszyklus bei Ratten* (Straus and Deleanu, 1970), and later the issue was extended to the relationship between air ionization and seasonal variations in anaphylactic sensitivity, in the study *Air ionization and circannual fluctuation of anaphylactic sensitivity* (Deleanu and Mărgineanu, 1986).

Through the diversity of topics addressed, from the physical characterization of air ionization and its spatio-temporal variation to the biological, medical and physiological effects of air ions, Mauriciu Deleanu's work represents an important contribution to the development of Romanian research on atmospheric ionization. His research has also contributed to connecting Romanian studies on air ionization with international concerns in the field and has created premises for continuing investigations on the relationship between the electrical properties of the atmosphere, the natural environment and the human body.

In the 1960s, research on atmospheric aeroionization occupied an important place in the scientific activity of the Romanian Meteorological Institute. These concerns were part of the broader effort to understand the physical properties of the atmosphere and, at the same time, were of particular interest to bioclimatology and the climatology of spa resorts. Knowledge of the degree of air ionization in different regions could contribute to the characterization of local climatic peculiarities and to the highlighting of differences between various types of geographical environments.

An important part of this research was published in the collections of works of the Institute of Meteorology, which represented a framework for the valorization and dissemination of the results obtained through meteorological observations and measurements carried out in different parts of the country. Studies devoted to air ionization aimed both at characterizing air ionization in certain localities and resorts, and at observing its variation over time and in relation to environmental particularities.

An important study is the one carried out by (Deleanu and Elges, 1967), entitled " *Observations on air ionization in Cluj over a period of 11 years 1955–1965* ", published in the Collections of Works of the Meteorological Institute. Compared to a research carried out in a short period or in a single season, this study stands out for the very long duration of the observation period, 11 years. Such a series of observations allowed the monitoring of the behavior of air ionization over a period long enough to capture its variations from one year to another, as well as the changes associated with different periods of the year. Therefore, the research in Cluj brings an important

temporal perspective on the phenomenon, completing the studies carried out in resorts or in more limited periods.

Another important direction of research focused on atmospheric ionization under fair-weather conditions. Frimescu and Creţeanu (1962) investigated air ionization in the Bucharest–Afumaţi area, emphasizing the importance of relatively stable atmospheric conditions for understanding the natural variability of aeroion concentrations. Their research provided a framework for distinguishing variations associated with normal atmospheric processes from those influenced by disturbed meteorological conditions. The Afumaţi observation site, located near Bucharest, offered a relevant setting for examining the aeroionic characteristics of the capital's surrounding area. Subsequent observations conducted by Frimescu and Creţeanu in May, August, and October 1964 indicated that total air ion concentrations exceeded 1,200 ions/cm^3 at 12:00 p.m., surpassing the values recorded by the same researchers in Sinaia and Mangalia.

A special place is occupied by the work "*Study of natural air ionization in Mangalia and Sinaia*", carried out by (Frimescu and Creţeanu, 1964). The research of the two localities introduces an important comparative dimension, because Mangalia and Sinaia represent two distinct geographical and climatic stages. Mangalia is associated with the relief stage belonging to the coast, while Sinaia belongs to the mountain relief stage. In Sinaia, the measurements were carried out in each season, in three different points: Păltiniș, Poiana Furnica and Pădurea Furnica, as well as in three different times of the day, respectively at 8 am, 12 pm and 4 pm. For Mangalia, the measurements were carried out in three seasons in spring, summer and autumn, at the same times of the day as in Sinaia, respectively at 8 am, 12 pm and 4 pm. In conclusion, the study highlights differences in total air ionization values between Mangalia, a resort located on the Black Sea coast, and Sinaia, a mountain resort, highlighting the importance of local physical-geographical factors in determining the concentration of air ions.

Taken together, these works highlight the diversity of research directions on air ionization in Romania during that period. Studies conducted in balneoclimatic resorts aimed to characterize air ionization in different natural environments, the research from Bucharest– Afumati analyzed the phenomenon in fine weather conditions, and the observations from Cluj, carried out over a period of 11 years, offered the possibility of following the evolution of the phenomenon over time.

Through this research, air ionization began to be approached not only as a physical phenomenon of the atmosphere, but also as an important component of the climatic characterization of different regions and resorts. The interest in this field reflects the concern of researchers from the Institute of Meteorology for identifying and describing elements of the atmospheric environment that could differentiate

certain geographical areas and, in the case of balneoclimatic resorts, could contribute to defining their climatic particularities.

In this context, the works of Cupcea et al. (1959), Deleanu and Elges (1967), as well as those of Frimescu and Creţeanu (1964) can be considered representative of the development stage of Romanian research on air ionization in the 1950s–1960s. They illustrate the concern for measuring, observing and comparing natural air ionization, both in balneoclimatic resorts and in urban centers or meteorological observation points, contributing to the shaping of a distinct research direction within the activity of the Institute of Meteorology.

In the eighth decade of the 20th century, the city of Botoşani hosted two important scientific events dedicated to the study of air ionization and its implications. The first symposium was organized in 1984, providing an opportunity to present and debate the results of research conducted in this field, and the second took place in 1986, continuing the scientific concerns and exchanges of experience initiated during the first event.

The first air ionization symposium in Romania represented an important moment in the development and consolidation of research dedicated to air ionization in our country. This symposium was attended by 43 researchers, with over 60 scientific papers presented and elaborated. The number of participants and the diversity of topics addressed highlight the interest that existed at that time in the study of air ionization and in identifying the implications of this phenomenon on the environment and the human body.

The papers presented at the symposium addressed several research directions, reflecting the interdisciplinary nature of the study of air ionization. Among the main topics addressed were the influence of air ionization on health, the characterization of air ionization in different regions and localities, as well as the techniques and methods used to measure air ions.

One of the main research directions addressed at the first National Symposium on Air Ionization focused on the potential influence of air ionization on human health. In this context, Bernea (1984) examined the importance of air ionization and bioclimatic factors in health promotion, emphasizing the relationship between atmospheric environmental conditions and human well-being. This approach reflected the growing interest in understanding air ionization as an environmental factor with potential implications for human health and as a component of the bioclimatic characteristics of different geographical environments.

A second important research direction focused on the geographical variability of atmospheric aeroionization, particularly the characterization of aeroelectric conditions and air ion concentrations in different urban and balneoclimatic environments. In this context, Moraru and Ciucianu (1984) investigated the

aeroelectric characteristics of the atmosphere in Bucharest, contributing to the understanding of air ionization in urban environments. Similarly, Benedek and Deleanu (1984) examined atmospheric aeroionization in the Covasna resort, focusing on the characterization of aeroionic conditions within a balneoclimatic setting. Together, these investigations reflected the growing interest in comparing atmospheric ionization across different geographical environments and highlighted the relevance of aeroionic measurements for the environmental characterization of urban areas and spa resorts.

Another important research direction focused on the development and improvement of techniques and methods for measuring atmospheric air ions. Accurate determination of air ion concentrations requires appropriate instrumentation and standardized measurement procedures to ensure the reliability and comparability of results obtained under different geographical and atmospheric conditions. In this context, Aionesei (1984) examined methodological aspects of aeroion measurement, contributing to the development of instrumental approaches for investigating atmospheric ionization.

The diversity of scientific contributions presented at the First National Symposium on Air Ionization, held in Romania in 1984, reflected the interdisciplinary development of research in this field. The studies addressed several complementary directions, including the potential effects of air ionization on human health (Bernea, 1984), the characterization of aeroionic conditions in different geographical environments (Benedek & Deleanu, 1984), and the improvement of air ion measurement techniques (Aionesei, 1984). Collectively, these contributions illustrate the expansion of Romanian aeroionization research beyond the observation of atmospheric electrical phenomena toward the investigation of bioclimatic and biological implications, geographical variability, and methodological advancements.

The second symposium dedicated to the issue of air ionization, held in Botoşani in 1986, brought together a significant number of specialists interested in the study of this phenomenon and its implications for the environment and the human body. The scientific event was attended by approximately 65 researchers, who presented a wide range of works devoted to various aspects of air ionization, their number exceeding 130 scientific articles and communications. Compared to the first edition of the symposium, organized in 1984, the scale of the 1986 event highlights a considerable increase in the interest of the scientific community in air ionization research and in identifying new directions for applying the results obtained.

The thematic diversity of the papers presented at the second edition of the symposium reflects the interdisciplinary nature of research on air ionization. The phenomenon was analyzed from multiple perspectives, addressing both aspects related to the presence and role of air ions in the environment, as well as issues

related to their production, determination and measurement. At the same time, the research followed the effects of air ionization on the human body and the possibility of its use in the medical field, as well as the application of the principles of air ionization in agriculture. In this context, several major thematic directions can be identified: air ionization of the environment, generation and measurement of air ions, use of air ionization in medicine and research on its effects in agriculture.

A first important research direction was represented by the aeroionization of the environment, with an emphasis on the role of aeroions in the living and working conditions of humans. The works included in this category aimed to characterize the aeroionization conditions in different spaces and highlight their importance for the quality of the ambient environment. Among the contributions presented, the work " *Aeroionization as a factor of the human living environment*" (Deleanu, 1986) stands out, which highlights the need to analyze aeroionization as an environmental factor with potential implications for the human body. Another relevant contribution is the work "*Data on aeroionization in inhabited and working spaces*" (Deleanu, 1986), oriented towards investigating the aeroionization conditions in the spaces where people carry out their daily activities. Also, the work "*Natural and artificial air ionization in treatment wards*" (Andriescu and Tihon, 1986) highlights the concern of researchers for the analysis of air ionization conditions in medical spaces and for the possibility of controlling or improving them by artificial means.

A second research direction, particularly important for the practical development of the field, was represented by the generation and measurement of aeroions. Research in this category aimed both at identifying efficient ways of producing aeroions, and at developing and improving methods for determining their concentration. In this regard, the work "*Considerations regarding the production of aeroions by corona discharge"* (Aionesei, 1986) is noteworthy , which addresses aspects related to the production of aeroions by means of electrical discharges. Another contribution, entitled "*Some problems regarding the measurement of aeroion concentrations*" (Aionesei, 1986), is oriented towards the difficulties and conditions specific to the quantitative determination of aeroions in the ambient environment. Also in this direction is the work "*Contributions regarding the construction of emission electrodes of atmospheric aeroion generators*" (Alexa et al., 1986), which highlights the concern for improving the technical components used in aeroion generation and for developing devices capable of producing aeroions under controlled conditions.

Another major direction addressed during the symposium was the use of air ionization in medicine, a field that demonstrates the interest of researchers in the biological effects of air ions and their valorization for therapeutic or prophylactic purposes. The research presented aimed to highlight how exposure to air ions, especially negative air ions, can influence certain physiological functions and

parameters of the human body. Among the relevant works are "*Therapeutic results in hypertension through exposure to negative air ions*" (Spulber, 1986), which addresses the possibility of using negative air ionization in the context of arterial hypertension. Another work, "*The influence of negative air ionization on the intellectual work capacity of students*" (Coșan and Deleanu, 1986), extends the area of research to the effects of air ionization on intellectual activity and work capacity, in the case of the school population. Also, the paper "*The influence of negative air ionization on the time of return to initial values of some cardio-respiratory parameters after a dosed physical effort*" (Lăscărache et al., 1986) highlights the concern for analyzing the effects of air ionization on the body's recovery processes following a controlled physical effort.

Therefore, the papers presented at the second symposium in Botoșani demonstrate a significant expansion of research on air ionization, both thematically and in terms of application. While the first concerns were mainly oriented towards characterizing the phenomenon and understanding its mechanisms, the research presented in 1986 indicates an increasingly complex approach, in which air ionization is simultaneously analyzed as an environmental factor, a measurable physical phenomenon and a possible tool with medical and practical applications. The diversity of the papers presented, the number of researchers involved and the variety of application areas are indicators of the development of interdisciplinary research on air ionization in Romania during that period.

A significant contribution to the study of air ionization in Romania was made by Liviu Enache. In his doctoral thesis, Enache (1977) investigated air ionization in Romanian balneoclimatic resorts, conducting his research at the University of Bucharest under the supervision of Academician Theodor V. Ionescu.

The work was included in the field of atmospheric electricity research, having a pronounced applied character and aiming at the characterization of air ionization in localities intended for rest and balneal treatment. The study started from the need to deepen a relatively little researched field in Romania and from the importance of highlighting the climatic and aeroelectric conditions favorable to the development of balneoclimatic treatment. The research aimed at identifying new aeroelectric resources of the climate and topoclimate of the balneal resorts, as well as bringing together existing information with the results of the author's own observations.

Experimental investigations were carried out in several balneoclimatic resorts, including Eforie Nord, Tușnad, Govora, Amara and Techirghiol. An important element of the research is the realization, through self-equipment and with personal contribution, of the device used to measure air ionization. Over the course of three years, 568 complete determinations were carried out, while the main climatic elements were analyzed in parallel. The results obtained allowed the characterization of the natural regime of air ionization in different areas of the country and the

establishment of an overall picture of the distribution of this aeroelectric factor in resorts and in some urban localities.

Through the breadth of observations and its orientation towards balneoclimatological applications, Liviu Enache's research represented an important contribution to the development of the study of air ionization in Romania, highlighting the need to correlate this factor with the climatic particularities and environmental conditions of spa resorts.

Liviu Enache's interest in the study of air ionization was not limited to the research carried out in his doctoral thesis, but continued and diversified over several decades. Subsequent research addressed both the characterization of air ionization in various natural and anthropized environments, as well as its relationship with meteorological factors, atmospheric pollution and the bioclimatic properties of balneoclimatic resorts. Among his works are "*Aspects of air ionization in balneoclimatic resorts on the Romanian Black Sea coast*", (Enache and Voiculescu, 1978), as well as "*Determinations regarding the influence of air ionization on air pollution*", (Enache and Andrişan, 1990). These concerns demonstrate the expansion of research from the simple determination of air ion concentrations to the analysis of their role as an indicator of the characteristics of the atmospheric environment.

Another important direction of Enache's scientific activity focused on the biological and medical effects of air ionization. Enache (1999) examined the interactions between atmospheric ionization as a physical environmental factor and living organisms, emphasizing its potential biological implications. Subsequently, his research expanded to underground environments, particularly those associated with speleotherapeutic applications. In collaboration with Filipescu, Simionca, and other researchers, Enache contributed to a study investigating natural and artificial air ionization in underground spaces, with particular emphasis on its potential therapeutic relevance in salt mines and other subterranean environments (Enache et al., 2005).

The research of this period was complemented by experimental studies on the effects of artificial air ionization on the body. In 2011, together with Iu. Simionca, Liviu Enache published two papers in Balneo Research Journal, "*The Artificial Air Ionization Effect (Negative and Positive) in Experiment on Some Hematological Parameters of Wistar Rats*" and "*The Experimental Effect of Artificial Air Ionization on Some Nonspecific Parameters of Immune System of Wistar Rats*" devoted to the effect of artificial ionization, both on some hematological parameters of Wistar rats, and on some nonspecific parameters of the immune system. This research illustrates the transition to an experimental approach to the biological effects of air ions and continues his concerns regarding the possibilities of therapeutic use of artificial ionization.

A comprehensive synthesis of these concerns is represented by the volume "*Biomedical Aspects of Air Ionization*", published in 2017 by SITECH Publishing House. The work brings together aspects regarding the history and mechanisms of air ionization, the factors that determine the concentration of air ions, natural and artificial ionization, the relationship between air ionization and air pollution, as well as the numerous biological and medical implications of this environmental factor. The effects on the respiratory and cardiovascular systems, the central nervous system and the immune system, as well as the possibilities of using air ionization for therapeutic purposes, are addressed, among others.

Therefore, Liviu Enache's scientific activity in the field of air ionization is notable for its continuity and progressive diversification of topics, from measuring air ionization in spa resorts and analyzing its relationship with environmental factors, to investigating the biological, medical and therapeutic effects of natural and artificial air ionization.

An important stage in the research of aeroionization of underground environments in Romania is represented by the contributions of the team from the National Institute of Recovery, Physical Medicine and Balneoclimatology, in which Iuri (Gheorghe) Simionca stood out. Since the late 1990s, Simionca, together with Elena Teodoreanu and Liviu Enache, participated in the work entitled "*Preliminary study of the microclimate of the Cacica salt pan, Suceava county in order to evaluate the balneotherapeutic possibilities*" (Simionca et al., 1999), research that aimed at characterizing the environmental conditions in the underground in the perspective of their therapeutic valorization. Later, the collective's concerns expanded to natural and artificial ionization of air in underground spaces, Simionca being co-author of the paper "*Natural and artificial ionization of air in underground spaces, an environmental factor with therapeutic potential*", published in 2005 in the Journal of Recovery, Physical Medicine and Balneoclimatology.

Research in the Cacica Salt Mine continued in the following years. A determination attributed to Simionca, made in 2008, indicated a total concentration of approximately 1,306 ions/cm^3 and a unipolarity coefficient of 0.98.

More recently, the team from the "Ştefan cel Mare" University of Suceava, coordinated by Dumitru Mihăilă, stands out, who carried out measurements of air ionization in various balneoclimatic resorts in northeastern Romania at Solca, Cacica and Gura Humorului, as well as in the Cacica salt pan and in the metropolitan area of the municipality of Suceava. The research of this team marks an important stage in the development of air ionization studies in Romania, by extending observations from point determinations to more complex spatial and temporal assessments of positive and negative ion concentrations.

In the study "*Research on air ionization in the tourist resorts of Solca, Cacica, Gura Humorului and in Cacica salt mine – north-eastern Romania*", (Mihăilă et al., 2023) they carried out measurements in May and August 2022, between 08:00 and 20:00, monitoring both the concentration of air ions and their relationship with the main meteorological parameters. The results revealed average values of the total concentration of air ions of over 1,000 ions/cm^3 in all three resorts analyzed: approximately 1,054 ions/cm^3 at Solca, 1,069 ions/cm^3 at Gura Humorului and 1,468 ions/cm^3 at Cacica. The authors believe that these values give the atmospheres of the three resorts a favorable potential for use for aeroionotherapeutic purposes.

A particularly interesting result was obtained underground, in the Cacica salt mine, where measurements made on September 15, 2022, at three points located at different levels of the mine, indicated total concentrations much higher than those recorded in the atmosphere of the resorts. The values ranged between 9,026.5 and 11,464.5 ions/cm^3, depending on the observation point. The highest value, of 11,464.5 ions/cm^3, was determined in the hall of the "Sfânta Varvara" Chapel, while in the Sports Hall, located at approximately −79 m, 10,434 ions/cm^3 were recorded. In the Lake Hall, at approximately −42 m, the value was 9,026.5 ions/cm^3. These results are also important in comparison with previous determinations carried out in the Cacica salt mine, which had reported significantly lower values, suggesting significant spatial and temporal variability of underground aeroionization.

The research was complemented by a separate study dedicated to the Suceava metropolitan area: "*The air ionisation in Suceava Metropolitan Area*", (Prisăcariu et al., 2023). The study represents, according to the authors, the first systematic research of this type carried out for a city and its surrounding area in Romania. The measurements were carried out in 34 points in the Suceava metropolitan area, in four periods of the year - January, March, July and November 2022 - and at different times of the day, monitoring active surfaces with different characteristics, from heavily anthropized spaces to natural and forest surfaces.

At the level of the entire metropolitan area, the annual average values determined in 2022 were 576.6 positive ions/cm^3 and 379.5 negative ions/cm^3. From a seasonal point of view, the concentration of negative ions reached a maximum in July, of 598.6 ions/cm^3, while positive ions recorded a minimum of 415.3 ions/cm^3 in the same month. The unipolarity coefficient, used by the authors to characterize the ratio between positive and negative ions, had an average value of 1.52 for the entire metropolitan area, with significant variations between 5.8 in January and 0.73 in July. The lowest values of the coefficient were identified in rural localities in the vicinity of Suceava municipality and in points characterized by natural surfaces, which indicates a favorable influence of less anthropized spaces on the aeroionic balance.

Therefore, the research of the team from the "Ștefan cel Mare" University of Suceava highlights very clear spatial differentiations of aeroionization, determined both by the particularities of the natural setting and by the degree of anthropization. Forest areas, rural areas and those associated with water or other natural surfaces tend to present more favorable conditions for the presence of negative ions, while highly anthropized urban environments are characterized by a more pronounced imbalance between positive and negative ions. In this context, the results obtained at Cacica are all the more relevant, since the very high values in the underground environment of the salt mine indicate the existence of a distinct aeroionic microclimate, with potential interest for research on balneoclimatic resources.

Recently, Ciuciu et al. (2026) investigated the differences in air ionisation between coastal and mountainous environments in Romania, focusing on the spatial and temporal variability of positive and negative air ion concentrations and the influence of meteorological conditions and local geographical characteristics on their distribution.

In recent research on air ionization in Romania, increasing attention has been directed toward the aeroionic characteristics of indoor environments, incorporating the measurement of positive and negative ion concentrations into the comprehensive assessment of air quality and microclimatic conditions. Specifically, investigations conducted in educational settings (Caciora et al., 2024), historic buildings of heritage value (Caciora et al., 2024), and museum spaces (Ilieș et al., 2025; Ilieș et al., 2026) have sought to characterize the aeroionic regime in relation to temperature, relative humidity, the concentration of suspended particles, the presence of atmospheric pollutants, and ventilation specifics. These studies have highlighted the variability of aeroion concentrations based on the characteristics of the spaces examined, as well as the existence of disparities between the concentrations of ions with opposite polarities, providing valuable insights into the dynamics of aeroionization within enclosed spaces. Through the interdisciplinary approach adopted, this research marks an expansion of scientific inquiry, moving from the characterization of aeroionization in outdoor environments to its assessment within built environments, where the aeroionic regime serves as an indicator for analyzing indoor environmental quality, ambient comfort, and conditions for heritage preservation.

Conclusion

The evolution of research on air ionization in Romania highlights the progressive development of an interdisciplinary field, from atmospheric measurements to the investigation of the biological effects and therapeutic potential of air ionization.

Between 1938 and 1950 , the first measurements made by Mircea Herovanu and the research initiated later laid the foundations for the study of air ionization in Romania. In the 1950s and 1960s, Salvator Cupcea and Mauriciu Deleanu contributed to the development of medical and geographical research, through studies on the effects on organisms and the distribution of air ions in different regions and spa resorts.

In the 1970s–1980s , concerns expanded to the physiological and biological effects of air ionization. National symposia organized in Botoşani in 1984 and 1986 strengthened interdisciplinary collaboration and diversified research topics, including measurements, technical applications, and effects on living organisms.

During the period 1990–2010 , research addressed the relationship between aeroionization and air pollution, the characteristics of the microclimate in underground spaces, and the effects of artificial ionization. Studies published in 2011 by Iu. Simionca and Liviu Enache investigated hematological and immune system parameters in Wistar rats, and the volume published by Enache in 2017 synthesized the main biomedical aspects of the field.

In the 2020s , research focused on detailed measurements in balneoclimatic resorts, salt flats and urban areas, highlighting spatial and seasonal variations in the concentration of air ions, carried out by the team of geographers at the "Ştefan cel Mare" University of Suceava.

Overall, the reviewed history reflects the diversification of research methods and directions. Standardized measurements and rigorous studies are still needed to clarify the relationship between air ionization, environmental characteristics, and possible health effects.

Funding: Not applicable.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this paper may be obtained on request from the corresponding author.

Conflicts of Interest: The author declare no conflict of interest.

References

Aionesei, M. (1984). Tehnica măsurării în aeroionizare [Measurement techniques in air ionization]. *Primul Simpozion Naţional de Aeroinizare*, I, 23–48.

Aionesei, M., & Andrişan, C. (1986b). Împământare sau nu? [Grounding or not?]. *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 221–228.

Aionesei, M., & Andrişan, C. (1986d). Timpul de viaţă al aeroionilor. Dispersia în spaţiile habituante [Lifetime of air ions. Dispersion in inhabited spaces]. *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 158–167.

Aionesei, M., & Andrişan, C. (1986e). Unele probleme privind dozarea aeroionilor [Some issues concerning air ion dosage]. *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 306–313.

Aionesei, M., & Andrişan, C. (1986f). Verificarea regimului de emisie al generatoarelor de aeroioni [Verification of the emission regime of air ion generators]. *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 258–263.

Aionesei, M., & Aniţei, I. (1986). Experienţe privind utilizarea aeroionizării în colonia de albine [Experiments on the use of air ionization in bee colonies]. *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 557–561.

Aionesei, M., & Fedor, P. (1986). Unele probleme privind măsurarea concentraţiilor de aeroioni. Contribuţii ale intreprinderii Electrocontact-Botoşani [Some issues concerning the measurement of air ion concentrations. Contributions of the Electrocontact-Botoşani enterprise]. *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 201–207.

Alexa, E. A., Iurea, D., Cadinoiu, L., & Belehuş, I. (1986a). Contribuţii privind construcţia surselor de înaltă tensiune a generatorilor de aeroioni atmosferici [Contributions to the construction of high-voltage sources for atmospheric air ion generators]. *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 292–296.

Alexa, E. A., Iurea, D., Cadinoiu, L., & Belehuş, I. (1986b). Generatoare de aeroioni cu circulaţie frontală [Air ion generators with frontal circulation]. *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 300–301.

Andriescu, L. (1984). Măsurători ale nivelului de aeroionizare în spaţii închise dotate cu surse artificiale de ioni mici [Measurements of air ionization levels in enclosed spaces equipped with artificial sources of small ions]. *Primul Simpozion Naţional de Aeroinizare*, I, 58–62.

Andriescu, L., & Tihon, V. (1986). Aeroionizarea naturală şi artificială în secţii de tratament [Natural and artificial air ionization in treatment wards]. *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 133–135.

Andrişan, C., & Aionesei, M. (1986). Definirea defectelor generatoarelor de aeroioni [Identification of defects in air ion generators]. *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 275–279.

Bejan, V. (1984). Preocupări de folosire a aeroionizării în practica fizioterapeutică [Considerations on the use of air ionization in physiotherapy practice]. *Primul Simpozion Naţional de Aeroinizare*, I, 58–62.

Bejan, V., Paraschiv, V., Paraschiv, M., Bejan, V.D., Alexa, E. M., & Andrişan, C. (1986). Argumente psihomedicale şi ergonomice relevante prin computerizare pentru utilizarea aeroionizării negative în microclimatul industrial [Psychomedical and ergonomic arguments supported by computerization for the use of negative air ionization in industrial microclimates]. *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 429–444.

Benedek, G., & Deleanu, M. (1984). Determinări de aeroionizare în staţiunea Covasna [Air ionization measurements in Covasna resort]. *Primul Simpozion Naţional de Aeroinizare*, 93–95.

Bernea, M. (1984). Importanţa aeroionizării şi a factorilor bioclimatici în promovarea sănătăţii [The importance of air ionization and bioclimatic factors in health promotion]. *Primul Simpozion Naţional de Aeroinizare*, I, 58–62.

Brădăţan, Gh, Hrâncă, Gh, Chiorescu, I., Andrişan, C., & Aionesei, M. (1986). Influenţa ionizării negative asupra microclimatului din adăposturi şi efectul acestora asupra performanţelor productive la ovinele CARACUL [Influence of negative ionization on shelter microclimates and their effects on productive performance in Karakul sheep]. *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 543–553.

Brînză, V. (1974). Asupra ionizării naturale a aerului în zona staţiunii balneoclimaterice Băile Herculane [On natural air ionization in the Băile Herculane balneoclimatic resort area]. *Hidrotehnica*, Bucureşti, 19(nr. 6).

Butoi, S., & Tumanov, S. (1969). Radioactivitatea naturală a aerului la Observatorul Meteorologic Bucureşti Băneasa [Natural radioactivity of air at the Bucharest Băneasa Meteorological Observatory]. *Culegere de Lucrări Ale Institutului Meteorologic*, 1967, 121–130.

Caciora, T., Ilieș, A., Berdenov, Z., Al-Hyari, H. S., Ilieș, D. C., Safarov, B., Hassan, T. H., Herman, G. V., Hodor, N., Bilalov, B., & Pereș, A. C. (2024b). Comprehensive analysis of classroom microclimate in context to health-related national and international *indoor air* quality standards. *Frontiers in Public Health*, 12, Article 1440376. https\://doi.org/10.3389/fpubh.2024.1440376

Caciora, T., Ilieș, D. C., Costea, M., Blaga, L., Berdenov, Z., Ilieș, A., Hassan, T. H., Pereș, A. C., Safarov, B., Josan, I., Noje, I.-C., Dehoorne, O., Grama, V., Baias, Ș., & Yun, G. Y. (2024a). Microclimate assessment in a 19th-century *heritage* building from Romania. *Indoor Air*, 2024, Article 2989136. https\://doi.org/10.1155/2024/2989136

Cadariu, G., Ionescu, A., & Petranu, D. (1972). Inluența aeroionizarii asupra capacitații de muncă [Influence of air ionization on work capacity]. *Fiziol. Normala Patolog*, 18, 461–468.

Ciuciu, A.-C., Caciora, T., & Herman, G. V. (2026). Air ionisation variability in coastal and mountainous areas. Case studies from Romania. *Present Environment and Sustainable Development,* 20(1). https://doi.org/10.47743/pesd2026201025

Coaşan, Aurelia, & Deleanu, M. (1986). Influența aeroionizării negative asupra capacității de muncă intelectuală a elevilor, [Influence of negative air ionization on students' intellectual work capacity]. *Al II-Lea Simpozion Național de Aeroionizare*, II, 332–340.

Coman, I., Bazgan, O., Hagiu, N., & Tudorache, R. (1984). Cercetări privind efectul ionilor negativi asupra sănătății și a performanțelor productive ale puilor Rroller [Research on the effects of negative ions on the health and productive performance of broiler chickens]. *Primul Simpozion Național de Aeroinizare*, I, 145–149.

Creţeanu, V., & Frimescu, M. (1965). Ionizarea aerului la Mangalia şi Govora comparativ cu valorile obținute la Observatorul de Fizica Atmosferei-București [Air ionization in Mangalia and Govora compared with values obtained at the Bucharest Atmospheric Physics Observatory]. *Culegere de Lucrări Ale Institutului Meteorologic Pe Anul 1963.*, *Culegere de Lucrări Ale Institutului Meteorologic Pe Anul 1963.*, 217–225.

Cupcea, S., Deleanu, M., Lenghel, I., Elges, E., & Gros, E. (1959). *Ionizarea aerului în cîteva staţiuni balneo-climaterice din RPR [Air ionization in several balneoclimatic resorts in the Romanian People's Republic].*

Deleanu, M. (1984a). Determinări de aeroionizare în diferite condiţii de mediu [Air ionization measurements under different environmental conditions]. *Primul Simpozion Național de Aeroinizare*, I, 49–56.

Deleanu, M. (1984b). Influența aeroionoterapiei asupra evoluției unor îmbolnaviri [Influence of air ion therapy on the course of certain illnesses]. *Primul Simpozion Național de Aeroinizare*, I, 173–177.

Deleanu, M. (1986a). Aeroionizarea ca factor al mediului de viaţă al omului [Air ionization as a factor in the human living environment]. *Al II-Lea Simpozion Național de Aeroionizare*, II, 10–40.

Deleanu, M. (1986b). Aplicarea aeroionoterapiei în vederea prevenirii recidivelor dureroase în ulcerul gastro-duodenal [Application of air ion therapy to prevent painful recurrences of gastroduodenal ulcers]. *Al II-Lea Simpozion Național de Aeroionizare*, II, 317–325.

Deleanu, M. (1986c). Date privind aeroionizarea în încăperi locuite şi de muncă [Data on air ionization in living and working spaces]. *Al II-Lea Simpozion Național de Aeroionizare*, II, 91–103.

Deleanu, M. (1986d). Elemente de fizica aeroionizării în troposfera joasă [Elements of air ionization physics in the lower troposphere]. *Al II-Lea Simpozion Național de Aeroionizare*, II, 41–63.

Deleanu, M. (1986e). Variaţii ale aeroionizării în mediul exterior natural. Troposfera joasă [Variations in air ionization in the natural outdoor environment. Lower troposphere]. *Al II-Lea Simpozion Național de Aeroionizare*, II, 69–86.

Deleanu, M., & Elges, E. (1967). Observaţii privind ionizarea aerului la Cluj pe o perioadă de 11 ani (1955-1965) [Observations on air ionization in Cluj over an 11-year period (1955–1965)]. *Culegere de Lucrări Ale Institutului Meteorologic*, 517–530.

Deleanu, M., & Mozes-Lörincz, M. (1975). *Effect of negative air ion exposure on adaptation to physical effort in young sportsmen.* College Park, Maryland, 131.

Drăghici, C., Man, C., & Bogdan, D. (1986). Aeroionii în creșterea și exploatarea animalelor de fermă [Air ions in the rearing and management of farm animals]. *Al II-Lea Simpozion Național de Aeroionizare*, II, 484–490.

Elges, E., & Straus, H. (1984). Influenţa aeroionizării în doze moderate asupra methemoglobinemiei produsă experimental [Influence of moderate doses of air ionization on experimentally induced methemoglobinemia]. *Primul Simpozion Naţional de Aeroinizare*, I, 150–155.

Elges, E., Rădulescu, N., & Deleanu, M. (1986). Aeroionii şi nucleii de condensare în atmosfera urbană poluată [Air ions and condensation nuclei in polluted urban air]. *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 115–126.

Enache, L. (1999). Ionizarea aerului şi efectele sale biologice [Air ionization and its biological effects]. *Sănătatea Plantelor*, (16), 9.

Enache, L. (2011). The Experimental Effect of Artificial Air Ionization on Some Nonspecific Parameters of Immune System of Wistar Rats. *Balneo Research Journal*.

Enache, L.M., & Andrişan, C. (1990). Determinări privind influenţa aeroionizării asupra poluării aerului [Measurements concerning the influence of air ionization on air pollution]. *Lucrări Ştiinţifice*, Îmbunătăţiri Funciare, Seria E, XXXIII,(I.A.N.B., Bucureşti).

Enache, L.-M., & Bunescu, I. (2019). Air ionization-an environmental factor with therapeutic potential. *GEOREVIEW: Scientific Annals of Stefan Cel Mare University of Suceava. Geography Series*, 29(1), 31–39.

Enache, L.M., & Voiculescu, Camelia (1978). Aspecte ale ionizării aerului în staţiuni balneoclimatice de pe litoralul românesc al Mării Negre [Aspects of air ionization in balneoclimatic resorts on the Romanian Black Sea coast]. *Lucrări Ştiinţifice*, , Îmbunătăţiri Funciare, Seria E, XX – XXI(I.A.N.B., Bucureşti), 3–18.

Enache, Liviu (2011). *Aspecte generale privind ionizarea naturală a aerului pe litoralul românesc al Mării Negre şi Delta Dunării [General aspects of natural air ionization on the Romanian Black Sea coast and in the Danube Delta].* Conferinţă Naţională de Balneologie, Neptun, 2011.

Frimescu, M., & Creţeanu, V. (1962). Aeroionizaţia de timp frumos la Bucureşti – Afumaţi, [Fair-weather air ionization in Bucharest–Afumaţi]. *Culegere de Lucrări Ale Institutului Meteorologic Pe Anul 1962.*, *Culegere de Lucrări Ale Institutului Meteorologic Pe Anul 1962.*, 189–197.

Frimescu, M., & Creţeanu, V. (1964). Studiul ionizării naturale a aerului la Mangalia şi Sinaia [Study of natural air ionization in Mangalia and Sinaia]. *Culegere de Lucrări Ale Institutului Meteorologic Pe Anul 1964*.

Gaceu O. et al (2003). Scurt istoric al cercetărilor microclimatice şi topoclimatice din România cu privire specială asupra Munţilor Apuseni [Brief history of microclimatic and topoclimatic research in Romania with special reference to the Apuseni Mountains]. *Analele Universităţii din Oradea*, Seria Geogrfie, Tom XIII, 69-76.

Galina, M., & Deleanu, M. (1986). Adaptarea organismului uman la exerciţiul fizic experimental sub influenţa aeroionizării negative [Adaptation of the human body to experimental physical exercise under the influence of negative air ionization]. *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 345–357.

Godeanu, M., Godeanu, Şt, Andrişan, C., Ieroveanu, V., Iacobaş, S., & Hijen, V. (1986). Influenţa aeroionilor negative asupra plantelor acvatice şi a capacităţii lor de depoluare a apelor [Influence of negative air ions on aquatic plants and their capacity to remove pollutants from water]. *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 140–147.

Goia, E. (1984). Regenerarea hepatica în contextual aeroionizării negative [Liver regeneration in the context of negative air ionization]. *Primul Simpozion Naţional de Aeroinizare*, I, 157–161.

Hirsikko, A., Nieminen, T., Gagné, S., Lehtipalo, K., Manninen, H. E., Ehn, M., Hõrrak, U., Kerminen, V.-M., Laakso, L., McMurry, P. H., Mirme, A., Mirme, S., Petäjä, T., Tammet, H., Vakkari, V., Vana, M., & Kulmala, M. (2011). Atmospheric ions and nucleation: A review of observations. *Atmospheric Chemistry and Physics*, 11, 767–798. https\://doi.org/10.5194/acp-11-767-2011

Hoppel, W. A., & Frick, G. M. (1986). Ion–aerosol attachment coefficients and the steady-state charge distribution on aerosols in a bipolar ion environment. *Aerosol Science and Technology*, 5(1), 1–21. https\://doi.org/10.1080/02786828608959073

Hõrrak, U., Salm, J., & Tammet, H. (2000). Statistical characterization of air ion mobility spectra at Tahkuse Observatory: Classification of air ions. *Journal of Geophysical Research: Atmospheres*, 105(D7), 9291–9302. https\://doi.org/10.1029/1999JD901197

Iida, K., Stolzenburg, M. R., McMurry, P. H., Dunn, M. J., Smith, J. N., Eisele, F., & Keady, P. (2006). Contribution of ion-induced nucleation to new particle formation: Methodology and its

application to atmospheric observations in Boulder, Colorado. *Journal of Geophysical Research: Atmospheres*, 111(D23), Article D23201. https\://doi.org/10.1029/2006JD007167

Ilieș V., Deleanu, M., Archinaș, A., & Dukasz, E. (1984). Optimizarea tratamentului hipertensiunii arteriale esențială prin exerciții respiratorii și aer ionizat negativ [Optimization of essential hypertension treatment through breathing exercises and negatively ionized air]. *Primul Simpozion Național de Aeroinizare*, I, 193–195.

Ilieș, A., Caciora, T., Ilieș, G., Hassan, T. H., Berdenov, Z., Ilieș, D. C., Pereș, A. C., Safarov, B., Grama, V., Sabina, H., Indrie, L., Mínguez-García, D., Belda-Anaya, R., & Diaz-Garcia, P. (2025). An integrated risk assessment model for *indoor air* quality impacts on museum exhibits and human health using microclimatic indices and AgNPs treatment. *PLOS ONE*, 20(12), Article e0336594. https\://doi.org/10.1371/journal.pone.0336594

Ilieș, A., Caciora, T., Mircea, C., Ilieș, D. C., Berdenov, Z., Josan, I., Safarov, B., Hassan, T. H., & Pereș, A. C. (2026). Integrated assessment of *indoor air* quality, fungal contamination and visitor perception in museum environments. *Heritage*, 9(5), Article 175. https\://doi.org/10.3390/*heritage*9050175

Ionuț, C. (1984). Aeroionizarea negativă moderată- factor reglator al răspunsului organismului la condiții stresoare [Moderate negative air ionization as a regulator of the body's response to stressful conditions]. *Primul Simpozion Național de Aeroinizare*, I, 100–107.

Ionuț, C. (1986). Cercetarea acțiunii unor factori stresanți și a ionizării aerului asupra glandei suprarenale [Investigation of the effects of stress factors and air ionization on the adrenal gland]. (*Al II-lea Simpozion național de aeroionizare*, Comunicări științifice, Botoșani), 361–368.

Kirkby, J., Curtius, J., Almeida, J., Dunne, E., Duplissy, J., Ehrhart, S., Franchin, A., Gagné, S., Ickes, L., Kürten, A., Kupc, A., Metzger, A., Riccobono, F., Rondo, L., Schobesberger, S., Tsagkogeorgas, G., Wimmer, D., Amorim, A., Bianchi, F., ... Kulmala, M. (2011). Role of sulphuric acid, ammonia and galactic cosmic rays in atmospheric aerosol nucleation. *Nature*, 476(7361), 429–433. https\://doi.org/10.1038/*nature*10343

Laakso, L., Gagné, S., Petäjä, T., Hirsikko, A., Aalto, P. P., Kulmala, M., & Kerminen, V.-M. (2007). Detecting charging state of ultra-fine particles: Instrumental development and ambient measurements. *Atmospheric Chemistry and Physics*, 7, 1333–1345. https\://doi.org/10.5194/acp-7-1333-2007

Lăscărache, Gh, Stroia, V., Boroș, I., & Dănilă, F. (1986). Influența aeroionizării negative asupra timpului de revenire la valorile inițiale a unor parametri cardiovasculari după un efort fizic dozat [Influence of negative air ionization on recovery time of cardiovascular parameters after controlled physical exertion]. *Al II-Lea Simpozion Național de Aeroionizare*, II, 446–453.

Lascu, N.I., Alexa, E. M., Aionesei, M., & Andrișan, C. (1986). Rezultate experimentale privind efectul aeroionizării asupra seminţelor [Experimental results on the effects of air ionization on seeds]. *Al II-Lea Simpozion Național de Aeroionizare*, II, 535–539.

M.E. Alexa, M. Aionesei, C. Andrișan, C. Savitescu, & G., Sulugiuc (1984). Consideraţii referitoare la adoptarea unor soluții constructive ale sursei de înaltă tensine de la aeroionizatoare [Considerations regarding design solutions for high-voltage sources in air ionizers]. *Primul Simpozion Național de Aeroinizare*, I, 58–62.

Manninen, H. E., Nieminen, T., Asmi, E., Gagné, S., Häkkinen, S., Lehtipalo, K., Aalto, P., Vana, M., Mirme, A., Mirme, S., Hõrrak, U., Plass-Dülmer, C., Stange, G., Kiss, G., Hoffer, A., Törő, N., Moerman, M., Henzing, B., de Leeuw, G., ... Kulmala, M. (2010). EUCAARI ion spectrometer measurements at 12 European sites – Analysis of new particle formation events. *Atmospheric Chemistry and Physics*, 10, 7907–7927. https\://doi.org/10.5194/acp-10-7907-2010

Mariana, F. (1984). Răspunsuri endocrino-metabolice la bolnavii cardiovasculari sub acțiunea aeroionizării mofetelor de la Covasna [Endocrine-metabolic responses in cardiovascular patients under the influence of air ionization in Covasna mofettes]. *Primul Simpozion Național de Aeroinizare*, I, 181–185.

Mihăilă, D., Roșu, C., Bistricean, P.-I., Prisăcariu, A., Mihăilă, E.-V., & Boiciuc, C. (2023). *Research on air ionization in the tourist resorts of Solca, Cacica, Gura Humorului and in Cacica salt mine-north-eastern Romania.* Present Environment, & Sustainable Development, 17(2).

Moraru, S. (1984). Dereglări funcționale apărute într-un mediu de muncă golit de aeroionii mici [Functional disorders occurring in a work environment depleted of small air ions]. *Primul Simpozion Național de Aeroinizare*, I, 118–121.

Moraru, S., & Ciucianu, C. (1984). Studiu privind siuaţia aeroelectrică la sol în oraşul Bucureşti [Study of ground-level atmospheric electrical conditions in Bucharest]. *Primul Simpozion Naţional de Aeroinizare*, I, 81–91.

Paraschiv, V., Bejan, V., & Andrişan, C. (1984). Modelarea cantitativă şi calitativă a structurilor analitice aptitudinale şi a structurilor de personalitate în condiţii de aeroionizare negativă [Quantitative and qualitative modeling of aptitude and personality structures under negative air ionization]. *Primul Simpozion Naţional de Aeroinizare*, I, 134–143.

Parescan, Gh (1986). Aspecte fizice implicate în fenomenele biologice şi posibilitatea influenţării lor în aeroionizare [Physical aspects involved in biological phenomena and the possibility of influencing them through air ionization]. *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 151–155.

Pascu, V., Andrişan, C., Aionesei, M., Cristea, M., & Ivanovici, T. (1984). Blocul funcţional de aeroionizare între optim şi funcţional [The functional air ionization unit between optimal and functional operation]. *Primul Simpozion Naţional de Aeroinizare*, I, 64–70.

Popovici M., Elges, R., Rusu, I., & Straus, H. (1984). Cercetări experimentale privind influenţa variaţiilor ambianţei termice şi a aeroionizării asupra organismului [Experimental research on the influence of thermal environmental variations and air ionization on the organism]. *Primul Simpozion Naţional de Aeroinizare*, I, 110–117.

Prisăcariu, A., Mihăilă, D., Bistricean, P.-I., & Roşu, C. (2023). *The air ionisation in Suceava Metropolitan Area.* Present Environment, & Sustainable Development, 17(1).

Radu-Tudorache, Gr, Halga, P., Coman, I., Marcu, E., Bogdan, O., Alexa, E. M., Aionesei, M., & Suluniuc, G. (1986). Acţiunea aeroionilor negative asupra puilor Broiler crescuţi în condiţiile unei staţii pilot [Effects of negative air ions on broiler chickens raised in a pilot facility]. *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 494–501.

Roşu, C., Mihăilă, D., Bistricean, P.-I., Prisăcariu, A., Mihăilă, E.-V., Mihăilă, A., & Boiciuc, C. (2024). The favorability for aeroionotherapy on two touristic resorts from the eastern flank of Romanian Carpathian Mountains. *Geographia Technica*, 19(2).

Rusu, Fl, Andrişan, C., Stan, M., & Vacariu, O. (1986). Aspecte ale influenţei mediului ionizat asurpa răsadurilor de tomate [Aspects of the influence of an ionized environment on tomato seedlings]. *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 419–523.

Rusu, Fl, Rusu, C., Andrişan, C., Ţepordei, V., Ivan, E., & Scripca, C. (1986). Observaţii asupra influenţei aeroionizării în sericicultură [Observations on the influence of air ionization in sericulture]. *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 527–531.

Rusu, I., Laza, V., Bocu, T., & Straus, H. (1984). Influenţa aeroionizării negative asupra unor indicatori fiziologici la tineri [Influence of negative air ionization on physiological indicators in young people]. *Primul Simpozion Naţional de Aeroinizare*, I, 129–131.

Simionca, I., & Enache, L. (2011). The artificial air ionization effect (negative and positive) in experiment on some hematological parameters of wistar rats. *Balneo-Research Journal*, 2(1), 15–40.

Spulber, E. (1986a). Diagrama pentru aprecierea dinamicii valorilor tensiunii arteriale în cursul tratamentului cu aeroioni negativi [Chart for assessing changes in blood pressure during treatment with negative air ions]. *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 373–379.

Spulber, E. (1986b). Dinamica valorilor T.A. sub tratament cu aeroioni negativi la un lot de pacienţi cu hipertensiune arterial "de graniţă." [Changes in blood pressure during negative air ion treatment in a group of patients with borderline hypertension] *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 382–390.

Spulber, E. (1986c). Rezultate terapeutice în hipertensiunea arterială (HTA) prin expunere la aeroioni negativi [Therapeutic results in hypertension following exposure to negative air ions]. *Al II-Lea Simpozion Naţional de Aeroionizare*, II, 393–397.

Straus, H. (1984). Importanţa biologică şi sanitară a aeroionizării şi aportul şcolii clujene la acest domeniu [Biological and health significance of air ionization and the contribution of the Cluj school to this field]. *Primul Simpozion Naţional de Aeroinizare*, I, 58–62.

Straus, H., Popovici, M., & Elges, E. (1984). Influenţa reziduului unei ape puternic mineralizate asupra organismului animal în condiţiile ulcerului experimental şi a aeroionizării [Influence of the residue of highly mineralized water on animals under conditions of experimental ulcer and air ionization]. *Primul Simpozion Naţional de Aeroinizare*, I, 20–22.

Tammet, H. (1995). Size and mobility of nanometer particles, clusters and ions. *Journal of Aerosol Science*, 26(3), 459–475. https\://doi.org/10.1016/0021-8502(94)00121-E

Văcaru-Opriș, I., Holtea, V., Bălan, I., Alexa, E. M., Andrișan, C., & Aionesei, M. (1986). Contribuții la cunoașterea influenței aroionizării negative asupra producției la păsările crescute intensive [Contributions to understanding the influence of negative air ionization on production in intensively raised poultry]. *Al II-Lea Simpozion Național de Aeroionizare*, II, 470–480.

Zeana, G. (1984). Optimizarea funcției respiratorii exprimată prin probe ventilatorii în urma aplicării aeroinoterapiei [Optimization of respiratory function as measured by ventilatory tests following air ion therapy]. *Primul Simpozion Național de Aeroinizare*, I, 164–172.